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Cuc Phuong National Park
Ninh Binh Province
Vietnam

Indochina is clearly a hotspot of primate diversity, endemism and, unfortunately, threat. In all, 28 primate taxa are currently recognized as occurring in Vietnam, Cambodia, Laos, and part of southern China, and, of these, 19 are endemic to this region – a very high number for a region of this size.

Based on the Red List workshop for Asia's primates conducted in 2006, of these 28 taxa fully eight are considered "Critically Endangered", eleven "Endangered" and seven "Vulnerable". This means that more than 90% of all taxa in the region are threatened with extinction, the highest level for any region on earth.

Much of the most up-to-date work relating to the species of the region is included in this current volume. The contributions provide a good overview about the status of primate taxa in the region, the knowledge about their biology, serve as background for further conservation interventions

I congratulate the editors on yet another impressive effort, and look forward to working with you to continue conserving the region's threatened primates.

Russell A. Mittermeier, Ph.D.
President, Conservation International; and
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VAN NGOC THINH has been working on primate studies in Vietnam for 15 years, and has conducted a comprehensive study on crested gibbons in Indochina. Currently he continues field work on primates in Vietnam for several conservation organizations.

Tilo Nadler . Benjamin Miles Rawson . Van Ngoc Thinh

CONSERVATION OF PRIMATES IN INDOCHINA

Conservation of Primates in Indochina

Edited by

Tilo Nadler
Benjamin Miles Rawson
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Contents

III. BEHAVIOR AND ECOLOGY

IV. CONSERVATION

Nội dung

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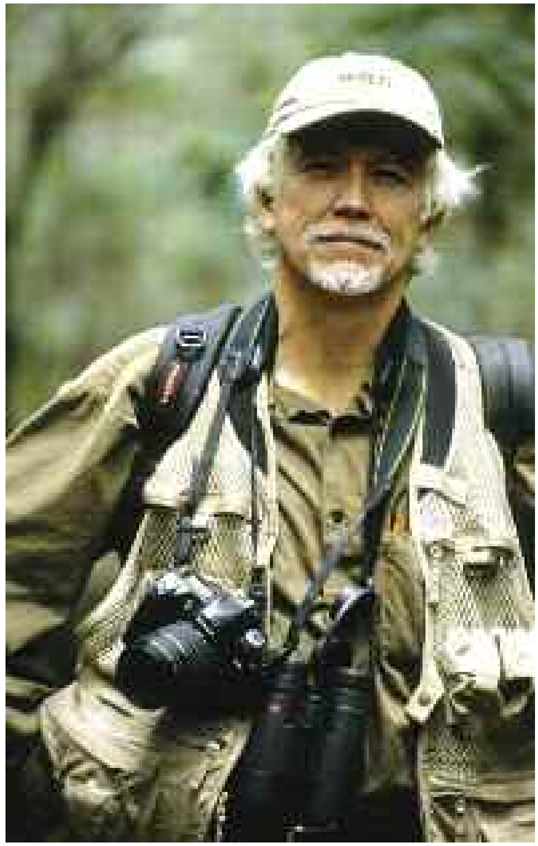
Foreword

I am pleased once again to be able to write a foreword to this important book, the latest in a series stemming from five yearly symposia in Indochina, which are really helping to advance the cause of primate conservation in the region. Indochina is clearly a hotspot of primate diversity, endemism and, unfortunately, threat. In all, 28 primate taxa are currently recognized as occurring in Vietnam, Cambodia, Laos, and partly southern China, and, of these, 19 are endemic to this region – a very high number for a region of this size. Threats to primates in the region, caused mainly by high hunting pressure for the wildlife trade, illegal logging and mining, and conversion of habitat for agriculture, have resulted in most of the taxa being threatened with extinction.

Based on the Red List workshop for Asia's primates conducted in 2006, of these 28 taxa fully eight are considered "Critically Endangered", eleven "Endangered" and seven "Vulnerable". This means that more than 90% of all taxa in the region are threatened with extinction, the highest level for any region on earth. In recognition of this high endemism and threat level, five species from this region, and specifically from Vietnam, have been listed on "Primates in Peril: The World's 25 Most Endangered Primates" every year since its inception in 2001, more than any other hotspot.

This continuing inclusion of five of Vietnam's primates on this list can be seen as both a lamentable tragedy and a call to arms. Arguably, their inclusion has raised the profile of these taxa globally, increasing interest in their study and conservation, and vitally, helping raise the necessary funding for implementing conservation interventions. I am pleased to note, that at least to some extent, the outlook for these species has improved since their initial inclusion on the list in 2001.

Among the positive developments we have the fact that Delacour's langur (*Trachypithecus delacouri*) and the enigmatic Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) now have one stable or increasing population in at least one protected area each, although several subpopulations have disappeared already. In addition, the Cat Ba langur's (*T. poliocephalus poliocephalus*) precipitous declines have been halted, and the grey-shanked douc (*Pygathrix cinerea*) has received considerable survey effort, revealing additional significant populations, although poaching is still a serious threat. The eastern black gibbon (*Nomascus nasutus*) was rediscovered in 2002, and hopefully transboundary conservation



Russell A. Mittermeier, Ph.D.
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Photo: Paula Rylands

activities can support to stabilize and increase this small population. Most of these taxa have also been the focus of long-term ecological studies for the first time in recent years. Much of the most up-to-date work relating to the species of the region is included in this current volume. The contributions provide a good overview about the status of primate taxa in the region, the knowledge about their biology, serve as background for further conservation interventions, and really lay the groundwork for even more success in the future.

One other point I would like to highlight for this region. For a while now, I have been promoting the concept of primate-watching and primate life-listing, based on the very successful model of bird watching in the ornithological community. The principal idea behind this is to encourage more and more people to visit the remote places where some of the world's most endangered primates occur, to help support local communities in conserving these animals, and to convince both these communities and national governments that these animals are an important economic resource as well. This is beginning to take hold, and there is no doubt that Indochina will be one of the most important target areas for future primate-watchers. I myself have had the privilege of seeing several of the region's unique species in the wild, but I am still missing quite a few, and plan to return many times in the hopes of seeing them all. I encourage all of you who read this excellent book to do the same.

In closing, I congratulate the editors on yet another impressive effort, and look forward to working with you to continue conserving the region's threatened primates.

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Lời nói đầu

Tôi cảm thấy vinh dự khi một lần nữa được viết lời nói đầu cho cuốn sách quan trọng này - cuốn kỷ yếu mới nhất trong bộ sách nói về chuyên đề linh trưởng ở Đông Dương được tổ chức sau năm năm. Loạt sách này thực sự hữu ích, giúp nâng cao hiểu biết về các nguyên nhân và chuyên nghành bảo tồn linh trưởng trong khu vực. Bán đảo Đông Dương là một điểm nóng về tính đa dạng, tính đặc hữu và cũng rất đáng tiếc rằng bao gồm cả về các mối đe dọa đối với các loài linh trưởng. Trên toàn bộ khu vực, có 28 taxa (loài và phân loài) linh trưởng hiện được xác định sinh sống tại Việt Nam, Cămpuchia, Lào và Nam Trung Quốc. Trong số này có đến 19 taxa đặc hữu - đây là một con số chiếm tỉ lệ rất cao cho một vùng có diện tích hẹp như vậy. Những mối đe dọa đối với các loài linh trưởng trong khu vực phần lớn là do tệ nạn săn bắt động thực vật hoang dã diễn ra với mức độ cao, khai thác gỗ và khai mỏ trái phép, kể cả việc lấn chiếm đất lâm nghiệp cho nông nghiệp gây nên mất sinh cảnh sống của động vật. Tất cả những nguyên nhân này đã làm cho hầu hết các taxa đang bị đẩy gần đến bờ đe dọa bị tuyệt chủng. Theo kết quả đánh giá từ Hội thảo về Danh lục Sách Đỏ các loài Linh trưởng Châu Á được tổ chức vào năm 2006, trong số 28 taxa có đến 8 taxa được liệt vào mức độ “Cực kỳ Nguy cấp”, 11 taxa “Nguy cấp” và 7 taxa “Dễ bị tổn thương”. Điều này chỉ ra rằng hơn 90% các taxa trong khu vực này đang có nguy cơ đe dọa bị tuyệt chủng, đây là nơi có mức độ bị đe dọa cao nhất so với bất kỳ khu vực khác trên thế giới. Nhận thức được tính đặc hữu và mức độ đe dọa cao, có 5 loài trong khu vực, đặc biệt đều là của Việt Nam luôn được liệt vào danh lục “ Linh trưởng gặp Nguy hiểm: 25 loài Linh trưởng Nguy cấp Hàng đầu trên Thế giới” kể từ khi danh lục này ra đời vào năm 2001, mức độ đe dọa là rất cao so với các khu vực điểm nóng khác.

Sự kiện 5 loài linh trưởng của Việt Nam liên tục được đưa vào danh lục có thể được xem là một bi kịch đáng buồn đồng thời gióng lên lời kêu gọi hãy cùng chung tay bảo vệ. Với Danh lục này đã đưa các taxa được đề cập vào trường quốc tế mang tính toàn cầu, làm tăng mối quan tâm đến công tác nghiên cứu và bảo tồn và một điều cực kỳ quan trọng là giúp kêu gọi nguồn ngân sách cần thiết để có thể tiến hành thực hiện những can thiệp bảo tồn. Tôi thật sự vui mừng xin thông báo rằng ít nhất theo một khía cạnh nào đó thì quan niệm đối với các taxa linh trưởng đã được cải thiện hơn hẳn kể từ khi chúng được đưa vào danh lục lần đầu tiên vào năm 2001.

Trong số những phát hiện tích cực, thực tế cho thấy rằng một số quần thể của loài voọc mông trắng (*Trachypithecus delacouri*) và loài voọc mũi hếch (*Rhinopithecus avunculus*) hiện đang ngày càng tăng lên hay giữ ở mức ổn định. Tối thiểu thì điều này đang diễn ra tại một khu bảo tồn cho mỗi loài, mặc dù có nhiều tiểu quần thể đã bị tiêu giảm và biến mất. Thêm vào đó, số lượng loài voọc Cát Bà (*T. poliocephalus poliocephalus*) bị giảm xuống mạnh nhưng đã được ngăn chặn. Voọc chà vá chân xám (*Pygathrix cinerea*) cũng nhận được các nỗ lực khảo sát đáng kể giúp hé mở thêm các thông tin về quần thể loài này. Tuy nhiên, nạn săn bắt vẫn là một trong những mối đe dọa nghiêm trọng. Vượn đen tuyền phía Đông (*Nomascus nasutus*) được tái phát hiện vào năm 2002, hy vọng rằng với các hoạt động bảo tồn xuyên quốc gia có thể hỗ trợ giúp giữ mức ổn định và tăng dần quần thể nhỏ bé này. Hầu hết các taxa linh trưởng đều là trọng tâm của các nghiên cứu sinh thái dài hạn đầu tiên trong những năm trở lại đây. Những công việc mới nhất liên quan đến các taxa trong khu vực đều được đưa vào trong cuốn sách này. Những đóng góp đã mang lại một cái nhìn khái quát tốt về tình trạng các taxa linh trưởng trong khu vực, kiến thức về sinh học được dùng làm bối cảnh cho các can thiệp bảo tồn về sau và thậm chí để lại nền tảng cho các thành công tiếp nối trong tương lai.

Một điểm nữa tôi muốn nhấn mạnh cho khu vực này. Từ trước cho đến nay, tôi đã luôn xúc tiến đẩy mạnh khái niệm về việc quan sát linh trưởng và các hoạt động trong cuộc sống của chúng dựa trên nền tảng mô hình quan sát chim rất thành công trong lĩnh vực nghiên cứu chim. Ý tưởng chủ đạo đằng sau việc này là để khuyến khích ngày càng có nhiều người hơn đến thăm những vùng sâu vùng xa nơi có một số loài linh trưởng đang bị đe dọa vào bậc nhất trên toàn thế giới; nhằm giúp cộng đồng địa phương trong công tác bảo tồn các loài này; thuyết phục các cộng đồng cũng như chính quyền nhận thức được rằng các loài này cũng là nguồn tài nguyên kinh tế quan trọng. Điều này khởi nguồn cho sự hiểu biết, và không nghi ngờ gì nữa khi khẳng định rằng Đông Dương sẽ là một trong các vùng mục tiêu quan trọng nhất đối với các nhà quan sát linh trưởng trong tương lai. Bản thân tôi có được đặc ân là đã quan sát được nhiều loài đặc hữu trong tự nhiên nhưng tôi vẫn chưa quan sát được một số loài ở khu vực này và đang lên kế hoạch trở lại khu vực này nhiều lần với hy vọng rằng có thể chiêm ngưỡng được tất cả chúng trong tự nhiên. Tôi khích lệ tất cả các độc giả đọc cuốn sách tuyệt vời này nên làm như tôi.

Cuối cùng, tôi xin chúc mừng các nhà biên tập vì một lần nữa cho thấy những nố lực tuyệt vời đồng thời tôi cũng mong đợi được cùng làm việc với các vị để tiếp tục trên con đường bảo tồn các loài linh trưởng đang bị đe dọa trong khu vực.

Tiến sĩ Russell A. Mittermeier
Chủ tịch, Tổ chức Bảo tồn Quốc tế (CI); và
Chủ tịch, Nhóm Chuyên gia Linh trưởng IUCN/SSC

Preface

From 27th-30th November, 2008 the Forestry Protection Department of Vietnam in association with Cuc Phuong National Park, Frankfurt Zoological Society and Conservation International held a four day symposium on the "Conservation of Primates in Indochina". The conference was held in Cuc Phuong National Park and attracted over 100 delegates conducting research in 12 different countries. This therefore represented a significant platform for transboundary networking and allowed for the sharing of lessons in primate conservation in both the region and beyond.

In total, 31 presentations were delivered during the symposium. These came from five countries in the region, Vietnam, Lao PDR, Cambodia, China and Thailand and covered diverse topics such as status and distribution, ecology, taxonomy, survey techniques, population assessment and monitoring, trade and reintroduction. On the final day a round-table workshop on translocation of primates was held.

During the symposium a discussion was initiated to invite the XXV. Congress of the International Primatological Society to Vietnam in 2014 and to prepare a bid for the invitation. The discussion group agreed that an IPS Congress in Vietnam would not only enable the global community of primatologists a closer view to the unique Vietnamese primate taxa but also support broader conservation activities in the country.

This book represents the proceedings of this symposium with the aim to more widely distribute the most up-to-date information about the regions primates. This symposium marked the 5th anniversary since the first primate conservation symposium held in Cuc Phuong in 2003, which was titled "Conservation of Primates in Vietnam." The preface for the proceedings of that symposium identified several issues which required additional focus and investment if primate conservation was to be successful. Looking back, there has been real development in subsequent years; the region has witnessed a thriving expansion of studies on the status, genetics, behavior, ecology, taxonomy, and conservation of primates.

While it is gratifying to retrospectively look at what has been achieved in recent years, the majority of the work is still ahead if a series of extinctions of the regions primates are to be avoided. In the long-term many species remain in highly fragmented populations of questionable viability and several populations show a dramatic decline in numbers. It appears that part of successful primate conservation in the region will require innovative measures for protection, consequent and strict law enforcement and a concentration of funds and capacity in protection activities.

Research and studies on primates provide the scientific background for conservation actions but the practice shows an insufficient response. No field study ends without conclusions and recommendations for improvement of protection but in general these are not recognized or enforced by local authorities. A number of field studies contribute to our knowledge only by documentation of the dwindling populations. Also the arduous way to establish a Species and Habitat Conservation Area is only a bureaucratic action if no well planned and organized activities follow. For most – if not for all – Indochinese primate taxa still have adequate habitat space available and there are still no considerable conflicts with the economic and agricultural development of the countries. The main factor for the dramatic decrease of populations is poaching, a criminal activity. And this is concentrated on the last refugees of different species - in protected areas, nature reserves and national parks. If these criminal activities cannot be stopped several taxa which are the subjects of primatological studies will disappear in the future.

Species conservation is a long-term goal. The listings of more than 90% of Vietnam's primates are threatened with extinction in the near future and the dramatic declines of several populations show the critical situation. High efforts and the focused use of limited funds for conservation are necessary to reach this goal. The increased capacity and interest in the regions primates and an ever growing cohort of competent confident and well trained national conservationists working on primate conservation gives hope for the preservation of unique primate species of Indochina.

The Editors
Hanoi, Vietnam – April 2010

Participants on the symposium "Conservation of Primates in Indochina", 27th-30th November 2008 in Cuc Phuong National Park, Vietnam.

Photo: N. Rowe.

Lời tựa

Từ ngày 27-30 tháng 11 năm 2008, Cục Kiểm lâm Việt Nam phối hợp với Vườn Quốc gia Cúc Phương, Hội Động vật học Frankfurt và Tổ chức Bảo tồn Quốc tế đã tổ chức một cuộc hội thảo chuyên đề kéo dài bốn ngày với chủ đề "Bảo tồn Linh trưởng ở Đông Dương". Hội thảo diễn ra tại Vườn Quốc gia Cúc Phương, đã thu hút sự tham gia của hơn 100 đại biểu, là những người đã từng thực hiện công tác nghiên cứu tại 12 quốc gia khác nhau. Do vậy, hội thảo này đã tạo ra nền tảng đầy ý nghĩa cho mạng lưới liên kết liên quốc gia đồng thời cho phép các đại biểu chia sẻ các bài học kinh nghiệm về bảo tồn linh trưởng trong và ngoài khu vực.

Tổng cộng có 31 bài tham luận được trình bày trong suốt hội nghị. Các bài viết đề cập đến 5 quốc gia trong khu vực là Việt Nam, Lào, Campuchia, Trung Quốc và Thái Lan, đã thể hiện đa dạng các đề tài từ tình trạng và sự phân bố cho đến, hệ sinh thái, sự phân loại loài, các kỹ thuật khảo sát, đánh giá và giám sát quần thể, buôn bán và tái hòa nhập vào tự nhiên. Vào ngày cuối của hội nghị là hội thảo bàn tròn cùng bàn luận về việc di dời linh trưởng.

Hội nghị cũng thảo luận về sáng kiến mời gọi tổ chức Đại hội lần thứ XXV của Hội nghị Linh trưởng học Quốc tế tại Việt Nam vào năm 2014 đồng thời chuẩn bị bỏ thầu cho sự kiện này. Nhóm thảo luận đồng ý với nhận định rằng một Đại hội của Hội Linh trưởng học Quốc tế (IPS) tại Việt Nam không chỉ cho phép cộng đồng các nhà nghiên cứu linh trưởng học có cái nhìn rõ hơn về các taxa linh trưởng độc nhất ở Việt Nam mà còn hỗ trợ các hoạt động bảo tồn quy mô hơn.

Cuốn sách này trình bày kỷ yếu của hội nghị chuyên đề nhằm mục đích phổ biến các thông tin mới nhất về linh trưởng trong khu vực ra phạm vi rộng hơn. Hội nghị này cũng đánh dấu lễ kỷ niệm năm thứ 5 kể từ khi hội nghị bảo tồn linh trưởng Việt Nam được tổ chức lần đầu tiên tại Cúc Phương vào năm 2003 với chủ đề "Bảo tồn Linh trưởng ở Việt Nam". Phần mở đầu cho kỷ yếu của hội nghị đã xác định được nhiều vấn đề cần được chú ý và đầu tư thêm để công tác bảo tồn linh trưởng có thể đi đến thành công. Nhìn lại chặng đường đã qua cho thấy có sự phát triển thật sự trong những năm về sau; khu vực đã chứng kiến sự mở rộng mạnh trong công tác nghiên cứu về tình trạng, loại gen, hành vi, sinh thái, phân loại và bảo tồn các loài linh trưởng.

Chúng ta hoàn toàn hài lòng khi nhìn lại trong quá khứ những gì đã đạt được trong những năm gần đây. Phần lớn công việc vẫn còn nằm ở phía trước giúp tránh được nguy cơ tuyệt chủng của một loạt các loài linh trưởng trong khu vực. Về lâu dài nhiều quần thể sinh sống bị chia cắt cao, khả năng tồn tại thấp và nhiều loài khác có số lượng giảm hẳn qua thời gian. Dường như một phần tạo nên thành công trong công tác bảo tồn linh trưởng trong vùng cần phải có những biện pháp mang tính sáng tạo về bảo tồn, thực thi pháp luật nghiêm minh và liên tục đồng thời tập trung nguồn ngân sách và năng lực vào các hoạt động bảo tồn.

Các nghiên cứu và tìm hiểu về linh trưởng đã mang lại được bối cảnh khoa học cho các hoạt động bảo tồn. Tuy nhiên thực tế chỉ ra rằng không có sự phản hồi đầy đủ. Không có chuyến khảo sát thực địa nào kết thúc mà không đưa ra kết luận và đề xuất cần cải thiện hoạt động bảo tồn nhưng nhìn chung lại không được các cơ quan chính quyền địa phương nhận thức hay tiến hành thực thi. Một số các nghiên cứu tại hiện trường chỉ mang tính đóng góp thêm vào nguồn kiến thức bằng cách tài liệu hóa thông tin về các quần thể đang bị thu nhỏ dần. Đồng thời chặng đường gian nan đi đến thành lập một vùng bảo tồn sinh cảnh và loài cũng chỉ là một hành động mang hình thức giấy tờ nếu không có bất kỳ hoạt động theo sau nào được tổ chức và lên kế hoạch cẩn thận. Hầu hết, nếu không nói là tất cả cho rằng quần thể linh trưởng trong khu vực Đông Dương vẫn có một sinh cảnh sống đầy đủ sẵn có và không có bất kỳ xung đột đáng kể nào gây ra bởi hoạt động phát triển kinh tế và nông nghiệp của các quốc gia. Nhân tố chính gây nên sự giảm sút nghiêm trọng của các quần thể chính là nạn săn bắn, bẫy bắt, một hoạt động tội phạm thiên nhiên. Và hoạt động này thậm chí còn tập trung vào những loài sống sót cuối cùng trong các khu bảo tồn thiên nhiên và vườn quốc gia. Nếu các hoạt động phạm pháp này không được ngăn chặn triệt để thì nhiều quần thể, đối tượng của các hoạt động nghiên cứu linh trưởng sẽ biến mất hoàn toàn trong một tương lai gần.

Bảo tồn loài là một mục tiêu mang tính chất lâu dài. Danh sách hơn 90% các loài linh trưởng tại Việt Nam đang bị đe dọa tuyệt chủng trong tương lai gần và tình trạng giảm đi ngày càng nghiêm trọng của nhiều quần thể đang gióng lên lời cảnh tỉnh về tình trạng báo động khẩn cấp. Các nỗ lực lớn và việc tập trung sử dụng nguồn ngân sạch hạn hẹp vào hoạt động bảo tồn đóng vai trò cần thiết để có thể đi đến thành công này. Việc nâng cao năng lực và mối quan tâm về các loài linh trưởng trong khu vực cùng với gia tăng số lượng các nhà bảo tồn linh trưởng trong nước có năng lực và được tập huấn tốt đang đem lại hy vọng bảo tồn các loài linh trưởng có một không hai này tại khu vực Đông Dương.

Các tác giả
Hà Nội, Việt Nam – tháng 4 / 2010

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Lời cảm ơn

Cuộc hội thảo chuyên đề về “Bảo tồn Linh trưởng ở Đông Dương” được thành công và có ý nghĩa là nhờ sự giúp đỡ và ủng hộ của các cơ quan, tổ chức và các cá nhân tham gia hội thảo.

Như cuộc hội thảo lần đầu tiên về “ Bảo tồn Linh trưởng ở Việt Nam” vào năm 2003 cũng nhận được sự ủng hộ của Cục Kiểm Lâm, Bộ Nông nghiệp và Phát triển Nông thôn Việt Nam. Chúng tôi chân thành cảm ơn ông Nguyễn Hũu Dũng, nguyên Trưởng phòng Bảo tồn, Cục Kiểm lâm đã đóng góp rất quý báu trong việc tổ chức và tham gia thảo luận về phía Việt Nam tại Hội nghị của Hiệp hội Linh trưởng Quốc Tế.

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Để tổ chức điều phối hội thảo thành công, chúng tôi chân thành cảm ơn bà Nguyến Thị Thu Hiền, cũng như sự đóng góp của bà trong dịch thuật và hiệu đính các tóm tắt tiếng Việt cho quyển sách này.

Hội thảo chuyên đề này thực hiện được nhờ sự tài trợ kinh phí của Hội Động vật học Frankfurt, Tổ chức Bảo tồn Quốc tế và Quỹ Bảo tồn Linh Trưởng. Lời cảm tạ trân trọng tới các tổ chức trên đã tài trợ cho hội thảo.

Sự tham gia đầy đủ và nhiệt tình của các quý vị đại biểu cùng với các bài tham luận ấn tượng, sâu sắc cũng như các cuộc thảo luận sôi nổi xung quanh chủ đề của hội thảo đã nói lên sự thành công của hội thảo.

Chúng tôi xin chân thành cảm ơn tất cả các tác giả của các bài tham luận trong quyển sách này.

Xin chân thành cảm ơn ông James Hardcastle, ông Jeremy Phan và bà Nguyến Thị Thu Hiền đã tham gia hiệu chỉnh bản thảo trong quá trình chuẩn bị cho quyển sách ra đời.

Distribution & Status

Chapter I

1

STATUS OF VIETNAMESE PRIMATES – COMPLEMENTS AND REVISIONS

TILO NADLER

SUMMARY

Status assessments, population estimates, new findings about distribution and taxonomic positions should be updated to provide background information for conservation activities. All Vietnamese primate species are under extremely high pressure and the decrease of populations show a dramatic loss of many, especially small and isolated subpopulations. The numbers of individuals in larger populations show a steady decrease. The total loss of some primate species for Vietnam in the long run can not be excluded. More than ninety percent of the species are on the brink of extinction for the country. Despite the decrease in numbers of several primate species already announced since the last twenty years no sufficient measures are implemented to stop further loss. Strong decisions and actions are necessary to avoid further extirpations. National and international conservation funds and capacity should be concentrated on active protection work and reduced in field studies in which the contents occasionally only record the dwindling of populations.

INTRODUCTION

The knowledge about the status of species and populations is an important conservation tool. Depending on the changes of limited funds for conservation activities, manpower, and education, efforts can be concentrated on projects to stabilize critical populations and to secure their survival. Data that is based on monitoring, new discoveries or dramatic population changes should be updated. A continual lack of actual data for a specific taxon in the assessment shows the need for further work. Several cases are known in which a late assessment of a believed common species has revealed a dire situation and then required a high effort in conservation activities.

This paper strives to actualize previous status assessments and to present an actual overview. The impact to the environment is high, the development fast and not all sources on information available. Therefore the paper also calls for corrections and will show gaps in information.

For Vietnam 25 primate taxa are recorded, the highest number in Southeast Asian countries (Table 1). In the past, some status reviews on Vietnamese primates have been published. The most comprehensive overview is given on threatened species, belonging to gibbons (Geissmann *et al*., 2000) and leaf monkeys, including langurs, douc langurs and the snub-nosed monkey (Nadler *at al*., 2003). A more comprehensive status review of lorises and macaques is still lacking. Some information about these species is provided by Nadler & Streicher, 2004, and Nadler *et al*., 2007. But since then no significant new information has been collected.

This paper will also compile and add new findings which include new insights and changes in the systematic positions of taxa. A change in the systematics can also lead to a change in conservation efforts for taxa and populations.

Table 1. Vietnamese primate taxa.

	Loridae	
1	Pygmy loris	*Nycticebus pygmaeus*
2	Northern slow loris	*Nycticebus bengalensis*
	Cercopithecidae	
3	Long-tailed macaque	*Macaca fascicularis fascicularis*
4	Con dao long-tailed macaque	*Macaca fascicularis condorensis*
5	Stump-tailed macaque	*Macaca arctoides*
6	Rhesus macaque	*Macaca mulatta*
7	Assamese macaque	*Macaca assamensis assamensis*
8	Northern pig-tailed macaque	*Macaca leonina*
9	Annamese silvered langur	*Trachypithecus margarita*
10	Indochinese silvered langur	*Trachypithecus germaini*
11	Grey langur	*Trachypithecus crepusculus*
12	Francois' langur	*Trachypithecus francoisi*
13	Hatinh langur	*Trachypithecus* [*laotum*] *hatinhensis*
14	Black langur	*Trachypithecus* [*laotum*] *ebenus*
15	Cat Ba langur	*Trachypithecus* [*poliocephalus*] *poliocephalus*
16	Delacour's langur	*Trachypithecus delacouri*
17	Red-shanked douc langur	*Pygathrix nemaeus*
18	Grey-shanked douc langur	*Pygathrix cinerea*
19	Black-shanked douc langur	*Pygathrix nigripes*
20	Tonkin snub-nosed monkey	*Rhinopithecus avunculus*
	Hylobatidae	
21	Western black gibbon	*Nomascus concolor*
22	Eastern black gibbon	*Nomascus nasutus*
23	Northern white-cheeked gibbon	*Nomascus leucogenys*
24	Southern white-cheeked gibbon	*Nomascus siki*
25	Yellow-cheeked gibbon	*Nomascus gabriellae*

A side effect of an overview is also a contribution to stabilize scientific and common names. Not only for a public understanding, but also for decisions, the release of regulations and laws, and lastly an agreement on the names of taxa reduces misunderstanding and misinterpretation. Scientific names are not only dependent on the level of scientific research, mostly based on molecular genetics, vocalization, behavior, and anatomical features. They also depend on the use of the species concept. The systematic position of a taxon – and following its name - can be different depending on the use of the phylogenetic species concept or the wide spread biological species concept, commonly used in the past.

Contrary to scientific names, common names depend only on the authors. It would be helpful to find a consensus for common names. Common names should be uncomplicated and preferably feature on typical habits or the distribution of a taxon. Wide spread "traditional" names are preferable and not new artificial creations, like "bar-headed black leaf monkey" for Hatinh langur, or "white-rumped black leaf monkey" for Delacour's langur etc. (Brandon-Jones *et al.*, 2004). Many names for one species often support confusion (like buff-cheeked, brown-cheeked, yellow-cheeked, and golden-cheeked gibbon, or -crested gibbon for Nomascus gabriellae). Here are scientific and common names recommended for the use of Vietnamese primates.

The status of IUCN listing is mentioned for each species (IUCN, 2009), and the listing under 25 the "World's Most Endangered Primates" (Mittermeier *et al.*, 2009).

PRIMATE TAXA OF VIETNAM

VULNERABLE

Pygmy loris (*Nycticebus pygmaeus*)

There are no new findings about the distribution and status of the pygmy loris. The number in the illegal trade is still very high. This also reflects the high number of 50 confiscated animals received at the Endangered Primate Rescue Center during the last five years.

VULNERABLE

Northern slow loris (*Nycticebus bengalensis*)

The population density of northern slow loris is probably overestimated. There are only few observations in the wild and the number of animals in the trade compared to the pygmy loris is very low. Le Khac Quyet & Nguyen Vu Khoi (this volume) added observations to the known occurrence of the taxa on Phu Quoc Island. It seems there is a gap in distribution between central Vietnam and the occurrence on Phu Quoc.

Macaques (*Macaca* sp.)

There are only scanty and scattered information for all *Macaca* species available. Some areas carry still reasonable populations where in other areas macaques populations are dwindling under hunting pressure. The natural distribution of some taxa is not clear due to the release of confiscated individuals or escape of captive or traded individuals.

VULNERABLE

Stump-tailed macaque (*Macaca arctoides*)

The original continuous distribution through the whole country from the North ends in the South, probably on the southern edge of the Annamite Mountain region, North of Ho Chi Minh City. Isolated records known from Con Dao Island, U Minh Thuong National Park and Phu Quoc Island probably resulted from escaped or released individuals. Rumors about the occurrence on Phu Quoc Island could not be confirmed with field observations (Le Khac Quyet & Nguyen Vu Khoi, this volume).

There exists only one quatitiative analysis for the species from Bach Ma National Park (Van Ngoc Thin, 2004). With an average density in primary forest of 10,15 individuals/km^2 and in secondary forest with 8,52 individuals/km^2 the total population was estimated to 660 individuals for 70 km^2.

LEAST CONCERN

Rhesus macaque (*Macaca mulatta*)

A border for the distribution of this species in central Vietnam is due to a hybridization zone with long-tailed macaques not clearly defined. A hybridization zone exists also in Laos where it is studied in more detail (Hamada *et al.*, this volume). Reintroduced animals in southern Vietnam (e.g. some dozen individuals in Cat Tien National Park) have established hybrid populations with *Macaca fascicularis*.

VULNERABLE

Assamese macaque (*Macaca assamensis assamensis*)

The Assamese macaque is distributed closer to and in the mountainous areas in northern Vietnam. Detailed information about the sympatric distribution with rhesus macaques is missing.

LEAST CONCERN

Long-tailed macaque (*Macaca fascicularis fascicularis, M. f. condorensis*)

The long-tailed macaque has a broad spectrum on habitats. The classic habitats for the species are coastal forests and mangrove swamps, but populations are also found in primary and secondary forests in higher altitudes in Vietnam, up to about 300 m asl.

Due to a hybridization zone with rhesus macaques on the northern border of the long-tailed macaques distribution there is no clear borderline to define between long-tailed macaques and rhesus macaque's distribution.

Confiscated animals in northern Vietnam are preferably released in protected areas, far from their natural occurrence (e.g. nature reserves Pu Luong, Bana Nui Chua, national parks Pu Mat, Cat Ba, and Ba Vi) and established small populations in some areas. A possible hybridization with different local macaque species is unknown and not studied.

There is now new information about the endemic subspecies *M. f. condorensis* from the Con Dao Archipelago in southern Vietnam. The taxon is listed as "Data Deficient".

The long-tailed macaque is under hunting pressure for its use in farms or as laboratory animals. The number of illegal extracted animals as founders for farming or direct export for laboratories is unknown for Vietnam but information from Laos show a high demand (Hamada *et al*., this volume).

VULNERABLE

Northern pig-tailed macaque (*Macaca leonina*)

The occurrence of pig-tailed macaques are confirmed in survey reports for the already known distribution in central and South Vietnam but no numbers about population density or population changes are available. Populations away from the known distributions (Nadler *et al*., 2007; Dang Ngoc Can *et al*., 2008) have been observed in Na Hang Nature Reserve (Hill & Hallam, 1997). The distribution of this species in northern Vietnam is not clear yet, but the wide distribution mentioned by Dang Huy Huynh *et al*. (2008) is questionable.

The pig-tailed macaque, as a more terrestrial species, is threatened through the use of snare traps. With the practice of gun control and gun registration in several areas the use of traps has increased and probably the threat to this species as well.

ENDANGERED

Francois' langur (*Trachypithecus francoisi*)

Francois' langur has only a very fragmented population in northern Vietnam with small subpopulations. All populations are under high hunting pressure and in the future it's expected that several subpopulations will be extirpated.

The largest population in Vietnam was found in a limestone area north-west of Na Hang Nature Reserve (Forest Protection Department of Tuyen Quang Province, 2004), with an estimated total of 35-44 individuals (Le Khac Quyet, 2003). But the hunting pressure is high and at least 5 individuals were killed between March and October 2003.

Ba Be National Park harbors one of the oldest known localities of Francois' langur in Vietnam (Ratajszczak *et al*., 1990). Poaching is still high and in 2009 there is only information of two groups (4 to 6 and 4 individuals) (Dong Thanh Hai, 2009). But the group with 4 to 6 individuals couldn't be confirmed by a second survey and has probably been extirpated already (M. Dine, pers. comm.).

In a limestone area between Na Hang Nature Reserve and Ba Be National Park partly belonging to the South Xuan Lac Species and Conservation Area for Francois' langurs exists also a small population (Le Trong Trai *et al*., 2004). In 2001 the population comprised of probably only around 30 individuals. The area is highly impacted by mining activities, hunting and logging (Le Trong Trai *et al*., 2004) and no newer information is available.

The existence of the species is still referred to in interviews during a survey in Kim Hy Nature Reserve, and animal parts are recorded – mostly in rice brandy as traditional tonic. Poaching is extremely high and gun shots are heard every day during the survey period (Geissmann *et al*., 2009). There is also an extremely high impact to the nature reserve through gold mining, logging and forest product collection.

For Cham Chu Nature Reserve, Tuyen Quang Province the species was commonly described in the mid ninety's but the population soon collapsed. In 2001 interviews reported 3 to 4 groups with 5 to 6 animals each (Long & Le Khac Quyet, 2001). Information about the existence of a group with 15 individuals was gathered during a survey in 2006 of which three individuals were already killed in 2005 (Dong Thanh Hai *et al*., 2006).

A population of Francois' langurs was discovered during field surveys for Tonkin snub-nosed monkey in Du Gia Nature Reserve and Khau Ca limestone complex, Ha Giang Province (Le Khac Quyet, 2002). No detailed survey in the area hasve been carried out.

CRITICALLY ENDANGERED

The Worlds 25 Most Endangered Primates

Delacour's langur (*Trachypithecus delacouri*)

The Delacour's langur is the longest and most detailed monitored langur taxon in Vietnam. In 1993 with the start of the “Vietnam Primate Conservation Programme” of Frankfurt Zoological Society surveys were carried out to gather information about distribution and status of the species. In 1996 the total population was estimated of 121-186 individuals (Nadler, 1996). Subsequent surveys added small and isolated subpopulations and revised this result. Nineteen subpopulations were found with a total of 50-57 groups and 281-317 individuals, but also realized that three additional subpopulations already extirpated. The result of the surveys presented the dramatic situation that 60% of the recorded individuals in subpopulations exist with less than 20 animals (Nadler, 2004). It was to expect that several subpopulations will disappear soon, and subsequent surveys confirmed this. Not all of the discovered subpopulations were surveyed again but during the last decade probably 6 to 7 subpopulations with about 60 individuals eradicated. In Ngoc Son-Ngo Luong Nature Reserve, Hoa Binh Province the population was also eradicated (Le Trong Dat *et al*., 2008). In 5 surveyed subpopulations the number of groups reduced in total from around 16 to 18 down to 10 to 11 and the number of individuals from around 91 to 96 down to 60 to 69 (Le Van Dung & Nadler, 2010). The population in Cuc Phuong National Park, the locality where the species was rediscovered in 1987, more than fifty years after its scientific description, decreased during the last decade of about 50% to probably 4 groups with 8 to 11 animals in total (Luong Van Hao & Le Trong Dat, 2008).

The only increased population exists in Van Long Nature Reserve, Ninh Binh Province. After the discovery of the occurrence of Delacour’s langur in 1993, the nature reserve was established in 2001. In close cooperation with the Management Board of the nature reserve Frankfurt Zoological Society supported the protection with the employment of 27 guards, construction of five ranger stations, equipment, and close contact to the surrounding communes. These activities eliminated the hunting pressure to the langurs and consequently since establishment of the reserve in 2001 the langur population, which contatined roughly 57 to 67 individuals doubled under strict protection measures to 100 to 120 individuals.

The total number of the Delacour’s langur comprises no more than 200 individuals.

ENDANGERED

Hatinh langur (*Trachypithecus* [*laotum*] *hatinhensis*)

The distribution of the taxon in Vietnam is restricted to Quang Bing and Quang Tri Provinces. A population in Quang Tri Province was discovered in 2005 (BirdLife International, 2005). A survey in Phong Nha-Ke Bang National Park with the largest known population resulted in an estimation of 1,670 to 2,610 individuals based on a survey on four locations inside the nature reserve (Haus *et al*., 2009). The high number exceeds the previous estimation of about 800 individuals (Pham Nhat, 2002) but it’s still questionable whether the relatively small survey areas were representative of the whole national park. Surveys in surrounding areas of Phong Nha-Ke Bang National Park brought no evidence of the existence of Hatinh langur populations (Nguyen Manh Ha, 2006).

VULNERABLE

Black langur (*Trachypithecus* [*laotum*] *ebenus*)

The systematic position of this taxon is still not verified. There are observations of this taxon in the wild in parapatric or sympatric distribution with Hatinh langurs (Le Khac Quyet, 2004) and with Lao langurs (*Trachypithecus* [*laotum*] *laotum*) as well (Nadler, 2009). But only two individuals are available for a molecular genetic investigation (the type specimen and one living animal at the Endangered Primate Rescue Center, Vietnam). These individuals show a very close relationship to Hatinh langurs and observations from the wild show a clinal variation in the extension of the white sign on the head what support the status as a color morph of Hatinh langurs.

On the supposition that *ebenus* has an allopatric distribution and based on the phylogenetic species concept Groves (2001) placed the taxon as valid species.

CRITICALLY ENDANGERED

The Worlds 25 Most Endangered Primates

Cat Ba langur (*Trachypithecus* [*poliocephalus*] *poliocephalus*)

After a dramatic decline during the last decades (Nadler & Ha Thang Long, 2000; Stenke & Chu Xuan Canh, 2004), it seems that the population stabilized on a very low number of 60 to 70 individuals (Schrudde *et al*., this volume). The problem of the population is that these individuals probably don’t represent a panmictic population, there are isolated groups which don’t contribute to the genetic pool of the whole population (Schrudde *et al*., this volume).

The Cat Ba langur has only a slight molecular genetic difference to the white-headed langur (*T.* [*p.*] *leucocephalus*) in Guangxi Province, China which places both taxa on subspecies level. But the allopatric distribution is the reason to upgrade the taxa to species level under the view of the phylogenetic species concept.

ENDANGERED

Grey langur (*Trachypithecus crepusculus*)

It seems that the name of the species not only describes the coloration of the species but also the occurrence. Since years there are only few direct observations made. It is probably one of the rarest langur species in Vietnam.

In 2002 five individuals were observed in Cuc Phuong National Park. During interviews one local mentioned an observation of 10 individuals in 1999 (Luong Van Hao & Nguyen Quang Trung, 2006). Based on feces samples the occurrence of the species was confirmed for Pu Luong Nature Reserve (Nadler *et al.*, 2004). From the neighboring Ngoc Son-Ngo Luong Nature Reserve only interview information indicates that probably few individuals exist (Le Trong Dat *et al.*, 2008).

The Mu Cang Chai Species/Conservation Area, Yen Bai Province and neighboring Muong La forest probably supports the largest population of this species. In 2004 a special field survey for the species was carried out in the area. As a result there is only interview information from locals about the existence of 4 to 5 groups with total of 31 to 39 individuals. Interview information during a survey and training course lists 4 to 7 groups with a total of 40 to 75 individuals for the area of Che Tao-Nam Pam, Mu Cang Chai District, Yen Bai Province and Muong La District, Son La Province (Le Trong Dat *et al.*, 2005). Despite the high number mentioned in interviews no direct observation was made during the survey.

In 2008 only one sighting of 6 to 8 animals was made in Mu Cang Chais's forest and based on interview information a population for the Mu Cang Chai – Muong La area is estimated of 9 to12 groups with a total of 50 to 83 individuals. The hunting pressure is high in the area and often several animals are killed per year (Le Trong Dat & Luong Van Hao, 2008).

ENDANGERED

Indochinese silvered langur (*Trachypithecus germaini*)

After the discovery of the differences in the silvered langur - group and the split into species, the Indochinese silvered langur occurs in a relatively restricted area in Vietnam, most probably only South of the Mekong (Nadler, *et al.*, 2005; Roos *et al.*, 2008). Populations are mostly concentrated on limestone areas, probably as refuge in the highly cultivated landscape. Beside the known occurrence of small and isolated populations in Kien Giang, An Giang, and Dong Thap Provinces, probably the largest and only viable population in Vietnam is confirmed on Phu Quoc Island with an estimated number of 31 to 44 individuals (Le Khac Quyet & Nguyen Vu Khoi, this volume).

ENDANGERED

Annamese silvered langur (*Trachypithecus margarita*)

The Annamese silvered langur occurs in Vietnam East of the Mekong (see above Indochinese silvered langur). Recent new information is only available about the population in Ta Kou Nature Reserve with at least 60 individuals (Hoang Minh Duc *et al.*, this volume).

ENDANGERED

Red-shanked douc langur (*Pygathrix nemaeus*)

The largest population of red-shanked douc langur exists in Lao PDR (Timmins & Duckworth, 1999). In Vietnam no new discoveries can be added since an overview about the distribution was published (Nadler *et al.*, 2003). Surveys in some populations verified the numbers of individuals. Most likely the largest population exists in Phong Nha-Ke Bang National Park, Quang Binh Province with an estimate of 445-2137 individuals (Haus *et al.*, 2009). The breath of the estimate shows an uncertainty and the real number is probably closer to the lower level.

In 2006 during a short term survey on Son Tra Nature Reserve, Danang 12 groups were found and the occurrence of 198 individuals estimated (Vu Ngoc Thanh *et al.*, 2007). A long-term study on the nature reserve confirmed 13 groups with 198-208 individuals (Dinh Thi Phuong Anh, this volume).

In 2008/2009 a study in Bach Ma National Park found 22-26 individuals (Le Thi Dien *et al.*, 2010).

CRITICALLY ENDANGERED

The Worlds 25 Most Endangered Primates

Grey-shanked douc langur (*Pygathrix cinerea*)

During the last years several surveys contributed to the knowledge of distribution and status about this last described primate species for Vietnam, and added to the first overview (Ha Thang Long, 2004b). Frankfurt Zoological Society carried out surveys to verify the northern and southern border of the distribution. On the northern border of the distribution it reaches the northeast corner of Quang Nam Province about 16°N where the species occurs parapatric or also sympatric with red-shanked douc langur. From the western area on the same latitude (Ba Na Nui Chua Nature Reserve) only red-shanked douc langurs were confirmed. There exists observations of presumably hybrids between the two taxa but there is no proven genetic evidence yet (Ha Thang Long, pers comm.; T. Nadler, pers observ.; Le Nho Nam, pers. observ.).

A larger population of grey-shanked douc langurs with at least 116 individuals was discovered in Que Phuoc District, Quang Nam Province (Thu Thao, 2007).

The largest population most likely occurs in Kon Ka Kinh-Kon-Cha Rang-Landscape, an area of global priority conservation. The forest between Kon Ka Kinh National Park and Kon Cha Rang Nature Reserve is under management of two State Forest Enterprises, Dakroong and Tram Lap.

An intensive study of grey-shanked douc langurs and conservation activities are carried out in Kon Ka Kinh National Park by Frankfurt Zoological Society (Ha Thang Long, 2004a; 2004b).

The population in Kon Ka Kinh National Park is comprised of about 200 individuals, in Kon Cha Rang 100-150 individuals and in the two State Forest Enterprises 100-150 individuals also exists (Ha Thang Long, pers. comm.).

The classification of the douc langurs in Mom Ray National Park, Kon Tum Province needs still clarification. There occur grey-shanked douc langurs but most probably also red-shanked douc langurs and hybridization is also not to exclude. Some individuals doesn't show the white arms, typically for the red-shanked doucs but intermingled reddish hair on the legs (Tran Huu Vy & Ho Tien Minh, 2008). Two specimen of douc langurs hunted in Mom Ray are definitely grey-shanked douc langurs. Mom Ray is probably a contact area between the more eastern distributed grey-shanked doucs and the more western distributed red-shanked doucs in Laos along the Vietnamese border. Red-shanked douc langurs are recently confirmed in southernmost Laos (Nadler, unpubl.), and northeast Cambodia (Rawson & Roos, 2008) West of Mom Ray National Park.

During surveys 2007/2008 the status of grey-shanked douc langur populations in Quang Ngai Province were verified. 32 groups with a total of 192 to 220 individuals were found but isolated in smaller subpopulations, 8 groups with 46 to 60 individuals in Tra Bong District, 8 groups with 45 to 55 individuals in Ba To District and 10 groups with about 100 individuals in Son Ha District (Nguyen Thanh Tuan *et al.*, this volume).

In November 2008 to January 2009 a survey was conducted in Ayun Pa Nature Reserve and the population of douc langurs estimated of 30 to 40 individuals. Interviews resulted in the information of a possible occurrence of grey- and black-shanked douc langurs. Locals claimed that two species occur in the area (Tran Huu Vy & Ho Tien Minh, 2009a).

Ayun Pa Nature Reserve is located about 50 km North of Ea So Nature Reserve, and 100 km East of Chu Prong Nature Reserve were only black-shanked douc langurs observed (Nguyen Manh Ha, pers. comm.; Tran Huu Vy & Ho Tien Minh, 2009b).

Despite some detailed information about separated populations missing the estimate of the total of existing grey-shanked douc langurs is less than 1000 individuals.

ENDANGERED

Black-shanked douc langur (*Pygathrix nigripes*)

The largest populations of black-shanked douc langurs occur in East Cambodia (Pollard *et al.*, 2007). The population in Vietnam is fragmented and there are only a few population estimates. The population in Nui Chua National Park comprises 38 groups with about 500 individuals, and in Phuoc Binh National Park 17 groups with probably 200 individuals, both areas located in Ninh Thuan Province (Hoang Minh Duc, 2007). Based on a survey in November/December 2008 in Chu Prong Nature Reserve, Gia Lai Province a population estimate was made of 25 to 30 groups with 200 to 250 individuals.

A recent study in Ta Kou Nature Reserve, Binh Thuan Province estimated a population with 8 groups and 64 individuals (Hoang Minh Duc *et al.*, this volume).

Based on a long-term study the population on the Hon Heo Peninsula, Khanh Hoa Province – an unprotected area - is estimated to be between 155 and 180 individuals (Nguyen Ai Tam, 2010).

A reasonable number of black-shanked douc langurs still remain at Chu Yang Sin National Park, Dak Lak Province but the population is under heavy hunting pressure. In 2007 forty four hunted black-shanked doucs were confiscated, destined for medical porposes or even glue making (BirdLife International, 2010).

CRITICALLY ENDANGERED

The Worlds 25 Most Endangered Primates

Tonkin snub-nosed monkey (*Rhinopithecus avunculus*)

Currently there are only five locations known with recent evidence of occurrence, and these are completely isolated.

Na Hang Nature Reserve, Tuyen Quang Province, where the species was rediscovered after more than 50 years without information comprise two parts (Tat Ke and Ban Bung sectors), These areas don't have any connection and therefore cannot support an exchange of individuals. The construction of a water power plant in the immediate vicinity of the nature reserve resulted in a high impact to the reserve. A high number of construction workers for the dam immigrated, the construction of access roads, lead to an increase in hunting and impacts the reserve, logging and collection of forest products. Surveys report the decrease of Tonkin snub-nosed monkeys in the Tat Ke sector during a decade since 1993 from about 70 to 80 individuals (Boonratana & Le Xuan Canh, 1994) down to 17 to 22 individuals (Dong Thanh Hai, 2007; Le Khac Quyet et al., 2009). In 1993 the number of individuals in Ban Bung sector was estimated to a maximum of 50 individuals (Boonratana & Le Xuan Canh, 1994). No recent survey was carried out since but the nature reserve administration reports that in both sectors only a few animals are left (B. Martin, pers. comm.).

In 1992, the population in Cham Chu Nature Reserve, Tuyen Quang Province was probably comprised of about 20 to 40 individuals. A survey in 2006 provided no sightings and interviews by locals indicate that probably 8 to 12 individuals still exist (Dong Thanh Hai *et al*., 2006).

In 2001 a population was discovered close to Du Gia Nature Reserve, Ha Giang Province which comprises about 90 individuals. Public awareness and community participation in protection activities under supervision of Fauna & Flora International ensure the stabilization of the population and classify this population as the only one with the chance for long-term survival (Le Khac Quyet, 2004; 2008).

In 2008 a second population of Tonkin snub-nosed monkeys was discovered in Ha Giang Province very close to the Chinese border, but comprises only about 20 to 40 individuals (BBC News, 2008; Le Khac Quyet *et al*., 2008; Le Khac Quyet & Covert, in press 2010). This population is threatened by hunting, logging, and shifting cultivation. Population size and pressure to the area and population make the possibility for a long-term existence unlikely (Le Khac Quyet *et al*., 2008).

The total population of the Tonkin snub-nosed monkeys is believed to be less than 200 individuals (Le Khac Quyet *et al*., 2009).

CRITICALLY ENDANGERED

Western black gibbon (*Nomascus concolor*)

The only known two populations of the species where their is a confirmed occurence during the last decade is in a remote area of the Hoang Lien Mountains in northern Vietnam: the Mu Cang Chai Species/Habitat Conservation Area, Yen Bai and Son La Provinces and Van Ban District, Lao Cai Province. These are two of the last areas of upper montane evergreen forest in northern Vietnam (Geissmann *et al*., 2000). The population in the Mu Cang Chai Species/Habitat Conservation Area shows a continuous decrease since the first survey in 2001. Despite conservation activities in the area the number of groups reduced from 39 in 2001 to 17 in 2008 and the number of individuals from 91 in 2001 to 57 in 2008 (Le Trong Dat & Luong Van Hao, 2008; Hoang Van Lam *et al*., this volume). The decrease of about 50% of the individuals in nine years moves the species on the brink of extinction in Vietnam. Few additional isolated groups can not contribute to stabilize the central population. No new information exists from the small isolated population in Lao Cai Province.

CRITICALLY ENDANGERED

The Worlds 25 Most Endangered Primates

Eastern black gibbon (*Nomascus nasutus*)

The eastern black gibbon is the last rediscovered primate species in Vietnam. In 2002 a small population was found close to the Chinese border in Trung Khanh District, Cao Bang Province (La Quang Trung & Trinh Dinh Hoang, 2004). With more intensive surveys in the area the number of recorded animals increased. First records estimated about 26 individuals (Geissmann *et al*. 2002), following surveys reported 37 individuals (Trinh Dinh Hoang, 2004). In 2006 a survey on the Chinese side close to the border in the contiguous forest block found 19 individuals, which was also a rediscovery for the country (Chan *et al*., 2008). In September 2007 a comprehensive transboundary census (in Vietnam and China) of the gibbon population was conducted over the entire area of viable habitat and 18 different groups were recorded, totaling about 110 individuals (Le Trong Dat *et al*., 2008; Long Yongcheng & Nadler, 2009; Insua-Cao *et al*., this volume). Three groups appear to move across the border. Conservation efforts on this species have been initiated in Vietnam and China to save this only known population.

CRITICALLY ENDANGERED

Northern white-cheeked gibbon (*Nomascus leucogenys*)

The species faced a dramatic decline during the last two decades and only few observations have been recorded (Nguyen Manh Ha, 2005) but several areas with historical records have not been surveyed in recent time. Probably largest population in Vietnam exists in Pu Huong Nature Reserve. There are 7 to 8 groups recorded with an estimation of 21 to 32 individuals (Luu Tuong Bach & Rawson, 2008). In the early eighties the northern white-cheeked gibbon was eradicated in China (Ma Shilai *et al*., 1987; 1989), and unfortunately it's to expect that the species will disappear in Vietnam also in the near future. The upgrade to the IUCN-status as "Critically Endangered" species reflects the dramatic situation (IUCN, 2009).

ENDANGERED

Southern white-cheeked gibbons (*Nomascus siki*)

Recent molecular genetic and vocalization studies require a revision of the distribution of the taxon (Van Ngoc Thin *et al*., 2010; Van Ngoc Thin *et al*., in prep.a; Van Ngoc Thin *et al*., in prep.b). The distribution in Vietnam is much more restricted than previously assumed. It was believed the species occur as far north as Pu Mat National Park, Nghe An Province (Geissmann *et al*., 2000) but molecular genetic data suggest its northernmost distribution in Phong Nha-Ke Bang National Park, Quang Binh Province.

ENDANGERED

Yellow-cheeked gibbon (*Nomascus gabriellae*)

The yellow-cheeked gibbon has the largest number of all crested gibbon taxa. The largest populations of yellow-cheeked gibbon exist in Cambodia (Pollard *et al*., 2007; Traeholt *et al*., 2005). The distribution of *N. gabriellae* has to be revised based on genetic and acoustic data (Van Ngoc Thin *et al*., in prep.a; Van Ngoc Thin *et al*., in prep.b). The northernmost distribution reaches about 13°30', the high of Ayun Pa Nature Reserve, contrary to former information by Geissmann (2000) and Kenyon (2007).

VIetnam has only a few population estimates and most likely the largest one is harbored in Cat Tien National Park. Based on an average of group density with 1.98/km^2 and an individual density of 8.92/km^2 (Kenyon, 2007) a careful estimate can be made, with about 70 groups and 300 individuals for the area.

CONCLUSIONS

All primate species in Vietnam are under very high pressure. But this is, unfortunately, an exclusive position among Vietnams wildlife in general. More than ninety percent of the species are on the brink of extinction in Vietnam, even if the globally IUCN-listings doesn't reflect this dramatic situation.

Since the early nineties studies on Vietnams wildlife from national and international institutions and organizations increased and contributed immensely to the knowledge about distribution, status, threats, behavior and the systematics of many species, particularly on primates.

Since than – 20 years ago – nearly all field and survey reports recognized already the dramatic decrease of wild populations. They have concluded with recommendations which culminated first in an improvement of protection activities and law enforcement. But all these recommendations seem to be ignored and there are nearly no consequences which face the dramatic development.

Education, poverty alleviation and the improvement of the standard of living are very important conservation supporters but such activities are effective under long-term conditions. Education of Vietnam's people would probably require one complete human generation. But a high number of Vietnam's wildlife species, in particular endemic species, can't wait for one generation until they are eradicated.

Education, poverty alleviation and the improvement of the standard of living are often the preferred conservation tools, because it is – without a doubt – a positive contribution to conservation, but the easiest, and unfortunately also the longest way to intensify conservation and environment protection. Direct protection work, law enforcement, fighting against corruption and mismanagement create unwelcome inconveniences and confrontations. A faster way must be found in order to win the competition against time, because it is not long before plant and animal species are gone forever.

Vietnamese authorities, institutions, and foreign organizations as well should concentrate funds and efforts on protection activities.

Several primate species in Vietnam are rediscovered after a long period – sometimes more than fifty years without any information. These are the Delacour's langur, Hatinh langur, black-shanked douc langur, Tonkin snub-nosed monkey, western and eastern black gibbon.

There are also new findings about the distribution of several taxa and the discovery of recently unknown populations. But new discovered populations are usually relatively small and under threat of eradication. Despite all these discoveries it's not to expect that large populations can be discovered which could serve as a reserve to save a species from a disappearance in Vietnam.

Most of the highly endangered species basic information are now sufficient to start with protection activities. Field reports very often recommend more and detailed surveys, mostly only to gather an "exact number" of a highly endangered species in an area. But funds and especially time for conservation are limited and these should be used to protect the now miniscule populations without having to know it's comprised of 65 or 85 individuals.

HIỆN TRẠNG THÚ LINH TRƯỞNG VIỆT NAM – BỔ XUNG VÀ RÀ SOÁT LẠI

TÓM TẮT

Những đánh giá hiện trạng, ước tính quần thể, phát hiện mới về phân bố và vị trí phân loại đều cần được cập nhật thông tin làm cơ sở cho các hoạt động bảo tồn. Tất cả các loài thú linh trưởng của Việt Nam đang chịu nhiều áp lực lớn và sự tiêu giảm số lượng quần thể cho thấy một kịch tính mất mát nghiêm trọng, đặc biệt đối với những tiểu quần thể nhỏ và sống biệt lập. Số lượng quần thể của một số đàn lớn cho thấy sự tiêu giảm dần đều. Số lượng của một số loài linh trưởng ở Việt Nam sẽ mất dần đi với một quá trình dài theo thời gian là điều không thể loại trừ. Hơn 90% các loài thú linh trưởng đang đứng trước bờ vực bị tuyệt chủng. Mặc dù số lượng của một số loài linh trưởng đã được cảnh báo về sự tiêu giảm từ 20 năm qua nhưng các chế tài vẫn chưa đủ hữu hiệu nhằm ngăn chặn nhiều mất mát. Những nghị định đúng đắn và các hoạt động mạnh là rất cấp thiết nhằm ngăn chặn những tệ nạn xâm hại rừng. Mọi nguồn nhân lực kinh phí của quốc gia và những hỗ trợ từ quốc tế cần tập chung nhiều hơn cho các hoạt động bảo tồn tại gốc và nên hạn chế các điều tra thực địa mà đôi khi các nội dung chỉ nhằm thu thập số liệu về sự tiêu giảm của quần thể mà chưa có đề xuất bảo tồn thiết thực.

REFERENCES

BBC News (2008): Glimmer of hope for a rare monkey. http://news.bbc.co.uk/2hi/science/nature/7767360.stm.

BirdLife International – Vietnam Programme (2005): The rare Hatinh langur discovered in Quang Tri Province for the first time. http:/www.birdlifeindochina.org/. Accessed 23. Nov. 2005.

BirdLife International (2010): The Biodiversity of Chu Yang Sin National Park, Dak Lac Province, Vietnam. Compiled and edited by Hughes, B., BirdLife International in Indochina, Hanoi.

Chan Bosco Pui Lok, Tan Xue-Feng & Tan Wu-Jing. (2008): Rediscovery of the critically endangered eastern black crested gibbon *Nomascus nasutus* (Hylobatidae) in China, with preliminary notes on population size, ecology and conservation status. Asian Primates Journal 1(1), 17-25.

Dang Huy Huynh, Cao Van Sung, Le Xuan Canh, Pham Trong Anh, Nguyen Xuan Dang, Hoang Minh Khien & Nguyen Minh Tam (eds.) (2009): Fauna of Vietnam 25. Primates, Carnivora, Artiodactyla, Perissodactyla, Rodentia. Science and Technics Publishing House.

Dong Thanh Hai (2007): Behavioral Ecology and Conservation of *Rhinopithecus avunculus* in Vietnam. Final report to the Rufford Small Grants Foundation, Canberra, Australia.

Dong Thanh Hai, Do Quang Huy, Luu Quang Vinh, Nguyen Duc Manh, Nguyen Hai Ha, Ngo Duy Bach & Vu Duc Kham (2006): A survey on distribution and population status of Tonkin Snub-nosed Monkey (*Rhinopithecus avunculus*) in Cham Chu Nature Reserve. Forest University of Vietnam. (Unpubl.).

Dong Thanh Hai (2009): Survey and Population Status of Francois' Langur, Ba Be National Park, Bac Kan Province. People Resources and Conservation Foundation (PRCF) Vietnam Program, Hanoi. (Unpubl.).

Geissmann, T., Nguyen Xuan Dang, Lormee, N. & Momberg, F. (2000): Vietnam Primate Conservation Status Review. Part I: Gibbons. Fauna & Flora International - Indochina Programme, Hanoi.

Geissmann, T., La Quang Trung, Trinh Dinh Hoang, Dang Ncoc Can, Pham Duc Tien & Vu Dinh Thong (2002): Report on an overall survey of the Cao Vit Gibbon Population (*Nomascus* sp. cf. *nasutus*) in Trung Khanh District, Cao Bang Province (Second overall survey) Fauna & Flora International – Asia Pacific Programme, Hanoi. (Unpubl.).

Groves, C. (2001): Primate Taxonomy. Smithsonian Insitution. Washington DC.

Ha Thang Long (2004a): A field survey for the grey-shanked douc langur (*Pygathrix cinerea*) in Vietnam. Frankfurt Zoological Society. (Unpubl.).

Ha Thang Long (2004b): Distribution and status of the grey-shanked douc langur (*Pygathrix cinerea*) in Vietnam. In: Nadler, T., Streicher, U. & Ha Thang Long (eds.): Conservation of primates in Vietnam; pp. 52-57. Frankfurt Zoological Society, Hanoi.

Haus, T., Vogt, M., Forster, B., Vu Ngoc Thanh & Ziegler, T. (2009): Distribution and population densities of diurnal primates in the karst forests of Phong Nha - Ke Bang National Park, Quang Binh Province, Central Vietnam. Int. J. Primatol. 30(2): 301-312.

Hill, M. & Hallam, D. (1997): Na Hang Nature Reserve. Part 2: Tat Ke Sector: Biodiversity survey. Society for Environmental Exploration. London. (Unpubl.).

Hoang Minh Duc (2007): Ecology and Conservation Status of the black-shanked douc (*Pygathrix nigripes*) in Nui Chua and Phuoc Binh National Parks, Ninh Thuan Province, Vietnam. PhD Dissertation University of Queensland.

IUCN (2009): IUCN Red List of Threatened Species <www.redlist.org>.

Kenyon, M.A. (2007): The ecology of the golden-cheeked gibbon (*Nomascus gabriellae*) in Cat Tien National Park, Vietnam, Dissertation University of Cambridge.

La Quang Trung & Trinh Dinh Hoang (2004): Status review of the Cao Vit black crested gibbon (*Nomascus nasutus nasutus*) in Vietnam. In: Nadler, T., Streicher, U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 90–94. Frankfurt Zoological Society, Hanoi.

Le Khac Quyet (2002): A field survey of primates, focus on Tonkin snub-nosed monkey (*Rhinopithecus avunculus*), in Du Gia Nature Reserve Ha Giang Province, northeastern Vietnam. Fauna & Flora International-Vietnam Programme, Hanoi. (Unpubl.).

Le Khac Quyet (2003): Report on a field survey of Francoisi' langur (*Trachypithecus francoisi*) in Lung Nhoi area, Na Hang District, Tuyen Quang Province, northeastern Vietnam. PARC Project Na Hang. (Unpubl.).

Le Khac Quyet (2004): A preliminary survey of primates in Nui Giang Man area, Quang Binh Province, central Vietnam. In: Nadler, T., Streicher, U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 45-51. Frankfurt Zoological Society, Hanoi.

Le Khac Quyet (2004): Distribution and conservation of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in Du Gia Nature Reserve, Ha Giang Province, northern Vietnam. In: Nadler, T., Streicher, U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 58-62. Frankfurt Zoological Society, Hanoi.

Le Khac Quyet (2008): A population survey of Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in Khau Ca area, Ha Giang Province, April-May 2007. Fauna & Flora International-Vietnam Conservation Support Programme. (Unpubl.).

Le Khac Quyet & Covert HH (in press 2010): Another population of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) discovered in Ha Giang Province, Vietnam. Vietnamese J. of Primatol. (1) 4, xx

Le Khac Quyet, Dong Thanh Hai & Nadler, T. (2009): Tonkin snub-nosed Monkey. In: Mittermeier, R.A., Wallis, J., Rylands, A.B., Ganzhorn, J.U., Oates, J.F., Williamson, E.A., Palacios, E., Heymann, E.W., Kierulff, M.C.M., Long Yongcheng, Supriatna, J., Roos, C., Walker, S., Cottez-Ortiz, L. & Schwitzer, C. (eds.): Primates in Peril: The World's 25 Most Endangered Primates 2008-2010; pp. 26. Primate Conservation 24, 1-57.

Le Khac Quyet & Trinh Dinh Hoang (2004): A field study of Phayre's leaf monkey (*Trachypithecus phayrei crepusculus*) in Che Tao Commune, Mu Cang Chai Species/Habitat Conservation Area, Mu Cang Chai District, Yen Bai Province. Fauna & Flora International-Vietnam Programme. (Unpubl.).

Le Khac Quyet, Vu Ngoc Thanh & Luu Tuong Bach (2008): Survey of Tonkin snub-nosed monkey

(*Rhinopithecus avunculus*) in Quan Ba District, Ha Giang Province, northeastern Vietnam. Fauna & Flora International-Vietnam Conservation Support Programme. (Unpubl.).

Le Thi Dien, Dong Thanh Hai, Le Doan Anh, Truong Cam, Le Van Tren & Tran Quoc Sinh (2010): Population, distribution and diet of the red-shanked douc langur (*Pygathrix nemaeus nemaeus*) in Bach Ma National Park, Thua Thien Hue Province, Vietnam. Hue University of Agriculture and Forestry, Forestry University of Vietnam, Bach Ma National Park. (Unpubl.).

Le Trong Dat, Do Quang Huy, Le Thien Duc, Luu Quang Vinh & Luong Van Hao (2008): Survey report on vertebrate fauna of Ngoc Son-Ngo Luong Nature Reserve. Ngoc Son-Ngo Luong Project. (Unpubl.).

Le Trong Dat, Fan Pengfei, Yan Lu, Le Huu Oanh, Nguyen The Cuong & Kempinski, J. (2008): Census report for the global Cao Vit gibbon (*Nomascus nasutus*) population. Fauna & Flora International-Vietnam and China Programmes. (Unpubl.).

Le Trong Dat & Luong Van Hao (2008): 2008 census of the Vietnam's largest known population of western black crested gibbon *Nomascus concolor*: Mu Cang Chai Species/Habitat Conservation Area (Yen Bai Province) and adjacent forests in Muong La District (Son La Province). Fauna & Flota International-Vietnam Country Programme. (Unpubl.).

Le Trong Dat, Swan, S. & Le Huu Oanh (2005): Final report on population monitoring training course and survey for western black-crested gibbons (*Nomascus consolor*) in Muong La, Son La. Fauna & Flora International - Vietnam Programme. (Unpubl.).

Le Trong Trai, Eames, J.C., Nguyen Duc Tu, Furey, N.M., Kouznetsov, A.N., Monastiyrskii, A.L., Dang Ngoc Can, Nguyen Truong Son, Nguyen Van Sang, Nguyen Quang Trung & Bui Xuan Phong (2004): Biodiversity report on the Ba Be / Na Hang Conservation Complex using Landscape Ecology. PARC Project VIE/95/G31&031, Government of Vietnam. Scott Wilson Asia-Pacific Ltd., Hanoi.

Le Van Dung & Nadler, T. (2010): Status of several subpopulations of Delacour's langur (*Trachypithecus delacouri*). Frankfurt Zoological Society. (Unpubl.).

Long, B. & Le Khac Quyet (2001): An intinal assessment of conservation requirements for Cham Chu, Tuyen Qyuang Province including mammal and bird diversity surveys. Fauna & Flora International. (Unpubl.).

Long Yoncheng & Nadler, T. (2009): Eastern black crested gibbon *Nomascus nasutus* (Kunkel d'Herculais, 1884). In: Mittermeier, R. A., Wallis, J., Rylands, A. B., Ganzhorn, J. U., Oates, J. F., Williamson, E. A., Palacios, E., Heymann, E. W., Kierulff, M. C. M., Long Yongcheng, Supriatna, J., Roos, C., Walker, S., Cortés-Ortiz, L. & Schwitzer, C. (eds.): Primates in peril: The World's 25 Most Endangered Primates, 2008–2010; pp. 26-27. Primate Conservation 24, 1-57.

Luong Van Hao & Le Trong Dat (2008): Report on the status of Delacour's langur (*Trachypithecus delacouri*) in Cuc Phuong National Park, Ninh Binh , Vietnam. Cuc Phuong National Park and Frankfurt Zoological Society. (Unpubl.).

Luong Van Hao & Nguyen Quang Trung (2006): First observation of the grey langur in Cuc Phuong National Park. Cuc Phuong National Park. (Unpubl., in Vietnamese).

Luu Tuong Bach & Rawson, B. (2008): An assessment of northeren white-cheeked crested gibbon (*Nomascus leucogenys*) population status in Pu Huong Nature Reserve, Nghe An Province, Vietnam. Conservation International. (Unpubl.).

Ma Shilai, Li Chongyuan & Wang Yinxiang (1987): Distribution and current status of endangered mammals in Honghe region. Survey report on bioresources of Honghe region, southern Yunann: Land Vertrebrates.

Ma Shilai, Wang Yinxiang & Poirier, F.E. (1989): Taxonomy, distribution and status of gibbons (*Hylobates*) in southern China and adjacent areas. Primates 29(2), 277-286.

Mittermeier, R.A., Wallis, J., Rylands, A.B., Ganzhorn, J.U., Oates, J.F., Williamson, E.A., Palacios, E., Heymann, E.W., Kierulff, M.C.M., Long Yongchen, Supriatna, J., Roos, C., Walker, S., Cortes-Ortiz, L. & Schwitzer, C. (2009): Primates in Peril: The World's 25 Most Endangered Primates 2008-2010. Primate Conservation 24, 1-57.

Nadler, T. (1996): Report on the distribution and status of Delacour's langur (*Trachypithecus delacouri*). Asian Primates 6, 1-4.

Nadler, T. (2004): Distribution and status of the Delacour's langur (*Trachypithecus delacouri*) and recommendations for its long-term conservation. In: Nadler, T., Streicher, U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 63-71. Frankfurt Zoological Society, Hanoi.

Nadler, T., Momberg, F., Nguyen Xuan Dang & Lormee, N. (2003): Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys. Fauna & Flora International-Vietnam Program and Frankfurt Zoological Society, Hanoi.

Nadler, T., Walter, L. & Roos, C. (2005): Molecular evolution, systematics and distribution of the taxa within the silvered langur species group (*Trachypithecus* [*cristatus*]) in Southeast Asia. Zool. Garten (NF) 75 (4), 238-247.

Nadler, T., Vu Ngoc Thanh & Streicher, U. (2007): Conservation status of Vietnamese Primates. Vietnamese J. Primatol. 1(1), 7-26.

Nadler, T. (2009): Oberservations of the Lao langur (*Trachypithecus* [*laotum*] *laotum* and black langur (*Trachypithecus* [*laotum*] *hatinhensis* morph *ebenus*) in Khammouane Province, Laos and remarks to their systematic position. Vietnamese J. Primatol. 1 (3), 9-15.

Nadler, T. & Ha Thang Long (2000): The Cat Ba Langur: Past, Present and Future. The Definitive Report on *Trachypithecus poliocephalus*, the World´s Rarest Primate. Frankfurt Zoological Society, Hanoi.

Nadler, T. & Streicher, U. (2004): The primates of Vietnam – an overview. In: Nadler, T., Streicher, U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 5-10. Frankfurt Zoological Society, Hanoi.

Nadler, T., Le Trong Dat & Luong Van Hao (2004): A primate field survey at Pu Luong Nature Reserve with the emphasis on Delacour's langur (*Trachypithecus delacouri*). Fauna & Flora International-Vietnam Conservation Support Programme and the Forest Protection Department, Hanoi, in association with Frankfurt Zoological Society-Vietnam Primate Conservation Programme.

Nguyen Ai Tam (2010): Study on black-shanked douc langurs (*Pygathrix nigripes*) on Hon Heo Peninsula, Khanh Hoa Province. Frankfurt Zoological Society. (Unpubl.).

Nguyen Manh Ha (2005): Status of white-cheeked crested gibbon (*Nomascus leucogenys*) in North central of Vietnam. Report to: The Great Ape Conservation Fund, US Fish and Wildlife Service, Center for Natural Resources and Envirinmental Studies-Vietnam National University, Allwetterzoo Münster. (Unpubl.).

Nguyen Manh Ha (2006): Some observations on the Hatinh langur, *Trachypithecus laotum hatinhensis* (Dao, 1970), in North central Vietnam. Primate Conservation 21, 149-154.

Pham Nhat (2002): Primates of Vietnam. Hanoi. (In Vietnamese).

Pollard, E., Clemets, T., Nut Meng Hor, Sok Ko & Rawson, B. (2007): Status and Conservation of globally threatened primates in the Seima Biodiversity Conservation Area, Cambodia. Wildlife Conservation Society-Camdodia Program. Phnom Penh.

Ratajszczak, R., Cox, R. & Ha Dinh Duc (1990): A preliminary survey of primates in North Vietnam. WWF Project 3869. (Unpubl.).

Rawson, B. & Roos, C. (2008): A new primate species record for Cambodia: *Pygathrix nemaeus*. Cambodia J. Natural History 1, 7-11.

Roos, C., Nadler, T., & Walter, L. (2008): Mitochondrial phylogeny, taxonomy and biogeography of the silvered langur species group (*Trachypithecus cristatus*). Molecular Phyologenetics and Evolution. 47, 629-636.

Stenke, R. & Chu Xuan Canh (2004): The golden-headed langur (*Trachypithecus poliocephalus poliocephalus*): on Cat Ba Island – status, threat factors and recovery options. In: Nadler, T., Streicher, U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 72-77. Frankfurt Zoological Society, Hanoi.

Thu Thao (2007): Population of Gray-Shanked Douc Monkeys discovered. http://www.saigon-gpdaily.com.vn/Nature/2007/7/56634.

Timmins, R.J. & Duckworth, J.W. (1999): Status and Conservation of Douc Langurs in Laos. Int. J. Primatol. 20, 469-489.

Traeholt, C., Bonthhoeun, R., Rawson, B., Samuth, M., Virak, C. & Vuthin, S. (2005): Satus review of pileated gibbons, *Hylobates pileatus* and yellow-cheeked crested gibbon, *Nomascus gabriellae*, in Cambodia. Fauna & Flora International-Cambodia Programme. Phnom Penh.

Tran Huu Vy & Ho Tien Minh (2008): Distribution and conservation status of grey-shanked douc langur (*Pygathrix cinerea*) in Chu Mom Ray National Park, Kon Tum Province. Frankfurt Zoological Society. (Unpubl.).

Tran Huu Vy & Ho Tien Minh (2009a): Survey on grey-shanked douc langurs in Ayun Pa Nature Reserve, Gia Lai Province. Frankfurt Zoological Society. (Unpubl.).

Tran Huu Vy & Ho Tien Minh (2009b): Survey on grey-shanked douc langurs in Chu Prong Nature Reserve, Gia Lai Province. Frankfurt Zoological Society. (Unpubl.).

Trinh Dinh Hoang (2004): Gibbon monitoring survey and training in Trung Khanh, Cao Bang Province. Fauna & Flora International-Vietnam

Programme, Hanoi. (Unpubl.).
Van Ngoc Thinh (2004): Assessment of population density and habitat quality of *Macaca arctoides* Geoffroy, 1831 for the formulation of management strategies in Bach Ma National Park. Master thesis Georg-August University, Göttingen.
Van Ngoc Thinh, Mootnick, A., Geissmann, T., Ming Li, Ziegler, T., Muhammed Agil, Moisson, P., Nadler, T., Walter, L. & Roos, C. (2010): Mitochondrial evidence for multiple radiations in the evolutionary history of small apes. BMC Evolutionary Biology 10, 74, 1-37 http://www.biomedcentral.com/1471-2148/10/74.
Van Ngoc Thinh, Rawson, B., Hallam, C., Kenyon, M., Nadler, T., Walter, L. & Roos, C. (in prep.a.): Phylogeny and distribution of crested gibbons (genus *Nomascus*) based on mitochondrial cytochrome b gene sequence data.
Van Ngoc Thinh, Hallam, C., Roos, C. & Hammerschmidt, K. (in prep.b.): Concordance between vocal and genetic diversity in crested gibbons.
Vu Ngoc Thanh, Le Vu Khoi, Le Khac Quyet (2007): Survey results for Red-shanked douc langur (*Pygathrix nemaeus nemaeus*) in Son Tra Nature Reserve, Da Nang City, Central Vietnam. Vietnam National University, Hanoi. (Unpubl.).

2

THE STATUS OF CAMBODIAN PRIMATES

BENJAMIN M. RAWSON

SUMMARY

Although primate research in Cambodia is a relatively recent phenomenon, initial work is demonstrating that the country contains globally significant populations of many taxa. Home to only eleven species of primate, including two lorises, three macaques, four colobines and two gibbons, Cambodia has relatively low diversity, and yet still retains high populations of most of these taxa relative to neighboring countries. Of particular significance are the country's populations of black-shanked douc, yellow-cheeked crested gibbon and pileated gibbon, although with additional work the relative significance of populations of pygmy loris, silvered langur and perhaps even red-shanked douc langur are likely to be found to be high. However, Cambodia's primates face numerous threats. Although all primate species are protected under the Law on Forestry, Cambodia primates are under threat from hunting, habitat loss and economic interests such as mining and economic land concessions. Despite this, Cambodia represents a very real opportunity for long-term conservation of many globally threatened primate species.

INTRODUCTION

This paper provides an overview of the current situation for primate taxa in Cambodia, attempting to list the most up-to-date information about the status of populations of Cambodia's primate species. Currently, Cambodia is recognized as having eleven primate species (Table 1) (Rawson & Roos, 2008). This has increased from nine in recent years due to the discovery of red-shanked doucs in the north of the country (Rawson & Roos, 2008) and a taxonomic reassessment of the silvered langur species group which suggests two species occur in Cambodia (Roos *et al*., 2008).

Of these eleven species there are two species of Loridae; the northern slow loris (*Nycticebus bengalensis*) and the pygmy loris (*N. pygmaeus*); three Cercopithicinae, the stump-tailed macaque (*Macaca arctoides*), the long-tailed macaque (*M. fascicularis fasicularis*) and the northen pig-tailed macaque (*M. leonina*); four Colobinae, the black-shanked douc langur (*Pygathrix nigripes*), the red-shanked douc langur (*P. nemaeus*) and two species of silvered langurs (*Trachypithecus germaini* and *T. margarita*), and two species of Hylobatidae, the yellow cheeked gibbon (*Nomascus gabriellae*) and the pileated gibbon (*Hylobates pileatus*).

Unlike Vietnam, none of these taxa are endemic to Cambodia, either existing in other countries within Indochina (e.g. the douc langur), or with populations being part of much larger distributions (e.g. the macaque species). Despite this, Cambodia represents a population stronghold for many of the taxa which do occur here, and as such, is of vital importance to the long-term viability of several primate species. This is especially true of the more distributionally restricted species, which are under significant threat across their range. For example, Cambodia undoubtedly contains the most significant

Table 1. Cambodian primate taxa.

	Loridae	
1	Pygmy loris	*Nycticebus pygmaeus*
2	Northern slow loris	*Nycticebus bengalensis*
	Cercopithecidae	
3	Long-tailed macaque	*Macaca fascicularis*
4	Stump-tailed macaque	*Macaca arctoides*
5	Northern pig-tailed macaque	*Macaca leonina*
6	Assamese silvered langur	*Trachypithecus margarita*
7	Indochinese silvered langur	*Trachypithecus germaini*
8	Red-shanked douc langur	*Pygathrix nemaeus*
9	Black-shanked douc langur	*Pygathrix nigripes*
	Hylobatidae	
10	Yellow-cheeked gibbon	*Nomascus gabriellae*
11	Pileated gibbon	*Hylobates pileatus*

populations of yellow-cheeked gibbons, pileated gibbons and black-shanked douc langurs globally and further population surveys may demonstrate its relative importance for other taxa such as the pygmy loris, red-shanked douc langur and silvered langurs.

While forest cover in Cambodia has declined significantly in the last 35 years, Cambodia still has one of the most significant levels of relative forested area in the region and maintains some 26% of land area in protected areas (SCW, 2006). Many of these protected areas and protected area networks are relatively large, and allow for significant unfragmented populations of primates to exist. Despite the large coverage of protected areas, many if not most are not effectively protected, and hunting, habitat degradation and illegal logging are impacting primate populations. Also of significant concern is the ever increasing impact of economic developments, including mining and economic land concessions, many of which occur within the protected area network.

Legally, all primates are protected under the Cambodian Law on Forestry (Anonymous, 2002). Article 48 of the law states that all wildlife is state property under the protection of the Forestry Administration, a division of the Ministry of Agriculture, Forestry and Fisheries, while under Article 49 it states that it is "strictly prohibited to hunt, harm or harass all wildlife." The law categorizes species as "Endangered", "Rare" or "Common" and has associated penalties for illegal use of each threat category. Penalties for hunting, killing, trading or exporting species are laid out in Articles 96-99 and include a system of fines and jail terms depending on the infraction (Anonymous, 2002). The categorization of species under this system is not contained within the Law on Forestry (Anonymous, 2002), but in a Ministerial decree (*Prakas*) which lists each wildlife species as either "Endangered", "Rare" or "Common". No primate species is currently listed as "Endangered". Enforcement of the Law on Forestry (Anonymous, 2002) is the duty of provincial Forestry Administration offices, however the process is often hamstrung by the lack of staff and capacity to enforce the law on the ground, lack of clarity about procedure, difficulty in identifying wildlife species and a system of fines which is open to exploitation (Ashwell & Walston, 2008).

The fact that relatively healthy populations of all taxa of Cambodia's primates can still be found (perhaps with the exception of *N. bengalensis*) provides a significant opportunity to make the country a leader in primate conservation within the region. The opportunity for use of these populations as flagship species for protected areas is large, as is the potential for detailed scientific research into these taxa. To date we have only scratched the surface, with detailed population studies conducted in only a handful of protected areas. Additional effort will undoubtedly demonstrate that Cambodia will play a significant role in the long-term conservation of global primate diversity.

The status of IUCN listing is mentioned for each species (IUCN, 2009).

PRIMATE TAXA OF CAMBODIA

VULNERABLE

Pygmy loris (*Nycticebus pygmaeus*)

The pygmy loris is restricted by the Mekong River to the east of the country. Recent work in Mondulkiri Province has provided a good context for the species status and distribution within the major protected areas in the province. Starr *et al*. (in press) found relative densities of 0.4 km^{-1} (± 0.41) in Seima Protected Forest, 0.1 km^{-1} (± 0.13) in Phnom Prich Wildlife Sanctuary and 0.0 km^{-1} in Mondulkiri Protected Forest. More recently, surveys in Veun Sai District of the more northerly Ratanakiri Province, show the highest relative densities of the species in the country recorded to date (Streicher & Rawson, 2010). Here relative densities reached 0.94 km^{-1} (± 0.25) in evergreen forest, significantly higher than mixed deciduous habitats (Streicher & Rawson, 2010). The species is hypothesized to reach close to normal densities at this site, and the possibility exists that a significant population persists here and into the expansive and naturally well protected areas of Virachey National Park. Streicher & Rawson's (2010) finding that loris at this site show a marked preference for evergreen forest runs contrary to Starr *et al*. (in press) observation in Cambodia that the species is most commonly observed in mixed deciduous forest and is commonly associated with bamboo, however this is possibly related to differential hunting pressure.

Pygmy loris are protected under the Cambodian Forestry Law under which they are listed as "Rare". Trade in pygmy loris is the most significant threat to the species in Cambodia, with the species commonly used for traditional medicine. The species is available, usually splayed and dried, in many provincial markets and villages and is said to have various medicinal qualities (Ashwell & Walston, 2008). Based on interview data, the species has suffered precipitous declines in many areas and despite often not being targeted specifically, is under heavy opportunistic hunting pressure with local extirpations over short periods of time being recorded in some areas (Starr *et al*., in press).

Knowledge about the degree of sympatry with the northern slow loris is limited by difficulty in identifications by inexperienced surveys and general lack of field data, however there are no confirmed sighting of the northern slow loris east of the Mekong in Cambodia where their theoretical distributions overlap (Starr *et al*., in press).

VULNERABLE

Northern slow loris (*Nycticebus bengalensis*)

Despite its wider distribution much less is known about the status of the northern slow loris in Cambodia. Theoretically this species occurs across all of Cambodia, being sympatric with the pygmy loris east of the Mekong River, however to date there are no confirmed records of the species east of the Mekong (Starr *et al*., in press) and it has been suggested that in fact they may not occur here although difficulty in identification by inexperienced surveyors and general lack of field data confound the issue (Starr *et al*., this volume). Recent loris surveys in Ratanakiri Province found considerable numbers of pygmy loris both in the field and in local markets, but no individuals of northern slow loris were detected (Streicher & Rawson, 2010).

Surveys for the species have been carried out in seven of Cambodia's protected areas but has only been found in two; Samkos Wildlife Sanctuary and Phnom Kulen National Park (Starr *et al*., this volume), although only one animal was detected in the latter protected area. Relative densities of the species in Cambodia where they have been detected are limited to Starr *et al*. (this volume) work in Samkos Wildlife Sanctuary, where an encounter rate of 0.46 (± 0.6) groups km^{-1} was found, although transects were located non-randomly in locations where previously lorises were detected. Given the large survey effort already expended by Starr *et al*. (this volume) considerable additional survey effort will be required to determine other key locations for the species within Cambodia.

Northern slow loris are protected under the Cambodian Forestry Law under which they are listed as "Rare". As with the pygmy loris, the slow loris is commonly exploited for its perceived medicinal values and can be commonly seen in local markets in Cambodia (Ashwell & Walston, 2008). It is utilized by women soon after childbirth, with dried lorises steeped in rice wine and consumed (Starr *et al*., this volume). Heavy exploitation for trade as medicine is the most serious threat to this species in Cambodia and local extirpation are likely to have already occurred (Starr *et al*., this volume)

Macaques (*Macaca* sp.)

As in Vietnam, there is little quantitative data about macaque populations in Cambodia. Three species occur here, the long-tailed macaque, the northern pig-tailed macaque and the stump-tailed macaque. It also appears that the southerly extent of the *M. fascicularis* x *M. mulatta* hybrid zone runs through the northeastern portion of the country (Heng Sokrith *et al*., in review). Populations appear to still be relatively robust in most protected areas, although removal of individuals for pets, incidental snaring of the more terrestrial taxa and targeted wildlife trade for *M. fascicularis* provide real threats to populations in country.

VULNERABLE

Stump-tailed macaque (*Macaca arctoides*)

Apparently the rarest of the macaques in Cambodia, little is known about the stump-tailed macaque. Population estimates for the species are lacking in all but one location, Seima Protected Forest, where a population of 393 groups (95% CI of 200 – 773 groups) or approximately 1600 individuals is estimated to exist using distance sampling approaches (O'Kelly, in litt.). In other locations the species has only been recorded as present with no relative or absolute density estimates available.

The stump-tailed macaque is protected under the Cambodian Forestry Law under which they are listed as "Rare". The stump-tailed macaque is the most susceptible of the macaques to incidental snaring because of its terrestrial habits and is occasionally seen in the pet trade, although less than other macaque species.

LEAST CONCERN

Long-tailed macaque (*Macaca fascicularis fascicularis*)

Long-tailed macaques occur across Cambodia, having been recorded both within and outside the protected area network. Population estimates for the species are however lacking. Only one estimate exists for the country which is from Seima Protected Forest, where a population of 580 groups (95% CI of 257 – 1309 groups) or approximately 4700 individuals is estimated to exist using distance sampling approaches (O'Kelly, in litt.), although a significant population is also shown to occur in Preah Viheah Protected Forest (Rainey, pers. comm.). They are noted to occur in many if not most of the country's protected areas however.

Long-tailed macaques are protected under the Cambodian Forestry Law under which they are listed as "Common". As in Vietnam, long-tailed macaques are under high hunting pressure for international trade driven by the pharmaceutical industry for biomedical research (Eudey, 2008). Increases in demand in the USA appears to have driven prices up to $1,475 per head for Cambodian sourced macaques, which has translated to a commensurate increase in price for local hunters who receive approximately $50 per head (Rawson, 2007) (although this is doubtless variable based on location) who feed the animals into well coordinated trade networks (Eudey, 2008). There is considerable concern that wild caught macaques are being laundered in legal breeding centers in Cambodia and elsewhere to fuel this trade, with serious impacts on wild population (Eudey, 2008). Long-tailed macaques are often also kept as household pets, although the pet trade is likely mostly local and represents a relatively small threat.

VULNERABLE

Northern pig-tailed macaque (*Macaca leonina*)

Little detail is available for the status of northern pig-tailed macaques in Cambodia. Only one population estimate exists for the country which is from Seima Protected Forest, where a population of 870 groups (95% CI of 495 – 1560 groups) or approximately 4700 individuals is estimated to exist using distance sampling approaches (O'Kelly, in litt.). They are however noted to occur in a number of other protected areas across the country such as in the Cardamom mountains (Daltry & Momberg, 2000), Phnom Prich Wildlife Sanctuary (Timmins & Ou Rattanak, 2001), Preah Vihear Protected Forest (Rainey *et al*., 2010) and Bokor National Park (Neath *et al*., 2001), although they undoubtedly occur in many other areas as well.

Northern pig-tailed macaques are protected under the Cambodian Forestry Law under which they are listed as "Common". They are often seen as pets within local villages and are susceptible to terrestrial snaring.

ENDANGERED

Silvered langurs (*Trachypithecus germaini* and *T. margarita*)

Two species of silvered langurs are recognized to occur in Cambodia, Trachypithecus germaini in the west and *T. margarita* in the east, possibly separated by the Mekong River (Roos *et al*., 2008).

Little is known about these species and their status, although silvered langurs are apparently widespread throughout the country but probably at low densities in most locations (Nadler *et al*., 2008).

Only one population estimate from one protected area exists for Cambodia to date. Based on distance sampling, Rainey *et al*. (2010) estimated a population of 634 groups (95% CI of 276 – 1476 groups) within Preah Vihear Protected Forest, northern Cambodia. Most other reports are simply presence/absence from general survey reports. For example, silvered langurs have been noted as present in Phnom Prich Wildlife Sanctuary (Timmins & Ou Rattanak, 2001), Seima Protected Forest (Pollard *et al*., 2007), northeastern Mondulkiri Province (Long *et al*., 2000), western Ratanakiri Province (Rawson, 2007), the Cardamom Mountains (Daltry & Momberg, 2000), along stretches of the Mekong (Bezuijen *et al*., 2008), and around Tonle Sap Great Lake (Campbell *et al*., 2006) where they likely occur in significant numbers. Undoubtedly many additional records exist.

Silvered langurs are protected under the Cambodian Forestry Law as *Semnopithecus cristatus*, where they are listed as "Common", clearly an underestimate of their abundance, likely based on outdated taxonomic assessments which considered all silvered langurs as a single species group (see Roos *et al*., 2008; for a review). Ashwell & Walston (2008) list silvered langur as used for traditional medicine in Cambodia but do not list what for, and seem to have only one example which is a live caught animal. Silvered langurs are occasionally seen as pets, but there is unlikely to be a specific pet trade. They are hunted along with other mammals (Bezuijen *et al*., 2008), although whether they are specifically targeted is unknown.

ENDANGERED

Black-shanked douc langur (*Pygathrix nigripes*)

Found only in eastern Cambodia, East of the Mekong River, and southern Vietnam, Cambodia undoubtedly represents the global stronghold for the black-shanked douc langur. Little population data is available, however one robust population estimate from Seima Protected Forest of 5956 groups (95% CI of 4484 – 7934 groups) or a population of approximately 42,000 individuals (Clements *et al*., 2008a; O'Kelly, in litt.) dwarf's anything known or expected from Vietnam. The species occurs at densities of 1.18 groups/km^2 at this location (Pollard *et al*., 2007), which is likely close to natural densities for the site (Rawson, 2009).

Black-shanked douc langurs are also known to occur in other protected areas such as Phnom Prich Wildlife Sanctuary (Timmins & Ou Rattanak, 2001), Snoul Wildlife Sanctuary (Walston *et al*., 2001) and Mondulkiri Protected Forest. One report suggests that in northeastern Cambodia the species is sympatric with the red-shanked douc langur (Rawson & Roos, 2008), however to date this one sighting has not been reconfirmed.

The species, once enigmatic, has now been the subject of several long-term research projects (Hoang Minh Duc, 2007; Rawson, 2009) and we are starting to understand the species ecology much better. Evidence from group sizes and encounter rates suggest that the species prefers evergreen forest to other habitat types, although it occurs extensively in semi-evergreen and mixed deciduous forest (Rawson, 2009). The species has been recorded in dry deciduous dipterocarp forest as well, however it is likely that it is utilized very minimally and only when in association with other preferred habitat types (Rawson, 2009). The species occurrence in apparently less optimal forest types, such as the very dry Nui Chua National Park in Vietnam, which is dominated by thorny forests (Hoang Minh Duc, 2007), suggest the species diet is quite adaptable.

Black-shanked douc langurs are protected under the Cambodian Forestry Law, although listed with outdated taxonomy as *Pygathrix nemaues*, where they are listed as "Rare". They do not appear to be heavily persecuted in Cambodia, unlike Vietnam where they have suffered massive population declines (Rawson *et al*., 2008). A historical reduction in the number of guns within Cambodia (EU-ASAC, 2004) has likely reduced the threat to this species, and indeed all arboreal diurnal primates, considerably.

ENDANGERED

Red-shanked douc langur (*Pygathrix nemaeus*)

Red-shanked douc langurs have only recently been recorded in Cambodia and only at one site, in Veun Sai District, Ratanakiri Province (Rawson & Roos, 2008). The pelage of the population here is variable, with "key" characteristics such as large amounts of red on the lower leg being absent and the typical long white "gloves" being restricted to just the wrists. Despite this, genetic analyses show they group most closely with red-shanked doucs (Rawson & Roos, 2008). The population size here is unknown, however appears to be healthy, and with large groups up to 50 animals commonly sighted even in areas close to human habitation (Rawson, pers. observ.). It is likely that a highly globally significant population of the species exists in this area and up through Virachey National Park.

The possibility also exists that grey-shanked douc langurs (*P. cinerea*) are found in Cambodia in the most north-easterly parts of the country. This is based on the discovery of a moribund *P. nemaeus* x *P. cinerea* F1 hybrid in Virachey National Park (Rawson & Roos, 2008). However, no confirmed records of non-hybrid animals have yet been made, although this is probably due to lack of survey effort as opposed to their genuine absence.

Red-shanked douc langurs are protected under the Cambodian Forestry Law under which they are listed as “Rare” and presumably, grey-shanked douc langur, should they occur in Cambodia, would have similar protection. Threats to the one known population of red-shanked douc langur are apparently low, with very few guns available in the immediate area (Rawson, pers obs.).

ENDANGERED

Yellow-cheeked gibbon (*Nomascus gabriellae*)

The yellow-cheeked gibbon is one of the better studied species in Cambodia. Occurring only east of the Mekong River (Groves, 2001), the species is found in eastern Cambodia and southern Vietnam. Recent vocal and genetic analysis suggests that northerly populations, possibly north of the Srepok River in Cambodia, are actually not *N. gabriellae* as has been traditionally assumed, but in fact an unnamed taxon, *N.* sp. (Konrad & Geissmann, 2006; Van Ngoc Thinh *et al.*, in press). Cambodia is undoubtedly the global stronghold for at least the former taxon, as populations in Vietnam are generally small, numbering in the hundreds of animals at best.

Population status for *N. gabriellae* has been documented in detail in two protected areas; Seima Protected Forest (SPF) and Phnom Prich Wildlife Sanctuary (PPWS). In SPF, population estimates for the core area based on auditory surveys suggested a population of 809 groups (95% CI of 646 – 972 groups) (Rawson *et al.*, 2009), while more recent distance sampling estimates place the population at 600 groups (95% CI of 432 – 832) (Clements *et al.*, 2008b). In PPWS, the population occurs in natural fragments of evergreen forest and is a small yet significant population of 189 groups (95% CI of 15-273 groups) (Phan Channa & Gray, 2009). Population estimates based on small sample sizes exist for several other protected areas but require additional survey effort for confirmation of their relative value (Traeholt *et al.*, 2006).

For *N.* sp, only a population in Veun Sai Forests, Ratanakiri Province, has been documented in any detail. Population estimates for this location are preliminary, but it appears that over 1000 groups may be present there within a relatively small area of 55,000 ha (Rawson, unpubl.). This, assuming it is part of a larger population which extends into Virachey National Park, would make it the largest known population of the genus.

Ecologically, it appears that the species is largely restricted to evergreen/semi-evergreen habitats or mixed deciduous forest in association with these habitats (Rawson *et al.*, 2009; Phan Channa & Gray, 2009). Based on a study in PPWS, it appears that forest patches smaller than 15 km^2 can not maintain a gibbon population (Gray *et al.*, 2010).

Yellow-cheeked gibbons are protected under the Cambodian Forestry Law under the name *Hylobates gabriellae* where they are listed as “Rare”. In terms of threats, habitat loss would appear to be the major threat to the species. The extent of hunting pressure for subsistence or trade is poorly documented for the species in Cambodia, however appears to be of secondary concern. Trade into Vietnam might be a threat, however it appears that the majority of gibbons in southern Vietnam are still sourced locally, rather than imported from Cambodia (Nguyen Manh Ha, 2009).

ENDANGERED

Pileated gibbon (*Hylobates pileatus*)

The most common of Cambodia’s gibbon species, the pileated gibbon population here likely represents the largest global stronghold (Traeholt *et al.*, 2006, Phoonjampa & Brockelman, 2008). Recent survey work in Thailand, where suitable habitat is now mainly restricted to protected areas, estimated a population of approximately 14,000, with the vast majority within four protected area complexes (Phoonjampa & Brockelman, 2008). In comparison, a country-wide survey in Cambodia returned figures of approximately 35,000 individuals, with the most important populations being in the Cardamom Mountains and Preah Long/Preah Vihear (Traeholt *et al.*, 2006). Although both of these population estimates for Thailand and Cambodia are based on relatively small sample sizes for such large areas under survey, the relative value of the populations in the two countries, with Cambodia containing a significantly larger population, is probably sound. Southwestern Lao PDR also contains a population of the species, however it is not globally significant (Duckworth, 2008).

Some protected areas have more detailed population data for the species. Rawson & Senior (2005) conducted preliminary surveys in Bokor National Park and estimated a population of 813 – 1074 groups; Frontier conducted surveys in Botum Sakor WS in 2009 and concluded a population of almost 2000 groups (Charkin pers. comm.); and Rainey *et al*. (2010) estimated a population of 179-974 groups in Preah Vihear Protected Forest based on distance sampling.

Pileated gibbons are protected under the Cambodian Forestry Law where they are listed as "Rare". Habitat loss and fragmentation represent the largest long-term threats to pileated gibbons through much of Cambodia; however there are still currently large contiguous areas of forest supporting significant populations of gibbons. A pet trade in gibbons exists in Cambodia, with many more pileated than *Nomascus* spp. gibbons seen in the trade. However, it is unclear whether this represents genuinely higher threat levels, higher levels of wildlife enforcement patrols in the southwest or that existing trade routes in the East of the country mean that most crested gibbons end up in the trade in Vietnam, although gibbons are still likely sourced locally there (Nguyen Manh Ha, 2009).

HIỆN TRẠNG THÚ LINH TRƯỞNG CĂMPUCHIA

TÓM TẮT

Mặc dù nghiên cứu linh trưởng ở Cămpucia chỉ diễn ra gần đây, các công tác nghiên cứu đầu tiên đã chỉ ra rằng đất nước này là nơi sinh sống của các quần thể thuộc nhiều taxa tiêu biểu trên toàn cầu. Là nơi cư trú của 11 loài linh trưởng bao gồm 2 loài cu li, 3 loài khỉ, 4 loài khỉ thuộc phân họ colobinae và 2 loài vượn. Cămpuchia có tính đa dạng sinh học tương đối thấp nhưng hầu hết các quần thể này vẫn giữ được mức cao tương đương với số lượng ở các nước bạn. Tiêu biểu nhất trong số các loài linh trưởng là quần thể vọoc chà vá chân đen, vượn má vàng và các loài thuộc họ vượn Hylobatidae. Tuy vậy các nghiên cứu bổ sung thêm cũng cho thấy rằng quần thể cu li nhỏ, vọoc bạc và thậm chí có thể là vọoc ngũ sắc có vẻ sẽ được tìm thấy với mật độ cao tại quốc gia này. Các loài linh trưởng ở Cămpuchia đang phải đối mặt với vô số các mối đe dọa. Mặc dù được luật pháp bảo vệ, tất cả các loài linh trưởng ở Cămpuchia vẫn đang gặp nguy hiểm do tệ nạn săn bắt trái pháp, mất sinh cảnh và các đầu tư kinh tế như khai thác mỏ và bị chuyển đổi sang đất làm kinh tế. Dù vậy, Cămpuchia vẫn thể hiện một cơ hội thực sự trong công tác bảo tồn lâu dài các loài linh trưởng đang bị đe dọa mang tính toàn cầu.

References

Anonymous (2002): Law on Forestry, Ministry of Agriculture, Forestry and Fisheries, Royal Government of Cambodia, Phnom Penh, Cambodia.

Ashwell, D. & Walston, N. (2008): An Overview of the Use and Trade of Plants and Animals in Traditional Medicine Systems in Cambodia. TRAFFIC Southeast Asia, Greater Mekong Programme, Hanoi.

Bezuijen, M.R., Timmins, R. & Teak Seng (eds.) (2008): Biological Surveys of the Mekong River between Kratie and Stung Treng Towns, Northeast Cambodia, 2006-2007. WWF Greater Mekong - Cambodia Country Programme, Cambodia Fisheries Administration and Cambodia Forestry Administration, Phnom Penh.

Campbell, I.C., Poole, C., Giesen, W. & Valbo-Jorgensen, J. (2006): Species Diversity and Ecology of Tonle Sap Great Lake, Cambodia. Aquatic Sciences 68, 355-373.

Clements, T., Rawson, B., Pollard, E., Nut Meng Hor & An Dara (2008a): Long-term monitoring of black-shanked douc langur (*Pygathrix nigripes*) and yellow-cheeked crested gibbon (*Nomascus gabriellae*) in the Seima Biodiversity Conservation Area, Cambodia. Primate Eye 96 - Special Issue, 275. Abstracts to the XXII Congress of the International Primatological Society Edinburgh, UK.

Clements, T., Rawson, B., Pollard, E., O'Kelly, H. & Nut Meng Hor (2008b): Conservation status and monitoring of black-shanked douc, *Pygathrix nigripes*, and yellow-cheeked crested gibbon, *Nomascus gabriellae* in Seima Biodiversity Conservation Area, Cambodia. Abstracts Conservation of Primates in Indochina, 19.

International Symposium Cuc Phuong National Park 27.-30. November 2008.

Daltry, J.C. & Momberg, F. (eds.) (2000): Cardamom Mountain Biodiversity Survey 2000. Fauna & Flora International, Cambridge, UK.

Duckworth, J.W. (2008): Preliminary Gibbon Status Review for Lao PDR 2008. Fauna & Flora International. (Unpubl.).

EU-ASAC (2004): European Union Assistance on Curbing Small Arms and Light Weapons in Cambodia. (Unpubl.).

Eudey, A.A. (2008): The Crab-eating Macaque (*Macaca fascicularis*): Widespread and Rapidly Declining. Primate Conservation 23, 129-132.

Gray, T.N.E., Phan, C. & Long, B. (2010): Modelling Species Distribution at Multiple Spatial Scales: Gibbon Habitat Preferences in a Fragmented Landscape. Animal Conservation, 1-9.

Groves, C.P. (2001): Primate Taxonomy. Smithsonian Institution Press, Washington DC.

Heng Sokrith, Hon Naven & Rawson, B. (in review): A New Record of *Macaca fascicularis* x *M. mulatta* Hybrids in Cambodia. Cambodian J. of Natural History.

Hoang Minh Duc (2007): Ecology and Conservation Status of the Black-shanked Douc (*Pygathrix nigripes*) in Nui Chua and Phuoc Binh National Parks, Ninh Thuan Province, Vietnam. PhD Thesis, University of Queensland, Brisbane.

IUCN (2009): IUCN List of Threatened Species. <www.iucnredlist.org>.

Konrad, R. & Geissmann, T. (2006): Vocal Diversity and Taxonomy of *Nomascus* in Cambodia. Int. J. Primatol. 27(3), 713-745.

Long, B., Swan, A.R. & Kry Masphal (2000): Biological Surveys in Northeast Mondulkiri, Cambodia. Fauna & Flora International, Phnom Penh. (Unpubl.).

Nadler, T., Timmins, R.J. & Richardson, M. (2008): *Trachypithecus germaini*. In: IUCN Red List of Threatened Species <www.iucnredlist.org> Downloaded on May 17th, 2010.

Neath, N., Setha, T., Bunnat, P. & Stuart, B. (2001): A Wildlife Survey of Bokor National Park Cambodia. Wildlife Conservation Society, Phnom Penh. (Unpubl.).

Nguyen Manh Ha (2009): The Illegal Trade in Gibbon in the Lowland Dong Nai Watershed Forest, Southern Vietnam. CRES, Hanoi. (Unpubl.).

Phan Channa & Gray, T. (2009): The Status and Habitat of Yellow-cheeked Crested Gibbon (*Nomascus gabriellae*) in Phnom Prich Wildlife Sanctuary, Mondulkiri. WWF, Phnom Penh. (Unpubl.).

Phoonjampa, R. & Brockelman, W.Y. (2008): Survey of Pileated Gibbon *Hylobates pileatus* in Thailand: Populations Threatened by Hunting and Habitat Degredation. Oryx 42(4), 600-606.

Pollard, E., Clements, T., Nut Meng Hor, Sok Ko & Rawson, B. (2007): Status and Conservation of Globally Threatened Primates in the Seima Biodiversity Conservation Area, Cambodia. Wildlife Conservation Society, Phnom Penh.

Rainey, H., Clements, T., Tan Setha, Thong Sokha, Rours Vann & Tyson, M. (2010): Large Mammal Surveys in Preah Vihear Protected Forest, Cambodia 2006-2009. Wildlife Conservation Society, Phnom Penh, Cambodia.

Rawson, B., Lippold, L., Timmins, R., Vu Ngoc Thanh & Nguyen Manh Ha (2008): *Pygathrix nigripes*. In: IUCN Red List of Threatened Species <www.iucnredlist.org> Downloaded on April 21st, 2009.

Rawson, B. & Roos, C. (2008): A New Primate Species Record for Cambodia: *Pygathrix nemaeus*. Cambodian J. Natural History 1(1), 7-11.

Rawson, B.M. (2007): Surveys, Trade and Training in Voensei Division, Ratanakiri Province, Cambodia. Conservation International and Forestry Administration, Phnom Penh. (Unpubl.).

Rawson, B.M. (2009): The Socio-Ecology of the Black-shanked Douc (*Pygathrix nigripes*) in Mondulkiri Province, Cambodia. PhD thesis, Australian National University, Canberra.

Rawson, B.M., Clements, T.J. & Nut Meng Hor (2009): Status and Conservation of Yellow-cheeked Crested Gibbons in Seima Biodiversity Conservation Area, Mondulkiri Province, Cambodia. In: Lappan, S. & Whitaker, D.M. (eds.):The Gibbons: New Perspectives on Small Ape Socioecology and Population Biology; pp. 387-408. Springer, New York.

Rawson, B.M. & Senior, B. (2005): Pileated Gibbon (*Hylobates pileatus*) Status in Preah Monivong 'Bokor' National Park, Cambodia. WildAid, Bangkok. (Unpubl.).

Roos, C., Nadler, T. & Walter, L. (2008): Mitochondrial Phylogeny, Taxonomy and Biogeography of the Silvered Langur Species Group. Molecular Phylogenetics and Evolution 47(2), 629-636.

SCW (2006): The Atlas of Cambodia: National Poverty and Environment Maps. Save Cambodia's Wildlife, Phnom Penh.

Starr, C., Nekaris, K.A.I., Streicher, U. & Leung, L.K.P. (in press): Field Surveys of the Threatened Pygmy Slow Loris (*Nycticebus* *pygmaeus*) Using Local Knowledge in Mondulkiri Province, Cambodia. Oryx.

Starr, C., Rogers, L., Nekaris, K.A.I. & Streicher, U. (this volume): Surveys and preliminary field observations of the northern slow loris (*Nycticebus bengalensis*) in Cambodia.

Streicher, U. & Rawson, B. (2010): Field Surveys for Lorises and Civets in Veun Sai Forests, Ratanakiri Province, Cambodia. Conservation International, Phnom Penh. (Unpubl.).

Timmins, R. & Ou Rattanak (2001): The Importance of Phnom Prich Wildlife Sanctuary and Adjacent Areas for the Conservation of Tigers and Other Key Species: A Summary. WWF Conservation Program, Phnom Penh.

Traeholt, C., Roth Bunthoen, Rawson, B.M., Mon Samuth, Chea Virak & Sok Vuthin (2006): Status Review of Pileated Gibbon, *Hylobates pileatus* and Yellow-cheeked Crested Gibbon, *Nomascus gabriellae*, in Cambodia. Fauna & Flora International - Indochina Programme, Phnom Penh.

Van Ngoc Thinh, Rawson, B., Hallam, C., Kenyon, M., Nadler, T., Walter, L. & Roos, C. (in press): Phylogeny and Distribution of Crested Gibbons (Genus *Nomascus*) Based on Mitochondrial Cytochrome b Gene Sequence Data. Am. J. Primatol.

Walston, J., Davidson, P. & Men Soriyun (2001): A Wildlife Survey in Southern Mondulkiri Province Cambodia. Wildlife Conservation Society, Cambodia Program, Phnom Penh. (Unpubl.).

3

DISTRIBUTION AND PRESENT STATUS OF MACAQUES IN LAO PDR

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SUMMARY

The current status and distribution of macaques were surveyed in Lao People's Democratic Republic (Laos hereafter). The distribution pattern of the northern pig-tailed macaque (*Macaca leonina*) is geographically clinal and density decreases with latitude. In southern Laos, they are frequently reported in every type of habitat, including the Mekong River area, the intermediate plains and dry hilly forest zones, and Xay Phou Louang (Annamite Mountain Range). However, the distribution of the Assamese macaque (*M. assamensis*) is the reverse, and the southern limit of their distribution is about 15°N. Stump-tailed macaques (*M. arctoides*) are uniformly found throughout Laos. Rhesus macaques (*M. mulatta*) are also uniformly distributed in Laos, except in the area of the western bank of the Mekong River in southern Laos. Their habitat preference differs from those of Assamese, northern pig-tailed, and stump-tailed macaques. Although it was supposed that the southern limit of distribution of rhesus macaques would be inside Laos, this limit has not yet been determined. Long-tailed macaques (*M. fascicularis*) are found only in the southern-most area, 15.2°N or lower latitude, where they appear to be sympatric with rhesus macaques, though it is probable that they inhabit forests of different conditions than rhesus macaques, such as riverine forest.

Hunting and habitat loss are key threats, driven by increasing economic development, human population increase, agricultural encroachment and transport infrastructure (roads and bridges) connecting Laos with neighboring countries. From the distribution patterns of macaques, implications to their phylogeography are provided. The number of 'monkey farm' commercial breeding centers is also increasing. Primates in Laos are losing habitat and under the high hunting pressure conservation measures are urgently required.

INTRODUCTION

Laos has a diverse environment, as it is situated in the center of the Indochina Peninsula, encompassing 14° to 22.5°N. It has the Xay Phou Louang (Annamite Mountain Range) in the East, the Mekong River in the West, and plains in between them. The forest cover in Laos is relatively high, and harbors a wide variety of wildlife. The primate fauna is also rich in Laos, from prosimians (lorises), cercopithecids, through lesser apes (gibbons). As their exact distribution and variations have not been studied, they have been neither properly classified and their phylogeographic histories have yet to be elucidated. However, populations of non-human primates are increasingly threatened and now face extinction. Their habitats have been affected by such human activities as logging, water power plant development, agriculture, which have in turn been exacerbated by population increase and economic development models dependent on natural resources. Hunting pressure on non-human primates, although it is banned by Government regulation, is still high, for food, trading, and pest control for agricultural crops. If this trend continues and expands, local populations of some taxa will be exterminated before they can be studied. For their conservation, the distribution and diversity should be delineated. More than 15% of the national land area is designated as National Biodiversity Conservation Areas (NBCAs) by the Government of Laos, and wildlife is conserved especially within those NBCAs. In the 1990's assessments on the wildlife, including primate fauna were carried out in these NBCAs, and the results of the national distribution of non-human primates were reported (Duckworth *et al*., 1999). The report gives an outline of primate distribution, but the details of distribution and present status, and distribution outside of NBCAs are not known.

Five species of macaques are distributed in Laos, which are also widely distributed in Asia. They should typically have shared habitat with different ecological niches, for example the forest types, e.g., broad-leaf evergreen forest vs others, and arboreality vs. terrestriality (Fooden, 1982). There are two points of interests in their distribution patterns. The first is on the distributions in Laos of rhesus macaques (*Macaca mulatta*) and long-tailed macaques (*M. fascicularis*), whether they are allopatric with each other, or they are parapatric and there are areas which the two species share. Local hybridization was suspected in the eastern half of the Indochina Peninsula between the two macaque species (Fooden, 1964; 1995; 2000; Hamada *et al*., 2006; 2008), and contact zone and the nature of hybridization should be delineated. The second is on the relationships in distribution between northern pig-tailed (*Macaca leonina*) and Assamese macaques (*M. assamensis*). Fooden (1982) hypothesized that the two macaque species are basically allopatric with each other as they prefer the same ecological setting, that is, they are arboreal, and prefer broad-leaf evergreen forests. The two species are considered to compete for the same habitats, and thus, they may be segregated by climate, that is, Assamese macaques tend to inhabit cooler area and pig-tailed macaques warmer areas.

The latitude which separates the distribution of the two pairs of macaques species, rhesus vs. long-tailed and Assamese vs. pig-tailed macaques is considered to be around 15° to 20°N (center in 18°N; Fooden, 1982). However, northern pig-tailed macaques were found to be distributed in northern Laos (Duckworth *et al*., 1999; Hamada *et al*., 2007). Assamese macaques are also distributed South as far as 14.3°N in Thailand (Erawan Waterfall, Malaivijitnond *et al*., 2005). Therefore, it is considered that they are sympatric in the Indochina Peninsula (in Myanmar, New *et al*., 2005), though the mechanism of sympatry has not been elucidated.

The phylogeographic history is reconstructed for macaques mainly on those distributed to the Sundaland (Abegg & Thierry, 2002; Ziegler *et al*., 2007). The phylogeography in the continental Southeast Asia has not been delineated, because of the difficulty in documenting the distributional patterns of non-human primates (Meijaard & Groves, 2006). Because of the intensive artificial influences on non-human primates, it is difficult to elucidate their distribution pattern in Vietnam (Nadler, 2004), for example, Assamese macaques are almost extinct in their range in central Vietnam, yet their populations survive in northern Vietnam. On the other hand, long-tailed macaques have widened their range to the higher latitude than 18°N (Nguyen Than Nhan, 2004), perhaps through transfer and introduction by humans, as is the case with many rhesus macaques that were also artificially transferred in the lower latitude area (Cat Tien NP; Polet *et al*., 2004). The distribution of primate fauna is less externally influenced in Laos, which gives an opportunity to study the distribution pattern.

We carried out field surveys on the distribution and present status of non-human primates, especially macaques both in central Laos, (Vientiane Province and Vientiane Prefecture), and in southern Laos, that is, areas south to the Bolikhamxay Province (Khammouane Province and southern provinces). We report the distribution and present status of non-human primates, and taking the distribution pattern in Thailand (Malaivijitnond *et al*., 2005) into consideration, we provide implications for the phylogeography of macaques in Laos.

MATERIAL AND METHODS

Field observation sites and interview

We conducted a road survey trip to cover central and southern Laos (Fig. 1), and interviewed people along the route. From 11th to 14th June, 2008, we surveyed in Vientiane Province and Vientiane Prefecture. We then surveyed along Route National (RN) 13, from Vientiane to Kasi, and then along provincial road from Hin Heub to Xaynamkhan via Namhi village (Fig. 2). Phou Phanang NBCA is located in this area to the West of RN-13 from Mekong River towards the North, to Hin Heub. The area between Vang Vieng and Kasi is mountainous, including lime-stone karst pinnacles. In Moung Fouang area, that is, from Hin Heub to Namhi villages, there are plains situated between lower altitude mountain chains to both the East and to the

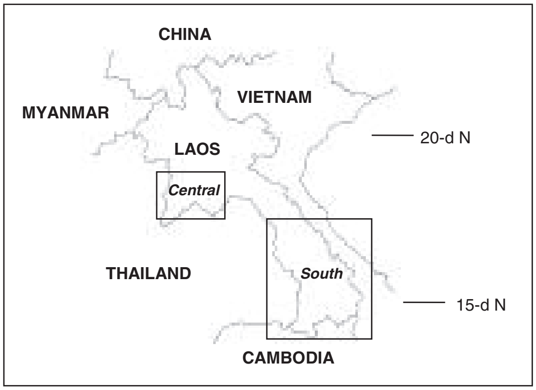

Fig. 1. Survey localities in central and south Laos.

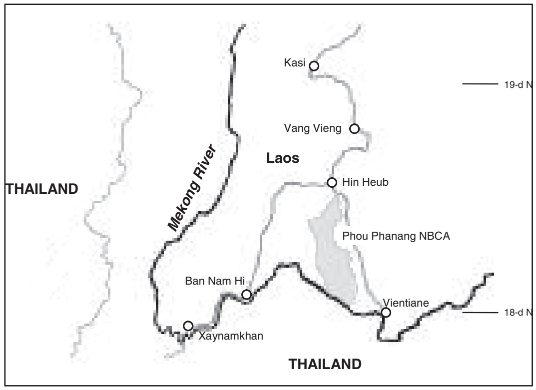

Fig. 2. Survey routes in central Laos, from Vientiane to Kasi along Route National 13, from Hin Heub to Xaynamkhan through Ban Nam Hi along the provincial road (near Phou Phanang National Biodiversity Conservation Area).

West. From Namhi to Xayankhan the route follows the Mekong River. We interviewed at 39 sites in total.

In the southern Laos, from 8th to 13th July, 2005, 18th to 26th January, 2007, and 6th to 14th September 2008, we surveyed from Khammouane Province to the southern end of Laos (Champasak and Attapeu Provinces (Fig. 3 and 4). The route led from Thakhek to the border with Cambodia along RN-13, then along RN-8 from Vieng Kham to Phonhom, and along RN-9 from Xeno to Den Sawan, the national boundary with Vietnam. We also surveyed along RN-23 and RN-16, from Pakse, via Thateng and Sekong to Attapeu; and then, from Attapeu to the West on RN-18 to Sanamxay and to the East on the new RN to Ban Xe Xou. In this area, South of Khammouane Province, the Mekong River flows in the West, bordering Thailand, and the Xay Phou Louang mountains (Annamite range) runs North to South in the East, and between them are plains and gently sloping areas with dry forest. As such, from these geographical conditions, there are three environmental types covered by the surveys, mountainous area, Mekong River side, and plains in between (Duckworth *et al.*, 1999). In the plain area, there are low altitudinal hilly areas, such as Phou Hin Poun and Phou Xang He NBCA which is covered by deciduous dipterocarpus forests. In the South from about 15.25°N, the Mekong River flows inside Laos, and there are plains in the West of the Mekong. In the far South, there is the Bolaven Plateau with the Xay Phou Louang to the East, and some low altitudinal hilly areas (Xe Pian NBCA) in the South of the Bolaven Plateau to the national boundary with Cambodia. Along these routes, we interviewed at 83 sites in total.

Following the interview items (Hamada *et al.*, 2007), and using photos and brochures with morphology and behavioral characteristics of primates that are supposedly distributed in Laos, we interviewed to determine the presence of primate species and their abundance, damage on agricultural crops, hunting, whether they are consumed etc. We observed pet monkeys and collected samples, and interviewed owners for the origin of captive animals, the way of capturing or hunting, purpose of the pet, etc. We followed the classification of macaques by Fooden (1976), rhesus (*Macaca mulatta*), northern pig-tailed (*M. leonina*), Assamese (*M. assamensis*), stump-tailed (*M. arctoides*), and long-tailed macaques (*M. fascicularis*). Although the classification of langurs (leaf monkeys) have been revised recently (Brandon-Jones, 2004; Roos *et al.*, 2007), we classified them into silvered (*Trachypithecus* [*cristatus*] *margarita*), grey langurs (*T.* [*phayrei*] *crepusculus*), and douc langurs (*Pygathrix* spp.), all of which were considered to be distributed in central and southern Laos. Gibbons in central and southern Laos are either *Nomascus siki* or *N. gabriellae*, though it is difficult to classify without sighting in the wild, and thus we recorded presence or absence of gibbons in general, rather than to species level. For captive animals, where possible, we measured head-body length (from the vertex of the head to the caudal end of the ischial callosity) and tail length with tape. Relative tail length was calculated by the division of tail length by head-body length multiplied by 100. In known bushmeat Markets, primate cages were located, and the number and species of primates sold or kept were recorded.

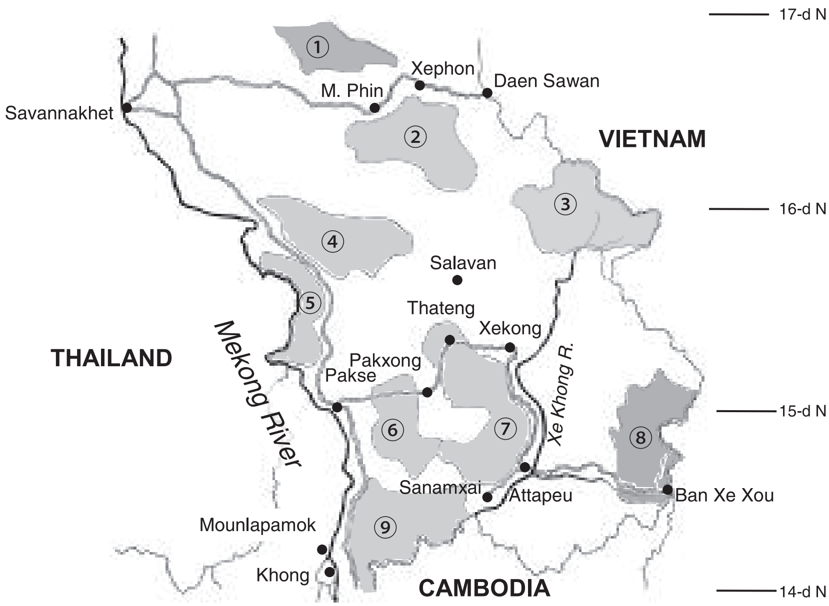

Fig. 3. Survey routes in southern Laos, from Savannakhet to Daen Sawan through Muang Phin and Xephoe along RN-9, from Savannakhet, through Pakse to the southern border along RN-13, from Pakse to Attapeu through Pakxong, Thateng, and Xekong along RN-23 and RN-16, from Attapeu to Sanamxay along RN-18, and from Attapeu to Ban Xe Xou along a new road. Grey areas mark National Biodiversity Conservation Areas: 1 - Phou Xang He, 2 - Dong Phou Viang, 3 - Xe Xap, 4 - Xe Ban Nuan, 5 - Phou Xiang Thong, 6 - Dong Hua Sao, 7 - Bolaven, 8 - Dong Amphan, 9 - Xe Pian.

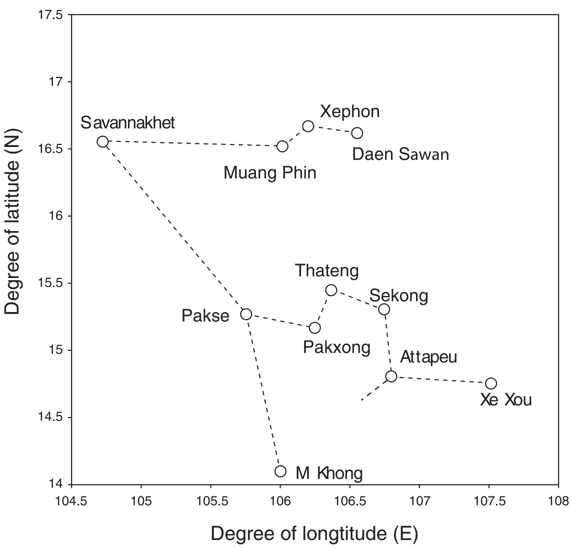

Fig. 4. Routes and sites covered by the survey in southern Laos.

RESULTS

Distribution and status of primates, especially macaques in Central Laos

Rhesus macaques were reported in 6 sites from the total of 39 sites in central Laos (Fig. 5). Two sites were near Hin Heub Village, and two were in and at the outskirt of Phou Phanang NBCA, and the other two were villages between Ban Nam Hi and Xaynam Kham City along the Mekong River. Thus, rhesus macaques were not reported in the mountainous areas between Vang Vieng and Kasi, but reported in the hilly areas close to town or forested area near the Mekong River or NBCA. Northern pig-tailed macaques were reported at 11 sites, and are considered to be uniformly distributed in central Laos (Fig. 5). Assamese macaques were reported in eight sites, including all areas surveyed. Stump-tailed macaques were reported in total of seven mountainous sites, north from Moung Fouang to Kasi (Fig. 5).

Northern slow loris (*N. bengalensis*) were distributed across all areas, that is, they were reported at 14 sites, while pygmy lorises (*N. pygmaeus*) were reported less frequently, at 7 sites

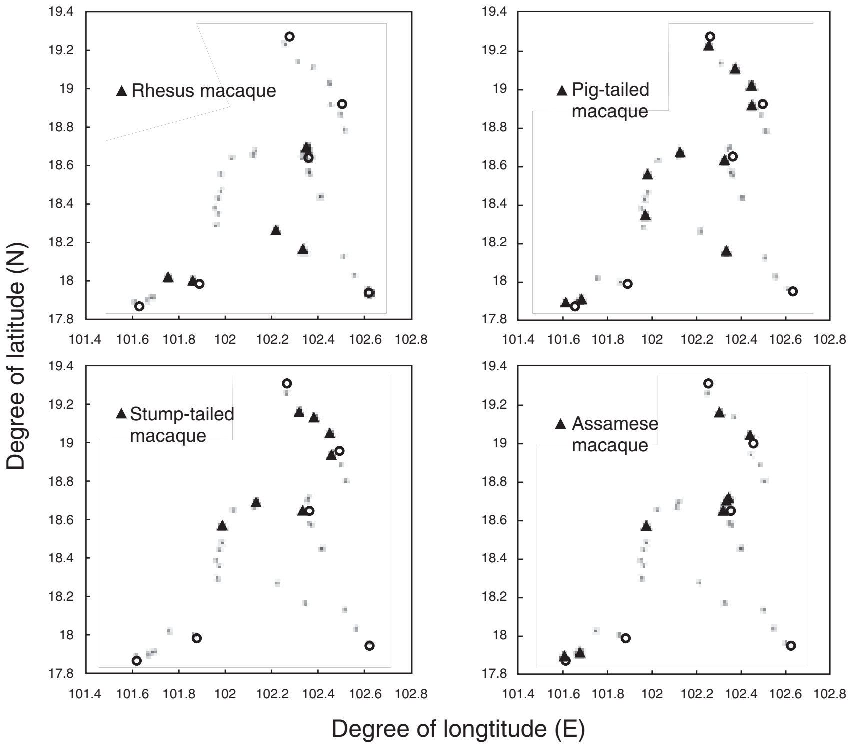

Fig. 5. Records of macaques in central Laos. Black triangles indicate the localities of the records.

(Fig. 6). Grey langurs (*Trachypitecus* [*phayrei*] *crepusculus*) or silvered langurs (*T*. [*cristatus*] *margarita*), were reported without specific determination, and were distributed both in mountainous and Mekong River areas, at 10 sites (Fig. 6). Within three sites out of 10, two species of langur were reported. Although historic distribution of gibbons was reported in the mountainous area between Vang Vieng and Kasi, they are currently reported absent (Fig. 6). Gibbons were reported at three sites in Moung Fouang area, however, two sites were neighboring each other, and the same populations may have been noticed by people of the two villages. Only one positive report was given in the Mekong River area, though in the past gibbons used to be found in three sites.

In total, 15 pet monkeys were observed; 3 rhesus macaques, 7 northern pig-tailed macaques, 2 Assamese macaques, and 3 stump-tailed macaques. Many of them were native, that is, they were caught nearby forests of the pet-owners' villages. However, the two Assamese macaque were not native, one was brought from far North, Phongsali Province; and another was claimed to have been bought in Vientiane City, which was most probably brought from other locality. One pig-tailed macaque was also brought from Salavan Province, in the far South (ca. 16^{o} N).

Hunting for primates is illegal, though the control does not appear strict and primates are hunted for food, trade, and for pest control. Some populations of macaques raid crops, and villagers have caught macaques with snares or shot them with guns.

In the area surveyed in central Laos, particularly Moung Fouang area, there are recently established villages in addition to those of longer permanence. A considerable number of the inhabitants are immigrants from northern Laos, which is, Luang Prabang, Phongsali, or Xieng Khouang Provinces. The forests in the plains or gently sloping hills have been cleared for agriculture.

Distribution and status of primates, especially macaques, in southern Laos

Interviews were conducted at 83 sites in total, including inspection of pet primates where possible. Rhesus macaques appear uniformly distributed, including the mountainous area to the south of Pakse, on the eastern bank of the Mekong River (Fig. 7). The

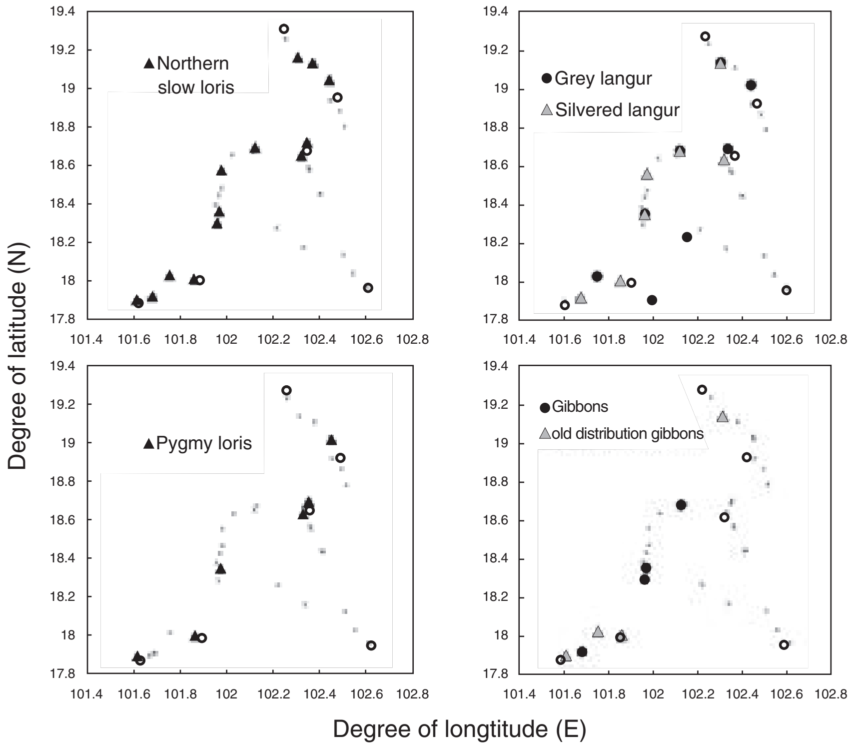

Fig. 6. Records of lorises, langurs, and gibbons in central Laos. Black triangles indicate the localities of the records.

southern-most recorded site was 14°N. However, Xay Phou Kiou, the forest in the Xe Pian NBCA, is contiguous with the forest in Cambodia across the national boundary, and is also reported to be inhabited by rhesus macaques. Rhesus macaques were also reported in the mountainous forests in the Bolaven Plateau, west of Attapeu City. They appear to be distributed in the Dong Amphan NBCA, which is located in the Xay Phou Louang, however, their absence was reported for the southern bank of Xe Xou River (tributary of Xe Kong River).

Long-tailed macaques were reported to inhabit the Bolaven Plateau at least in the eastern and southern slopes, south of 15.2°N; South of Attapeu (southern bank of Xe Xou River); and southern half of the Xe Pian NBCA (Fig. 7). Therefore, long-tailed and rhesus macaques co-habit the area bordered by 15.2°N to 14°N (in the Xe Pian NBCA, Champasak Province), and northern bank of the Xe Xou River in Attapeu Province. In the Bolaven Plateau, long-tailed macaques reportedly tend to inhabit the riverine forests, and rhesus tend to inhabit other types of forests.

Khong Island in the Mekong River (Fig. 3), spanning about 18 km North to South and 8 km East to West, at around 14.2°N, used to be inhabited by gibbons and other non-human primates, however, most of the primate populations were extinct through habitat loss (agricultural encroachment) and hunting. At present small population(s) of "macaques with medium length of tail" remain in isolated forests. Although surveys were not carried out in the area of the eastern bank of the Mekong River, south of 15.2°N , according to the distribution of macaques in Thailand (Malaivijitnond *et al.*, 2005), this area may be inhabited by long-tailed and northern pig-tailed macaques. The provenance of the pet long-tailed macaques observed in the Khong Island was reported to be this area, Mounlapamok District. This area is mountainous, and notable for the location of the Wat Phou ruins, and are densely covered by forest. However, no presence of primates was reported.

Northern pig-tailed macaques were the most frequently reported for their presence, and they were distributed throughout southern Laos (Fig. 8). They are distributed in all types of environment, that is, Mekong River area, intermediate dry plain and hilly area, and mountainous area (Xay Phou Louang).

There were only four sites with a positive report for Assamese macaques, and only in mountainous

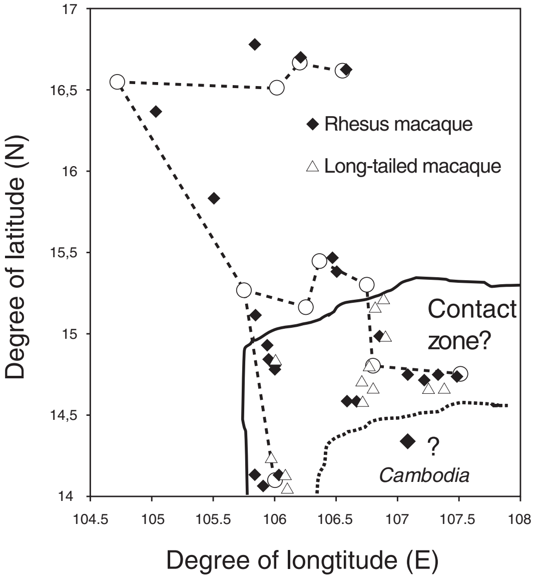

Fig. 7. Records of rhesus macaques (*Macaca mulatta*) and long-tailed macaques (*Macaca fascicularis*) with supposed contact zone. The southern border of the rhesus macaque distribution is uncertain.

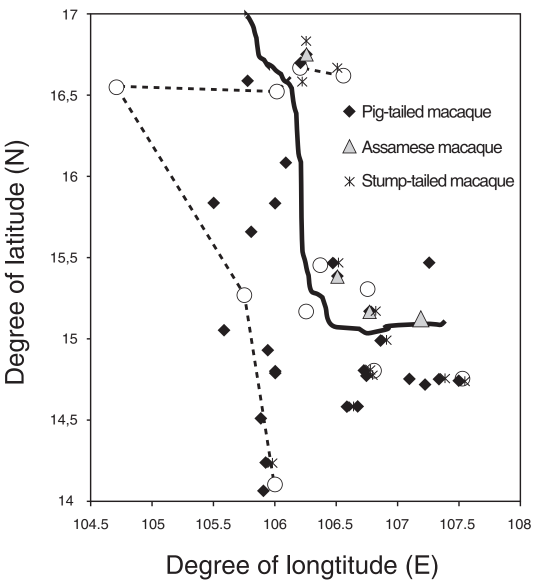

Fig. 8. Records of northern pig-tailed macaques (*Macaca leonina*), Assamese macaques (*Macaca assamensis*), and stump-tailed macaques (*Macaca arctoides*). Assamese macaques are considered to occur in mountainous forests in the eastern half of southern Laos from around 15°N to the North.

areas (Fig. 8). The southern-most report was at 15.2°N in the Bolaven Plateau. At Ban Xe Xou, locating inside Dong Amphan NBCA, they were reported to be absent. Assamese macaques were reported at Ban Samboun (Attapeu Province, 14.9°N), located on the western outskirts of Dong Amphan NBCA. Therefore, it is possible that northern area of that NBCA is inhabited by Assamese macaques. Thus, Assamese macaques, although less frequently encountered, are distributed in the Xay Phou Louang mountainous forests in Sekong Province, continuously from central Laos. In southern Laos, northern pig-tailed and Assamese macaques appear to share habitats, especially mountainous areas.

Stump-tailed macaques were reported rather more frequently in mountainous forest area than other areas (Fig. 8), however, they were also reported in Mekong River area and intermediate dry plain/hilly forested areas. Thus the Xay Phou Louang mountainous area was inhabited by four species, and the Bolaven Plateau was inhabited by five species of macaques with different densities between species.

Northern slow lorises were uniformly reported, but less frequently in the intermediate plain/hilly forested area and Mekong River area (Fig. 9). They are rather more frequent in the area south of Pakse. Pygmy lorises were reported uniformly, rather more frequent in the area north of Pakse than the area south of Pakse (Fig 9). Red-shanked douc langurs (*Pygathrix nemaeus*) were reported, though less frequently in the forested area of the Xephon District, Xe Pian NBCA, Bolaven Plateau, and Xay Phou Louang area including Dong Amphan NBCA (Fig. 9). It is likely that grey langurs (though the possibility of silvered was not thoroughly ruled out) inhabited the area north to Pakse, mainly Phou Xang He NBCA and the forests in the Mekong River area (Fig. 9). In the area south of Pakse, grey langurs or silvered langurs were frequently reported, that is, in Xe Pian NBCA, Bolaven Plateau, Dong Amphan NBCA, and other forested areas. Gibbons were reported in the mountainous forests in the south of Pakse, excepting one from Xephon (16.7°N; Fig. 9).

Seventy-eight pet primates were inspected; 42 northern pig-tailed, 6 long-tailed, 14 rhesus, 5 Assamese, and 4 stump-tailed macaques, 1 grey langur, 2 red-shanked douc langurs, and 4 gibbons. The provenances for these pets were given by owner, and some of them were brought from distant locality and others were caught nearby forests including those probably caught in NBCA close to the village, e.g., Phou Xang He, Xe Pian. There are

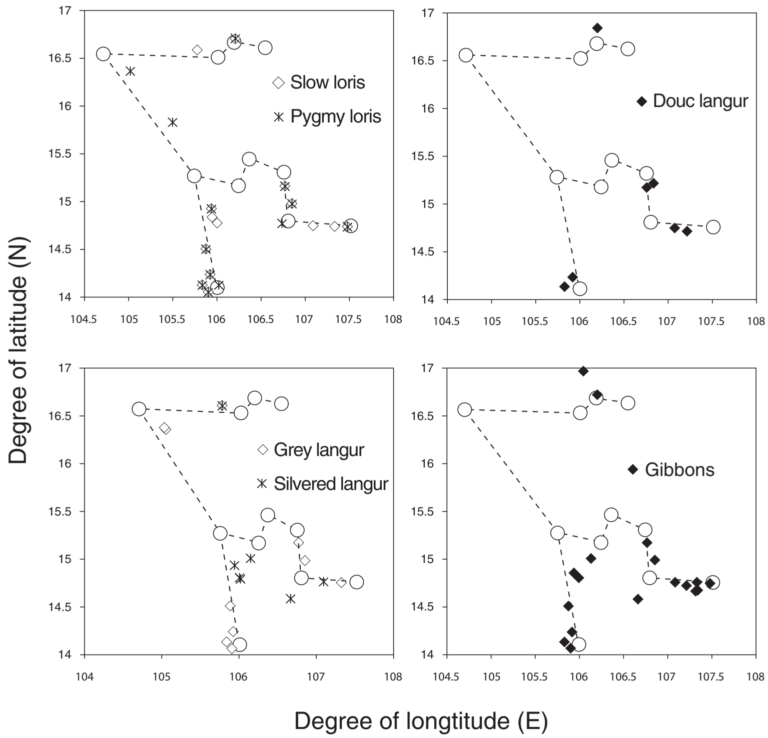

Fig. 9. Records of lorises, langurs, and gibbons in southern Laos.

some localities that are popular for wildlife inclusive primates, for example Virabury, situated about 50 km north-east of Xephon where copper and gold mine has recently started operation, and with Dakchung and Xekong city nearby, along with the national border with Vietnam. Pet long-tailed macaques that were observed in Pakse City and in the area south of Pakse City were brought from Attapeu to Pakse City, from Mounlapamok (west of Mekong River at around 14.5°N) and Cambodia to Khong Island.

Geographic variation of relative tail length in rhesus macaques

We measured tail and head-body lengths on 6 rhesus macaques in southern Laos. Within these samples, one from 16.6°N (which came from Phou Xang He NBCA) and another from 16.62°N (from Ban Den Savan, the outskirt of the Phou Xang He NBCA) recorded shorter tails, 45% and 52% of head-body length, respectively. On the other hand, three rhesus macaques from 15.9, 15.1, and 14.77°N were recorded to have longer tails, that is, 72.5%, ca. 80%, and 78%, respectively. A population of rhesus macaques that inhabits Ban Don Mouang (16.54°N, Xavannakhet Province) were also inspected. They have tails of middle length, that is, the average was 51.9% (sd=3.71%, n=27, Hamada *et al.*, *in preparation*). Rhesus macaque pets inspected in the suburbs of Vientiane (on 11th June, 2008), whose provenance was reportedly Xephon (ca. 16.5°N), had a tail of 54.9% of head-body length.

In Central Laos, we inspected two rhesus macaques which were claimed to have been obtained from Phou Phanang NBCA or its periphery forests, and which had tails of about 45% and 49.7%, respectively. In northern Laos, two rhesus macaques inspected, caught in the forest near the site of interview, 20.5 and 21.4-degree N, had tails of 32%, and about 40%, respectively (Hamada *et al.*, 2007).

From these data, the relative tail length showed a significant negative geographical clinal variation with latitude (r^2=0.791) that is, northern individuals tend to have relatively shorter tails while southern ones have longer tails (Fig. 10).

Bushmeat Markets

Bushmeat markets were found along RN's, in Bolikhamxay and Savannakhet Provinces along RNs-

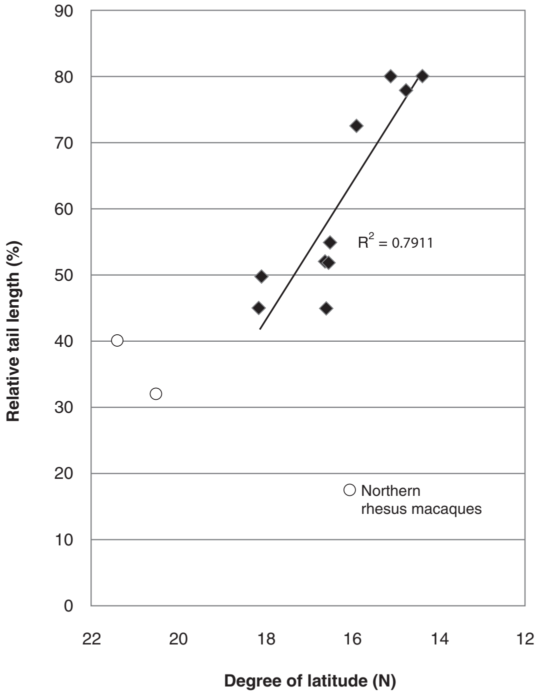

Fig. 10. Geographical clinal variation of the relative tail length of rhesus macaques (*Macaca mulatta*) in Laos (standardized by the head-body length in percent). Regression line is superimposed for the central and southern macaque populations.

13 and 9, in Attapeu Province along the newly constructed (asphalted) RN connecting Attapeu to Dak To in Vietnam. A variety of bushmeat is sold, mainly rodents, ungulates (muntjacs), civets, birds, lizards and turtles. Primates were less frequently traded, once a week or so. Along the RNs running East to West and connecting Vietnam and Laos, factories, mines, and large-scale agricultural areas have recently been established or are being constructed, and construction workers and laborers (mainly Vietnamese) consume considerable amount of meat and bushmeat for special energy and nutrients.

'Monkey Farms'

A monkey farm (commercial breeding center) in Bolikahmxay Province along RN-13 is operating and expanding, and is managed by the same company (China based) as a monkey farm near Vientiane City. Several thousand long-tailed macaques are housed. In September 2008, about 2000 macaques were housed, and a new cage-house was almost finished which is planned to accommodate another 1000 monkeys.

Another monkey farm (Vietnam based company) was under construction along the RN-13, 36 km south of Pakse City. Construction workers claimed that 10,000 macaques will be housed in the colony.

These centers are keeping, and will keep, long-tailed macaques. The macaques recorded were juveniles or young adults, without any infants or full adults, indicating that they were not bred in the colony, but brought from elsewhere. These macaques cannot be supplied from Laos, as the wild populations were limited in the southern-most area in Laos, but from nearby countries, such as Thailand and Cambodia. According to the farm keeper, monkey populations inhabiting Buddhist temples and City Parks in Thailand are habituated and their population sizes are sometimes huge, that is, more than 1,000. They were caught (illegally, as the Thai Government would not permit such transaction), and sold at $US80/animal. We have heard that in some Buddhist Temple in Nakhon Sawan Province in Thailand, there were more than 1,000 monkeys and someday hunters came and caught several hundreds of monkeys, and brought them to Vientiane by trucks. The chief monk and villagers chased the truck and confiscated the monkeys. However, such illegal hunting and smuggling could likely occur elsewhere.

Monkeys from Cambodia, cought from the wild (not habituated) are reportedly more healthy than those from Thailand, according to the workers at the farm, as well as the local villagers. Villagers in the southern-most Laos (below 15°N) along RN-13 try to catch long-tailed macaques. According to interviews, monkeys, after recovering health from transportation and reception to a farm, are tested with drugs (e.g. insulin of 10 times a standard treatment dose), and those individuals that survive are sent to Ho Chi Minh City or Hong Kong. Then, they would be exported to US and Europe for biomedical experiments or for drug tests at the price of 1000 $ US or more. A Vietnamese company reportedly has farms in Vietnam, near Ho Chi Minh City.

Threats to non-human primates

Local populations are facing extinction through a significant variety and severity of threats. The basic drivers are the population growth of people and economic development. Agricultural land (encroachment) is widely developed, especially large-scale farmland for the production of such commercial commodities as sugar cane, rubber, coffee, corn, which are established and managed by foreign capital. Habitat loss is also caused by mining and constraction of water power plants. Hunting and trade of wildlife and their products (meats and bones) is prevalent. Detailed surveys are necessary to evaluate the impact of these activities on local populations.

DISCUSSION

Distribution patterns of macaques

From the data obtained in the present study and those in northern Laos (Hamada *et al*., 2007), the distribution pattern of macaques in Laos is delineated. In northern Laos (above 20°N), rhesus, Assamese and stump-tailed macaques are distributed densely, and the density of northern pig-tailed macaques was about one third or one fourth of those of the other three macaque species. This observation and report by Duckworth *et al*. (1999) deny Fooden (1975) who described that the (northern) pig-tailed macaques are distributed south of the 18°N, based on records at the time.

In central Laos (Vientiane Province and Vientiane Prefecture) four species of macaques occur, and the pig-tailed macaque was reported most frequently. The topography of this locality is complicated, from limestone steep cliffy mountainous area (Vang Vieng – Kasi), plain and hilly area (Moung Fouang) and Mekong River area. This locality has also been inhabited by humans for a long time, as it is along the main route connecting Vientiane and Louang Prabang. Therefore, a considerably wide area of macaque habitat is now disturbed forest.

Five species of macaque, adding long-tailed macaque to the members found in central and northern Laos, are found in southern Laos, 16° to 14°N. It was the northern pig-tailed macaques that were the most frequently reported. The environments of southern Laos consist of Mekong River area in the West, Xay Phou Louang mountainous area in the East, and plain/hilly dry forest area in between. The last area was widely disturbed by humans, to which northern pig-tailed macaques could have adapted better than other macaque species.

Rhesus macaques are distributed almost uniformly in Laos and show a different habitat preference than the other three species of macaques in central Laos. Rhesus macaques were confined to two areas, firstly near Hin Heub town at the intersection of the main routes (RN-13) and Provincial Road, and have long history of human settlements, or along the Mekong River area. They were not reported in the mountainous area between Vang Vieng and Kasi and the Moung Fouang area. In the latter area, immigrants have converted the low profile hilly forests for agriculture, where rhesus macaques had previously inhabited. It suggests that local populations of rhesus macaques may have become extinct. This could be supported by the fact that rhesus macaques inhabit Phou Phanang NBCA near Moung Fouang area. Rhesus macaques are the second most frequently reported species in southern Laos, though they do not appear to adapt to the dry hilly forests where northern pig-tailed macaques occur. Rhesus macaques are not likely distributed on the western bank of Mekong River, which is contiguous with Thailand. Long-tailed and pig-tailed macaques occur there. In northeast Thailand, rhesus macaques are confined to the area above 16.5°N (Malaivijitnond *et al*., 2005). The absence of rhesus macaques in this area is also explained by their habitat preference, that is, avoiding the dry hilly forests that tend to be patchy. In the eastern bank, on the other hand, mountainous forests are contiguous from North to South.

The southern border of rhesus macaque distribution has not yet been determined. It is necessary to study the forested area on the eastern bank of the Mekong River, that is, Xe Pian NBCA; and its tributary of Xe Khong River, and also in the forested area in north-eastern Cambodia, in Rattanakiri and Steng Trieng Provinces. Assamese macaques show similar distribution to stump-tailed macaques in northern and central Laos as a whole (Hamada *et al*., 2007), however, they tend to inhabit different environmental settings in northern Laos (Hamada *et al*., 2007). Assamese macaques were more frequently reported in Louang Nam Ta area where hilly (low altitudinal) forests prevail, though less frequently reported in Phongsali area where higher altitudinal mountains that are intersected by deep valleys. In southern Laos, Assamese macaques were reported at only four sites. One reason for the lower density of Assamese macaques in southern Laos is that their preferable climate is cooler than that in this region. A second reason may be that the forest condition, assuming that the Assamese macaque prefers mountainous forests compared with the dry hilly forests and disturbed forests of southern Laos.

Stump-tailed macaques are uniformly distributed throughout Laos. They tend to inhabit mountainous forests. In central Laos, they inhabit mountainous area between Vang Vieng and Kasi, which include limestone cliff mountains. In southern Laos, they are distributed inside or nearby the Xay Phou Louang

(Annamite Mountains), southern most forested areas as Xe Pian NBCA and those souths to Attapeu City which are continuous to the forested area of north-eastern Cambodia (Rattanakiri Province). Thus, stump-tailed macaques have better adapted to the warmer climate area and to dry and disturbed forests than Assamese macaques.

Long-tailed macaques are distributed in the southern-most part of Laos; in the Bolaven Plateau (15.2°N), and widely in the forests in Attapeu Province. In the Xay Phou Louang range, they probably inhabit forests South of Xe Xou River (tributary of Xe Khong River). They are also found to be distributed in Xe Pian NBCA (Champasak Province). Therefore, they are sympatric with rhesus macaques in the area from 15.2°N to the southern national border in the West, to the southern bank of Xe Xou River in the East.

Interspecific relationship

There is a question whether macaque distribution is determined by the interspecific relationships, that is, ecological competition for the same resources. According to Fooden (1982), northern pig-tailed and Assamese macaques ecologically compete with each other because their habitat preferences are similar with one another, that is, they prefer broad-leaf evergreen forests and they tend to be arboreal. Although stump-tailed macaques also prefer the same kind of forests, as they are terrestrial, they avoid competition with the two other species. Fooden (1982) proposed “ecological segregation hypothesis” that the two species are allopatric with each other, and Assamese macaques tend to be distributed in higher latitudes (cooler area) and pig-tailed macaques in the lower latitude, and the boundary between the two is approximately at around 18°N. However, the distribution patterns of the two species in Laos does not show any definite boundary, as Assamese macaques are found as low latitude as 15°N and northern pig-tailed macaques are found throughout Laos. Rather there is a geographic clinal variation of the densities in the two species; Assamese macaques become less dense in southern Laos (below 16°N), while northern pig-tailed densities are lower in northern Laos (above 20°N).

It is also found that pig-tailed macaques appear to adapt to the wider habitat conditions including dry and disturbed forests in central and southern Laos, in which Assamese and stump-tailed macaques are never or rarely found. This is also true in north-eastern Thailand, that is, that pig-tailed macaques are found in the dry small hilly forests and long-tailed macaques inhabit riverine forests (Malaivijitnond *et al*., 2005), where Assamese and stump-tailed macaques could not be found. Assamese and stump-tailed macaques are found in the large-scale mountainous forests, such as Phou Khieow Wildlife Sanctuary (16.3°N, Koenig *et al*., 2003). It is less probable that populations of Assamese and stump-tailed macaques, but not pig-tailed macaques, have been extirpated by hunting. Thus, the ecological segregation hypothesis of Fooden (1982) is generally right, however, there are no clear-cut boundaries between Assamese and northern pig-tailed macaques, but they show clinal density according to latitude (climate). The adaptability to dry forests, which would be fragile to the climate fluctuation, and to the disturbed forests, also differs with macaque species, which in turn influences density and distribution.

Rhesus and long-tailed macaques are considered to be allopatrically distributed in the ecological segregation hypothesis (Fooden, 1982), because they tend to inhabit forests other than “broad-leaf evergreen forests” that pig-tailed, stump-tailed, and Assamese macaques prefer. Thus, rhesus macaques tend to be distributed in higher latitudes and the long-tailed macaques in the lower latitudes. In southern Laos, the two species were found sympatric in the area between 15.2°N and 14.0°N. The topography of that locality is diverse, and it is possible that they inhabit different settings of forests as a villager claimed. The sympatry of the two species was also reported for the Huai Kha Khaeng Wildlife Sanctuary in Thailand (about 15.2°N, inside Dawna Range). The distribution patterns of long-tailed and rhesus macaques in NE Thailand (Malaivijitnond *et al*., 2005) suggest that long-tailed macaques could adapt to the disturbed and dry forests where rhesus macaques could not inhabit.

In central Laos, rhesus macaques are generally sympatric with northern pig-tailed, Assamese, and stump-tailed macaques, but rhesus are found less frequently in the mountainous areas between Vang Vieng and Kasi in which three other species were found. Rhesus macaques were found in low altitudinal hilly forests and in the Mekong River area. Such forests tend to have been converted to the farmland and wildlife living there would have been under hunting pressure (Moung Fouang District). The artificial influence on macaque distribution is necessary to be studied for the reconstruction of natural distribution pattern.

Hybridization or Introgression between rhesus and long-tailed macaques

Fooden (1995; 2000) classified long-tailed macaques into ten subspecies, and the populations inhabiting Indochina Peninsula as the nominotypical subspecies (*Macaca fascicularis fascicularis*) which is also distributed on such SE-Asian islands as Sumatra, Borneo, Java, Bali; and abandoning the subspecific classification, he classified rhesus macaques into eastern (distributed China and its vicinity) and western groups (India and its vicinity). These classifications have been supported by molecular phlyogenetic analyses (e.g. Smith *et al*., 2005; 2007; Satkoski *et al*., 2007), though Indochina and insular SE Asian long-tailed populations could be differently clustered (Blancher *et al*., 2008). Long-tailed macaques in the Indochina Peninsula have longer tails that are 110 % of the head-body length (Fooden, 1997; Fooden & Albrecht, 1999; Hamada *et al*., 2008) on the other hand, rhesus macaques have much shorter tails, 35.3% in the eastern group and 42.5 % in the western group (Hamada *et al*., 2005). In the eastern half of the Indochina Peninsula, around the division zone between the two species (15-20°N), suspected hybrid macaques with tails of intermediate length were found (Fooden, 1964; 1995; 2000; Hamada *et al*., 2006; 2008). Molecular phylogeographic studies showed that male rhesus macaques have introgressed with females of long-tailed macaques (Tosi *et al*., 2002; 2003; Bonhomme *et al*., 2008). Reverse introgression was suggested by Malaivijitnond *et al*. (2007; 2008) but definite cases have not been reported because of the difficulty in accession of “hybrid” rhesus in the Indochina Peninsula. The exact nature of hybridization or introgression is the future subject of study.

We inspected pet long-tailed and rhesus macaques in Laos from North to South, which would gave implications for the hybridization of the two species. The provenance of long-tailed macaques inspected were reportedly Attapeu and Mounlapamok (West of the Mekong River). They have shorter tails, about 100-110%, comparable to that in conspecifics inspected in Thailand north to the Isthmus of Kra (ca. 10.5°N; Hamada *et al*., 2008).

In rhesus macaques, relative tail length showed a significant negative geographical clinal variation with latitude (Fig. 9), that is, northern individuals tend to have relatively shorter tails, and southern ones longer tails. The tails of northern-most rhesus are comparable to that of eastern group of rhesus macaques (Chinese), and those of middle latitude are intermediate range of 45-55%, and those of lower latitude, 15.9°N to 14.8°N, are very long, ranging 75-80%. The clinal variation found in rhesus macaques in the central and southern Laos is statistically significant (r^2=0.791). This clinal variation could be explained by the climate difference, that is, cold adaptation (Allen’s rule). However this is not the case, because both of the eastern and western groups of rhesus macaques do not show such clinal variation within each group, and also the rhesus macaques from northern Laos do not have tails short enough to conform to the regression line for length against latitude for rhesus from central and southern Laos (Fig. 9). Therefore, the hybridization would be the causality of the tail length variation. The intensity of hybridization or introgression appears clinal in middle and lower latitude areas.

The clinal variation of tail length in rhesus macaques could be realized by either one-way (introgression) or two-way (hybridization) genetic flow. It is not impossible that the ancestors of rhesus(-like) macaques with longer tails would have been long-tailed macaques which received heavy introgression from rhesus macaques, which changed the morphological characters into that of rhesus macaques (e.g. pelage color pattern and cranio-facial morphology). Recent molecular studies showed that the rhesus are composed of eastern and western major clusters, and that each of the major clusters consists of several sub-clusters. However Indochinese rhesus macaques have not been analyzed except those from Vietnam (probably from northern Vietnam) which are found to be clustered with southern Chinese populations (Satkoski *et al*., 2008). Single nucleotide polymorphism analysis showed complicated genetic relationships between the two species (Street *et al*., 2007). Therefore, at present there is no data on the direction and the degree of introgression between long-tailed macaques and rhesus macaques.

Distribution of macaques in Laos and the implications for their phylogeography

The distribution pattern of the northern pig-tailed macaques in Laos drawn from the present study infers that they are an opportunistic species and have a wide adaptability from wet mountainous intact forests to rather dry and disturbed forests, which made them disperse geographically to wide areas in continental Asia in the postglacial period. This may conform to the scenario (‘go-west’ model) of Ziegler *et al*. (2007). For macaques distributed in the continental Asia, their ancestors would have been confined to some refuge that are supposed to have been located in Indochina, southern China to Xay Phou Louang mountainous area, NE India (Kasi hill; Eudey, 1980), Dawna Range (Eudey, 1980) and NE-Thai mountains (including present day Phu Khieow Mountains; Koenig *et al*., 2003), and in Sundaland (e.g. south-western coast of Malay peninsula, Sumatra and vicinity islands, and northern Borneo (Gathorne-Hardy *et al*., 2002). The geographical cline in the density of northern pig-tailed macaques observed in Laos implies that they have not adapted to the cooler climate and environment, meaning that their ancestors would have come from southern refugia, probably that would be located in Sundaland, and they have widely dispersed in the postglacial period.

Assamese macaques belong to the *sinica* species group. According both to the traditional phylogeographic scenario based on morphology (Fooden, 1980; Delson, 1980) and recent scenario based on mtDNA and TSPY gene sequence analyses (Chakraborty *et al*., 2007), Assamese macaques are considered to have ranged and range areas of intermediate and higher latitude, such as the vicinity around northern India (Bhutan and Nepal), northern Indochina Peninsula, and southern China. Although the localities of refuge for their ancestors have not been determined, the range of Assamese macaques could have expanded or shrunken with climate fluctuation or migrating North and South tracing mountain chains. Their range is considered to be and to have been also influenced by the presence of other macaque species, such as northern pig-tailed and rhesus macaques; however, the distribution pattern in Laos suggests that it is not the case. The diversity of environmental settings found in Laos would help sympatry between these species.

Stump-tailed macaques belong either to their own species group (Fooden, 1976; 1990) or to the *sinica* group (Delson, 1980). Fooden (1990) gave an evolutionary scenario for stump-tailed macaques that their ancestor diverged as the southern-most population of Tibetan macaques (*Macaca thibetana*) in southern China, and then they have dispersed to wide geographical range to the West and to the South. Their dispersion was hindered by a barrier (Brahmaputra River) and perhaps by the competition with southern pig-tailed macaques in the Malayan Peninsular (Fooden, 1982; 1990). The uniform distribution pattern of stump-tailed macaques in Laos suggests that they are not influenced by climate so much as Assamese and northern pig-tailed macaques are, and they could have expanded to the South down until 8.25°N in the Malayan Peninsular (Malaivijitnond *et al*., 2005).

Based on molecular phylogenic studies, Tosi *et al*. (2002; 2003) hypothesized that stump-tailed macaques have originated from the hybridization between female long-tailed macaques and male proto-assamese or proto-Tibetan macaques. At present, Assamese and long-tailed macaques are partially sympatric in the southern-most area of Laos and in Dawna Range (Eudey, 1980), meaning that it was possible for the two parent species to have shared the common habitat. However, this scenario should be tested.

Influences from humans

In northern Laos, mountainous lands are used for traditional shifting agriculture. However, recent land-use regulation and the population increase have shortened the interval of shifting. Growth of secondary forests now sparse in these areas, which were used by primates, as assisting some species to migrate and connect between forest areas (such as northern pig-tailed macaques). Forests have been encroached for agricultural development, even in higher altitudinal forests. Additionally, commodity crop cultivation is driven by national development policies and with encouragement from neighboring countries, such as rubber, ginger, or corn. This trend will be driven by South-North corridor roads connecting southern China, Thailand, Myanmar, and Laos. Immigration within the country is widespread, especially in central Laos, including Vientiane Province and Vientiane Prefecture where still untouched landscapes have been left, though that frontier will soon disappear.

In southern Laos, in addition to the intersection of mountainous forests with agricultural lands, the wide area of forest in the less steep lands have been cut away and turned into the large-scale farmlands for the production of commodity crops. By the construction of East-West roads and Mekong River Bridges, connecting Vietnam, Thailand and Laos, accelerated economic development through mining and factory establishments will further drive habitat loss and increase hunting pressure for the bushmeat trade.

Commercial monkey farming is now expanding in Laos, and is managed by Chinese and Vietnamese companies. Long-tailed macaques are brought from elsewhere (including neighboring countries), and exported to developed countries via Vietnam and/or China. The supposed origin countries have banned exportation of wild-caught monkeys as they have ratified the Washington Convention (CITES). It did not appear that the monkeys were bred on site in the farms visited. It is also feared that monkeys would escape from their enclosures and mix with local populations.

The future of primates in Laos

The present survey is not enough to describe the distribution and present status of primates in Laos. Nationwide distribution and current status surveys are urgently needed. Surveys on the density and abundance of primates are also necessary with microhabitat evaluation. NBCAs in Laos have information of the presence/absence of primate species, but more detailed ecological surveys have not been carried out. While conserving primate populations, management of primate populations from the perspective of agricultural damage should also be considered.

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HIỆN TRẠNG VÀ PHÂN BỐ CÁC LOÀI KHỈ Ở CHDCND LÀO

TÓM TẮT

Ngiên cứu hiện trạng và phân bố các loài khỉ đã được thực hiện ở nước Cộng hòa Dân chủ Nhân dân Lào (Báo cáo của Lào). Vùng phân bố của khỉ đuôi lợn phía Bắc (*Macaca leonina*) cùng với các loài linh trưởng khác thì mật độ giảm dần theo vỹ tuyến. Ở phía Nam Lào, loài này được báo cáo là phân bố ở mọi kiểu sinh thái rừng bao gồm vùng sông Mekong, đồng bằng Trung du, vùng rừng khô và Xay Phou Louang (dãy Trường Sơn). Tuy nhiên, sự phân bố của loài khỉ *M. assamensis* thì ngược lại, phân bố rất ít ở phía Nam từ khoảng vỹ tuyến 15°N. Khỉ mặt đỏ (*M. arctoides*) được xem là rất phổ biến khắp rừng Lào. Khỉ vàng (*M. mulatta*) cũng được xem là phổ biến phân bố khắp rừng Lào, ngoại trừ vùng phía Tây của sông Mêkông ở phía Nam. Vùng sinh cảnh phù hợp cho mối loài thì khác nhau giữa các loài khỉ Assamese, khỉ đuôi lợn phía Bắc, và khỉ mặt đỏ. Mặc dầu được biết khỉ vàng phân bố rất ít ở phía Nam, tuy nhiên ở các vùng khác cũng chưa được nghiên cứu hết. Khỉ đuôi dài (*M. fascicularis*) được ghi nhận hầu hết ở ranh giới phía Nam, ở vỹ tuyến 15.2°N hay thấp hơn nơi mà vùng phân bố trùng với vùng phân bố của khỉ vàng, mặc dù vùng sinh cảnh của nó khác so với khỉ vàng như phân bố ở rừng ven sông suối. Săn bắt và mất sinh cảnh là những yếu tố đe dọa lớn nhất do sự phát triển kinh tế, dân số tăng cao, mở rộng đất nông nghiệp và xây dựng cơ sở hạ tầng (đường và cầu) để nối liền giữa các tỉnh và với các quốc gia láng giềng. Từ những ghi nhận vùng phân bố của các loài khỉ cho phép xác nhận được sự phát sinh địa lý phân bố của chúng. Thêm vào đó, số lượng các trại nuôi sinh sản khỉ làm kinh tế đang ngày một nhiều. Linh trưởng ở Lào đang mất dần sinh cảnh sống cùng với áp lực săn bắt, do vậy những giải pháp bảo tồn là rất cấp thiết để bảo vệ các loài linh trưởng ở đây.

REFERENCES

Abegg, C. & Thierry, B. (2002): Macaque evolution and dispersal in insular south-east Asia. Biological Journal of Linnean Society 75, 555 – 576.

Blancher, A., Bonhomme, M., Crouau-Roy, B., Terao, K., Kitano, T. &Saitou, N. (2008): Mitochondrial DNA Sequence Phylogeny of 4 Populations of the widely Distributed Cynomolgus Macaque (*Macaca fascicularis fascicularis*). J. of Heredity, 99(3), 254 – 264.

Bonhomme, M., Cuartero, S., Blancher, A. & Crouau-Roy, B. (2008): Assessing Natural Introgression in 2 Biomedical Model Species, the Rhesus Macaque (*Macaca mulatta*) and the Long-tailed Macaque (*Macaca fascicularis*). J. of Heredity, 100 (2), 158 – 169.

Brandon-Jones, D. (2004): A Taxonomic Revision of the Langurs and Leaf Monkeys (Primates: Colobinae) of South Asia. Zoos' Print Journal 19(8), 1552 – 1594.

Chakraborty, D., Ramakrishnan, U., Panor, J., Mishra, C., & Sinha, A., (2007): Phylogenetic relationships and morphometric affinities of the Arunachal macaque *Macaca munzala*, a newly described primate from Arunachal Pradesh, northeastern India. Molecular Phylogenetics and Evolution 44(2), 838-849.

Delson, E. (1980): Fossil Macaques, Phyletic Relationships and Scenario of Deployment. In: Lindburg D.G. (ed.): The Macaques: Studies in Ecology, Behavior and Evolution; pp. 10 – 29. Van Nostrand Reinhold, New York.

Duckworth, J.W., Salter, R.E. & Khounboline, K. (compilers) (1999): Wildlife in Lao PDR: 1999 Status Report; pp. 275. IUCN-The World Conservation Union / Wildlife Conservation Society / Centre for Protected Areas and Watershed Management. Samsaen Printing, Bangkok.

Eudey, A.A. (1980): Pleistocene Glacial Phenomena and the Evolution of Asian Macaques. In: Lindburg, D.G. (ed.): The Macaques: Studies in Ecology, Behavior and Evolution; pp. 52 – 83. Van Nostrand Reinhold, New York.

Fooden, J. (1964): Rhesus and Crab-Eating Macaques: Intergradation in Thailand. Science 143, 363 – 365.

Fooden, J. (1975): Taxonomy and Evolution of Liontail and Pigtail macaques (Primates: Cercopithecidae). Fieldiana Zoology 67, 1 – 169.

Fooden, J. (1976): Provisional Classification and Key to Living Species of Macaques (Primates: *Macaca*). Folia Primatol. 25, 225 – 236.

Fooden, J. (1979): Taxonomy and Evolution of the *sinica* Group of Macaques: I. Species and subspecies Accounts of *Macaca sinica*. Primates 20(1), 109 – 140.

Fooden, J. (1980): Classification and Distribution of Living Macaques (Macaca Lacepede, 1799). In: Lindburg D.G. (ed.): The Macaques: Studies in Ecology, Behavior and Evolution; pp. 1 - 9. Van Nostrand Reinhold, New York.

Fooden, J. (1982): Taxonomy and Evolution of the *sinica* group of macaques: 3. Species and subspecies accounts of *Macaca assamensis*. Fieldiana Zoology New 10, 1 – 52.

Fooden, J. (1982): Ecogeographic Segregation of Macaque Species. Primates 23(4), 574 – 579.

Fooden, J. (1983): Taxonomy and evolution of the *sinica* group of macaqeus: 4. Species account of *Macaca thibetana*. Fieldiana Zoology New 17, 1 – 20.

Fooden, J. (1986): Taxonomy and Evolution of the *sinica* Group of Macaques: 5. Overview of Natural History. Fieldiana Zoology 29, 1 – 22.

Fooden, J. (1988): Taxonomy and Evolution of the *sinica* Group of Macaques: 6. Interspecific Comparisons and Synthesis. Fieldiana Zoology 45: 1 – 44.

Fooden, J. (1990): The bear macaque, *Macaca arctoides*: a systematic review. Journal of Human Evolution 19, 607 – 686.

Fooden, J. (1995): Systematic Review of Southeast Asian Longtail Macaques, *Macaca fascicularis* (Raffles, [1821]). Fieldiana Zoology 81, 1 – 206.

Fooden, J. (1997): Tail Length Variation in *Macaca fascicularis* and *M. mulatta*. Primates 38(3), 221 – 231.

Fooden, J. & Albrecht, G.H. (1999): Tail Length Variation in *fascicularis*-Group Macaques (Cercopithecidae: *Macaca*). Int. J. Primatol. 20(3), 431 – 440.

Fooden, J. (2000): Systematic Review of the Rhesus Macaque, *Macaca mulatta* (Zimmermann, 1780). Fieldiana Zoology 96, 1 – 180.

Hamada, Y., Watanabe, T., Chatani, K., Hayakawa, S., & Iwamoto, M. (2005): Morphometrical comparison between Indian- and Chinese-derived rhesus macaques (*Macaca mulatta*). Anthropological Science 113, 183 – 188.

Hamada, Y., Urasopon. N., Hadi, I,, & Malaivijitnond S (2006): Body Size and Proportions and Pelage Color of Free-Ranging *Macaca mulatta* from a Zone of Hybridization in Northeastern Thailand. Int. J. of Primatol. 27 (2), 497 – 513.

Hamada, Y., Malaivijitnond, S., Kingsada, P. & Bounnam, P. (2007): The Distribution and Present Status of Primates in the Northern Region of Lao PDR. J. Natural History Chulalongkorn University 7(2), 161 – 191.

Hamada, Y., Suryobroto, B., Goto, S. & Malaivijitnond, S. (2008): Morphological and Body Color Variation in Thai *Macaca fascicularis fascicularis* North and South of the Isthmus of Kra. Int. J. Primatol. 29, 1271-1294.

Kanthaswamy, S., Satkoski, J., George, D., Kou, A., Erickson, B.J-A, & Smith, D.G. (2008): Hybridization and Stratification of Nuclear Genetic Variation in *Macaca mulatta* and *M. fascicularis*. Int. J. Primatol. 29(5), 1295-1311.

Koenig, A., Larney, E., Kreetiyutanont, K. & Borries, C. (2003): The primate Community of Phu Khieo Wildlife Sanctuary, Northeast Thailand. Am. J. Primatol. 60 (supplement 1), 64.

Malaivijitnond, S. & Hamada, Y., (2005): A New Record of Stump-tailed Macaques in Thailand and the Sympatry with Long-tailed Macaques. J. Natural History Chulalongkorn University 5(2), 93 – 96.

Malaivijitnond, S., Hamada, Y., Varavuddhi, P., & Takenaka, O., (2005): The Current Distribution and Status of Macaques in Thailand. J. Natural History Chulalongkorn University, Supplement 1, 35- 45.

Malaivijitnond, S., Takenaka, O., Kawamoto, S., Urasopon, N., Hadi, I. & Hamada, Y. (2007):

Anthropogenic macaque hybridization and genetic pollution of a threatened population. J. Natural History Chulalongkorn University 7(1), 11 – 23.

Malaivijitnond, S., Sae-Low, W. & Hamada, Y. (2008): The human-ABO blood groups of free-ranging long-tailed macaques (*Macaca fascicularis*) and parapatric rhesus macaques (*M. mulatta*) in Thailand. J. Med. Primatol. 37(1), 31-37.

Meijaard, E., & Groves, C.P. (2006): The Geography of Mammals and Rivers in Mainland Southeast Asia. In: Lehman, S.M. & Fleagle, J.G. (eds.): Primate Biogeography; pp. 305 – 329. Springer, New York.

Nadler, T. & Streicher, U. (2004): The Primates of Vietnam – an overview -. In: Nadler, T., Streicher, U., & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 5-11. Frankfurt Zoological Society, Hanoi.

Nguyen Than Nhan (2004): The status of primates at Pu Mat National Park and suggestions for sustainable conservation approaches. In: Nadler, T., Streicher, U., & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 85-89. Frankfurt Zoological Society, Hanoi.

New, D.T., San, A.M., Min, N.W.W., Thu, M.K., Oi, T. & Hamada, Y. (2005): Species Diversity and Distribution of Primates in Myanmar. J. Natural History Chulalongkorn University, Supplement 1, 47-53.

Polet, G., Murphy, D.J., Becker, I. & Thuc, P.D. (2004): Notes on the primates of Cat Tien National Park. In: Nadler, T., Streicher, U., & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 78-84. Frankfurt Zoological Society, Hanoi.

Roos, C., Nadler, T. & Walter, L., (2008): Mitochondrial phylogeny, taxonomy and biogeography of the silvered langur species group (*Trachypithecus cristatus*). Molecular Phylogenetics and Evolution 47, 629 – 636.

Satkoski, J., George, D., Smith, D.G. & Kanthaswamy, S., (2008): Genetic Characterization of wild and captive rhesus macaques in China. J. Medical Primatol. 37, 67-80.

Smith, D.G. & McDonough, J.W. (2005): Mitochondrial DNA Variation in Chinese and Indian Rhesus Macaques (*Macaca mulatta*). Am. J. Primatol. 65, 1 – 25.

Smith, D.G., McDonough, J.W. & George, D.A. (2007): Mitochondrial DNA Variation Within and Among Regional Populations of Longtail Macaques (*Macaca fascicularis*) in Relation to Other Species of the *fascicularis*-Group of Macaques. Am. J. Primatol. 69, 182 – 198.

Street, S.L., Kyes, R.C., Grant, R. & Ferguson, B. (2007): Single nucleotide polymorphism (SNPs) are highly conserved in rhesus (*Macaca mulatta*) and cynomolgus (*Macaca fascicularis*) macaques. BMC genomics 8, 480 – 488.

Tosi, A.J., Morales, J.C. & Melnick, D.J. (2002): Y-Chromosome and Mithochondrial Markers in *Macaca fascicularis* Indicate Introgression with Inodochinese *M. mulatta* and a Biogeographic Barrier in the Isthmus of Kra. Int. J. Primatol. 23(1), 161 – 178.

Tosi, A.J., Morales, J.C. & Melnick, D.J. (2003): Paternal, Maternal, and Biparental Molecular Markers Provide Unique Windows onto the Evolutionary History of Macaque Monkeys. Evolution 57(6), 1419 – 1435.

Ziegler, T., Abegg, C., Meijaard, E., Perwitasari-Farajallah, D., Walter, L., Hodges, J.K. & Roos, C. (2007): Molecular phylogeny and evolutionary history of Southeast Asian macaques forming the *M. silenus* group. Molecular Phylogenetics and Evolution 42, 807 – 816.

4

SURVEYS AND PRELIMINARY FIELD OBSERVATIONS OF THE NORTHERN SLOW LORIS (*NYCTICEBUS BENGALENSIS*) IN CAMBODIA

CARLY STARR, LARA ROGERS, K.A.I. NEKARIS, AND ULRIKE STREICHER

SUMMARY

We conducted field surveys of the northern slow loris (*Nycticebus bengalensis*) across seven protected areas in Cambodia. Opportunistic observations of trade, and confiscation records from the Wildlife Alliance for slow lorises from 2002-2009 are collated. Northern slow lorises were observed in dry dipterocarp and semi-evergreen forests in Samkos Wildlife Sanctuary and Phnom Kulen National Park. 39 hours of preliminary field observations were collected from 18 un-habituated individuals, and we present preliminary activity budgets and feeding observations from Samkos Wildlife Sanctuary. We conclude by making recommendations for conserving populations of northern slow lorises in Cambodia.

INTRODUCTION

The northern slow loris (*Nycticebus bengalensis*) is distributed across north-eastern India, Bhutan, Myanmar, Cambodia, southern China, Laos, Vietnam, and Thailand (north of the Isthmus of Kra) (Brandon-Jones *et al*., 2004) (Fig. 1). Groves (1998) distinguished the northern slow loris from the Sunda slow loris (*Nycticebus coucang*), a distinction reaffirmed via genetic studies (Roos, 2003; 2004). Northern slow lorises are classified by the IUCN as 'Vulnerable' based on habitat loss alone, but there is limited field data available to support this listing. Population decline, and local extinction have been documented in India (Choudhury, 2001), with more recent studies reaffirming low encounter rates (Radhakrishna *et al*., 2006; Das *et al*., 2009; Nadini *et al*., in print)). Local extinction has also been reported for some parts of Vietnam, particularly south of Quang Nam Province and in parts of the Central Highlands (Vu Ngoc Thanh, 2002). Several reports on northern slow lorises are available from Laos (Duckworth, 1994; Alterman & Freed, 1997), however no survey has been conducted to assess the status of the species. Two short-term field studies investigated the feeding ecology of northern slow lorises in India (Swapna, 2008) and Thailand (Pliosoengeon & Savini, 2008) No previous studies have been conducted in Cambodia prior to the presented field surveys.

Northern Slow lorises are protected throughout their range under the national laws of India, Bhutan, Myanmar, Laos, Cambodia, Vietnam, China and Thailand. In June, 2007 all *Nycticebus* species were transferred from Appendix II to Appendix I of the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) based on an increasing and unsustainable demand for slow lorises in international trade (Nekaris & Nijman, 2007). One recent study identified this upgrade has had little effect at reducing domestic trade of slow lorises within Cambodia, with a large number of dried lorises still observed in marketplaces in provincial areas (Starr *et al*., in review-a).

The current study took place in seven conservation areas, and aimed to determine presence/absence of northern slow lorises using

Fig. 1. Northern slow loris (*Nycticebus bengalensis*).

Photo: Tilo Nadler.

spotlighting surveys. We also assimilate confiscation and trade data of slow lorises, and provide preliminary field observations on the species from Cambodia.

MATERIALS AND METHODS

Spotlight surveys and interviews were conducted in the Seima Biodiversity Conservation Area (Seima BCA), Phnom Prich Wildlife Sanctuary (Phnom Prich WS), Mondulkiri Protected Forest (Mondulkiri PF), Central Cardamoms Protected Forest (Central Cardamoms PF), Samkos Wildlife Sanctuary (Samkos WS), Phnom Kulen National Park (Phnom Kulen NP), and Bokor National Park (Bokor NP) (Fig. 2). Confiscation data were obtained from the Wildlife Alliance-Cambodia Program and we recorded opportunistic observations of trade whilst conducting field surveys. Surveyed forest types included: semi-evergreen; mixed deciduous; evergreen; and dry dipterocarp forests.

Reconnaissance survey techniques (White & Edwards, 2000) were used for spotlighting surveys of lorises over the following study periods: 10 to 15 July 2006; 22 to 26 November 2006; 3 to 8 December 2006; 2 to 20 May 2007; 19 to 28 January 2008; 23 to 29 April 2008; 13 to 17 December 2008 and 25 April to 30 May 2009.

Petzl Zoom 4.5v headlamps (Petzl, Crolles, France) with a red filter were used to detect animals. Old logging paths, trails, roads, dry river beds and cut transects were walked slowly (500-1000 m/hr) by a team of 2 to 3 people and all levels of the vegetation were scanned by each surveyor, who were spaced at least 10 m apart. This method was effective in detecting lorises in previous studies (Nekaris, 2003; Nekaris & Jayewardene, 2004; Streicher, 2004a; Nekaris *et al.*, 2008). Once an animal was sighted by a surveyor, a halogen spotlight was used to confirm species identification with the aid of 10 x 40 binoculars. Transect length, number of individuals sighted, height of individuals in trees, tree species and distance from transects were recorded. Surveys began at dusk, and finished between one and four hours. In most areas we were unable to randomize the location of transects surveyed due to the lack of access and difficulty of the terrain. In Seima BCA and Samkos WS some new tracks were cut to access

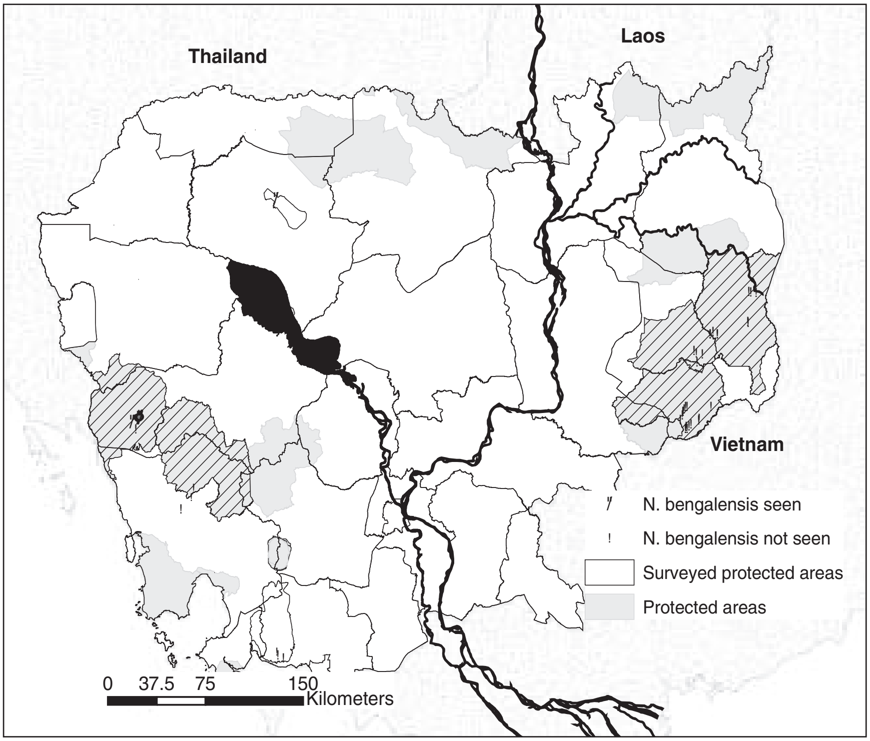

Fig. 2. Localities of spotlight surveys for northern slow loris (*Nycticebus bengalensis*) in Cambodia.

densely vegetated areas. In Samkos WS, where animals were detected, ten transects of 1 km were placed at random within the study area to generate density estimates (Roos & Reeve, 2003).

The index used for assessing the relative abundance of northern slow lorises is the linear encounter rate: number of animals encountered per kilometer (Sutherland, 2002) and density (the number of animals encountered per square kilometer. Density (D) was estimated following the formula (Sutherland, 2002):

$$D = n/2wl$$

w = The strip width determined by the furthest observations on either side of the transect line
l = The length of the transect
n = The number of loris observed.

We planned to use the program 'Distance' to estimate detection probability, but total number of detections were too low.

Behavioral data were collected independently of survey data between 6 pm and 5 am in May and June 2009; 18 unknown individuals were observed for a total of 39 hours. We used focal animal instantaneous point sampling at 5 min intervals to generate preliminary activity budgets. We adapted behavioral categories from Gursky (2003) and Nekaris (2001): resting, sleeping, moving, alert, feeding, grooming, social interaction, and vocalization. We employed *ad libitum* sampling (Altmann, 1974; Martin & Bateson, 2007) to collect feeding observations following Nekaris & Rasmussen (2003). Feeding tree species were identified by local experts.

RESULTS

A total of ten northern slow lorises were sighted over 49 transects (total = 198 km; mean transect length = 3.98 ± 1.87 km) in Cambodia (Table 1). At sites where northern slow lorises were detected, density estimates ranged from 25 to 75 loris/km^2 and linear encounter rates ranged from 0.5 to 1.5/km. All sightings were in Samkos WS and Phnom Kulen NP. No northern slow lorises were encountered in the other protected areas surveyed. The mean height that animals were observed in the canopy was 12 ± 2.18 m, and lorises were detected in trees with a mean height of 14.5 ± 2.13 m.

Table 1. Spotlight survey results for northern slow loris (*Nycticebus bengalensis*) and survey effort across the seven sites.

Sites surveyed	Distance (km)	No. animals sighted per km ±SD	Total no. loris sighted	No. Transects	Hours	No. Animals per km^2 ± SD
Bokor NP	24	0.00	0	5	29	0.00
Central Cardamoms PF	22.5	0.00	0	4	27.5	0.00
Samkos WS	20	0.46 ± 0.6	9	10	25	22.5 ± 32.2
Phnom Kulen NP	2	0.50 ± 0.0	1	1	1.5	25.0 ± 0.00
Seima BCA	55.5	0.00	0	15	68.6	0.00
Phnom Prich WS	40.0	0.00	0	8	47.5	0.00
Mondulkiri PF	34.0	0.00	0	6	37.0	0

Northern slow lorises were detected in dry dipterocarp forest in Samkos WS, and one individual was observed in semi-evergreen forest in Phnom Kulen NP. Structure of dry dipterocarp forests differed greatly across transects where lorises were detected, and some areas were dominated by open grassland with few trees. The lorises moved through thick grass along the ground, which dominated the shrub layer, especially in areas that lacked continuity between trees. Lorises were observed in *Terminalia alata*, *Garcinia schefflerі*, *Dipterocarpus alutus* and in one unidentified tree species.

39 hours of field observations were collected on unidentified individuals in Samkos WS over 18 observation periods. The proportion of each observed behavior across 469 instantaneous sample points was: alert 0.06; resting 0.36; sleeping 0.06, moving 0.32; feeding 0.05, grooming 0.03; and out of sight 0.12. On three occasions two animals came into close proximity to one another (10-15 m). No calls were heard in the field; however indigenous people who were previously hunters reported to locate animals via their calls at night in the Central Cardamoms PF. We observed feeding observations 24 times, these were: insects licked from tree trunks and branches (n=6); flying arthropods (n=3), which were always caught with one hand; leaves of *Terminalia alata* (n=10); and bark that was scraped from dead trees (n=3). These tree trunks and branches were covered in ants and termites, and no gouge holes could be found. We also observed captive northern slow lorises at Phnom Tamao zoo in Cambodia for 12 hours. Although fed on a diet of fruit, these animals spent 2 to 3 hours of the night hunting insects from the roof of their enclosure.

Across the sites, gun shots and chainsaws were heard at night whilst conducting surveys, and signs of logging were encountered within the conservation areas. People were seen at night with spotlights in the conservation areas, and local guides reported they were hunting wildlife (including lorises) in these areas. In many of the sites, surveys coincided with periods where local people were burning the forest to access resin trees, particularly in February and March. During the study period, local conservation staff sent pictures of northern slow lorises in trade to CRS (Fig. 3 and 4) and nine animals were opportunistically observed for sale in markets whilst conducting field surveys. All were observed in provinces west of the Mekong River. Traditional medicine sellers living near Phnom Samkos WS and the Central Cardamoms PF reported northern slow lorises are used locally for women after childbirth:

Fig. 3. Sale of live northern slow lorises (*Nycticebus bengalensis*) in Sihanoukville Province, Cambodia (2009).

Photo: Robert Overtoom.

Fig. 4. The preparation of a northern slow loris for traditional medicine in Preah Vihear Province, Cambodia (2007).

Photo: Maggie Turnbull.

ideally, three lorises are dried, and then placed in rice wine, which is taken soon after childbirth. One or two lorises may be used, but the potency would be reduced. Lorises are also used locally in rice wine as a cure for backache.

The Wildlife Alliance-Cambodia Programme confiscated 277 slow lorises between June 2002 and April 2009 (72 live, 205 dead). We collated data from the Wildlife Alliance and field observations of trade and the province from where animals were confiscated/observed (Fig. 5). The highest confiscations occurred in Kampong Thom (76), Kratie (37) and Mondulkiri Province (29).

DISCUSSION

Whilst in nearly all survey sites we were unable to detect northern slow lorises, in Phnom Samkos WS encounter rates were relatively high compared to other surveys. Low encounter rates seem to

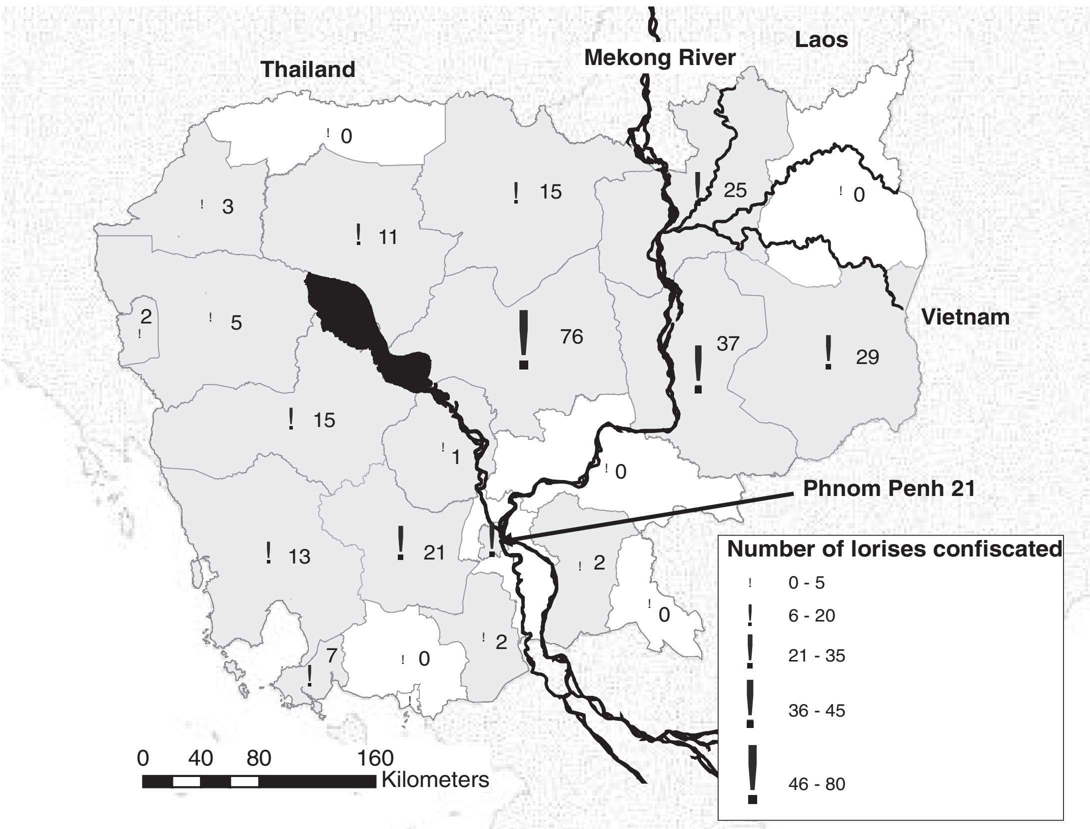

Fig. 5. Confiscated northern slow lorises (data sourced from the Wildlife Alliance- Cambodia program June 2002 – April 2009) and opportunistic observations of trade. Shaded areas indicate provinces where lorises were confiscated and/or observed.

characterize *Nycticebus species*, ranging from 0.02/km for the Bornean slow loris (*N. menagensis*) to 0.80/km for the Sunda slow loris (*N. coucang*) (Nekaris *et al*., 2008). Previous surveys of northern slow loris yielded variable encounter rates, ranging from 0.03 – 0.33/km in India (Radhakrishna *et al*., 2006; Das *et al*., 2009) to 0.64/km in Thailand (Manoon Pilosungnoen, pers. comm.). Our results indicate Phnom Samkos WS as being an important site for northern slow loris conservation in Cambodia. Considering northern slow lorises were only encountered in two sites, and are threatened by increasing habitat loss and known demand for traditional medicines, we suggest that the conservation status of northern slow lorises in Cambodia should be 'Endangered'. As our knowledge of the genetics and morphology of slow lorises increases, so do the number of species, making conservation decisions at the population level increasingly important.

Our results provide the first field data that northern slow lorises are likely to only occur west of the Mekong River in Cambodia. They were not detected in any of the surveyed sites east of the Mekong River in Cambodia, nor were they observed in trade in these provinces by the authors or during previous studies (Starr *et al*., in review-b; Starr *et al*., in review-a). Northern slow lorises are known to occur east of the Mekong in Laos and north of the Cambodia border in Xe Pian National Protected Area (Duckworth *et al*., 1994). The Kong, San and Srepok Rivers may cause a faunal barrier in Cambodia for Northern slow lorises, and the species may occur north of these rivers in Ratanakiri Province. However, further surveys are required to affirm this.

Northern slow lorises in this study spent a great proportion of follows inactive. Although this may be attributed to heavy rain, or fear of an observer for un-habituated animals, these behaviors might also be adaptations to the cool climate during which the study took place. A long-term radio-tracking study in eastern Cambodia identified pygmy lorises reduced activity during cooler periods (CRS, pers. observ. 2009). Captive studies of both northern slow and pygmy lorises also identified a reduction in activity when animals were kept outdoors in northern Vietnam (Streicher, 2004b). Spotlight surveys in Laos also failed to detect animals during December and January (Evans *et al*., 2000). Many of our surveys were conducted during this cooler period, and sightings might have been influenced by limited activity of the animals. We recommend caution in conducting surveys of slow lorises during cooler months, and suggest seasonal influences should also be taken into consideration when surveying all species of the genus.

Northern slow lorises have been found in a wide variety of habitats across their distributional range. In India they are thought to prefer sub-tropical, tropical and semi-evergreen forests (Swapna, 2008); in Thailand, they have been observed in old plantations (M. Pilosungnoen, pers. comm.); and in Laos they are known to occur in semi-evergreen and evergreen forests (Duckworth, 1994; Evans *et al*., 2000). Sightings in Vietnam of slow lorises are scarce (Fitch-Snyder *et al*., 2002) and the only places where slow lorises are regularly encountered in night surveys appear to be Phu Quoc island (Nguyen Van Quyet, pers comm.). Lorises are renowned for their specialized non-saltatory locomotion (Osman-Hill, 1953), and it has been suggested that because lorises cannot leap or jump, those areas they inhabit should be characterized by continuous canopy (Singh *et al*., 1999). In this study, however, northern slow lorises were found in dry dipterocarp forest and in vast areas within this forest type that were dominated by open grassland, which animals frequently traversed. Sunda slow lorises in Malaysia (Wiens, 2002), and slender lorises in India (Nekaris, 2001) also use the ground when the forest lacked continuity. In our study lorises may have moved into the grass due to a greater abundance of flying insects available here during the earlier parts of the evening, which they were observed catching on night follows. These grasslands offer an increase in light availability, which attracts insects and enables this active prey to be more easily caught. However, this behavior also increases their vulnerability to predators. Lorises are presumed to be predated on by reptiles such as snakes (Wiens & Zitzmann, 1999), civets, small cats and owls (Bearder *et al*., 2002). Lagos *et al*. (1995) hypothesized that in a small neotropical rodent when predators are excluded from their environment, they were more likely to increase their use of open space. Predation risk may be low in this site, and the benefits of increased access to food may outweigh predation risk.

On night follows, northern slow lorises moved into neighbouring thicker forest early in the morning (2:00 to 4:00 am), where they presumably slept. Lorises were quickly lost around this time, as following them in thick terrain proved difficult. They probably rely on a mosaic of forest types, particularly in the dry season when grass may be burnt, which is common throughout the country.

The northern slow loris in India has been found to be highly exudativorous, however we did not observe lorises feeding on exudates in this study. A study by Swapna (2008) identified seasonal differences in India, with an increase in exudates in the diet during winter months when there appeared to be a scarcity in other food items. It has been suggested that lorises switch to gum as a food source to overcome periods of food shortage (Streicher, 2009). In this study, lorises were observed during the wet season, when invertebrates appeared to be abundant, and feeding on exudates might be more common during the dry season in this site. Initially, it appeared lorises in this study were gouging during night follows, however no gouge holes could be found on closer inspection of dead branches, and high numbers of ants and termites were observed.

Large numbers of slow lorises have been confiscated in Cambodia by the Wildlife Alliance, particularly in Kampong Thom, Kratie and Mondulkiri Province. We predict based on field surveys and trade data both in this study and previous studies (Starr *et al*., in review-b; Starr *et al*., in review-a), confiscated animals in Kratie and Mondulkiri are likely to have being pygmy lorises. Confiscation numbers may be due to higher enforcement initiatives in these provinces. A separate study, however, also identified large numbers of pygmy lorises for sale in Mondulkiri Province, and reported decreases in local populations (Starr *et al*., in review-a). Opportunistic observations of dried animals for sale and confiscation numbers are likely to be a large underestimate of real trade numbers in Cambodia. For example 16 lorises were confiscated in 2007 and 2008 by the Wildlife Alliance, however 58 slow lorises were opportunistically observed in villages and marketplaces from 2007-2008 whilst conducting field surveys (Starr *et al*., in review-b; Starr *et al*., in review-a). Northern slow lorises are known to be traded throughout their range, and many animals have been observed in marketplaces (Dang Huy Huynh, 1998; Ratajszczak, 1998; Streicher, 2004a), particularly in Phnom Penh in the 1990s (Baird, 1993; Broad, 1994; Martin & Phipps, 1996; Stich & Krüger, 2002). Local people in the Cardamom Mountains PF reported high hunting pressure, and population extinction in some areas was thought to have already occurred (Starr *et al*., in review-b). In Samkos WS local people reported that lorises were hunted primarily for local use, with little trade to urban areas (Starr *et al*., in review-b). In Cambodia, the pygmy loris is believed to have a higher medicinal value, and is preferred and traded more widely than the slow loris (Starr *et al*., in review-b). In Vietnam the Northern slow loris is preferred in traditional medicines, due to their larger size, having a greater monetary value when traded with China (Fitch-Snyder & Vu Ngoc Thanh, 2002). Trade in northern slow loris to neighboring countries may occur, and they are known to be popular in Vietnam for both pets and traditional medicines (Dang Huy Huynh, 1998; Streicher, 2004a). Slow lorises are also locally traded as food items in Vietnam and Laos (Vu Ngoc Thanh and Luzia Rast, pers. comm.).

Despite northern slow lorises appearing to be less traded than pygmy lorises in Cambodia, all slow lorises are particularly vulnerable to over-exploitation. They have long gestations, low birth weights, long lactation periods and long intervals between births (Martin, 1990). Metabolic rates are also extremely low (Muller, 1979; Muller *et al*., 1985; Rasmussen, 1986; Wiens *et al*., 2006), and hunting of these animals is likely to be detrimental to populations. To conserve remaining populations of northern slow lorises in Cambodia and throughout their range, we recommend:

- Further extensive field surveys to determine the range of Northern slow loris in Cambodia. These should incorporate local people and use local ecological knowledge;
- Long-term studies of the ecology of this primate;
- Increased, stronger law enforcement initiatives in sites where northern slow lorises are known to occur, and in major rural marketplaces where animals are sold;
- Education programs targeting rangers and park protection staff, as lorises are currently considered a low priority and are rarely confiscated within protected areas;
- Education programs that target the users of medicines produced using loris body parts.

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Animal ethics approval for this project (Approval number: SAS/696/07/PhD) was approved by the University of Queensland Animal Ethics Committee. Human ethics approval for this project (Approval number: 2006000222) was approved by the University of Queensland Behavioural and Social Sciences Ethical Review Committee.

ĐIỀU TRA VÀ BƯỚC ĐẦU QUAN SÁT TRÊN THỰC ĐỊA LOÀI CU LI LỚN (*NYCTICEBUS BENGALENSIS*) Ở CAMPUCHIA

TÓM TẮT

Chúng tôi đã tiến hành điều tra loài cu li lớn (*Nycticebus bengalensis*) trên bảy Khu bảo tồn ở Campuchia. Đối chiếu quan sát mua bán và trích liệu thu giữ từ Liên minh Động Thực vật hoang dã (Wildlife Alliance) về loài cu li lớn từ năm 2002 - 2009. Cu li lớn được quan sát ở các khu rừng khộp và nửa rụng lá ở Khu bảo tồn hoang dã Samkos và Vườn Quốc gia Phnom Kulen. 39 giờ quan sát hiện trường sơ bộ đã thu được 18 cá thể khác nhau và đã đề xuất ngân sách hoạt động và quan sát chế độ thức ăn từ Khu bảo tồn động vật hoang dã Samkos. Chúng tôi kiến nghị việc cấp thiết bảo tồn cho quần thể cu li lớn ở Campuchia.

REFERENCES

Alterman, L. & Freed, B.Z. (1997): Description and survey of three *Nycticebus* species in Bolikhamxay Province, Laos. Primate Eye 63, 16.

Altmann, J. (1974): Observational study of behaviour: sampling methods. Behaviour 49, 227-265.

Baird, I. (1993): Logging and lorises in Cambodia. IPPL News 20, 19-20.

Bearder, S.K., Nekaris, K.A.I. & Buzzell, C.A. (2002): Dangers of the night: are some primates afraid of the dark? In: Miller, L.E. (ed.): Eat or Be Eaten: Predator Sensitive Foraging in Primates; pp. 21-43. Cambridge University Press, Cambridge.

Brandon-Jones, D., Eudey, A.A., Geissmann, T., Groves, C.P., Melnick, D.J., Morales, J.C., Shekelle, M. & Stewart, C.B. (2004): Asian primate classification. Int. J. Primatol. 25, 97-164.

Broad, S. (1994): Trip report: Phnom Penh, Cambodia; pp. 24-27. TRAFFIC Southeast Asia. (Unpubl.).

Choudhury, A.U. (2001): Primates in northeast India: An overview of their distribution and conservation status. In: Gupta, A.K. (ed.): ENVIS Bulletin: Wildlife and Protected Areas, Non-human Primates of India; pp. 92-101. Wildlife Institute of India, Dehradun.

Dang Huy Huynh (1998): Ecology, biology and conservation status of prosimian species in Vietnam. Folia Primatol. 69, 101-108.

Das, N., Biswas, J., Das, J., Ray, P.C., Sangma, A. & Bhattacharjee, P.C. (2009): Status of Bengal slow loris *Nycticebus bengalensis* (Primates: Lorisidae) in Gibbon WIldlife Sanctuary, Assam, India. Journal of Threatened Taxa 1, 558-561.

Duckworth, J.W. (1994): Field sightings of the pygmy loris, *Nycticebus pygmaeus* in Laos. Folia Primatol. 63, 99-101.

Duckworth, J.W., Timmins, R.J., Thewlis, R.C.M., Evans, T.D. & Anderson, G.Q.A. (1994): Field observations of mammals in Laos, 1992-1993. Natural History Bulletin of the Siam Society 42, 177-205.

Evans, T.D., Duckworth, J.W. & Timmins, R.J. (2000): Field observations of larger mammals in Laos, 1994-1995. Mammalia 64, 55-100.

Fitch-Snyder, H. & Vu Ngoc Thanh (2002): A preliminary survey of lorises (*Nycticebus* spp.) in Northern Vietnam. Asian Primates 8, 1-3.

Groves, C. (1998) Systematics of tarsiers and lorises. Primates 39, 13-27.

Gursky, S. (2003) Lunar Phillia in a nocturnal primate. Int. J. of Primatol. 24, 351-367.

Lagos, V.O., Bozinovic, F. & Contreras, L.C. (1995): Microhabitat use by a small diurnal rodent (*Octodon degus*) in a semiarid environment: Thermoregulatory constraints or predation risk? J. of Mammalogy 76, 900-905.

Martin, E. & Phipps, M. (1996): A review of wild animal trade in Cambodia. TRAFFIC Bulletin 16, 45-60.

Martin, P. & Bateson, P. (2007): Measuring

Behaviour. An Introductory Guide. 3rd edition. Cambridge University Press, Cambridge.

Martin, R.D. (1990): Primate origins and evolution: A phylogenetic reconstruction. Chapman and Hall, London.

Muller, E.F. (1979): Energy metabolism, thermoregulation and water budget in the slow loris (*Nycticebus coucang*, Boddaert 1789). Comparative Biochemistry and Physiology 64A, 109-119.

Muller, E.F., Nieschalk, U. & Meier, B. (1985): Thermoregulation in the slender loris (*Loris tardigradus*). Folia Primatol. 44, 216-226.

Nadini, R., Kashmira, K. & Nimesh, V. (in print): Occurence records of the Bengal slow loris *Nycticebus bengalensis* in Assam and Meghalaya. Asian Primates.

Nekaris, K.A.I. (2001): Activity budget and positional behavior of the Mysore slender loris (*Loris tardigradus lydekkerianus*): Implications for slow climbing locomotion. Folia Primatol. 72, 228-241.

Nekaris, K. A. I. (2003) Spacing system of the Mysore slender loris (*Loris lydekkerianus lydekkerianus*). Am. J. of Physiological Anthropology, 121, 86-96.

Nekaris, K.A.I., Blackham, G.V. & Nijman, V. (2008): Conservation implications of low encounter rates of five nocturnal primate species (*Nycticebus* spp.) in Asia. Biodiversity and Conservation 17, 733-747.

Nekaris, K.A.I. & Jayewardene, J. (2004): Survey of the slender loris (Primates, Lorisidae gray, 1821: *Loris tardigradus* Linnaeus, 1758 and *Loris lydekkerianus cabrera*, 1908) in Sri Lanka. Journal of Zoology (London) 262, 327-338.

Nekaris, K.A.I. & Nijman, V. (2007): CITES proposal highlights rarity of Asian nocturnal primates (Lorisidae: *Nycticebus*). Folia Primatol. 78, 211-214.

Nekaris, K.A.I. & Rasmussen, D.T. (2003): Diet and feeding behaviour of Mysore Slender Lorises. Int. J. Primatol. 24, 33-46.

Osman-Hill, W.C. (1953): Primates, Comparative Anatomy and Taxonomy. Edinburgh University Press, Edinburgh.

Pliosoengeon, M. & Savini, T. (2008): Spatial and feeding behavior of the endangered Bengal slow loris, *Nycticebus bengalensis* in Khao Angrunai Wildlife Sanctuary, Thailand. Primate Society of Great Britain. (Unpubl.)

Radhakrishna, S., Goswami, A.B. & Sinha, A. (2006): Distribution and conservation of *Nycticebus bengalensis* in north eastern India. Int. J. Primatol. 27, 971-982.

Rasmussen, D.T. (1986): Life history and behaviour of slow lorises and slender lorises. Duke University.

Ratajszczak, R. (1998): Taxonomy, distribution and status of the lesser slow loris *Nycticebus pygmaeus* and their implications for captive management. Folia Primatol. 69, 171-174.

Roos, C. (2003): Molecular phylogeny of prosimians, langurs and gibbons. PhD thesis. Technische Universität München.

Roos, C. (2004): Molecular evolution and systemmatics of Vietnamese primates. In: Nadler, T., Streicher, U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 23-28. Frankfurt Zoological Society, Hanoi.

Roos, C. & Reeve, N. (2003): Survey and census methods: population distribution and density. In: Setchell, J. & Curtis, D. (eds.): Field and laboratory methods in primatology: A practical guide; pp. 90-109. Cambridge University Press, Cambridge.

Singh, M., Lindburg, D.G., Udhayan, A., Kumar, M.A. & Kumara, H.N. (1999): Status survey of slender loris *Loris tardigradus lydekkerianus* in Dindigul, Tamil Nadu, India. Oryx 33, 31-37.

Starr, C.R., Nekaris, K.A.I., Streicher, U. & Leung, L.K.-P. (in review-a): Field surveys of the threatened pygmy slow loris (*Nycticebus pygmaeus*) using local knowledge in Mondulkiri Province, Cambodia. Oryx.

Starr, C.R., Nekaris, K.A.I., Streicher, U. & Leung, L.K.-P. (in review-b): Use of slow lorises (*Nycticebus bengalensis* and *N. pygmaeus*) in traditional medicines in Cambodia: implications for conservation. Endangered Species Research.

Stich, I. & Krüger, K.-O. (2002): Artenschutz in Kambodscha. ZGAP Mitteilungen, 18 (2), 7-9.

Streicher, U. (2004a): Aspects of Ecology and Conservation of the Pygmy *Loris Nycticebus pygmaeus* in Vietnam. PhD thesis. Ludwig-Maximilians University

Streicher, U. (2004b): Seasonal changes in colouration and fur patterns in the pygmy loris (*Nycticebus pygmaeus*). In: In: Nadler, T., Streicher, U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 29-32. Frankfurt Zoological Society, Hanoi.

Sutherland, W.J. (2002): Mammals. In: Sutherland, W.J. (ed.): Ecological Census Techniques; pp. 260-278. Cambridge University Press, Cambridge.

Swapna, N. (2008): Assessing the feeding ecology of the Bengal slow loris (*Nycticebus bengalensis*) in

Trishna Wildlife Sanctuary, Tripura. Masters Thesis, Manipal University.

Vu Ngoc Thanh (2002): The status and conservation of the loris species, Nycticebus coucang and N. pygmaeus in Vietnam. Abstracts of the XIXth Congress of the International Primatological Society, Beijing; p. 254.

White, L. & Edwards, A. (2000): Methods for assessing the status of animal populations. In: White, L. & Edwards, A. (eds.): Conservation Research in the African Rain Forests: a Technical Handbook; pp. 91-201. Wildlife Conservation Society, New York.

Wiens, F. (2002): Behaviour and Ecology of Wild Slow Lorises (*Nycticebus coucang*): Social Organisation, Infant Care System, and Diet. PhD thesis. Bayreuth University.

Wiens, F. & Zitzmann, A. (1999): Predation on a wild slow loris (*Nycticebus coucang*) by a reticulated python (*Python reticulatus*). Folia Primatol. 70, 362-364.

Wiens, F., Zitzmann, A. & Hussein, N.A. (2006): Fast food for slow lorises: is low metabolism related to secondary compounds in high-energy plant diet? J. of Mammalogy 87, 790-798.

5

PRIMATE CENSUS IN DIFFICULT TO ACCESS KARST FORESTS IN PHONG NHA – KE BANG NATIONAL PARK, CENTRAL VIETNAM

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SUMMARY

In 2007 we conducted systematic surveys to determine the distribution and population densities of the primates in the Phong Nha-Ke Bang National Park (PNKB NP). As part of the Annamite Mountains the PNKB NP is characterized by numerous steep limestone hills with dense primary forests. A comparative study of point and line transect sampling was designed to provide information on the efficiency of both methods in difficult to access karst forest areas. From April to August we carried out a total of 117 line transect walks and 55 point surveys. Within the framework of our surveys we could confirm five primate taxa, Hatinh langurs (*Trachypithecus hatinhensis*), red-shanked douc langurs (*Pygathrix nemaeus*), stump-tailed macaques (*Macaca arctoides*), eastern Assamese macaques (*M. assamensis assamensis*) and southern white-cheeked gibbons (*Nomascus siki*). We recorded the same primate taxa with both point and line transect sampling with the exception of stump-tailed macaques which we did not detect during point transect surveys. Here we present the pros and cons of both methods; however, we conclude that to investigate distribution and densities of all primate taxa in the PNKB NP, line transect sampling is preferable as more taxa are detectable and with higher probability, although point transects may be more effective for some taxa.

INTRODUCTION

Knowledge of distribution and population densities allows recognition of changes in population structure and size in time, and therefore to induce appropriate conservation measures. One aim of our study was to collect data to estimate population densities of primate taxa in the Phong Nha – Ke Bang National Park (PNKB NP; Haus *et al*., 2009). Located in the Quang Binh Province in Central Vietnam and bordering Lao PDR, the PNKB NP is characterized by the Annamite Mountain Chain which extends from North to South in the border regions of Lao PDR and Vietnam.

Line transect sampling is an established method in primatology, particular in dense forests where the detection of all primates within the survey area can not be guaranteed. As part of the Central Annamite Mountains the PNKB NP is characterized by numerous steep limestone hills and cliffs, and the primary forest remains almost unaffected in large portions of the National Park (Cao Xuan Chinh, 2005; Haus *et al*., 2009a; Haus *et al*., 2009b). In addition to the dense vegetation there are further difficulties for conducting line transect sampling; several steep hills have to be bypassed and it is almost impossible to create randomly distributed straight and parallel lines in the survey area as described in literature (Buckland *et al*., 2001; Ross & Reeve, 2003). Furthermore cutting transects through the dense vegetation is not only time-consuming, but also may lead to further usage by loggers and hunters, which should be avoided. In difficult terrain, observers are also often distracted by obstacles and uneven ground (Ross & Reeve, 2003). Therefore in our study we decided to apply point transect sampling in addition to line transect sampling and to analyse pros and cons of both methods in dense karst forests.

As documented by several authors, nine primate taxa from five genera occur in PNKB NP. The status of the two nocturnal lorises, northern slow loris (*Nycticebus bengalensis*) and pygmy loris (*N. pygmaeus*) is still unclear and most reports are based on information by local loggers and hunters (Le Xuan Canh *et al*., 1997). We confirmed the pygmy loris in PNKB NP twice during night surveys in 2005 (Haus *et al*., 2009b) and 2008 (Vogt, pers. comm.). But in our recent study we focused on diurnal primates. There are different reports on the occurrence and abundance of macaques in PNKB NP; however, in previous studies researchers documented a total of four macaque taxa: stump-tailed (*Macaca arctoides*), eastern Assamese (*M. assamensis assamensis*), pig-tailed (*M. leonina*), and rhesus macaques (*M. mulatta*). Other documented species include, red-shanked douc langurs (*Pygathrix nemaeus*), Hatinh langurs (*Trachypithecus hatinhensis*), and southern white-cheeked gibbons (*Nomascus siki*) (Dinh Hai Duong, 2005; Haus *et al*., 2009b; Le Khac Quyet *et al*., 2002; Le Xuan Canh *et al*., 1997; Nguyen Quang Vinh, 2002; Pham Nhat *et al*., 1996; Pham Nhat & Nguyen Xuan Dang, 2000; Timmins *et al*., 1999).

METHODS

Point and line transect sampling represent the principal distance sampling methods, for which it is assumed that not all objects within the survey area will be detected (Buckland *et al*., 2001; Ross & Reeve, 2003; Thomas *et al*., 2002).

We conducted line transect sampling in four different survey areas, each containing three transects. The lines ran nearly parallel at ca. 500 m from each other or from our base camp into different directions. Due to the cliffy terrain we predominantly followed pre-existing trails. The lengths of transects varied between 2 km and 5 km; depending on terrain and distance we were able to walk within four hours (Haus *et al*., 2009b). We carried out point transect sampling alongside the two roads crossing the NP and distributed 16 survey points randomly along these roads with usually a gap of about 570 m between points. The area of observation of each point never overlapped with that of other points. The only precondition was that at least one limestone cliff was present within the survey area, because we assumed a higher detection probability for Hatinh langurs at their exposed sleeping sites (Haus *et al*., 2009a)(Fig. 1A and 1B).

We carried out line transect sampling during two phases from April to June and July to August in 2007. Due to the assumed low primate density, we intended to survey each transect 10 times; twice a day we walked the transects between 06:00 and 10:00 and 14:00 and 18:00. Analyses revealed no impact of the morning transect walk on the afternoon walk, if a midday break of at least three hours was kept (Haus *et al*., 2009b). We walked very slowly and as quietly as possible, stopping often to avoid obstacles and uneven ground, striving to meet the assumptions that all primates directly on and above the line are detected and that they do not move in response to the observers before they are detected (Buckland *et al*, 2001; Haus *et al*., 2009b; Ross & Reeve, 2003). Point transect sampling was conducted from May to August in 2007. Each point should be visited four days in sequence. We started the point surveys around 16:15 and continued to dusk, so that each survey took around two hours (Haus *et al*., 2009a).

We observed the survey areas with binoculars and the points additionally with a spotting scope (Bushnell, D=63mm, model 787363). For each survey we recorded date, time, and observer, point or transect identity, and weather conditions. At each detection event we measured the radial distance from the point or line and the sighting angle to the first sighted individual using a range finder (Bushnell, Yardage Pro Legend) and a compass (Buckland *et al*., 2001; Ross & Reeve, 2003). Furthermore we recorded time, group size and structure, detection cue, substrate and activity (Haus *et al*., 2009a, Haus *et al*., 2009b). To analyse primate densities using line transect data the perpendicular distances from the line are needed. Therefore we calculated the perpendicular distance multiplying the radial distance by the sine of the angle (Buckland *et al*., 2001; Ross & Reeve, 2003).

RESULTS

We walked the 12 transects a total of 117 times, covering an area of 2410ha with a total length of 358 km. For point transect sampling we collected 55 samples from 16 different points. We observed a total of 72 primate groups during line transect sampling and 43 primate groups during point transect sampling (Fig. 2). We recorded five diurnal primate taxa with line transect surveys; Hatinh and red-shanked douc langurs, eastern Assamese and stump-tailed macaques, and southern white cheeked gibbons. During point surveys we recorded the same taxa except for stump-tailed macaques. During some

Fig. 1A, 1B. Hatinh langur group close to the sleeping site. *Photos: Tilo Nadler.*

sightings we were not able to identify the taxon, because the primates fled before (n.d. in Fig. 2). Both methods returned higher detection rates of Hatinh langurs than all other primate taxa, with gibbons returning the fewest (Fig. 2).

Analyzing the group sizes using both methods comparatively, we obtained higher group sizes for Hatinh langurs and a higher maximum group size for Assamese macaques with point transect sampling. The median group sizes of red-shanked douc langurs were similar in both point and line transect sampling, but we observed a higher maximum group size during line transect inspections (Fig. 3).

Along line transects the average sighting distance measured 59 m whereas the sighting distance in point transect sampling was 309 m on average. Accordingly, we more often detected primates by acoustical cues during line transect surveys and more often by visual cues during point surveys for all taxa observed (Fig. 4 and 5).

To compare the efficiency of both methods, we analyzed hours in days spent with the surveys in relation to the number of primates sighted. We carried out more line transect surveys resulting in a total of 17.5 days survey effort, whereas point transect sampling was conducted for a total of 4.8 days. Line transect sampling required more time, and in terms of survey effort we detected more than twice for the number of encounters per unit effort for point (8.96 records/day) as for line (4.12 records/day) transect sampling for all taxa pooled. We also analysed the efficiency for Hatinh langurs separately and revealed efficiencies of 1.55 records/day with line and 4.79 records/day with point transect sampling.

During line transect sampling we observed stump-tailed macaques foraging on the ground in 40% of all sightings and we detected them in a median tree height of 15 m (range: 10-25m). During the daytime Hatinh langurs, red-shanked douc langurs and Assamese macaques were always observed in trees; we never saw these species on the ground. Alongside the transect lines we found Hatinh langurs in a median tree height of 9 m (5-20 m), whereas Assamese macaques and douc langurs used higher tree levels of 22.5 m (18-27 m) and 20 m (15-30 m), respectively. During point surveys we observed sleeping sites of Assamese macaques and Hatinh langurs; Hatinh langurs used crevices in steep limestone cliffs whereas the macaques slept on trees growing on cliffs.

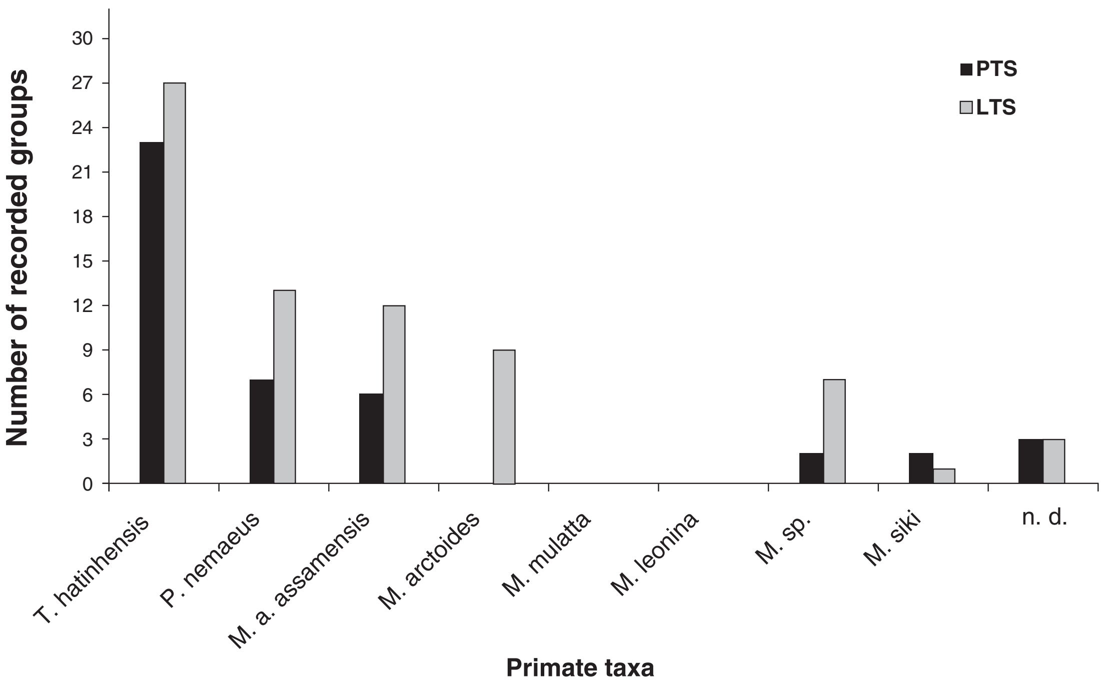

Fig. 2. Number of recorded primate groups during point (PTS) and line (LTS) transect sampling in the Phong Nha – Ke Bang National Park in 2007.

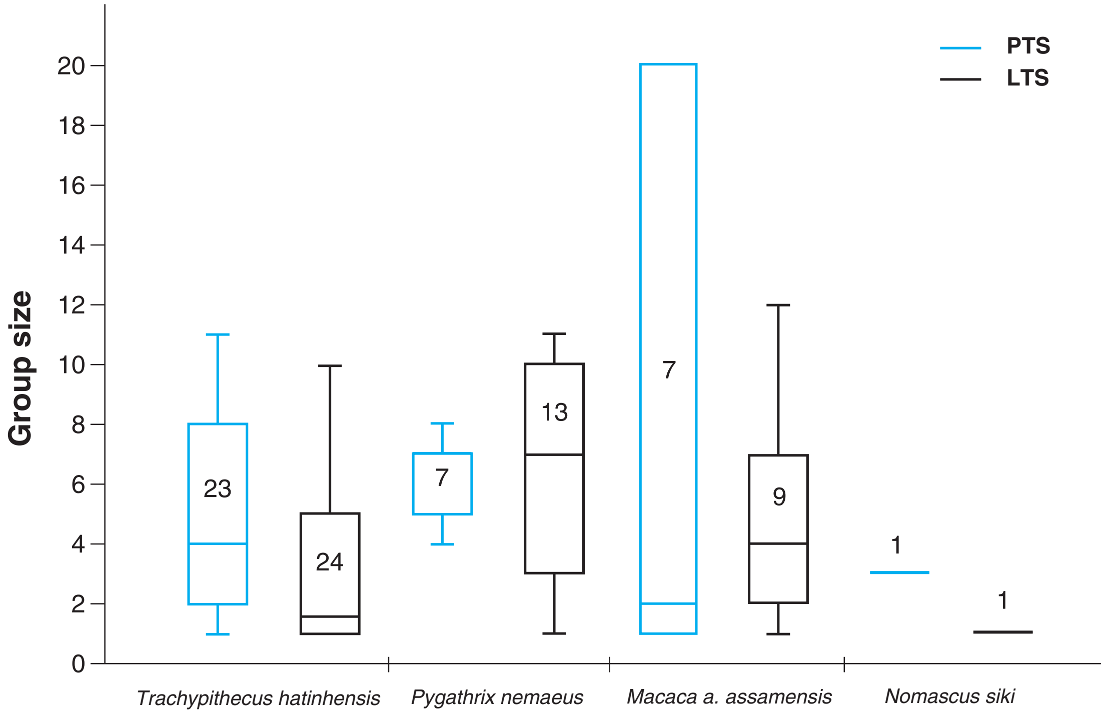

Fig. 3. Box plots comparing group sizes of point (PTS) and line (LTS) transect sampling.

DISCUSSION

Design and effort

Line transect sampling was difficult to design in the dense karst forests of the PNKB NP, whereas points were easier to distribute randomly along roads. In addition the procedure of line transect sampling was very time consuming and required high physical effort, because we stayed in the forest for many days and walked a total distance of 358 km. The points were much easier to access by motorbike or car, and each survey took only a few hours. Therefore the results of line transect surveys show a low efficiency in comparison to point transect sampling, especially for Hatinh langurs (Haus *et al.*, 2009a).

Detection probabilities

Due to shorter sighting distances in line transect sampling more primates were detected by aural cues, whereas in point surveys the primates were more often seen first. A higher detection probability by aural cues is advantageous, because researchers can not see in different directions simultaneously, and hence probably more primates remained undetected within the points transects' survey areas. Furthermore, during line transect sampling we encountered primates in the canopy as well as on the ground and in the understorey whereas during point surveys we detected primates only at exposed sites and in the upper canopy due to our birds eye view. As we observed during line transect surveys, stump-tailed macaques often foraged on the ground and utilized the lower canopy. Therefore we suggest that we could not see stump-tailed macaques during point surveys because the vegetation obscured them.

Estimating population densities

During line transect sampling we covered a wide area and therefore returned more encounters with primates in total. Conversely, the sample size derived from point transect samples was too small to estimate population densities with the computer program DISTANCE (Thomas *et al.*, 2006), because the program requires a sample size of at least 60-80 sightings (Buckland *et al.*, 2001). Due to low primate densities, a large number of point transects, with wide visibility ranges, have to be chosen. Furthermore, wide visibility ranges and the mountainous terrain of karst forests may lead to incorrect estimation of the survey area and primate

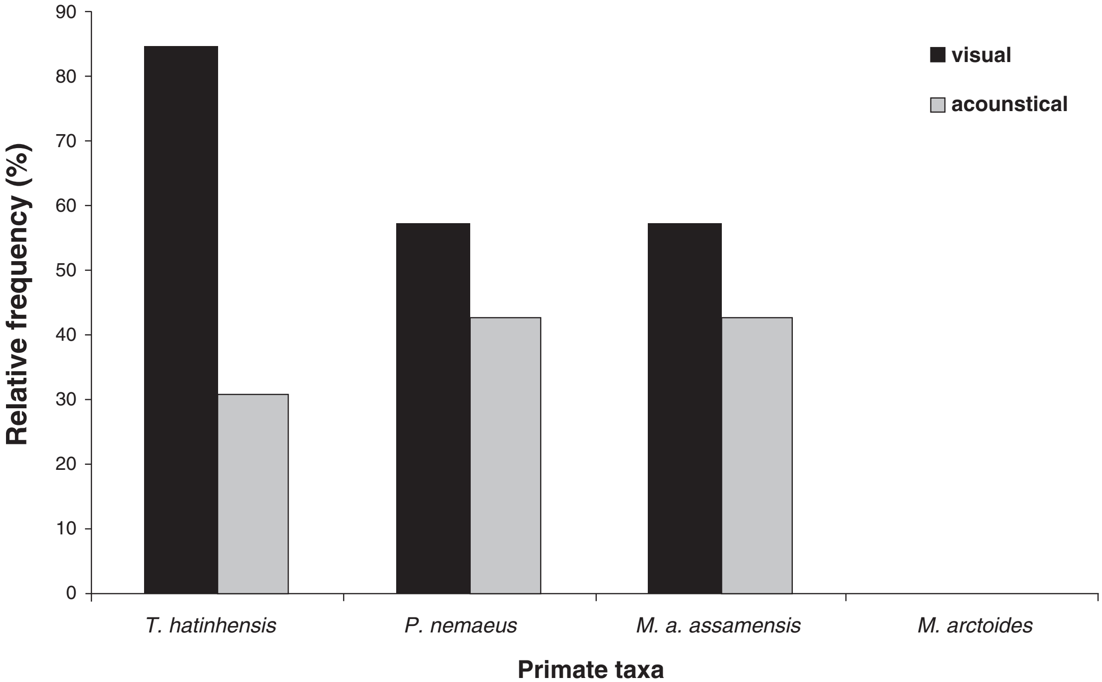

Fig. 4. Relative frequency of detection cues during point transect sampling.

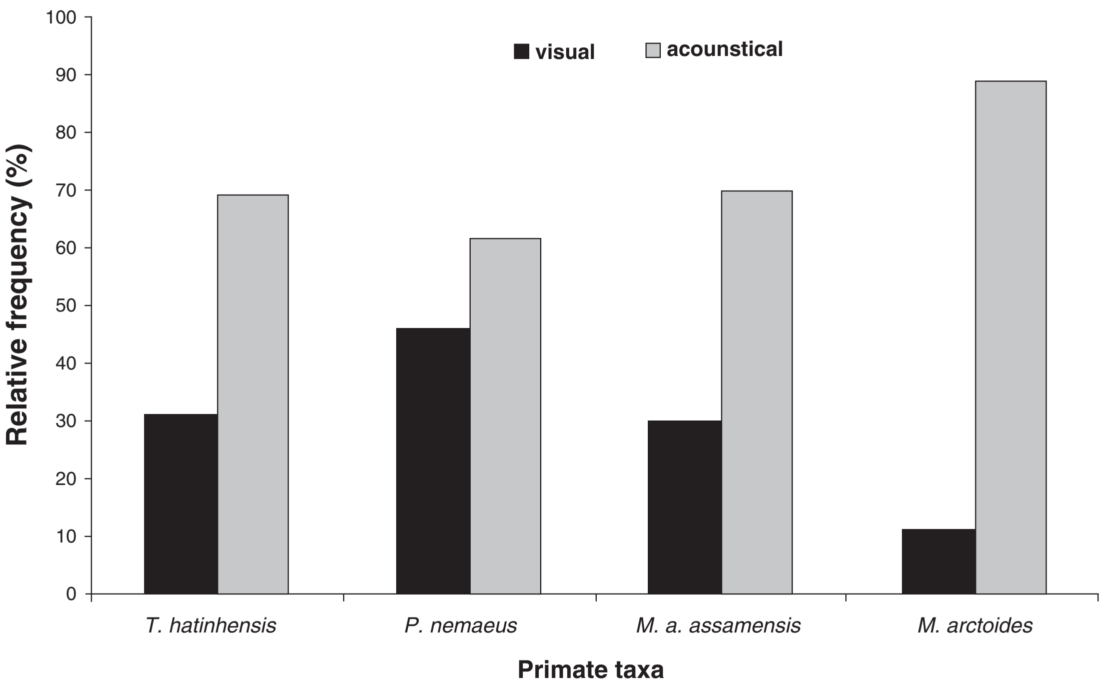

Fig. 5. Relative frequency of detection cues during line transect sampling.

abundances respectively (Haus *et al.*, 2009a). Additional point surveys would be necessary to analyse the population densities of both methods comparatively, thus we estimated population densities only with line transect data (Haus *et al.*, 2009b).

Mean group sizes are also an important factor for the assessment of population densities. In dense forests some individuals may remain undetected due to the dense vegetation and the dispersal of group members over a large area. We obtained a significantly higher and more reliable mean group size for Hatinh langurs with point transect sampling. If we used the mean group size of point surveys to estimate the population density using line transect data, the density of the Hatinh langur population increased by 44% (Haus *et al*., 2009b). For species like Hatinh langurs and Assamese macaques that occupy exposed sleeping sites, point transect sampling provides an opportunity to get more detailed information about group size and structure.

CONCLUSIONS

Due to the differences in distance, cues and viewpoints we suggest a higher detection probability of all primate taxa with line transect sampling, and accordingly would choose this method to estimate population densities of all primate taxa in the PNKB NP (Fig. 6). However, to record Hatinh langurs, with regard to the survey effort to return ratio, point transect sampling represents an effective method to observe changes in group size, structure and density alongside the roads in PNKB NP (Fig. 7). In spite of large distances the groups are detectable at their exposed sleeping sites, and the points can be reached and surveyed much more easily than line transects in the difficult to access karst forests. Furthermore point transect sampling offers more reliable data of group sizes, which is very important for the assessment of population densities.

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Fig. 6. Viewpoint during line transect sampling. View from bottom up to the canopy.

Photo: Tanja Haus.

Fig. 7. Viewpoint during point transect sampling. View from above at survey point.

Photo: Tanja Haus.

NHỮNG KHÓ KHĂN TRONG VIỆC ĐÁNH GIÁ MẬT ĐỘ QUẦN THỂ LINH TRƯỞNG TRONG VÙNG NÚI ĐÁ VÔI CỦA VƯỜN QUỐC GIA PHONG NHA – KẺ BÀNG, MIỀN TRUNG VIỆT NAM

TÓM TẮT

Vào năm 2007, chúng tôi đã tiến hành các đợt khảo sát có hệ thống nhằm mục đích xác định sự phân bố và mật độ quần thể các loài linh trưởng tại Vườn Quốc gia Phong Nha-Kẻ Bàng (VQG PN-KB). Nằm trong dãy Trường Sơn, VQG PN-KB bao gồm nhiều ngọn núi đá vôi dốc đứng bao phủ bởi rừng nguyên sinh dày đặc. Một cuộc nghiên cứu mang tính chất so sánh giữa các điểm và tuyến khảo sát được lập nên giúp đem lại thông tin về tính hiệu quả của hai phương pháp này trong việc đánh giá rừng đá vôi. Từ tháng 4 đến tháng 8, chúng tôi đã tiến hành thực hiện trên 117 tuyến và 55 điểm khảo sát. Trong khuôn khổ phạm vi khảo sát, chúng tôi đã xác định được 5 nhóm loài linh trưởng, gồm voọc Hà Tĩnh (*Trachypithecus hatinhensis*), voọc chà vá chân đỏ (*Pygathrix nemaeus*), khỉ mặt đỏ (*Macaca arctoides*), khỉ mốc (*M. assamensis assamensis*) và vượn đen má trắng (*Nomascus siki*). Tại các điểm và các tuyến, chúng tôi đều ghi nhận được sự hiện diện của các loài này ngoại trừ loài khỉ mặt đỏ thì không được ghi nhận trong các điểm khảo sát. Trong phạm vi nghiên cứu này, chúng tôi trình bày cả những thuận lợi cũng như bất lợi của hai phương pháp. Tuy nhiên, chúng tôi kết luận rằng để nghiên cứu sự phân bố và mật độ của tất cả các đàn linh trưởng tại VQG PN-KB thì các việc lập tuyến có hiệu quả hơn vì phương pháp này có khả năng giúp phát hiện ra nhiều nhóm loài hơn so với phương pháp khảo sát địa điểm mặc dù nghiên cứu bằng địa điểm có thể đem lại hiệu quả cao hơn cho một số loài.

REFERENCES

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. & Thomas, L. (2001): Introduction to Distance Sampling. Estimating Abundance of Biological Populations. Oxford University Press, New York.

Cao Xuan Chinh (2005): Conservation and development of the heritage values of Phong Nha–Ke Bang National Park, current situation and solution. In: Training Workshop memories on strengthening the management and protection capacities of the Phong Nha–Ke Bang National Park, the World Heritage Site Dong Hoi, Vietnam, pp. 103–107.

Dinh Hai Duong (2005): Survey results of primate species in the Phong Nha–Ke Bang National Park and adjacent areas. Report to the administration of the Phong Nha–Ke Bang National Park. (in Vietnamese, unpubl.).

Haus, T., Vogt, M. & Forster, B. (2009a): Observations on the Hatinh langur (*Trachypithecus hatinhensis*) during point and line transect sampling in the Phong Nha – Ke Bang National Park, Central Vietnam. Vietnamese Journal of Primatology 1(3), 17-27.

Haus, T., Vogt, M., Forster, B., Vu Ngoc Thanh & Ziegler, T. (2009b): Distribution and population densities of diurnal primates in the karst forests of Phong Nha - Ke Bang National Park, Quang Binh Province, Central Vietnam. Int. J. Primatol. 30(2): 301-312.

Le Khac Quyet, Dinh Hai Duong, Bui Ngoc Thanh & Le Van Long (2002): Results of Surveys on Primates in Vuc Tro and Hung Dang Areas, Phong Nha–Ke Bang National Park, Quang Binh Province, Vietnam, 09/2002. Report to Fauna and Flora International - Vietnam Programme, Hanoi. (In Vietnamese, unpubl.).

Le Xuan Canh, Truong Van La, Dang Thi Dap, Ho Thu Cuc, Ngo Anh Dao, Nguyen Ngoc Chinh, Nguyen Quoc Dung, Pham Nhat, Nguyen Thai Tu, Nguyen Quoc Thang & Tran Minh Hien (1997): A Report on Field Surveys on Biodiversity in Phong Nha–Ke Bang Forest (Quang Binh Province) Central Vietnam. WWF and UNDP, Hanoi.

Nguyen Quang Vinh (2002): Report on primate monitoring in the third conduct. Areas: Cop Bo Binh and Hung Lau. Phong Nha–Ke Bang National Park, WWF LINC Project. (In Vietnamese, unpubl.).

Pham Nhat, Do Tuoc & Truong Van La (1996): Preliminary survey for Hatinh langur in north central Vietnam. Asian Primates 6(3), 13-17.

Pham Nhat & Nguyen Xuan Dang (2000): Field guide to the key mammal species of Phong Nha–Ke Bang. Fauna & Flora International-Indochina Programme, Hanoi.

Ross, C. & Reeve, N. (2003): Survey and census methods: Population distribution and density. In: Setchell, J.M. & Curtis, D.J. (eds.): Field and laboratory methods in primatology. A practical guide; pp. 90–109. Cambridge University Press, Cambridge.

Thomas, L., Buckland, S.T., Burnham, K.P., Anderson, D.R., Laake, J.L., Borchers, D.L. & Strindberg, S. (2002): Distance Sampling. In: El-Shaarawi, A.H. & Piegorsch, W.W. (eds.): Encyclopedia of Environmetrics Vol. 1; pp. 544-552. John Wiley & Sons, Chichester.

Thomas, L., Laake, J.L., Strindberg, S., Marques, F.F.C., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Hedley, S.L., Pollard, J.H., Bishop, J.R.B. & Marques, T.A. (2006): Distance 5.0. Release 2. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. <http://www.ruwpa.st-and.ac.uk/distance/>. Downloaded 19, 2007.

Timmins, R.J., Do Tuoc, Trinh Viet Cuong & Hendrichsen, D.K. (1999): A preliminary assessment of the conservation importance and conservation priorities of the Phong Nha-Ke Bang proposed National Park, Quang Binh Province, Vietnam. Fauna & Flora International – Indochina Programme, Hanoi.

6

NEW DATA ON THE DISTRIBUTION OF GREY-SHANKED DOUC LANGURS (*PYGATHRIX CINEREA*) IN QUANG NGAI PROVINCE, VIETNAM

NGUYEN THANH TUAN, LE VU KHOI, AND LE KHAC QUYET

SUMMARY

From April 2007 to October 2008, 21 field surveys with 251 field-days were carried out in 21 locations belonging to 14 communes of Tra Bong, Ba To and Son Ha Districts, Quang Ngai Province. Survey results recorded 32 groups of 192 to 220 grey-shanked douc langurs (*Pygathrix cinerea*) in 23 surveyed areas including eight groups of 46 to 60 individuals in Tra Bong, eight groups of 45 to 55 individuals in Ba To and ten groups of about 100 individuals in Son Ha. Main threats to the grey-shanked douc langurs in Quang Ngai include hunting, habitat loss and habitat disturbance.

INTRODUCTION

Grey-shanked douc langur (*Pygathrix cinerea*) is listed as ‘Critically Endangered’ (IUCN, 2008) and is considered one of the 25 most endangered primates in the world (Mittermeier *et al*., 2007) (Fig. 1). This species is restricted to central provinces of Vietnam including Quang Nam, Quang Ngai, Binh Dinh, Kon Tum and Gia Lai (Dang Ngoc Can *et al*., 2007; Nadler *et al*., 2003; 2004; 2007; Pham Nhat, 2002). It is threatened by hunting, habitat loss and habitat disturbance (Nadler *et al*., 2003).

Quang Ngai is a coastal province in central Vietnam with total area of 5,856 km^2. Although impacted by human activities, this province still has large areas of forest in Ba To, Tra Bong, Son Ha and Son Tay Districts. Therefore, fauna and flora in Quang Ngai Province are rich and abundant (Le Khac Huy *et al*., 2001).

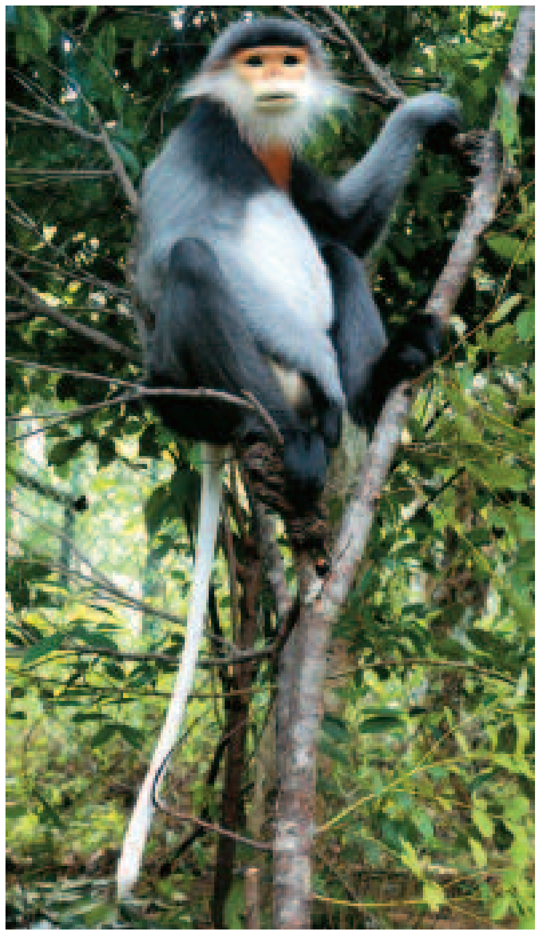

Fig. 1. Grey-shanked douc langur, adult male (*Pygathrix cinerea*). *Photo: Tilo Nadler.*

There are records of grey-shanked douc langurs in Ba To District and probably in Tra Bong District (Ha Thang Long, 2004; Nadler *et al.*, 2003; 2004; 2007). However, there has not been any intensive survey of status and distribution of *P. cinerea* in Quang Ngai. This report presents the results of field surveys focused on *P. cinerea* carried out in Tra Bong, Ba To and Son Ha Districts of Quang Ngai from April 2007 to October 2008.

MATERIALS AND METHODS

Study Site

In the period from April 2007 to October 2008 there were 21 field surveys with 251 field-days carried out in 21 locations belonging to 14 communes of Tra Bong, Ba To and Son Ha Districts, Quang Ngai Province (Fig. 2 and Table 1).

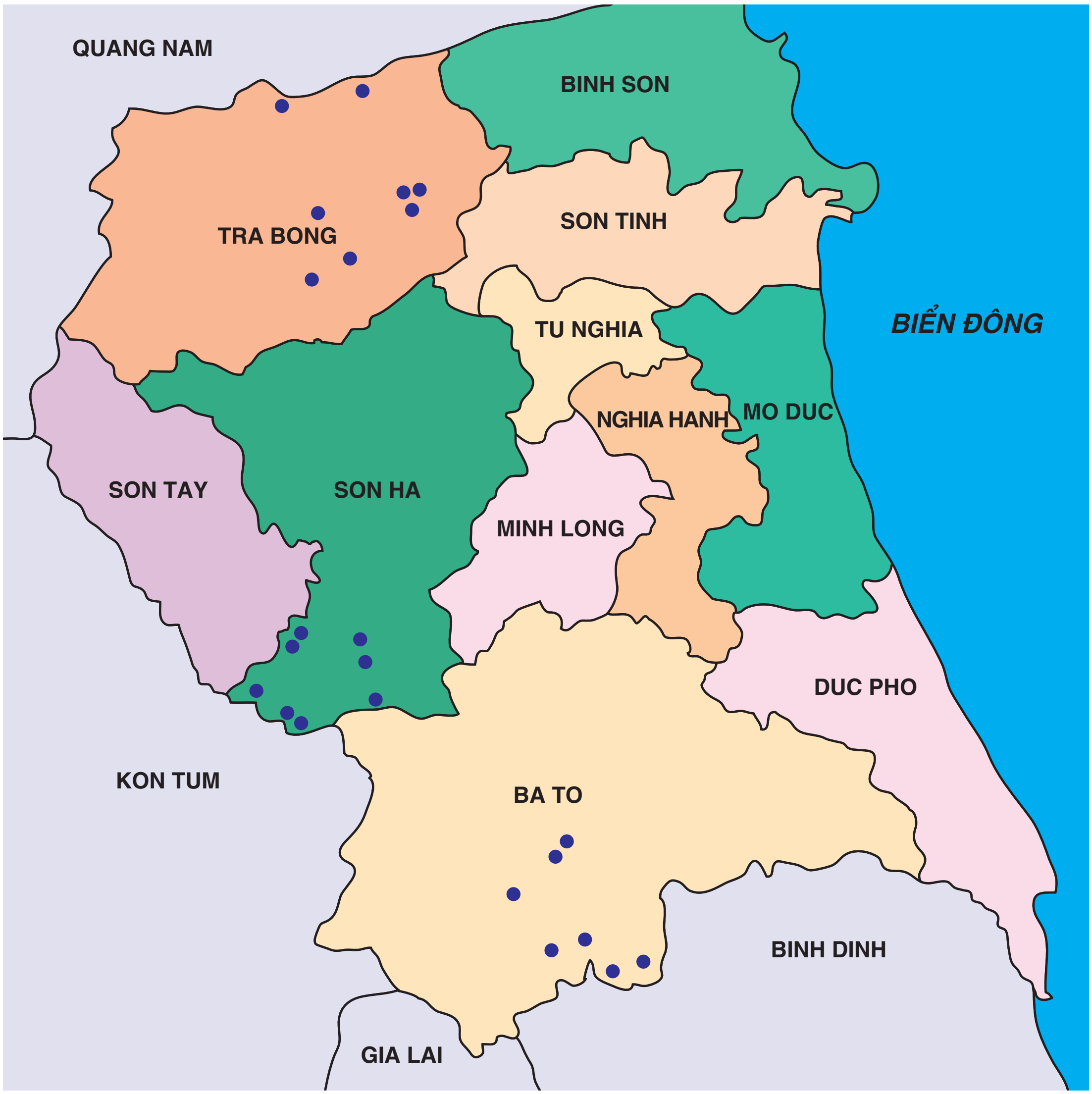

Fig. 2. Records of grey-shanked douc langurs (*Pygathrix cinerea*) in Quang Ngai Province.

Table 1. Locations and duration of field surveys focused on the grey-shanked douc langurs (*Pygathrix cinerea*) in Quang Ngai Province; April 2007 – October 2008.

No.	Location	Duration	Number of days
I. Ba To District			
1	Ba Bich Commune	- April 02 – 14, 2007 - June 09 – 16, 2008	12 07
2	Ba Thanh Commune	- April 28 – May 11, 2007	13
3	Ba Le commune	- May 04 – 20, 2008 - October 20 – 27, 2008	16 07
4	Ba Nam Commune	- May 25 – June 05, 2008 - October 01 – 15, 2008	10 15
5	Ba Xa Commune	- June 08 – 19, 2008	11
II. Tra Bong District			
6	Tra Giang Commune	- June 01 – 11, 2007	10
7	Tra Son Commune	- June 15 – July 02, 2007 - September 20 -30, 2007	17 10
8	Tra Thuy Commune	- July 05 – 18, 2007 - March 06 – 16, 2008	13 10
9	Tra Tan Commune	- July 22 – 31, 2007 - September 01 – 15, 2007	09 14
10	Tra Bui Commune	- March 19 – 27, 2008	08
III. Son Ha District			
11	Son Giang Commune	- August 03 – 21, 2007	18
12	Son Thuy Commune	- June 23 – July 06, 2008	13
13	Son Ky Commune	- July 09 – 25, 2008 - September 21 – 28, 2008	16 07
14	Son Ba Commune	- September 03 – 18, 2008	15
		Total	**251**

Interviews

Information was first collected through semi-structured interviews with rangers, commune officals and local people who frequently go into the forest and who possess knowledge of the primates and other mammals in the forest areas near to their residences. In this way, basic information such as distribution, status and threats to the species could be obtained. The interviews were carried out at any appropriate opportunity through "open" questioning of the interviewees by the interviewer, and the work did not follow any fixed questionnaire or structures. During the interviews, pictures of primates and other animals were shown to interviewees to verify identifications. The specimens found in villages were also documented with photographs and where possible collected, although none were purchased.

Field surveys

Field surveys were carried out via observation transect walks in the forest from 6:30 am to 5:30 pm. Survey teams followed existing trails or newly cut transects. The species were recorded by direct observations (naked eye or binoculars). Upon sighting an individual, thirty seconds were taken to identify its species classification as well as to count other individuals - such as its infants - within each view. GPS waypoints were collected at all sight locations. All GPS waypoints were marked on topographical maps of the area and photographs were taken when possible.

Survey team members also recorded tracks, footprints and other observations of animals encountered during field surveys, especially mammals. These records would contribute to a full assessment of biodiversity in the survey area. Threats to primates and their habitat as well as other wildlife were recorded for the purpose of evaluating the status of forest protection, management in the survey area and to provide recommendations for conservation activities in Quang Ngai Province.

RESULTS AND DISCUSSIONS

Morphological features

Measurements and weights of three killed grey-shanked douc langurs and one stuffed specimen recorded in Tra Son and Tra Thuy (Tra Bong District), Son Ky (Son Ha District) and Ba Nam (Ba To District) are provided in Table 2. These individuals have been bigger in size, and heavier than data show from the Endangered Primate Rescue Center (Nadler *et al*., 2003).

Status and Distribution

As a result of 21 field surveys with total of 251 field-days, there were records of 32 groups in total of 192 to 220 grey-shanked douc langurs in 23 survey areas including eight groups in total of 46 to 60 individuals in Tra Bong District, eight groups in total of 45 to 55 individuals in Ba To District and ten groups in total of about 100 individuals in Son Ha District (Table 3). Survey results show that the grey-shanked doucs inhabit remote areas with tall trees and minimal disturbance by human activities. Group size is small with 5 to 7 individuals per group and rarely 10 to 15 individuals per group.

Threats

Hunting is the most serious threat to the grey-shanked douc langurs in Quang Ngai Province. During the surveys, there were records of at least 25 individuals captured and killed by hunting with guns or traps (Table 4). Grey-shanked doucs were hunted for local foods, traditional medicines (monkey balm) and decorations.

Habitat loss is also a major threat to the douc langurs in Quang Ngai Province. Due to high pressure from human population growth and associated increased food demand, many forest areas have been cleared for agriculture. In 2007, Quang Ngai Provincial Forestry Protection Department recorded 129 cases of illegal activity with 30.55 ha of forest area cleared for agriculture; in 2008, 212 cases with 66.45 ha of forest area were cleared. In addition, there were many other forested areas cultivated for agro-industry species such as rubber, *Acacia* and cinnamon-trees.

Habitat disturbance is also a threat to the grey-shanked doucs in Quang Ngai Province, including hydro-electric dam constructions (Tra Bong and Son Ha Districts), illegal logging, and non timber forest product collection.

Conservation Status

In recent years, appropriate authorities in Quang Ngai Province have made strong efforts to enhance law enforcement in forest and wildlife protection by strengthening patrols, monitoring extraction and trade of timber and wildlife, and by severely punishing law-breakers.

Table 2. Morphological features of grey-shanked douc langurs (*Pygathrix cinerea*) from Quang Ngai Province.

No.	Age / Sex	Weight (kg)	Head-body Length (mm)	Tail length (mm)	Hind foot (mm)	Ear length (mm)	Breast girth (mm)	Location
1	Adult male	12.5	701.0	612.0	207.0	35.5	420.0	Tra Son
2	Adult male	11.7	697.0	609.0	200.0	35.0	412.0	Tra Thuy
3	Adult male	c. 15.0	710.0	563.0	181.0	38.0	565.0	Son Ky
4	Adult female	10.0	620.0	590.0	183.0	27.0	394.0	Ba Nam
Mean (n=4)		**12.3**	**682.0**	**593.5**	**192.75**	**33.88**	**447.75**	

Table 3. Records of the grey-shanked douc langurs (*Pygathrix cinerea*) in Quang Ngai Province (O = Observation; I = Interview).

No.	Location	Date	Record type	Number of groups	Number of individuals
I. Tra Bong District					
1	Ka Tu stream, Tra Son Commune	June 27 and 29, 2007	O	1	05
2	Nuoc Ngam stream, Tra Son Commune	September 25, 2007	O	2	10
3	Mount Peo, Tra Tan Commune	July 25 and 26, 2007; September 10, 2007	O	2	15
4	Mount Ca Roc, Tra Thuy Commune	July 11 and 16, 2007	O	1	05
5	Mount Chua, Tra Thuy Commune	March 10, 2008	O	1	04
6	Mount 355, Tra Bui Commune	March 25,2008	I	1	05
II. Ba To District					
7	Hill Ja Cut, Ba Nam Commune	June 01, 2008	O	1	10 - 13
8	Vo Village, Ba Nam Commune	October 10, and 12, 2008	O	1	07
9	Mount Nuoc Xua, Ba Nam Commune	May 05, 2008	I	1	12
10	Hill Ca La, Ba Nam Commune	May 26, 2008	I	1	07 - 10
11	Nuoc Nang Stream, Ba Le Commune	May 12, 2008	O	1	7 - 10
12	Mount Nuoc Ty, Ba Le Commune	May 18 and October 22, 2008	O	2	08
13	Nuoc Tuoi Stream, Ba Le Commune	May 05, 2008	I	2	20 - 25
14	Ram Village, Ba Le Commune	May 05, 2008	I	1	05 - 07
15	Y Vong Pass, Ba Bich Commune	April 08 and 13, 2007	O	2	08 - 12
16	Nuoc Quam Stream, Ba Quam Commune	June 13, 2008	O	1	05
17	Ba Ria Stream, Ba Bich Commune	April 02, 2007	I	1	06
III. Son Ha District					
18	Mount Pong, Son Ky Commune	July 13, 16 and 18, 2008	O	3	08 - 09
19	Mount Ngo, Son Ky Commune	September 22, 2008	O	1	06
20	Nuoc Nga Stream, Son Ky Commune	September 24, 2008	O	1	07 - 08
21	Mount Da Danh-Sa Rung, Son Ky Commune	September 26 and 27, 2008	O	3	18 - 22
22	Mount Ca Vang, Son Ba Commune	September 04, 2008	I	1	06 - 08
23	Mount Ca Noi, Son Ba	September 12 and 15, 2008	O	1	08
Total				**32**	**192 - 220**

Table 4. Number of grey-shanked douc langurs (*Pygathrix cinerea*) killed in Quang Ngai Province from April 2007 to December 2008.

No.	Location	Number of grey-shanked doucs killed	Recorded by
I. Ba To District			
1	Ba Le Commune	3	01 killed animal; 01 skull; 01 lower jaw
2	Ba Nam Commune	2	02 killed animals
3	Ba Dinh Commune	1	01 stuffed specimen
II. Tra Bong District			
4	Tra Thuy Commune	4	01 adult male; 01 adult female; 01 female infant; 01 skull
5	Tra Son Commune	8	02 stuffed specimen; 02 killed animals in alcohol; 02 killed animals; 01 skull; 01 lower jaw
6	Tra Tan Commune	1	01 lower jaw
III. Son Ha District			
7	Son Ba Commune	4	01 skull; 03 killed animals
8	Son Ky Commune	2	01 lower jaw; 01 killed animals
Total		**25**	

Awareness of authorities and communities has improved through conservation awareness campaigns using propaganda in legal documents, distribution of posters, brochures and leaflets to inform about forest and wildlife protection.

RECOMMENDATIONS

Field surveys activities for grey-shanked douc langurs and other primates in Quang Ngai Province should continue.

Hunting and trapping activities in the forest, in particular hunting of grey-shanked douc langurs and other endangered species in Quang Ngai Province should be monitored and violations strictly punished and penalized.

Information about laws regarding protection should be widely spread.

Awareness among of local peoples about conservation and protection of the forest and endangered species should be increased.

ACKNOWLEGMENTS

Thanks to Kon Tum Teachers's Training Colleage, Vietnam National University Hanoi, Quang Ngai Provincial Forest Protection Department, and Forest Protection Departments of Tra Bong, Ba To and Son Ha Districts for their permits and support. Special thanks to local guides for their support during fieldwork. Sincerely thanks to Lois K. Lippold, Vu Ngoc Thanh and the Douc Langur Foundation for the support through funding of some field surveys in 2008 and to Conservation International for funding in 2007.

NHỮNG DẪN LIỆU MỚI VỀ SỰ PHÂN BỐ CỦA CHÀ VÁ CHÂN XÁM (*PYGATHRIX CINEREA*) Ở TỈNH QUẢNG NGÃI, VIỆT NAM

TÓM TẮT

Trong thời gian từ tháng 4/2007 đến tháng 10/2008, 21 đợt với 251 ngày điều tra thực địa đã được tiến hành tại 21 khu vực của 14 xã thuộc 3 huyện Trà Bồng, Ba Tơ và Sơn Hà, tỉnh Quảng Ngãi. Kết quả điều tra đã ghi nhận được 32 đàn chà vá chân xám (*Pygathrix cinerea*) gồm 192 – 220 cá thể tại 23 khu vực đã điều tra, trong đó 8 đàn với 46 – 60 cá thể ở huyện Trà Bồng, 8 đàn với 45 – 55 cá thể ở huyện Ba Tơ và khoảng 10 đàn với 100 cá thể ở huyện Sơn Hà. Săn bắt trái phép, mất sinh cảnh và sinh cảnh bị tác động đang là những mối đe dọa chính đối với quần thể chà vá chân xám ở Quảng Ngãi.

REFERENCES

Dang Ngoc Can, Hikeki Endo, Nguyen Truong Son, Tatsuo Oshida, Le Xuan Canh, Dang Huy Phuong, Lunde, D.P., Shin-Ichiro Kawada, Akiko Hayashida & Mototki Sasaki (2008): Checklist of Wild Mammal Species of Vietnam. Shoukadou Book Sellers, Kyoto.

Ha Thang Long (2004): Distribution and status of the grey-shanked douc langur (*Pygathrix cinerea*) in Vietnam. In: Nadler T., Streicher U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 52-57. Frankfurt Zoological Society, Hanoi.

IUCN (2008): 2008 IUCN Red List of Threatened Species. http://redlist.org.

Le Khac Huy, Le Van Tan, Vo Van Phu, Le Quang Minh & Do Xuan Cam (2001): Biodiversity of Quang Ngai Province. Department of Information and Culture, Quang Ngai City. (In Vietnamese).

Ministry of Science and Technology & Vietnam Academy of Science and Technology (2007). Red Data Book of Vietnam. Vol. I: Animals. Publishing House of Science and Technology, Hanoi.

Ministry of Science and Technology & Vietnam Academy of Science and Technology (2008): Vietnam's Fauna. Vol. 25: Mammals. Publishing House of Science and Technology, Hanoi.

Mittermeier, R.A., Ratsimbazafy, J., Rylands, A.B., Williamson, L., Oates, J.F., Mbora, D., Ganzhorn, J.U., Rodríguez-Luna, E., Palacios, E., Heymann, E.W., Kierulff, M. C.M., Yongcheng, L., Supriatna, J., Roos, C., Walker, S. & Aguiar, J.M. (compiler) (2007): Primates in Peril: The World's 25 Most Endangered Primates, 2006-2008. Primate Conservation 22, 1-40.

Nadler, T., Momberg, F., Nguyen Xuan Dang, Lormee N. (2003): Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys. Fauna & Flora International – Vietnam Program and Frankfurt Zoological Society, Hanoi.

Nadler, T., Vu Ngoc Thanh, Streicher, U. (2007): Conservation status of Vietnamese primates. Vietnamese J. Primatol. 1(1), 7-26.

Pham Nhat (2002): Primates of Vietnam. Agricultural Publishing House, Hanoi (in Vietnamese).

7

STATUS AND DISTRIBUTION OF RED-SHANKED DOUC LANGURS (*PYGATHRIX NEMAEUS*) AND THREATS TO THEIR POPULATION AT SON TRA NATURE RESERVE, DANANG CITY

DINH THI PHUONG ANH, NGUYEN DINH HONG CHUNG, AND HUYNH THI NGUYET HANG

SUMMARY

From July 2007 to August 2008 status and distribution of red- shanked douc langurs (*Pygathrix nemaeus*) at Son Tra Nature Reserve, Danang was studied and threats for the population evaluated. The population of douc langurs was observed in two forest types: moist evergreen broad-leaf forest and regeneration forest. A total of 13 groups with 198-208 individuals were recorded. The key threats to the population are mainly habitat loss through increasing tourism development and road construction. Illegal logging and collection of non timber forest products create additional pressure. Conservation measures are urgently required.

INTRODUCTION

The distribution of red-shanked douc langurs (*Pygathrix nemaeus*) in Vietnam range from Pu Mat National Park, Nghe An Province in the North (19°02' N) to the Kon Ha Nung area, Gia Lai Province in the South (14°33' N) (Nadler *et al*., 2003). An isolated population exists at Son Tra Nature Reserve close to Danang City, first mentioned by van Peenen (1969)and van Peenen *et al*. (1971). Some studies, and surveys on this species were carried out in the area (Lippold 1977; Dinh Thi Phuong Anh, 1997; Vu Ngoc Thanh *et al*., 2007), but there is still a lack on information about status and distribution of the animals on the peninsula, and the current threats especially under the recent development of the peninsula to a tourism spot.

MATERIAL AND METHODS

Research area

Son Tra Nature Reserve is located on a peninsula and belongs to Tho Quang Commune, Son Tra District, about 10 km from centre of Da Nang City toward north-east direction. The peninsula measures 13 by 7 km (Fig. 1). The nature reserve was established in 1992 and covers an area of about 4,400 ha. The northern border of the peninsula forms the Danang Gulf, north east and south east is open sea and in south west the connection to the mainland and the Song Han port (Fig. 2 and 3).

The shape of Son Tra Peninsula is formed like a fish, and stretches out towards west to east with the coordinates 16^0 05' 50" to 16^0 09' 06" N and 108^0 12' 45" to 108^0 20' 48" E. The north east part is higher than the south west area with slopes from 25^0 - 30^0. The hills are disrupted by many streams and rivers. The highest mountain on Son Tra Peninsula is the Oc Peak with 696 m asl; next a television peak with 647 m asl and the Three-Balls Peak with 621 m asl.

About 985 plant species in 483 genera, and 143 families were recorded. 22 belong to rare and endangered species and listed in the Vietnam Red Book Data (Ministry of Science and Technology & Vietnam Academy of Sciences and Technology, 2007). In particular, *Parashorea* sp. and *Fagaceae* sp. are wide spread and are a dominant vegetation type. 15 animal species are recorded which are listed as rare and endangered in the Vietnamese

Fig. 1. Son Tra Peninsula from North. South of the peninsula the densely populated suburb from Danang City.

Fig. 2. Son Tra Peninsula from West with Danang Harbour.
Photo: Tilo Nadler.

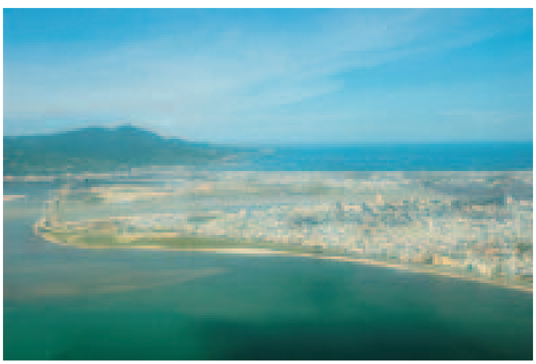

Fig. 3. The suburb from Danang City stretched until the foothills of Son Tra Peninsula.
Photo: Tilo Nadler.

Government decree (Government of Vietnam, 2006). Among these, the red-shanked douc langur is considered as the flagship species of Son Tra Nature Reserve (Dinh Thi Phuong Anh, 1997).

Methods

The study on the distribution of the langurs follows the methods of Brockelman & Ali (1987) and Altmann (1974). Transect lines were designed and the observers walked slowly along these transect lines and recorded observations using GPS coordinates. Photo and video cameras were used for documentation of group structures and behavior.

Information about the threats were collected during field observation and also through interviews of local people, rangers and soldiers. For interviews a special questionaire form was used.

RESULTS

Forest structure at Son Tra Nature Reserve

Dinh Thi Phuong Anh (1997) classified three main forest types at Son Tra Nature Reserve:

Tropical moist evergreen broad-leaf forest (Fig. 4 and 5), dry secondary forest (Fig. 6), and scrub and grass vegetation (Fig. 7).

We designed five transect lines through the moist evergreen broad-leaf forest in the northern part of the peninsula, from the Hai Dang Peak (535 m asl) to the Oc Peak on the southwest part. The mountains reach from 170 m to 520 m asl with steep slopes from 25° to 30°.

The canopy is more than 20 m high and dominated by trees belonging to Dipterocarpaceae, Fagaceae, Anacardiaceae, Moraceae, Myrtaceae, Rubiaceae, Theaceae, Euphorbiaceae, Meliaceae, Sapindaceae, Clusiaceae, Annonaceae. The middle layer is densely formed by fruit trees like *Syzygium* sp., *Garcinia oblongifolia*, *Mischocarpus sundaicus*. The lowest layer consists of *Ardisia* sp., *Dracontomelum duperreanum*, *Pandanus* sp. Lianas grow trough all layers, mostly *Gnetophyta* sp., *Calamus* sp., and *Flagellaria indica*.

The secondary forest is located at the top of the mountain on altitude between 170 m to 500 m asl. The tree high is 8 m to 10 m and consists of scattered fast growing trees of Fagaceae, Cornaceae, and *Ficus* sp.

Fig. 5. The primary forest has reach liana vegetation.
Photo: Tilo Nadler.

Distribution of red-shanked douc langurs at Son Tra Nature Reserve

During 46 survey days, we observed red-shanked douc langurs in the tropical moist evergreen broad-leaf forest and in secondary forest, never in the scrub vegetation (Table 1). We recorded 13 douc langur groups with a total of 198-208 individuals (Fig. 8). The distribution of the langurs was located in three areas (Fig. 9) Four groups (group 1, 2, 3, 4) were recorded in the northwest of the nature reserve. In the central area of the nature reserve were also four groups recorded (group 5, 6, 7, 8), and in the northeast part five groups observed (group 9, 10, 11, 12, 13) (Table 2). The groups are separated trough roads. However an exchange of individuals between group 2 and group 6 was observed.

The male/female ratio with 1:2 is nearly equal in all groups (Table 2). The largest groups consisted of 24 (group 6) and 40 individuals (group 2), the smallest group comprised 6 individuals (group 12). Larger groups regularly split in the morning into smaller units and regroup in the afternoon.

Fig. 4. Primary moist evergreen broad-leaf forest on steep hill slopes.
Photo: Tilo Nadler.

Fig. 6. Secondary forest parts.
Photo: Tilo Nadler.

Fig. 7. Patched of shrub and grassland, secondary forest, and in the background primary forest on the hill slopes.
Photo: Tilo Nadler.

Fig. 8. Red-shanked douc langurs (*Pygathrix nemaeus*) foraging.
Photo: Tilo Nadler.

Threats to the red-shanked douc langur population

The tourism development, including extensive road construction (Fig. 10 and 11), construction of resorts, guest houses and hotels, and recreation areas create a pressure to the population, and reduce noticeably the habitat for the langurs. Logging for tourism constructions, blasting for road construction and buildings and increasing traffic scare the animals and cause a change of locations. Illegal logging, collection of non-timber forest products, tourist hikes through the forest also create additional unrest for the langurs.

Merremia (*Merremia peltata*) an invasive climbing vine spreads rapid over the peninsula and covers already about 1000 ha, nearly one quarter of the peninsula (Fig. 12). Further spread cause a shrinking habitat for the langurs. The forest trees die under the shadow of the fast growing plant. The vine following land disturbance and land clearing by road construction and spreads from these areas to the forest.

Table 1. Number of surveys and observations of red-shanked douc langurs (*Pygathrix nemaeus*) in different forest types.

Survey month	Number of surveys	Number of observations	Moist evergreen forest	Dry secondary forest
Sept 2007	9	9	6	3
Oct 2007	4	2	2	-
Nov 2007	8	7	5	2
Dec 2007	8	5	5	1
Jan 2008	7	6	3	3
Feb 2008	5	2	1	1
Mar 2008	5	5	2	3
TOTAL	46	37	24	13

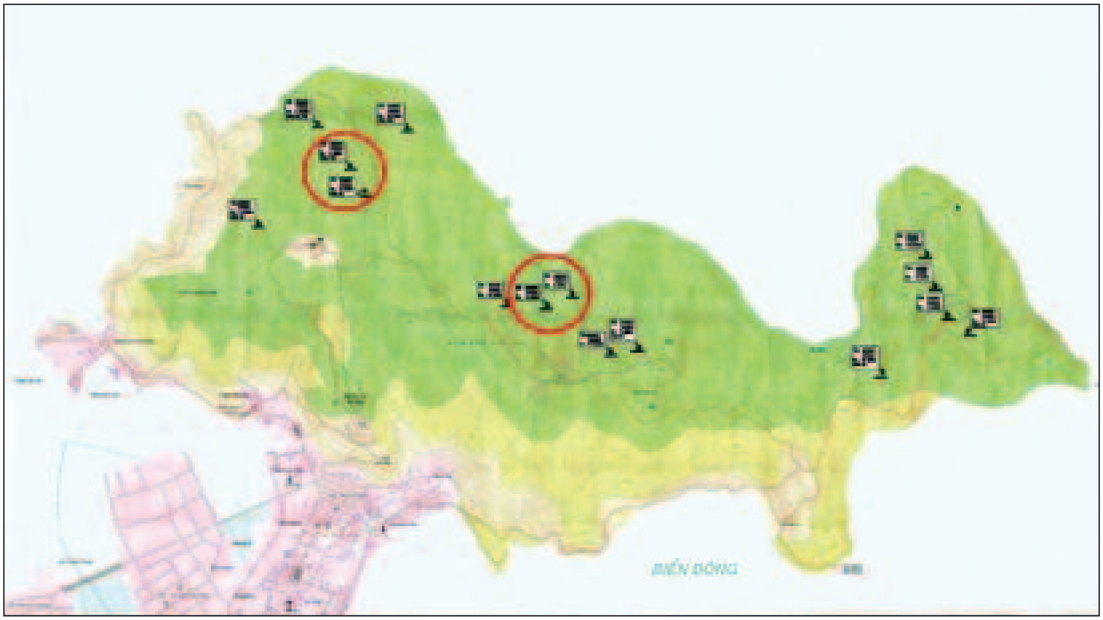

Fig. 9. Distribution of Red shanked douc langur groups at Son Tra Nature Reserve.

Table 2. Group structure of red-shanked douc langurs (*Pygathrix nemaeus*) at Son Tra Nature Reserve

Group	Individuals	Males	Females	Juveniles	Immatures
1	11	2	5	3	1
2	40	8	18	10	4
3	8	2	4	2	
4	15	4	7	2	2
5	10	2	5	2	1
6	24	6	12	4	2
7	11	3	5	2	1
8	12	3	6	2	1
9	15	3	7	3	2
10	13	3	6	3	1
11	19	4	9	4	2
12	6	3	3		
13	14	3	7	2	2

DISCUSSION

Dinh Thi Phuong Anh (1997) recorded 4 groups with total of 30 to 40 individuals. Vu Ngoc Thanh *et al.*, (2007) observed 12 groups with 171 indivudals and estimated a population with 198 individuals. No information was collected about the group structure and male/female ratio. With the result of this study it seems that the population increased during the last years, but the recently started extensive human activities on the peninsula dramatically increased the pressure to the population. An additional threat; the invasive climbing vine (*Merremia peltata*), also shrinks the habitat for the douc langurs.

ACKNOWLEDGEMENTS

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SỰ PHÂN BỐ VÀ CÁC MỐI ĐE DỌA ĐẾN QUẦN THỂ VOỌC CHÀ VÁ CHÂN NÂU (*PYGATHRIX NEMAEUS*) TẠI KHU BẢO TỒN THIÊN NHIÊN SƠN TRÀ THÀNH PHỐ ĐÀ NẴNG

TÓM TẮT

Kết quả nghiên cứu nơi sống, sự phân bố, tập tính di chuyển của quần thể voọc chà vá chân nâu (*Pygathrix nemaeus*) tại Khu bảo tồn thiên nhiên Sơn Trà, Đà Nẵng từ tháng 7/2007 – tháng 8/2008. Ghi nhận quần thể voọc chà vá chân nâu chủ yếu phân bố ở 2 sinh cảnh rừng lá rộng thường xanh mưa mùa nhiệt đới và sinh cảnh rừng phục hồi. Tại đây có sự phân bố của 13 đàn với tổng số cá thể quan sát khoảng từ 198-208 cá thể. Các mối đe dọa đến sự tồn tại của quần thể là: phát triển du lịch, hoạt động làm đường, thực vật xâm lấn, các hoạt động khai thác gỗ và lâm sản ngoài gỗ.

Fig. 10. The road construction creates wide gaps through forested areas.

Photo: Tilo Nadler.

Fig. 11. Road constructions are extended until the remotest end in the East of the peninsula.
Photo: Tilo Nadler.

Fig. 12. The invasive climber species Merremia (*Merremia peltata*) cavers already large parts of forest and spread further, following in particular the road construction.
Photo: Tilo Nadler.

REFERENCES

Altmann, J. (1974): Observational study of behavior: Sampling methods. Behaviour 49, 227–267.

Brockelman, W.Y. & Ali, R. (1987): Methods of surveying and sampling forest primate populations. In: Marsh, C.W & Mittermeier, R.C. (eds.) Primate Conservation in Tropical Rainforest; pp. 23-62. Alan R.Liss, New York.

Dinh Thi Phuong Anh (1997): Sudies on fauna, flora and impact factors in Son Tra Nature Reserev with recommendations for conservation. University of Danang, College for education. (In Vietnamese, unpubl.).

Government of Vietnam (2006): Decree No. 32/2006/ND-CP of March 30, 2006, on management of endangered, precious and rare forest plants and animals.

Lippold, L.K. (1977): The douc langur. A time for conservation. In: HSH Prince Rainier & Bourne, G.H. (eds.): Primate Conservation, pp. 513-538. Academia Press, New York.

Lippold, L.K. (1998): Natural history of douc langurs. In: Jablonski, N.G. (ed.): The Natural History of the Doucs and Snub-nosed Monkeys. World Scientific Publishing, Singapore.

Ministry of Science and Technology & Vietnam Academy of Sciences and Technology (2007): Red Data Book of Vietnam, Part II. Plants. Publ. House Nat. Science & Technology, Hanoi. (In Vietnamese).

Nadler T., Momberg F., Nguyen Xuan Dang & Lormee N. (2003): Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys. Fauna & Flora International-Vietnam Program and Frankfurt Zoological Society, Hanoi.

Van Peenen, P.F.D. (1969): Preliminary Identification Manual for Mammals ò South Vietnam. Smithsonian Institution, Washington.

Van Peenen, P.F.D., Light, R.H. & Duncan, J.F. (1971): Observations of Mammals of Mt. Sontra, South Vietnam. Mammalia 35(1), 126-143.

Vu Ngoc Thanh, Le Vu Khoi, Le Khac Quyet (2007): Survey results for Red-shanked douc langur (*Pygathrix nemaeus nemaeus*) in Son Tra Nature Reserve, Da Nang City, Central Vietnam. Vietnam National University, Hanoi. (Unpubl.).

8

STATUS AND HABITAT OF YELLOW-CHEEKED GIBBONS (*NOMASCUS GABRIELLAE*) IN PHNOM PRICH WILDLIFE SANCTUARY, MONDULKIRI, CAMBODIA

PHAN CHANNA AND THOMAS NEILL EDWARD GRAY

SUMMARY

Yellow-cheeked gibbon (*Nomascus gabriellae*) is a globally threatened species, listed as "Endangered" (IUCN, 2008), and restricted to the east of the Mekong River in Cambodia, Vietnam and Laos. Surveys were conducted in Phnom Prich Wildlife Sanctuary, Mondulkiri Province, Cambodia to assess the status of the gibbon population around this protected area. Distribution and population size were obtained from auditory sampling undertaken between January and April 2008. The survey used single listening posts, visited on three consecutive mornings, to estimate the density of gibbon groups. Fifty-three listening posts were established across 866 km^2 of suitable habitat. These were used to obtain a gibbon population estimate. The estimated total population size within Phnom Prich WS was 149 (95% CI range: 15-273) gibbon groups. Suitable habitat in the north-west of the site, and within Lumphat Wildlife Sanctuary, Ratanakiri, were unoccupied by gibbon suggesting Phnom Prich Wildlife Sanctuary may represent the northern distributional limit of typical yellow-cheeked gibbon. Our population estimate compares to >800 groups within Seima Biodiversity Conservation Area, the only other site within the species' range with similarly robust population estimates. Among protected areas, Phnom Prich Wildlife Sanctuary may support the 2nd largest global population of taxonomically unambiguous *Nomascus gabriellae*. Threats to gibbon within Phnom Prich WS largely derive from habitat loss and degradation driven by extractive activities (mining and logging) and associated infrastructure developments. However given strong future management the site has good potential conservation value for yellow-cheeked crested gibbon due to the current relatively manageable threat levels and a habitat mosaic that includes several large patches of suitable evergreen forest.

INTRODUCTION

Crested Gibbons (*Nomascus*) are one of four main taxonomic groups within the Gibbon family (Hylobatidae) and are represented by 6 recognized species occurring in the tropical evergreen and semi-evergreen forests of Indochina east of the Mekong river (Brandon-Jones *et al*., 2004). All species are IUCN listed as globally threatened (IUCN, 2008), making the genus a priority for primate conservation. Yellow-cheeked gibbon (*Nomascus gabriellae*) is traditionally regarded as occurring in northeastern Cambodia, southern Vietnam and southern Laos (Duckworth *et al*., 1995; Geissmann *et al*., 2000; Rawson *et al*., 2009) and was listed in the 2000 IUCN Red List as "Vulnerable" (Fig. 1 and 2). Despite having the largest distribution range and presumed population size of any *Nomascus* gibbon the species is considered "Endangered" based on an estimated population decline of over 50% within the past 45 years (three generations) primarily resulting from hunting and habitat loss (Geissmann, 2007; IUCN, 2008).

Nomascus gibbon taxa are widely distributed in Cambodia east of the Mekong River, ranging from

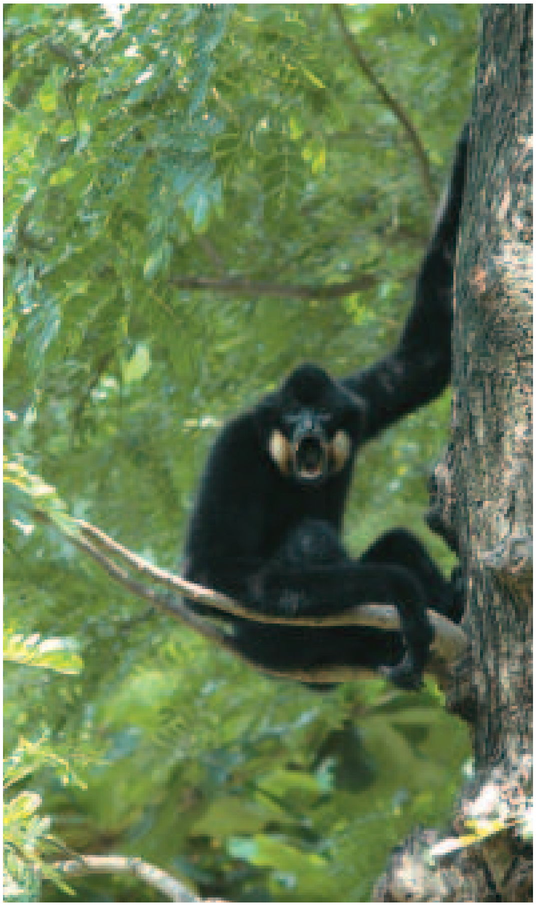

Fig. 1. Male yellow-cheeked gibbon (*Nomascus gabriellae*).

Photo: Tilo Nadler.

Fig. 2. Female yellow-cheeked gibbon (*Nomascus gabriellae*) with baby (behind the thigh).

Photo: Tilo Nadler.

Snoul Wildlife Sanctuary in Kratie north to Virachey National Park in Stung Treng and Ratanakiri Provinces (Fig. 3). However the taxonomic status of gibbon within northern Cambodia is unclear. The Virachey population, which is contiguous with areas in southern Laos, has been assigned, on the basis of vocalisations (Konrad & Geissmann, 2006) and genetics (Van Ngoc Thinh, pers. comm.), to an ambiguous, possibly hybrid, taxon with closer affinities to the southern white-cheeked gibbon (*Nomascus siki*) of central Vietnam and Laos than the more typical *N. gabriellae* of southern Mondulkiri and Kratie. Further studies have therefore been recommended to assess the genetic and taxonomic status of *Nomascus* species in north-eastern Cambodia (Geissmann, 2007).

Although rapid reconnaissance surveys of most large blocks of suitable gibbon habitat across the species' Cambodian range were conducted in the early 2000s (Traeholt *et al*., 2005), population estimates using standard techniques, and representatively covering sites with sufficient sample size, have only been conducted at one site, Seima Biodiversity Conservation Area in southern Mondulkiri (Rawson *et al*., 2009; Pollard *et al*., 2007). Additional surveys to clarify the status of yellow-cheeked gibbon within other Cambodian sites are therefore a priority. Previous surveys have documented the presence of yellow-cheeked gibbon, believed to be of the typical *N. gabriellae* form, within Phnom Prich Wildlife Sanctuary (PPWS) in the centre-west of Mondulkiri Province (Timmins & Ou, 2001; Traeholt *et al*., 2005) (Fig. 3). Given the remoteness of this wildlife sanctuary, combined with

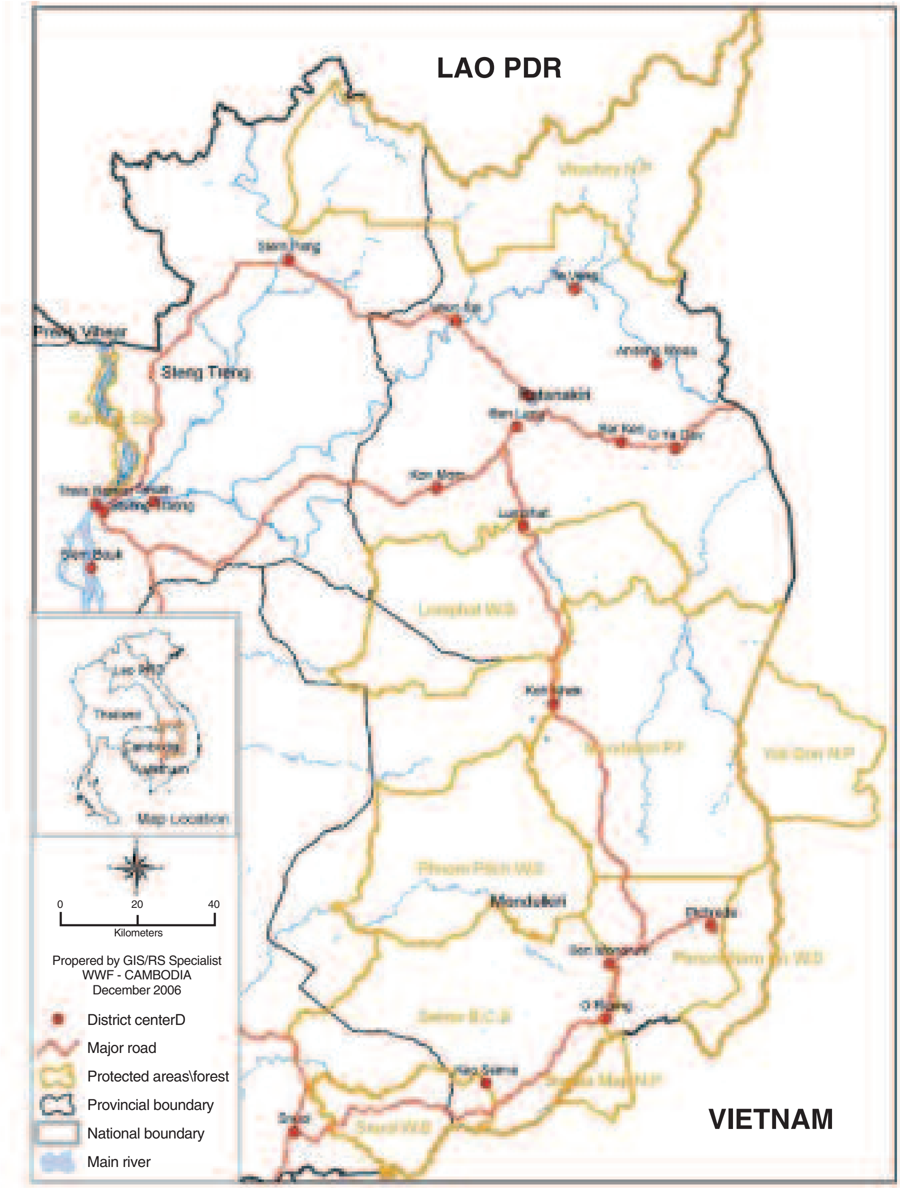

Fig. 3. Location of Phnom Prich Wildlife Sanctuary, and other protected areas mentioned in text, in northeast Cambodia.

manageable levels of threat including limited recent evidence of habitat loss or degradation and few reports of gibbon hunting, Traeholt *et al.* (2005) identified PPWS as being of high potential conservation value for the species. The aims of this study were to use single listening point count surveys (Brockelman & Srikosamatara, 1993) to determine the distribution and population density of yellow-cheeked crested gibbon in Phnom Prich Wildlife Sanctuary.

MATERIAL & METHODS

Study area

Phnom Prich Wildlife Sanctuary (PPWS) is located in the West of Mondulkiri Province, northeast Cambodia (centered on 12.8° N, 106.5° E) (Fig. 3) and covers 2,225 km^2. Terrain is characterized by higher elevation and relief (max. 640 m asl) in the southeastern section near the Mondulkiri Plateau, and sloping down towards the North and West to gently undulating lowlands with elevation ca. 80-200 m asl. PPWS forms part of one of the largest remaining relatively undisturbed landscapes in mainland Southeast Asia and consists of a mosaic of deciduous (or dry) dipterocarp forest and woodland (1027 km^2), evergreen (262 km^2), and semi-evergreen (808 km^2) forests.

Survey design

Yellow-cheeked gibbons within Phnom Prich Wildlife Sanctuary (PPWS) were sampled using auditory surveys recording from 'listening posts' (Brockelman & Ali, 1987). Based on prior knowledge of gibbon habitat preferences within PPWS listening posts were restricted to evergreen and semi-evergreen forest patches and no surveys were conducted within the dipterocarp forest. Listening posts were distributed randomly within 4 habitat strata (2 major classes and 2 minor classes) generated from the MPW-JICA-2000 land cover data set (JICA, 2000). The two initial major classes were evergreen and semi-evergreen forest. Within each of these major classes a substratum for a riparian zone i.e. a buffering of the major streams by 250 m on either side (total riparian zone width 500 m) was generated. This stratification resulted in 4 classes: evergreen forest, riparian evergreen forest, semi-evergreen forest and riparian semi-evergreen forest. From each of these four strata 15 survey sites were generated randomly across the whole of PPWS, using the x-tools extension in ArcGIS (ESRI, 1999), with the restriction that no two listening posts be located closer than 3 km from each other. A total of 60 listening post sites were identified; however data were not collected from 7 listening posts (2 in evergreen forest, 2 in semi-evergreen forest and 3 in riparian semi-evergreen forest) leaving a final data set of 53 listening posts for analysis (Fig. 4).

Survey timing and methodology

Previous observations of yellow-cheeked gibbon in Cambodia and Vietnam suggest vocalizations are more frequent in the dry season (November-April), with heavy rainfall suppressing vocal activity (Rawson, 2004; Rawson *et al.*, 2009). Consequently, to maximize the song bouts heard by surveyors, data collection was carried out during the dry season with surveys conducted between January and April 2008. Listening post surveys were conducted on 3 consecutive mornings between 05:00 and 12:00, with all duet and solo songs recorded. For all song bouts the following information was recorded: compass bearing direction to the group, estimated distance of calling, time of starting and ending of all song bouts, and type of song. As solo songs can be performed by non-mated individuals who are not resident within the area, data from solo songs were excluded from final analysis. In addition given that variation in topography and weather conditions between listening posts are both known to affect carrying distance of gibbon calls (Cheyne *et al.*, 2008) it was assumed that song bouts >1.5 km from listening posts could not be recorded reliably and consistently. Therefore prior to data analysis all calling records estimated to be >1.5 km from listening posts were also excluded.

Data Analysis

The total number of gibbon groups within PPWS was estimated based on gibbon densities surrounding each listening post calculated using Jiang *et al.*, (2006) modified version of the equations from Brockelman & Ali (1987).

Gibbon calling frequency (p) across PPWS was calculated by summing the vocalizations from all posts for the first day and dividing by the sum of the cumulative vocalizations of all posts over the three day period (Jiang *et al.*, 2006). Across our listening posts this value was 0.77. The cumulative proportion of the total number of gibbon groups heard calling over 3 survey days at listening posts (calling probability p(m)) can subsequently by determined by the equation:

$$p(m) = 1- [1- p]^m$$

Where p = calling frequency and m = number of survey days i.e. 3

Across the listening posts surveyed this calling probability, over 3 consecutive survey days, was 0.988.

The total estimated number of gibbon groups at each listening post (X^i) was then estimated using the equation:

$$X^i = n^i / P(m)$$

Where n^i = cumulative number of gibbon groups heard in the three days period at listening post i, P(m) = calling probability over 3 survey days (i.e. 0.988).

The density of gibbon at each listening post (D^i) was then calculated using the equation:

$$D^i = X^i / a^i$$

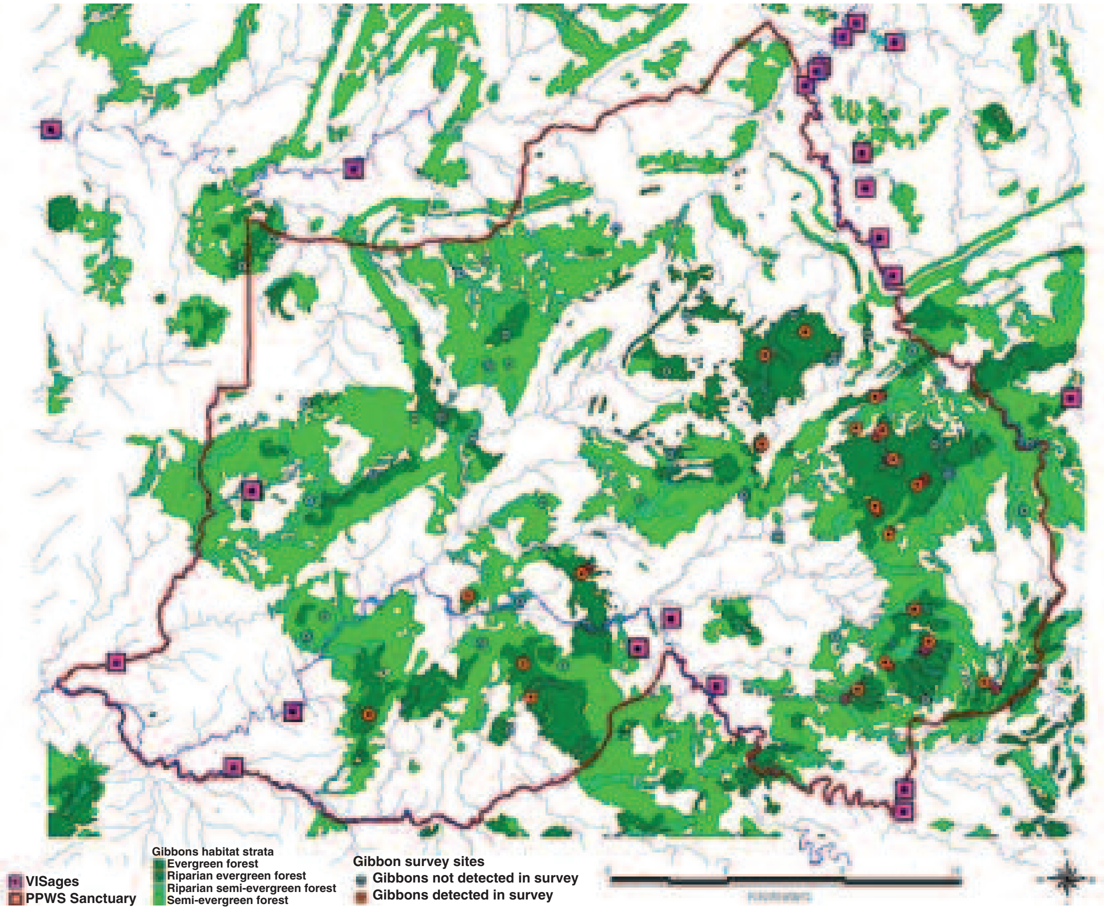

Fig. 4. Distribution of listening posts and presence/absence of yellow-cheeked gibbon (*Nomascus gabriellae*) from these listening posts within Phnom Prich Wildlife Sanctuary.

Where X^i = estimated number of gibbon groups at listening posti; ai = survey area at listening posti (i.e. 7.065 km^2; see below).

This estimate depends upon the effective survey area surrounding listening posts, and previous studies on yellow-cheeked gibbons, including Rawson's *et al*. (2009) observation of focal individuals, have suggested 1.5 km as a reasonable maximum carrying distance for vocalizations (Duckworth *et al*., 1995; Traeholt *et al*., 2005). Therefore gibbon densities were calculated within a 1.5 km radius (7.065 km^2) of each listening post.

Mean gibbon density within each habitat stratum was subsequently calculated from densities at all listening posts within each habitat type. The total population of gibbon groups within each habitat stratum (X^y) was then calculated using the equation:

$$X^y = d^y * S^y$$

Where d^y= mean density of gibbon groups across all listening posts within habitat stratum y, S^y= total area of habitat stratum y.

The total gibbon population across PPWS was then calculated by summing the estimated total population of gibbon groups across the four habitat strata.

Field surveys within Lomphat Wildlife Sanctuary and Prey Khieu

In order to clarify the distribution of yellow-cheeked gibbons North of PPWS, listening posts were established within suitable evergreen forest in Lumphat Wildlife Sanctuary (approximately 13.2^o N, 106.3^o E; 2 listening posts) and Prey Khieu (former Kingwood logging concession) on the

Mondulkiri/Kratie provincial border (approximately 13.3º N, 106.4º E; 3 listening posts). Listening posts within Lomphat were located within Prey Thmon, an evergreen forest block of approximately 80 km^2, close to the Mondulkiri/Ratanakiri provincial border (Fig. 3). Listening posts were surveyed on three consecutive mornings at each site during February and March 2008. During both surveys local villagers, particularly older people and former hunters, were interviewed by MoE rangers and questioned about the presence/absence of gibbon within the area.

RESULTS

Population size of yellow-cheeked crested gibbon in Phnom Prich Wildlife Sanctuary

Yellow-cheeked gibbons were detected from all surveyed habitat strata and from four of the six management ranges of Phnom Prich Wildlife Sanctuary (Fig. 4). A total of 57 gibbon groups were heard with records from 17 (32%) of the 53 listening posts. The number of gibbon groups heard per listening post ranged from 0 to 7 groups, with a mean of 1.08 groups (± 1.875 SD). Density of gibbon groups varied between 0.12 and 0.19/km2 across the four habitat strata with non-riparian forest apparently holding higher gibbon densities (Table 1). Semi-evergreen forest within the wildlife sanctuary is estimated to support 89 gibbon groups, with 36 in evergreen forest and a total of 24 between riparian evergreen and semi-evergreen forests (Table 1). The total gibbon population within PPWS was therefore estimated at 149 groups. Assuming an average group size of 4 individuals (an adult pair and 1-4 sub-adults; Geissmann *et al.*, 2000), and ignoring non-mated individuals, gives a population estimate for the site of approximately 600 individuals.

Distribution of yellow-cheeked crested gibbon in Phnom Prich Wildlife Sanctuary

Based on the distribution of occupied listening posts the yellow-cheeked gibbon population within PPWS is largely restricted to evergreen forest patches in the South and East of the wildlife sanctuary (Fig 4) with records from two distinct blocks: Phnom Kongshal/Kong Chilok/Laoka to the East and around Sre Khitong in the southwest. These strongly correspond to the largest blocks of evergreen forest within the wildlife sanctuary, highlighting the importance of medium-large fragments of such forest for the species (Fig. 3). Yellow-cheeked gibbons were not recorded from either Antrong management range, in the North-west of the site, or from the smaller Dei Ey range in the East.

Status of yellow-cheeked crested gibbon within Lomphat WS and Prey Khieu

No gibbons were recorded from any of the listening posts within Lomphat WS or Prey Khieu. Local people encountered around Prey Khieu reported gibbon had never been present within the area. Interviewees from villages surrounding Prey Thmon, Lumphat reported gibbon were present during the 1960s and 1970s but were heavily hunted and are no longer present.

DISCUSSION

The yellow-cheeked gibbon population within Phnom Prich Wildlife Sanctuary (PPWS) is of global significance for the conservation of this endangered species. We estimate 149 groups within the protected area which, assuming 4 individuals per group

Table 1. Mean density (± SEM) of yellow-cheeked gibbon groups (*Nomascus gabriellae*) surrounding listening posts within four habitat strata, and estimated total number of groups (95% CI range) within each habitat strata, in Phnom Prich Wildlife Sanctuary, Mondulkiri

Habitat Type	Area (km^2)	Group density (km^{-2})	Number of groups
Evergreen forest	205	0.18 ± 0.19	36 (15-57)
Semi-evergreen forest	469	0.19 ± 0.36	89 (0-183)
Riparian evergreen forest	46	0.13 ± 0.25	6 (0-12)
Riparian semi-evergreen forest	146	0.12 ± 0.28	18 (0-21)
TOTAL			149 (15-273)

(Geissman *et al.*, 2000; Pollard *et al.*, 2007), gives an overall estimate of > 550 individuals. This represents the first robust population estimate for yellow-cheeked gibbons at this site and complements a similarly rigorous estimate of approximately 800 groups (>3,500 individuals) from the adjacent Seima Biodiversity Conservation Area (SBCA; Rawson *et al.*, 2009; Pollard *et al.*, 2007). Assessing the global relevance of these populations is, however, clouded by uncertainties of the taxonomic status of *Nomascus* taxa within Laos and northern Cambodia, and the lack of rigorous population estimates from elsewhere within the species' range. Traeholt *et al.* (2005) estimated in excess of 10,000 gibbon groups around Virachey National Park, Ratanakiri and whilst, as the authors acknowledged, this rapid survey may overestimate the population, Virachey is still likely to support the largest *Nomascus* population within Cambodia. Recent genetic (Van Ngoc Thinh, pers. comm.) and vocalization studies (Konrad & Geissman, 2006) however suggest this population more closely resembles *N. siki* of southern Laos and central Vietnam. Only limited evergreen forest remains between PPWS and Virachey and, with our surveys suggesting gibbon absence from Lumphat WS and Prey Khieu, PPWS may represent the current northern limit of typical *N. gabriellae*. Prey Khieu, in the former Kingwood logging concession, forms part of an apparently large block of evergreen forest (>1,000 km^2) east of the Mekong river in Stung Treng and Kratie Provinces. This area was also partially surveyed by Traeholt *et al.* (2005) in 2003; again no gibbon was recorded.

In southern Vietnam substantial populations of yellow-cheeked gibbon are believed to be restricted to Cat Tien National Park (estimated <200 groups in two sub-populations) and possibly Bu Gia Map National Park to the south of SBCA (Geissmann *et al.*, 2000; Rawson, pers. comm.). Both populations may be severely targeted by hunters. Given apparent rapid and on-going habitat loss within two additional protected areas within the species' range (Snoul Wildlife Sanctuary, Kratie and Phnom Nam Lyr Wildlife Sanctuary, Mondulkiri) it seems likely that PPWS supports the second largest protected area population (after the adjacent SBCA) of yellow-cheeked gibbons. These two protected areas are therefore essential for the species' survival.

Limitation of current survey

Although more rigorous than the previous estimate of 360 groups residing in PPWS, derived from the rapid surveys of Traeholt *et al.* (2005), this current study may inaccurately estimate the population of yellow-cheeked gibbons within PPWS for a number of reasons. Variation in effective survey area around listening posts may affect the precision of our final population estimates. Carrying distances of gibbon calls can be affected by terrain (Cheyne *et al.*, 2008). Therefore variation in topography surrounding the randomly distributed listening posts within PPWS could have caused non consistent survey areas between listening posts. As with previous studies on yellow-cheeked gibbon (Duckworth *et al.*, 1995; Traeholt *et al.*, 2005; Rawson *et al.*, 2009) we calculated gibbon density assuming a maximum carrying distance of song bouts of 1.5 km. However under some circumstances, for example if listening posts are located within valleys, carrying distance may be reduced, which could lead to an underestimation of the total gibbon population. For example, using the more conservative value of 1 km gives a total estimate of >300 gibbon groups within PPWS.

Population estimates may also be affected by inaccurate identification of the extent of available habitat from remotely sensed data sets. Within SBCA Rawson *et al.* (2009), also using the 2000 JICA data-set, found no significant differences in gibbon density between evergreen, semi-evergreen and mixed deciduous forests dominated by *Lagerstroemia spp.*. It was concluded that the resolution of JICA was insufficient to represent the heterogeneous nature of deciduous forests within SBCA with many gibbon groups in these areas utilising small patches of evergreen forest located on hills or along rivers. Ad-hoc ground-truthing of the JICA data set during 2008 around PPWS (e.g. near Dei Ey) has also found some areas classified as deciduous dipterocarp forest strongly resemble semi-evergreen forest and may thus be suitable for gibbon (Gray, pers. observ.).

Conversely assuming that the entire habitat classified by JICA as evergreen/semi-evergreen forest is suitable for gibbons may over-estimate the population. These forest types are often patchily distributed within the deciduous forest matrix of PPWS (Fig 4) and many fragments may be too small or isolated to support gibbon. The preliminary results of a logistic regression model of gibbon habitat preferences and distribution within PPWS, based on gibbon presence/absence from the listening posts, indicates a potential threshold fragment size of >15 km^2; smaller fragments, representing greater than 50% of the evergreen forest cover within PPWS, were predicted as unsuitable for the species (Gray *et al.*, unpubl.). Restricting the extent of suitable habitat to that predicted by the model gives an estimate of <100 gibbon groups within PPWS (Gray *et al.*, unpubl.). Further work exploring the minimum fragment size of evergreen/semi-evergreen forest capable of supporting gibbon is clearly necessary for accurate assessment of gibbon population size for monitoring purposes.

Habitat preferences of yellow-cheeked gibbons in Phnom Prich Wildlife Sanctuary

Within PPWS yellow-cheeked gibbons were detected within all four habitat types surveyed: evergreen forest, semi-evergreen forest, riparian evergreen forest and riparian semi-evergreen forest type. These findings confirm that the species may be quite flexible in its habitat usage (Rawson. *et al.*, 2009) and is not restricted to one specific habitat type. Mean density of gibbon groups did not differ greatly between habitat types although densities appeared lower in riparian than non-riparian habitats. Highest gibbon densities were apparently found within semi-evergreen forest (0.19 groups/km^2) with an estimated population within this habitat type of 89 groups; two-thirds of the total within PPWS. Previous gibbon studies, other than Rawson *et al.* (2009) in SBCA, have however suggested that evergreen forest is the preferred habitat for gibbon. In contrast our results indicate that semi-evergreen forest in PPWS supports a higher population density than evergreen forest. It is possible however that this conclusion is misleading as the boundary between semi-evergreen and evergreen forest can be gradual and thus difficult to define precisely. Therefore the remote sensing-generated classification used here may not be precise. There is also the distinct possibility that some listening posts located in semi-evergreen forest allowed detection of gibbon groups that actually were occurring in evergreen forest. The habitat preference model (Gray *et al.*, unpubl.) and the distribution of occupied listening posts across PPWS (Fig. 4) strongly suggest that evergreen forest is the preferred habitat of yellow-cheeked gibbons with a high proportion of listening posts within semi-evergreen forest unoccupied. Within PPWS gibbon presence within semi-evergreen forest may be highly dependent upon the proximity to large blocks of evergreen forest. The variety of resources present year-round within these evergreen forests may be essential for maintaining gibbon populations in this habitat type even during periods of low-resource availability.

Gibbon densities within PPWS (<0.2 groups/km^2) are lower than the adjacent SBCA (>0.7 groups/km^2). This probably reflects the patchier and fragmented distribution of suitable habitat within the deciduous dipterocarp (DDF) matrix with a number of evergreen/semi-evergreen forest patches within PPWS too small or isolated to support gibbon groups. Despite the presence of considerable evergreen and semi-evergreen forest (c. 200 km^2) yellow-cheeked gibbons were not recorded within the North-west of PPWS e.g. Antrong range and North-west Keo Ropov. These areas are separated from other, occupied areas of PPWS, by considerable DDF containing only small fragments of semi-evergreen forest and evergreen forest (Fig. 4). This DDF may act as a barrier to gibbon dispersal (Srikosamatara & Doungkhae, 1982) preventing the colonisation of northwestern PPWS.

Threats to yellow-cheeked gibbons in Phnom Prich Wildlife Sanctuary

The main threats to yellow-cheeked gibbons within PPWS appear to be habitat loss and degradation caused by legal and illegal extractive activities (primarily gold mining and selective logging) and associated activities within the wildlife sanctuary. Yellow-cheeked gibbons are, however, regarded as generally tolerant to, at least, minor habitat alterations (Geissmann *et al.*, 2000; Rawson *et al.*, 2009). Indeed wider studies into the long-term affects of commercial logging on primates have largely demonstrated a surprising resilience to habitat alteration particularly among species with high dietary flexibility (Plumtree, 1994; Chapman *et al.*, 2000; Guo *et al.*, 2008). However infrastructure developments associated with logging and other extractive activities are well documented to ease access to remote forest areas thereby facilitating hunting, permanent settlements and further habitat degradation (Schwartzman *et al.*, 2000; Laurance *et al.*, 2008).

As with much of Mondulkiri poorly regulated mining operations appear likely to have the biggest impact on the conservation value of PPWS in the near future. Gold mining activities were recorded during field surveys in the vicinity of four listening posts. Habitat degradation associated with gold mining includes harvesting of wood for fuel in mineral processing and for the construction of stairs and supports for underground mines (Claassen & Ou, 2007). Human population density can also increase around gold mines with outsider laborers coming in to work the mines, and clearing forest for settlement and subsistence agriculture. This in-migration into PPWS may also increase the demand for wildlife products.

Survey teams also recorded evidence of illegal logging and associated infrastructure within PPWS. Most loggers appeared to be from outside

Mondulkiri, and were targeting *Afzelia xylocarpa*, a globally threatened and valuable tree (IUCN listed as "Endangered"; IUCN, 2008). Although gibbons are widely hunted across Indochina hunting activity of gibbons was not recorded in PPWS during this survey. However hunting is likely to remain at least a background threat, and enforcement patrols, particularly targeting core gibbon areas and around mining and logging camps, are necessary.

Although the gibbon population within PPWS seems relatively large and may therefore be resilient to extinction in the short-term, increased enforcement, through patrols to limit hunting and, more importantly, prevent further land-use change within the wildlife sanctuary are essential. Local extinctions of gibbons associated with habitat clearance and intensive hunting are widely reported in the literature (Geissmann *et al*., 2003; Zhou *et al*., 2005; Jiang et al., 2006) and our interviews suggest extinction from Lumphat Wildlife Sanctuary during the Khmer Rouge-era (see results). It seems possible therefore that, despite some tolerance to habitat degradation, gibbons may be amongst the species most rapidly lost from poorly protected habitat.

CONCLUSIONS

Despite acute threats to its potential biodiversity value, primarily from mining and illegal logging, Phnom Prich Wildlife Sanctuary has the potential to be crucial for conservation and the ecological integrity of the Eastern Plains Landscape of Cambodia. Estimating population size for focal species, and assessing their distribution within PPWS, is essential. This study establishes a baseline population estimate for yellow-cheeked gibbons and highlights the global significance of PPWS for this endangered primate, and suggests the site represents the northern limit of the species' distribution within Cambodia. The study provides further support to WWF's commitment to conservation within the sanctuary and highlights the global conservation value of evergreen forest patches within the deciduous dipterocarp matrix of the Lower Mekong Dry Forest Ecoregion.

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THỰC TRẠNG PHÂN BỐ VÀ SINH CẢNH CỦA LOÀI VƯỢN ĐEN MÁ HUNG (*NOMASCUS GABRIELLAE*) TẠI KHU BẢO TỒN THIÊN NHIÊN HOANG DÃ PHNOM PRICH, MONDULKIRI, CAM PU CHIA

TÓM TẮT

Vượn đen má hung (*Nomascus gabriellae*) hiện đang là loài bị đe dọa trên toàn cầu (IUCN-loài Nguy cấp), phân bố hẹp tại phía đông sông Mê kông thuộc Campuchia, Việt Nam và Lào. Các đợt khảo sát được tiến hành tại Khu bảo tồn thiên nhiên hoang dã Phnom Prich, tỉnh Mondulkiri, Campuchia nhằm đánh giá thực trạng quần thể loài vượn đen má hung đang sinh sống trong và quanh khu bảo tồn này. Dữ liệu về phân bố và mật độ quần thể loài này được thu thập qua việc ghi âm tiếng hót của động vật từ tháng 1 đến tháng 4 năm 2008. Đoàn khảo sát đã ghi âm tiếng vượn hót ở các địa điểm độc lập và thực hiện ghi âm vào ba buổi sáng liên tiếp nhau nhằm ước tính mật độ các đàn vượn. Ba mươi lăm địa điểm để ghi âm tiếng vượn hót được lập ra trên một diện tích 866 km2 có sinh cảnh sống phù hợp của loài này. Các địa điểm này được dùng để ghi nhận ước tính về mật độ quần thể loài vượn. Quần thể vượn trong Khu bảo tồn thiên nhiên Phnom Prich ước tính 149 đàn vượn (95% hạng CI : 15-273). Tuy nhiên sinh cảnh sống phù hợp của loài tại phía tây bắc của khu bảo tồn này và một phần thuộc Khu bảo tồn thiên nhiên Lumphat thuộc tỉnh Ratanakiri, nhưng không có ghi nhận gì về sự hiện

diện của loài vượn này ở đây. Với kết quả trên đã cho thấy giới hạn cư trú loài này ở phía bắc Khu bảo tồn thiên nhiên Phnom Prich. Ước tính quần thể vượn trong khu bảo tồn tương ứng với tổng số > 800 đàn vượn tại Khu bảo tồn đa dạng sinh học Seima, có một khu bảo tồn khác đã ghi nhận phân bố của loài vượn với số quần thể tương tự như vậy. Trong số các khu bảo tồn, Khu bảo tồn thiên nhiên Phnom Prich có thể là nơi sinh sống lớn thứ hai trên toàn cầu của quần thể loài vượn đen má hung (*Nomascus gabriellae*) nhưng hiện nay chúng vẫn chưa được phân loại rõ ràng. Các mối đe dọa đến loài vượn trong Khu bảo tồn thiên nhiên Phnom Prich phần lớn là do mất sinh cảnh sống và sự thoái hóa rừng của các hoạt động khai thác (khai mỏ và gỗ) cũng như các hoạt động phát triển cơ sở hạ tầng liên quan khác. Tuy nhiên với sự quản lý chặt chẽ hơn trong tương lai thì khu bảo tồn này sẽ là nơi đem lại giá trị bảo tồn đầy tiềm năng cho loài vượn đen má hung nhờ vào các biện pháp bảo tồn đang thực hiện nhằm giảm thiểu được mức độ đe dọa lên loài và sinh cảnh sống đa dạng của dãy rừng thường xanh rộng lớn này.

REFERENCES

Brandon-Jones, D., Eudey, A.A., Geissmann, T., Groves, C.P., Melnick, D.J., Morales, J.C., Shekelle, M. & Stuart, C.B. (2004): Asian primate classification. Int. J. Primatol. 25, 97-164.

Brockelman, W.Y. & Ali, R. (1987): Methods of surveying and sampling forest primate populations. In: Marsh, C.W. & Mittermeier, R.A. (eds.) Primate Conservation in the Tropical Rainforest; pp. 23-62. Alan R. Liss, Inc, New York.

Brockelman, W.Y. & Srikosamatara, S. (1993): Estimating density of gibbon groups by use of the loud songs. Am. J. Primatol. 29, 93–108.

Champan, C.A,, Balcomb, S.R., Gillespie, T.R., Skrupa, J.P. & Struhsaker, T.T. (2000): Long-term effects of logging on African primate communities: a 28-year comparison from Kibale National Park, Uganda. Conservation Biology 14, 202-217.

Cheyne, S.M., Thompson, C.J.H., Phillips, A.C., Hill, R.M.C. & Limin, S.H. (2008): Density and population estimate of gibbons (*Hylobates albibarbis* in the Sabangau catchment, Central Kalimantan, Indonesia. Primates 49, 50-56.

Claassen, A.H. & Ou R. (2007): A stream and wetland survey of southwestern Phnom Prich Wildlife Sanctuary and adjacent areas, with a focus on large waterbirds. WWF Greater Mekong, Cambodia Country Programme, Phnom Penh.

Duckworth, J.W., Timmins, R., Anderson, G.Q.A., Thewlis, R.M., Nemeth, E., Evans, T. D., Dvorak, M. & Cozza, K.E.A. (1995): Notes on the status and conservation of the gibbon Hylobates (*Nomascus*) gabriellae in Laos. Tropical Biodiversity 3, 15-27.

ESRI (1999): ArcView GIS 3.2a. Environmental Systems Research Inc, Redlands, California, USA.

Geissmann, T. (2007): Status reassessment of the gibbons: Results of the Asian Primate Red List Workshop 2006. Gibbon Journal 3, 5-15.

Geissmann, T., Nguyen Xuan Dang, Lormee, N. & Momberg, F. (2000): Vietnam Primate Conservation Review 2000. Part 1: Gibbons. Fauna & Flora International – Indochina Programme, Hanoi.

Geissmann, T., Nguyen Xuan Dang, Lormée, N. & Momberg, F. (2003): Status review of gibbons in Vietnam. Asian Primates 8, 10-12.

Guo S.T., Ji W.H., Li B.G. & Li M. (2008): Responses of a group of Sichuan snub-nosed monkeys to commercial logging in the Qinling Mountains, China. Conservation Biology 22, 1055-1064.

IUCN (2008): IUCN red-list 2008. http://www.iucnredlist.org/.

Jiang X.L., Luo Z.H. & Zhao S.Y. (2006): Status and distribution patterns of black crested gibbon (*Nomascus concolor jingdongensis*) in Wulian Mountains, Yunnan, China: implications for conservation. Primates 47, 264-271.

JICA (2000): Cambodia Reconnaissance Survey Digital Data Project. Ministry of Public Works and Transportation. Phnom Penh, Cambodia.

Konrad, R. & Geissmann, T. (2006): Vocal diversity and taxonomy of Nomascus in Cambodia. Int. J. Primatol. 27, 713-745.

Laurance, W.F., Croaes, B.M., Guissouegou, N., Buih, R., Dethier, M. & Alonso, A. (2008): Impacts of Roads, Hunting, and Habitat Alteration on Nocturnal Mammals in African Rainforests. Conservation Biology 22, 721-732.

Plumptree, A.J. (1994): The effect of selective logging on the primate populations in the Budongo Forest Reserve, Uganda. J. Applied Ecology 31, 631-641.

Pollard, E., Clements, T., Nut Meng Hor, Sok Ko & Rawson, B. (2007): Status and conservation of globally threatened primates in the Seima

Biodiversity Conservation Area, Cambodia. WCS, Phnom Penh.

Rawson, B.M. (2004): Vocalisation Patterns in the Yellow-cheeked Crested Gibbon (Nomascus gabriellae). In: Nadler, T., Streicher, U. and Ha Thang Long (eds.) Conservation of Primates in Vietnam; pp. 130-136. Frankfurt Zoological Society, Hanoi.

Rawson, B.M., Clements, T.J. & Nut Meng Hor (2009): Status and Conservation of Yellow-cheeked Crested Gibbons in Seima Biodiversity Conservation Area, Mondulkiri Province, Cambodia. In: Lappan, S. & Whitaker, D.M. (eds.) The Gibbons: New Perspectives on Small Ape Socioecology and Population Biology. Springer, New York.

Schwartzman, S., Moreira. A. & Nepstad, D. (2000): Rethinking tropical forest conservation: Perils in Parks. Conservation Biology 14, 1351-1357.

Srikosamatara, S. & Doungkhae, S. (1982): Dry dipterocarp forest as a barrier to gibbon dispersal: A survey in Phu Phan National Park, northeast Thailand. Nat. Hist. Bull. Siam Society 30, 25–32.

Timmins, R.J. & Ou R. (2001): The Importance of Phnom Prich Wildlife Sanctuary and Adjacent Areas for the Conservation of Tigers and Other Biodiversity. WWF Cambodia Conservation Program, Phnom Penh, Cambodia.

Traeholt, C., Bunthoeun, R., Rawson, B., Samuth, M., Virak, C. & Vuthin, S. (2005): Status review of pileated gibbon Hylobates pileatus and yellow cheeked crested gibbon *Nomascus gabriellae* in Cambodia. Fauna & Flora International - Cambodia Programme, Phnom Penh.

Zhou, J., Wei, F. & Li, M. (2005): Hainan black-crested gibbon is headed for extinction. Int. J. Primatol. 26, 453-465.

9

CONSERVATION STATUS OF PRIMATES IN TA KOU NATURE RESERVE

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SUMMARY

Ta Kou Nature Reserve (NR) is situated in the southern central coastal region of Vietnam and is characterized by a dry coastal monsoon climate. The total protected 11,866 ha core-zone includes 1,104 ha on the 697 m high Ta Kou Mountain and a 10,762 ha coastal sandy flat area. The 5,957 ha buffer-zone includes anthropogenesis ecosystems and desertified coastal sandy land. Using intensive survey our ongoing project has confirmed the occurrence of six primate species including two species of leaf monkeys (*Trachypithecus*), three species of macaques (*Macaca*) and one species of loris (*Nycticebus*). Numbers of both colobine species are more than 60 based on best count method. While the Annamese silvered langur (*Trachypithecus margarita*) and the black-shanked douc langur (*Pygathrix nigripes*) are restricted to the mountain, the three macaques are found in most areas of the reserve and often seen close to agricultural areas. The pygmy loris (*Nycticebus pygmaeus*) is found in the lowland dry dipterocarp-dominated forests and semi-evergreen forest on the mountain. The project also addressed three main threats on the primates in the reserve: trapping, disturbance by tourists and potential disease transmitting from uncontrolled release of animals, especially primates by Buddhists. Our preliminary results suggest that Ta Kou NR plays an important role in conservation of biodiversity in the coastal areas of Vietnam and may be considered as an example of how small forest patches may serve as a sink for recolonisation of important elements of biodiversity in this region. In addition, it is an ideal place to study niche-partitioning by sympatric colobine species and we plan to test a number of hypotheses about ecological differences between members of *Pygathrix* and *Trachypithecus*.

INTRODUCTION

At the country level, six primate genera and 24 (or 25) primate taxa are recognized (Brandon-Jones *et al*., 2004; Pham Nhat, 2002). The taxonomy and distribution of Vietnam primates has been reviewed in several works of national and international primatologists (Brandon-Jones *et al*., 2004; Corbet & Hill, 1992; Fooden, 1996; Groves, 2003; Nadler *et al*., 2003; Nadler, *et al*., 2005; Pham Nhat, 2002) and conservation status of these primates have also been assessed (MacKinnon & MacKinnon, 1987; Nadler *et al*., 2007; Ratajszczak, 1989). In recent years there is an increasing knowledge about the systematic classification, distribution, threats and also about the biology and ecology of the primates in Vietnam (Nadler *et al*., 2007); however, conservation status of most species, especially population size are still unknown except for some species with populations less than 1000 individuals such as the Cat Ba langur, Delacour's langur, Tonkin snub-nosed monkeys, grey-shanked douc langur, and the eastern black gibbon (Mittermeier *et al*., 2007). Moreover, there is still a lack of information on the occurrence of several species and many areas in Vietnam have yet to be intensively surveyed (Nadler *et al*., 2007). Most primate surveys have focused on the central and northern region of the country, only a few studies have been conducted in the southern region. Thus, the distribution and conservation status of primates in southern Vietnam are understudied and most information on this topic come from protected area feasibility studies conducted by Forest Inventory and Planning Institute. In Ta Kou NR, the feasibility study listed five primate taxa including the pygmy loris (*Nycticebus pygmaeus*), pig-tailed macaque (*Macaca leonina*), long-tailed macaque (*Macaca fascicularis*), stump-tailed macaque (*Macaca arctoides*) and silvered langur (*Trachypithecus margarita*). However, these reports do not provide adequate citations or records for the presence and the status of these primate species and are limited value. Thus there is a need to assess the current status of all primate taxa in the nature reserve to provide the management board of the reserve high quality information about the conservation status of primates in particular and biodiversity in general. In December 2007 we initiated a long-term study to assess the status of primates in Ta Kou NR, with a particular focus on the populations of the black-shanked douc langur (*Pygathrix nigripes*) and the Annamese silvered langur to better understand the habitat requirements of these primates in the reserve. The study is a part of projects funded by IUCN NL/Ecosystem Grants Programme and SeaWorld and Busch Garden Conservation Fund.

MATERIAL AND METHODS

Study area

Ta Kou Nature Reserve is situated in the southern central coastal region of Vietnam and is characterized by a dry coastal monsoon climate. Its coordinates are 10°41' - 10°53' N, latitude and 107°52' - 108°01' E longitude. The total protected 11,866 ha core-zone includes 1,104 ha on the 697 m high Ta Kou Mountain and a 10,762 ha coastal sandy flat area. The 5,957 ha buffer-zone includes anthropogenesis ecosystems and desertified coastal sandy land. With 751 vascular plants and 178 terrestrial vertebrates recorded by FIPI II (1996) Ta Kou NR was considered to have a low biodiversity value. However, current knowledge on the area places Ta Kou NR within a critical priority landscape in the Southern Annamite, i.e. SA7 (Baltzer *et al*., 2001) and its native forests should be recognized for their high biodiversity (Ly & Luu, 2007). The reserve supports at least four main ecosystems: sub-tropical evergreen forest, tropical semi-deciduous forest, deciduous forest, and dipterocarp lowland forest.

Methods

- Semi-structure interview: before conducting field surveys, semi-structure interviews were carried out focusing on local people especially retired and active hunters, traditional healers, and rangers to obtain information on the diversity, distribution and status of primates in the area. This method was also used to assess threats to and trends of primate populations during the last 30 years.
- Transect surveys: after reviewing the results of the interviews in light of our knowledge of the nature reserve, we conducted both day and night time surveys along transects in the forests on the mountain and lowland areas. Because of difficult terrain on the mountain, available trails were used for the surveys. There were 48 days of 9 surveys carried out in the areas from December 2007 to May 2009. Daytime observations usually began at 5:30 am and finished at 18:00, and night time surveys were carried out between 19:30 and 22:30. Primates observed were allocated to species based on diagnostic features and we attempted to photograph primates whenever they were encountered. The number of animals, their sex and age class were recorded if possible (following Brockelman & Ali, 1987). The time of observation was noted and location was marked with the GPS. On the mountain, because of rough terrain, location of animal/group was identified by location of observer, distance from observer to animal/group and angle between observation direction and the North direction. The habitat of the animal, such as habitat type and forest condition was also noted.

- Total census: During transect surveys the location and group size of the two colobines were recorded. To get a better understanding of the conservation status and population dynamics of black-shanked douc and silvered langurs we conducted a 5-day total census on the mountain with 10 observers. Group size, sex and age classes of all individuals were determined whenever the doucs were encountered. For the Annamese silvered langur, only group size and age classes were noted due to modest level of sexual dimorphism exhibited by adults.

RESULTS AND DISCUSSION

List of primates observed in the reserve

Most people interviewed reported the occurrence

Fig. 1. Ta Kou Mountain, Ta Kou Nature Reserve. *Photo: Luu Hong Truong.*

of five primate species with the black-shanked douc langur not being noted. Only two traditional medical heelers, who collect herbal plants, and a veteran soldier reported the presence of doucs on the mountain. No information regarding gibbons now or in the past was recorded for this area. In addition, we used informal information for assessing threats to biodiversity in general and primates in particular and for trends on population size changes for the last 30 years. Through our surveys, we are able to confirm six primate species to occur in the reserve including the pygmy loris, long-tailed macaque, northern pig-tailed macaque, stump-tailed macaque, Annamese silvered langur and black-shanked douc langur.

According to local people the populations of all species in the reserve have declined over the last 30 years. However, it appears that the Annamese silvered langur and black-shanked douc langur populations have been recovering in the recent years, while the population of three macaque species have sharply decreased. The main reason for this is the fact that hunting pressures have decreased while trapping is still common so that terrestrial and semi-terrestrial animals (including macaques) are expected to be impacted more than arboreal species (including the colobines).

Species account

Pygmy loris (*Nycticebus pygmaeus*): the species was reported to be most often seen in the lowland forest dominated by dipterocarps. During our survey, we observed one animal in the lowland forest and two in the semi-deciduous forest on the Takou Mountain. Three pygmy lorises, a mother with twins were confiscated from a local household and then released into the forest on February 19, 2009. The total population of the species in the nature reserve

Fig. 2. Pygmy loris (*Nycticebus pygmaeus*) at Ta Kou Nature Reserve.

Photo: Tran Van Bang.

is still unknown but seems to be more abundant than other protected areas in southern Vietnam based on our survey records.

As noted by Nadler *et al*. (2007) the pygmy loris is widely distributed in Indochina but total population is unknown. IUCN listed the species as VU and predicts additional decline in population due to it being hunted for food, traditional medicine, and pet trade.

Long-tailed macaque (*Macaca fascicularis*): This species is mainly found in evergreen, semi-deciduous and deciduous forests closed to agricultural land and at elevation below 550 m asl. Two groups with at least 15 animals were seen in the deciduous forest below 200 m. One small group of five was seen at the elevation of 550 m asl. in the same habitat as the colobines. According to local people long-tailed macaques are quite abundant on Ta Kou and Ta Dang Mountains. One animal was seen with a collar ring and we assume it was released in Ta Kou NR by Buddhists. Local people blame the long-tailed macaque for raiding banana farms and this species is the target of trapping.

This species has one of the largest geographic distributions of any nonhuman primate being found in throughout southern Indochina, Myanmar, Indonesia, and the Philippines. Groves (2001) recognizes 10 subspecies for this species, two of which are found in Vietnam. *M. f. condorensis* that occurs on the Con Dao Islands and *M. f. fascicularis* that occurs on the mainland of Vietnam south of about 140N. Large groups with several dozen individuals have been observed in Nui Chua NP. Between 2004 and 2008, an average of 24,000 long-tailed macaques was traded for laboratory purposes (Eudey, 2008) and most are traded from China, a country outside of the species natural range. It is suspected that many of the long-tailed macaques traded from China were captured in their natural habitat and were illegally traded to China (Eudey, 2008).

Northern pig-tailed macaque (*Macaca leonina*): This species also has a wide geographic range being found throughout Indochina, peninsular Thailand, Myanmar, Bangladesh, India and southern China (Groves, 2001). At Ta Kou this species is primarily found in deciduous forests closed to agricultural land, and evergreen and semi-deciduous forests at the elevation range between 300m and 500 m asl. Three groups with at least 20 animals were observed in Ta Kou NR. Northern pig-tailed macaques are quite rare in Ta Kou NR and are usually found in small groups and even solitary individuals have been observed. A group of more than 60 individuals was seen in Bu Gia Map NP where human disturbance is lower than at Ta Kou. In Nui Chua and Phuoc Binh NPs, groups of more than 20 individuals were most often seen. The small group size of northern pig-tailed macaques in Ta Kou NR could be related to the high pressure of trapping.

Stump-tailed macaque (*Macaca arctoides*): This macaque ranges through southern China and much of Indochina north of 110N thus Ta Kou is at the southern most part of its range. This species was observed several times by one of the authors during surveys for previous projects (Luu Hong Truong, pers. com.). Local people and rangers also reported the stump-tailed macaque on the mountain but we did not record any in this project. The species was reported to forage in semi-deciduous forest and only some solitary animals were seen in the nature reserve.

Stump-tailed macaques have been reported to forage in groups from five to 60 individuals (Fooden, 1990; Rowe, 1996). High pressure of trapping in Ta Kou NR may lead to solitary animals are seen more frequently than groups since as more terrestrial species, the stump-tailed macaque is more affected by trapping than other macaques (Duckworth *et al*., 1999).

Annamese silvered langur (*Trachypithecus margarita*): this species was first reported to occur at Ta Kou in 1996 by Forest Inventory and Planning Institue under the scientific name of Presbytis critata, however, the source of this information was unclear as was the species' status. We first photographed the species in the reserve in 1999 (Hoang Minh Duc, 2003). During our recent surveys, three groups with at least 60 individuals were observed in the nature reserve. The largest group of more than 35 individuals is most often seen close to the large reclining Buddha statue and is fairly habituated. The social structure of the species appears to be multi-male and multi-female. The color of both sexes is similar and lighter than *Trachypithecus germaini* from the Hon Chong limestone area and Phu Quoc NP. While the male's face is totally black, some females have pink eye rings. Babies with typical orange coat were seen from April to July. There is one albino individual that is a member of a group of 17. The species is found in semi-deciduous forest and evergreen forest at the elevation range between 400 m and 650 m asl.

The Annamese silvered langur has recently been proposed to be a distinct species from other silvered langurs with a distribution east of the Mekong River in Laos, Cambodia, and Vietnam (Nadler *et al.*, 2007; 2005). According to Nadler *et al.* (2005) this species differs from the Indochinese silvered langur (*Trachypithecus germaini*) by having pink eye rings. We also have recorded a female Anammese silvered langur with pink eye rings in Bu Gia Map NP; however, this feature cannot be argued to be a typical or diagnostic characteristic of the species since all males in Ta Kou NR have a black face and only some females have pink eye rings. While the status of the species in other countries is unknown it is only poorly know in Vietnam with most information on its distribution being based on interviews or hunting specimens. The species use to be quite abundant in the Central Highlands including Dak Nong, Dak Lak and Gia Lai Provinces (Hoang Minh Duc, pers. observ.). Recently we have recorded this species in the upper region of the Se San River (Chu Pah, District, Gia Lai Province), Bu Gia Map NP (Binh Phuoc Province – in captivity), and Cat Tien NP (Dong Nai Province). Nadler *et al.* (2007) reported that Dong Nai Province is its southern limit and Quang Tri Province its northern limit in Vietnam. We are unaware of any recent confirm sightings of this species north of Gia Lai Province however.

Fig. 3. Annamese silvered langur (*Trachypithecus margarita*) at Ta Kou Nature Reserve.
Photo: Tran Van Bang.

Black-shanked douc langur (*Pygathrix nigripes*): The species was first confirmed to be present in the nature reserve in 2007. During our census at least 64 individuals in eight groups with group size ranging between three and 30 individuals and fission – fusion was seen daily and seasonally. The largest group was 30 individuals observed in December 2008. The reason for fission – fusion of black-shanked douc langurs is still unclear. At least three neonates were seen from February to April. Among the 64 observed individuals, only 40 were classified as adult, juvenile, infant and baby. The ratio between mature and immature is 1:0.46. We could not identify sex of 37 individuals because of canopy obstruct and long distance between observers and the animals. Sex ratio among known sexual individuals is 1 male to 0.88 female. The species is found in semi-deciduous forest and

Fig. 4. Black-shanked douc langurs (*Pygathrix nigripes*) at Ta Kou Nature Reserve.
Photo: Hoang Minh Duc.

evergreen forest between 350 and 630 m asl. One group is frequently found on both sides of the cable line and thus apparently often crosses over a 20m wide patch of ground. The black-shanked douc langur is sympatrically distributed with the Annamese silvered langur. This species has a fairly broad distribution across southern Vietnam and southeastern Cambodia (to the east of the Mekong River) and certainly appears to be common in Vietnam than is the Annamese silvered langur.

THREATS

Trapping

While hunting by firearms is absent from the reserve thanks to a gun confiscation program in the last decade, trapping is still common, especially on the mountain where the rough terrain limits patrolling by rangers. Long-tailed and pig-tailed macaques are two main targets of poachers. Instead of setting snare traps, poachers leave maize in some areas to attract long-tailed and pig-tailed macaques. After the monkeys are get use to feeding on this maize, the poacher constructs a big enclosure and place maize within it. Using this method they are able to attract a number of monkeys into the enclosure and thus capture several monkeys at once. We lack information on wildlife trade routes in the area but expect live animals, such as monkeys, to be transported to other provinces.

Human disturbance

A major threat to primates specifically and all animals more generally at Ta Kou is the high level of human activities. There are three pagodas on the mountain which attract visits by about 300,000 people each year. Because of the lack of awareness on environmental protection, visitors disposed huge amount of rubbish (primarily cans, plastic bottles, and food wrappers) along the cable line, around the Buddha statues and inside the forest. Most tourists did not know they are in a protected area and therefore, are required to follow regulations when visiting. Furthermore, noise from the cable driver and the many human visitors disturb a wide range of animals on the mountain.

Transmission of diseases from uncontrolled release of primates

A common Buddhist practice is to release animals on homeless souls' days. In addition to releasing birds, two primate species, pygmy lorises and long-tailed macaques are commonly released at this time. These primates are brought from outside the NR and are released without health checks or consultation with the NR management board. These activities may foster the transmission of diseases from released animals to native primates.

Agriculture encroachment

In the lowland areas of the NR agriculture encroachment is a continuing problem. In 2008, over 80 ha of the ecological rehabilitation area was illegally converted to agriculture land. At the lower altitudinal zone of the Ta Kou Mountain, people also slash and burn forest to establish banana farms. These activities reduced the habitat of primates in the reserve.

Although not as serious of a problem, tapping resin and charcoal production also affects the animals and their habitats. Tapping resin and charcoal production activities often accidentally cause forest fires that regularly threaten portions of Ta Kou. It is estimated that approximately 80% of the Ta Kou NR forest is flammable so most is threatened by fire.

CONCLUSIONS AND RECOMMENDATIONS

- Ta Kou Nature Reserve is an important refuge for primates and other animals and thus, its protection is critical for biodiversity conservation in this region of Vietnam.
- Further studies should be conducted to:
  - Continue to study the status of primates
  - Predict the viability of douc and silvered langurs populations using Vortex
  - Study niche-partitioning by two sympatric colobine species

We also plan to continue our efforts to educate local governments, tourist agencies, conservation organizations of the importance of Ta Kou Nature Reserve; to develop programs to increase the awareness of biodiversity and the environment for local communities; and to work closely with the NR management board to provide biodiversity conservation skills and awareness to the staff of Ta Kou.

ACKNOWLEDGEMENTS

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HIỆN TRẠNG BẢO TỒN LINH TRƯỞNG TẠI KHU BẢO TỒN THIÊN NHIÊN TÀ KOU

TÓM TẮT

Khu bảo tồn thiên nhiên Tà Kou nằm trên vùng bờ biển miền Trung Nam bộ Việt Nam và mang đặc điểm gió mùa khô ở ven biển. Tổng diện tích vùng lõi của khu bảo tồn là 11,866 ha trong đó ngọn núi Tà Kou cao 697 m chiếm diện tích 1,104 ha và phần còn lại 10,762 ha là vùng cát biển bằng phẳng. Vùng đệm có diện tích 5,957 ha bao gồm các hệ sinh thái đang chịu tác động của con người và vùng đất cát bờ biển hoang hóa. Bằng cách sử dụng phương pháp khảo sát chuyên sâu, dự án hiện nay của chúng tôi đã xác định được sự hiện diện của sáu loài linh trưởng bao gồm hai loài voọc, ba loài khỉ và một loài culi. Tổng số cá thể 2 loài voọc khoảng hơn 60 con, ghi nhận được dựa trên phương pháp đếm tốt nhất. Trong lúc loài voọc bạc và loài chà vá chân đen sinh sống chủ yếu trong vùng núi thì ba loài khỉ được ghi nhận hầu hết trên toàn bộ khu bảo tồn và thường được nhìn thấy gần các khu vực sản xuất nông nghiệp. Culi nhỏ được tìm thấy trong các khu rừng khô, thấp với cây họ dầu chiếm đa số và rừng bán thường xanh trên núi. Nghiên cứu cũng hướng đến các biện pháp giải quyết ba mối đe dọa chính lên loài linh trưởng trong khu bảo tồn, đó là: đặt bấy, sự quấy rầy của khách du lịch và khả năng truyền bệnh từ các loài động vật hoang dã khác được phóng thích mà không được quản lý như điều kiện sức khỏe hay loài không phân bố ở đây, còn nữa là một số linh trưởng được các nhà sư phóng thích vào tự nhiên. Các kết quả ban đầu của dự án đã chỉ ra rằng KBT Ta Kou đóng vai trò quan trọng trong công tác bảo tồn đa dạng sinh học ở vùng bờ biển Việt Nam. Nơi đây được xem như một ví dụ điển hình về khu bảo tồn có diện tích nhỏ nhưng vẫn có thể bảo vệ và bảo tồn được nhiều loài động thực vật bản địa. Thêm vào đó, đây cũng là một nơi lý tưởng có thể nghiên cứu phân loại của các loài khỉ ăn lá đang sinh sống trong cùng khu vực. Chúng tôi hiện đang lập kế hoạch kiểm tra một số giả thuyết về sinh thái khác nhau giữa các cá thể của *Pygathrix* và *Trachypithecus* trong KBT này.

REFERENCES

Baltzer, M.C., Nguyen Thi Dao & Shore, R.G. (eds.) (2001): Towards A Vision for Biodiversity Conservation in The Forests of The Lower Mekong Ecoregion Complex, Hanoi and Washington D.C., WWF Indochina/WWF US.

Brandon-Jones, D., Eudey, A.A., Geissmann, T., Groves, C.P., Melnick, D.J., Morales, J.C., Shekelle, M. & Stewart C.-B. (2004): Asian Primate Classification. Int. J. Primatol. 25, 97-164.

Brockelman, W.Y. & Ali, R. (1987): Method of surveying and sampling forest primate populations. In: Marsh, C.W. & Mittermeier, R.A. (eds.): Primate Conservation in The Tropical Rain Forest. New York, Alan R. Liss.

Corbet, G.B. & Hill, J.E. (1992): The Mammals of The Indomalayan Region: A Systematic Review. Natural History Museum Publications, Oxford University Press.

Duckworth, J.W., Salter, R.E. & Khounboline, K. (compilers) (1999): Wildlife in Lao PDR: 1999 status report. Vientiane, IUCN – The World Conservation Union / Wildlife Conservation Society / Centre for Protected Areas and Watershed Management.

Eudey, A.A. (2008): The crab-eating macaque (*Macaca fascicularus*): Widespread And Rapidly Declining. Primate Conservation 23, 129-132.

Fooden, J. (1990): The bear macaque, *Macaca arctoides*: a systematic review. J. of Human Evolution 19, 607-686.

Fooden, J. (1996): Zoogeography of Vietnamese Primates. Int. J. Primatol. 17, 845-899.

Groves, C.P. (2003): Primate Taxonomy. Smithsonian Institution Press, Washington D.C. and London.

Groves, C.P. (2003): Taxonomy and Biogeography of Primates in Vietnam and neighbouring Regions. In: Nadler, T., Streicher, U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam. Frankfurt Zoological Society, Hanoi.

Hoang Minh Duc (2003): New Record on Distribution of the silvered langur in Limestone Mountain of Kien Luong District, Kien Giang Province, Vietnam. Asian Primates 8, 21-23.

Ly, N.S. & Luu, H.T. (2007): Ecological characteristics of forest types on Ta Kou Mountain, Binh Thuan Province. Proceedings of the 2nd National Scientific Conference on Ecology and Biological Resources. Hanoi 26. October 2007; pp. 556-562. Agriculture Publishing House. (In Vietnamese with English abstract).

MacKinnon, J. & MacKinnon, K. (1987): Conservation status of the primates of the Indo-Chinese Subregion. Primate Conservation 8, 187-195.

Mittermeier, R.A., Ratsimbazafy, J., Rylands, A.B., Williamson, L., Oates, J.F., Mbora, D., Ganzhorn, J.U., Rodríguez-Luna, E., Palacios, E., Heymann, E.W., Cecília, M., Kierulff, M., Long Yongcheng, Supriatna, J., Roos, C., Walker, S., & Aguiar, J.M. (2007): Primates in Peril: The World's 25 Most Endangered Primates 2006-2008. Primate Conservation 22, 1 – 40.

Nadler, T., Momberg, F., Nguyen Xuan Dang & Lormee, N. (2003): Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys. Fauna & Flora International-Vietnam Program and Frankfurt Zoological Society, Hanoi.

Nadler, T., Vu Ngoc Thanh & Streicher, U. (2007): Conservation status of Vietnamese Primates. Vietnamese J. Primatol. 1(1), 7-26.

Nadler, T., Walter, L. & Roos, C. (2005): Molecular evolution, systematics and distribution of the taxa within the silvered langur species Group (*Trachypithecus* [*cristatus*]) in Southeast Asia. Zool Garten (NF) 75, 238-247.

Pham Nhat (2002): Primates of Vietnam. Agriculture Publishing House, Hanoi (in Vietnamese).

Ratajszczak, R. (1989): Notes on The current status and conservation of primates in Vietnam. Primate Conservation, 134-136.

Rowe, N. (1996): The Pictorial Guide to the Living Primates. Pogonias Press, New York.

10

PRELIMINARY SURVEY ON PRIMATES IN PHU QUOC NATIONAL PARK, KIEN GIANG PROVINCE, VIETNAM

LE KHAC QUYET AND NGUYEN VU KHOI

SUMMARY

Two field surveys focused on primates were carried out in Phu Quoc National Park, Kien Giang Province, from 7th to 20th December 2008, and 23rd to 24th March 2009. Field observations confirmed two individuals of northern slow loris (*Nycticebus bengalensis*), seven groups with a total of 30 individuals (estimated 31 to 44 individuals) of Indochinese silvered langurs (*Trachypithecus germaini*), and five groups of long-tailed macaques (*Macaca fascicularis*) with a total of 22 individuals (estimated 37 to 41 individuals) This is the first confirmation of *N. bengalensis* as well as the first population estimation of *T. germaini* in Phu Quoc National Park. The occurrence of *M. arctoides*, reported from surveys in the past, could not be confirmed through observations. Threats to the primates in Phu Quoc National Park include hunting and habitat disturbance due to human activities. These are important points to take into account for a management plan for the park. Management and conservation activities in the national park have been enhanced, but there are still some human activities that are affecting the conservation outcomes in the national park.

It is recommended that further field surveys are conducted to gather accurate information on the primate fauna in Phu Quoc National Park.

INTRODUCTION

Phu Quoc National Park consists of a 31,442 ha core zone, 6,144 ha of land-buffer zone and about 20,000 ha of sea-buffer zone. The national park is located in six communes of Phu Quoc District: Cua Cạn, Ganh Dau, Bai Thom, Ham Ninh, Duong To and Cua Duong.

To date, there is limited information concerning the mammal fauna of Phu Quoc National Park. In the past there were only 25 mammal species known (Dang Huy Huynh *et al*., 1994; Morovov, 2005; Abramov *et al*., 2007). In the most recent report, 43 mammal species belonging to 18 families and six orders are listed (Nguyen Xuan Dang & Dang Huy Phuong, 2007). A new species, the white-toothed shrew (*Crocidura phuquocensis*) was discovered in 2008 (Abramov *et al*., 2008).

According to prior survey results, there are four primate species recorded; the northern slow loris (*Nycticebus bengalensis*), pygmy loris (*Nycticebus pygmaeus*), long-tailed macaque (*Macaca fascicularis*) and Indochinese silvered langur (*Trachypithecus germaini*) (Morovov, 2005; Nguyen Xuan Dang & Dang Huy Phuong, 2007). However, there has not yet been any intensive primate survey in the national park.

MATERIAL

Study Site

This report presents the results of a field survey on primates in Phu Quoc National Park, carried out from 7th to 20th December 2008, and 23rd to 24th March 2009. During 15 field days, field surveys were carried out in five locations at the national park including Quoc Phong forest, Ham Rong, Hon Chao, Nui Chua and Rach Tram (within the core zone).

METHODS

Interviews

During field work, interviews were conducted to gather basic information of the survey areas, and to select local guides. In addition, local guides provided further information during the course of the field work. Information was first collected through semi-structured interviews with local people and national park rangers/staff who possess knowledge of the primates and other animals in the forest areas near to their homes. In this way, basic information on the distribution, status and threats to the species could be obtained.

The interviews were carried out at any appropriate opportunity through "open" questioning of the interviewees and did not follow any fixed questionnaire or structure. During the interviews, pictures of primates and other animals were shown to interviewees to verify identification. As information gathered during these interviews may be erroneous, this information is quoted directly or in square brackets.

Field surveys

Field surveys were carried out via observation transect walks in the forest from 6:30 am to 5:30 pm. The survey team was divided into small groups of three or four people, including: one surveyor, one or two national park staff and one local guide. Survey teams followed existing trails or newly cut transects. The species were recorded by direct observations (naked eye or binoculars). Upon sighting an individual, thirty seconds was taken to identify its species classification as well as to count other individuals - such as its infants - within view. GPS waypoints were collected at all sight locations. All GPS waypoints were marked on topographical maps of the area and photographs were taken when possible.

Survey team members also recorded tracks, footprints and other observations of animals encountered during field surveys, especially mammals, birds, reptiles and amphibians. These records would contribute to a full assessment of biodiversity in the survey area. Threats to primates and their habitat as well as other wildlife were recorded for the purpose of evaluating the status of forest protection management in the survey area and to provide recommendations for conservation of the national park.

Data analysis

Records of primates and other animals were updated and analyzed at the end of each day. This analysis helped all members of the survey team to see results and indicate potential areas for field surveys during the following days.

Species identification of mammals was based on knowledge of the surveyors and then confirmed by referring to literature; for mammals Corbert & Hill (1992), Groves (2001), Dang Huy Phuong *et al*. (2007), Nguyen Xuan Dang & Dang Huy Phuong (2007) was utilized.

RESULTS AND DISCUSSION

Primate species

As a result of field surveys performed between 7th to 20th December 2008, and 23rd to 24th March 2009, there are records of four primate species in the survey areas within Phu Quoc National Park (Table 1). For each species, detailed field notes are provided as well as distribution and habitat data.

Pygmy loris (*Nycticebus pygmaeus*)

The pygmy loris is widely distributed in Vietnam. This species is threatened by hunting for traditional medicine and the pet trade (Fooden, 1996; Pham Nhat, 2002; Nadler *et al*., 2007; Dang Ngoc Can *et al*., 2007).

In Phu Quoc National Park, *N. pygmaeus* has been reported in Ganh Dau and Quoc Phong forests by Dang Huy Phuong *et al*. (2007). However, we did not make any observations of this species in the field during five night-time surveys. According to interviews, it was difficult to identify *N. pygmaeus* or *N. bengalensis* in Phu Quoc National Park. Nguyen Xuan Dang & Dang Huy Phuong (2007) only reported the pygmy loris in Phu Quoc from captive animals on the island.

From interviews, Dang Huy Phuong *et al*. (2007), Nguyen Xuan Dang & Dang Huy Phuong (2007) reported the pygmy loris in Ganh Dau and Quoc Phong forests of Phu Quoc National Park. In 2007, two pygmy lorises were recorded in captivity in a local house in Da Chong Commune (Nguyen Xuan Dang & Dang Huy Phuong, 2007) (Fig. 1). During this survey, we did not record any individuals of *N. pygmaeus* in the wild.

Northern slow loris (*Nycticebus bengalensis*)

The northern slow loris is distributed in the northern and central provinces of Vietnam. This species is rare in most of its distribution range. It is

Table 1. Primates recorded in Phu Quoc National Park in December 2008 and March 2009.

	Location	Conservation status	
		IUCN	**VN**
[Pygmy loris] (*Nycticebus pygmaeus*)	GD (in captivity)	VU	VU
Northern slow loris (*Nycticebus bengalensis*)	QP, HC, GD	VU	VU
Indochinese silvered langur (*Trachypithecus germaini*)	QP, HR, HC, NC	EN	VU
Long-tailed macaque (*Macaca fascicularis*)	QP, HR, HC, NC, CT, GD	LR	LR

[...] – Provisional record
QP – Quoc Phong forest, HR – Ham Rong, HC – Hon Chao, NC – Nui Chua, CT – Cau Trang, GD – Ganh Dau
VN – Vietnam Red Data Book; IUCN – 2008 IUCN Red List of Threatened Species;
EN – Endangered; VU – Vulnerable; LR – Lower Risk.

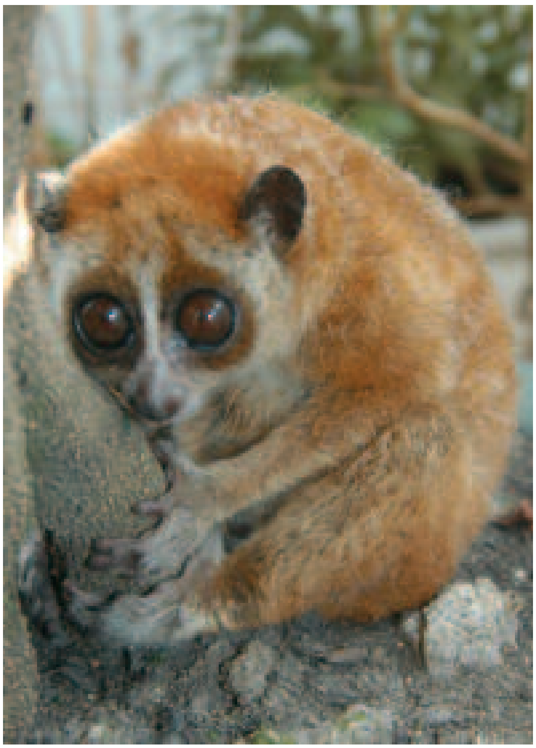

Fig. 1. Pygmy loris (*Nycticebus pygmaeus*) in a rescue centre.

Photo: Nguyen Vu Khoi

threatened by hunting for the pet trade and habitat loss (Fooden, 1996; Pham Nhat, 2002; Dang Ngoc Can *et al*., 2007; Nadler *et al*., 2007).

In Phu Quoc National Park, *N. bengalensis* is reported by Ngo Van Tri (2002), Dang Huy Phuong *et al*. (2007), and Nguyen Xuan Dang & Dang Huy Phuong (2007). The first record of northern slow loris was made by photographs of an individual confiscated in the south of Phu Quoc Island in 2006 (Nguyen Vu Khoi, pers. obs. 2006). In September 2008, Nguyen Vu Khoi (pers. obs.) again recorded one confiscated animal in An Thoi Commune of Phu Quoc by photograph (Fig. 2). This animal was released into Quoc Phong forest of the national park. During this survey, no *N. bengalensis* was recorded.

However, eight observation nights conducted by Nguyen Vu Khoi (pers. obs.) in January 2007 revealed the regular occurrence of *Nycticebus* sp. in Quoc Phong forest, in the forest edge on the road to Bai Thom and road to Ganh Dau. The observation time was from 7 pm to 9 pm. A total of five observations were made in Quoc Phong forest; two observations on the road to Ganh Dau, and one observation on the road to Bai Thom. A spot survey at the beginning of 2009 on Quoc Phong road, recorded two *N. bengalensis* (Table 2). A specimen and DNA sample were collected and conserved for further studies at the Zoological Museum of the Faculty of Biology – Vietnam National University, Hanoi

Indochinese silvered langur (*Trachypithecus germaini*)

In Vietnam, *T. germaini* is distributed from Quang Tri Province (16º37’N) southwards to the Mekong delta (Fooden, 1996; Nadler *et al*., 2003). Nadler *et al*. (2007) reported that *T. germaini* was recorded only in Kien Giang Province within Phu Quoc National Park. Recently, there have been some opportunistic records of *T. germaini* on Phu Quoc Island (Ngo Van Tri, 2002; Abramov *et al*., 2007; Nguyen Xuan Dang & Dang Huy Phuong, 2007, and Dang Huy Phuong *et al*., 2007).

This species is one of the most common primates in Phu Quoc National Park. It was reported in all interviews with the national park’s staff and rangers as well as local people. During the survey seven groups in total of 22 individuals were observed, and an occurrence of 31 to 44 in the survey areas estimated (Table 2; Fig. 3 and 4).

As a result of the field survey, a first population assessment of *T. germaini* in Phu Quoc National Park is possible. In comparison with previous reports of *T. germaini* in other locations (Nadler *et al*., 2003;

Fig. 2. Released northern slow loris (*Nycticebus bengalensis*) in Phu Quoc National Park.
Photo: Nguyen Vu Khoi

Nadler *et al*., 2007), Phu Quoc National Park harbors probably one of the largest populations of *T. germaini* in Vietnam.

Long-tailed Macaque (*Macaca fascicularis*)

The long-tailed macaque is widely distributed in South Vietnam (Fooden, 1996; Pham Nhat, 2002; Nguyen Xuan Dang & Dang Huy Phuong, 2007; Nadler *et al*., 2007; Dang Ngoc Can *et al*., 2008). According to Groves (2001) and Brandon-Jones *et al*. (2004), two subspecies of *M. fascicularis* occur in Vietnam: *M. f. fascicularis* and *M. f. condorensis*. However, the subspecies taxonomy of *M. fascicularis* in Phu Quoc National Park could not be determined due to a lack of molecular genetic data, specimens and field observations. On Phu Quoc, *M. fascicularis* is commonly kept in local households in Ganh Dau, Bai Thom (Fig. 5), Cua Can, Ham Ninh and Duong To Communes (Dang Huy Phuong et al., 2007; Nguyen Xuan Dang & Dang Huy Phuong, 2007).

This species is one of the most common primates in Phu Quoc National Park. There were records of *M. fascicularis* in most survey areas. During interviews, local people reported this species as common throughout Phu Quoc Island, particularly in mountainous and mangrove forests. There were records of five groups of *M. fascicularis* in Quoc Phong, Ham Rong, Hon Chao and Nui Chua areas (Table 2).

Stump-tailed Macaque (*Macaca arctoides*)

The stump-tailed macaque is distributed in most forested areas in the mainland of Vietnam (Fooden, 1996; Pham Nhat, 2002; Nadler *et al*., 2007; Dang Ngoc Can *et al*., 2007). On Phu Quoc, this species is often kept in local households. Dang Huy Phuong *et al*. (2007) reported stump-tailed macaques in Ganh Dau Commune with speculation about their introduction to Phu Quoc Island. There were records of *M. arctoides* in Hon Chao and Ham Rong Mountains (Nguyen Xuan Dang & Dang Huy Phuong, 2007; Dang Huy Phuong *et al*., 2007). During this survey, no individual was recorded.

Table 2. Primates recorded in Phu Quoc National Park in December 2008 and March 2009.

Group No.	**Location**	**Coordinates**	**Date of observation**	**Group size**	
				Observed	Estimated
Northern slow loris (*N. bengalensis*)					
1	Quoc Phong	UTM 48P 392340; 1141730	20/3/2009	1	1
2	Quoc Phong	UTM 48P 392321; 1141755	21/3/2009	1	2
Total				**2**	**3**
Indochinese silvered langur (*T. germaini*)					
1	Ham Rong	UTM 48P 387235; 1150498	11/12/2008	5	7
2	Ham Rong	UTM 48P 387379; 1149657	11/12/2008	4	5-7
3	Ham Rong	UTM 48P 386982; 1150574	15/12/2008	5	5-7
4	Hon Chao	UTM 48P 388399; 1153519	12/12/2008	4	5-7
5	Hon Chao	UTM 48P 389858; 1153474	14/12/2008	5	7
6	Nui Chua	UTM 48P 397288; 1143848	17/12/2008	1	3-5
7	Nui Chua	UTM 48P 395367; 1143505	18/12/2008	6	6
Total				**30**	**31-44**
Long-tailed macaque (*M. fascicularis*)					
1	Quoc Phong	UTM 48P 392334; 1141728	09/12/2008	3	10
2	Ham Rong	UTM 48P 386909; 1148898	11/12/2008	5	7
3	Ham Rong	UTM 48P 386748; 1150188	15/12/2008	4	5-7
4	Hon Chao	UTM 48P 388758; 1153202	13/12/2008	4	5-7
5	Nui Chua	UTM 48P 395249; 1146796	19/12/2008	6	10
Total				22	37-41

Fig. 3. Indochinese silvered langur (*Trachypithecus germaini*) in Phu Quoc National Park.
Photo: Le Khac Quyet.

Threats

Illegal hunting and trapping is a major threat to all wild animals in Phu Quoc National Park. Trapping activity is currently occurring in the national park. During the survey, a high number of old and new traps (made from iron cable and twigs by local people) were encountered. A dead common palm civet (*Paradoxurus hermaphroditus*) was recorded having been killed in one trap.

The traps pose a serious threat to wild animals, particularly to terrestrial animals in the national park. Hunted animals are used for local food and trade. It is necessary to prevent all hunting and trapping activities in the national park.

Non-timber forest product collection used to be common and uncontrolled in the national park, particularly *Dipterocarpus* resin. This activity not only impacts on the survival of *Dipterocarpus* trees but also seriously impacts on the habitats of wild animals, particularly primates and other endangered species in the national park. This activity no longer occurs in the park due to a regular patrol of rangers. It is necessary to maintain prevention of this activity in the national park.

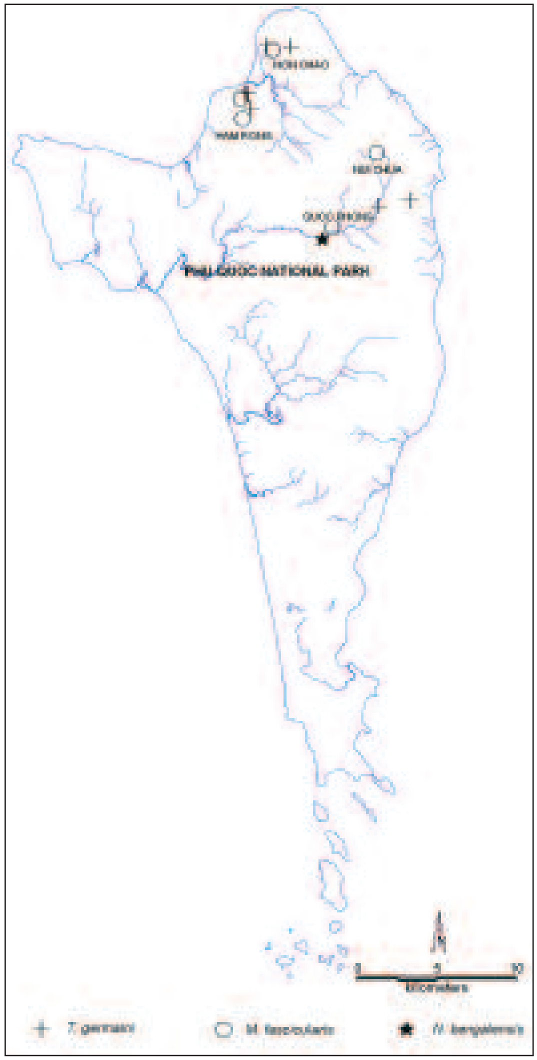

Fig. 4. Records of primates in Phu Quoc National Park. + silvered langur (*Trachypithecus germaini*); o long-tailed macaque (*Macaca fascicularis*); * Bengal slow loris (*Nycticebus bengalensis*).
Map: Bui Huu Manh.

Infrastructure development

Phu Quoc National Park is an important area for tourism and therefore there are many infrastructure projects (roads, resorts, etc.) underway in the national park. A road system is nearly completed inside the national park and in the surrounding area. This road system has fragmented the habitat of primates and other large mammals in the national park. It is a disadvantage for the long-term existence of animal populations, especially the Indochinese silvered langur.

Tourist areas and tourism activities (including eco-tourism) in Phu Quoc National Park will bring jobs and income for local people. However, these activities will have direct and indirect impacts on the national park, such as disturbance of wild animals and their habitats, littering, increasing demand for wildlife products (bush meat) and non-timber forest products. Therefore, it is necessary to improve the cooperation among various local agencies in the implementation and management of conservation activities in order to minimize their impacts on the national park and wildlife.

Conservation activities

At the moment, thanks to the efforts of the national park's management board, human activities impacting the biodiversity of Phu Quoc National Park have been considerably reduced over the last few years, especially hunting with guns. Nonetheless, due to a lack of human resources for a large national park, and the relative ease of access, there are still human activities in the core zone of the national park as detailed above.

Although Phu Quoc National Park is assessed as an area with high biodiversity values, up until now, there has been little research and few surveys of biodiversity in the national park.

RECOMMENDATIONS

The highest priority for primates in Phu Quoc National Park is a census of the population and distribution of the silvered langur. Further field surveys and studies on the northern slow loris and pygmy loris should focus on population size and distribution in Phu Quoc National Park.

A conservation awareness program for local people about the importance of the national park and its conservation, in particular for primates and other endangered animals should be initiated.

Cooperation for scientific research and conservation activities between the management board of the national park and national and international institutions should also be established.

The national park staff should be trained on data collection, survey techniques, and wildlife management.

Fig. 5. Long-tailed macaques (*Macaca fascicularis*) in captivity in Phu Quoc National Park.
Photo: Nguyen Vu Khoi.

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A sincere thanks goes to the management board of Phu Quoc National Park, for allowing field work in the national park, and to Wildlife at Risk (WAR) Vietnam for its support of this field survey.

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ĐIỀU TRA BAN ĐẦU VỀ CÁC LOÀI LINH TRƯỞNG Ở VƯỜN QUỐC GIA CÔN ĐẢO, TỈNH KIÊN GIANG, VIỆT NAM

TÓM TẮT

Hai đợt điều tra thực địa về các loài linh trưởng đã được thực hiện ở Vườn Quốc gia Phú Quốc, tỉnh Kiên Giang, từ ngày 7 – 20 tháng 12/2008 và ngày 23 – 24 tháng 3/2009. Kết quả điều tra đã ghi nhận được 4 loài linh trưởng ở vườn quốc gia này. Chúng tôi đã có ghi nhận bằng quan sát thực địa được 2 các thể Cu li lớn (*Nyticebus bengalensis*), 7 đàn với 30 (31 – 44) cá thể voọc bạc (*Trachypithecus germaini*) và 5 đàn với 22 (37 – 44) cá thể khỉ đuôi dài (*Macaca fasicularis*). Đây là xác nhận đầu tiên về loài *N. bengalensis* và ước tính số lượng quần thể của loài *T. germaini* ở Vườn Quốc gia Phú Quốc. Các mối đe dọa đối với các loài linh trưởng ở Vườn Quốc gia Phú Quốc là săn bắt và sinh cảnh bị tác động. cần có thêm những cuộc điều tra thực địa để thu thập thêm những thông tin chính xác về khu hệ linh trưởng ở Vườn Quốc gia Phú Quốc.

REFERENCES

Abramov, A.V. Kalinin, A.A., Morozov, P.N. (2007): Mammal survey on Phu Quoc Island, southern Vietnam. Mammalia 71(1/2): 40–46.

Abramov, A.V., Jenkins, P.D., Rozhnov, V.V. & Kalinin, A.A. (2008): Description of a new species of Crocidura (Soricomorpha: Soricidae) from the island of Phu Quoc, Vietnam. Mammalia 72 (4): 269–272.

Brandon-Jones D., Eudey A.A., Geissmann T., Groves C.P., Melnick D.J., Morales J.C., Shekelle M. & Stewart C.B. (2004): Asian Primate Classification. Int. J. Primat. 25, 1, 97-164.

Corbet G.B. & Hill J.E. (1992): The Mammals of the Indomalayan Region: A Systematic Review. Natural History Museum Publications, Oxford University Press.

Dang Huy Phuong, Nguyen Quang Truong, Nguyen Truong Son & Nguyen Vu Khoi (2007): A Photographic Guide to Mammals, Reptiles and Amphibians of Phu Quoc Island, Kien Giang Province, Vietnam. WAR Ho Chi Minh City. General Publishing House, Ho Chi Minh City.

Dang Ngoc Can, Hikeki Endo, Nguyen Truong Son, Tatsuo Oshida, Le Xuan Canh, Dang Huy Phuong, Lunde D.P., Shin-Ichiro Kawada, Akiko Hayashida & Mototki Sasaki (2008): Checklist of Wild Mammal Species of Vietnam. Shoukadou Book Sellers, Kyoto.

Fooden J. (1996): Zoogeography of Vietnamese primates. Int. J. Primatol. 17, 845-899.

Groves C.P. (2001): Primate Taxonomy. Smitsonian Institution Press, Washington DC.

IUCN (2009): Red List of Threatened Species <www.iucnredlist.org>. Downloaded on 12. January 2009.

Ministry of Science and Technology & Vietnam Academy of Science and Technology (2007): Vietnam Red Data Book, Part I. Animals. Publishing House of Science and Technology, Hanoi.

Morozov, P.N. (2005): New data on the bat fauna (Chiroptera) of Phu Quok Island (Vietnam). Plecotus 8: 62-67. (In Russian with English summary).

Anatomy, Taxonomy and Genetics

Chapter II

11

FURTHER OBSERVATIONS ON THE PLACENTAS OF LEAF MONKEYS

KURT BENIRSCHKE AND TILO NADLER

SUMMARY

In a review of placental slides of douc langurs, the absence of atrophied villi in the free membranes was reexamined, the superficial placentation of the implanting placenta is demonstrated in a young gestation, the frequency and potential causes of placental infarcts is reviewed, and it is urged that future studies of leaf-eating primates direct their attention to the possible presence of cell-free DNA in the maternal circulation.

INTRODUCTION

In a previous publication, the placentas of a variety of Colobine primates was summarized (Benirschke, 2008). That publication dealt primarily with the macroscopic features of this hemochorial placenta, it provided measurements and drew attention to the differences in the placental structure from that of other Cercopithecinae. Here we describe more details of the free membranes of leaf monkeys from the series of placentas delivered at Cuc Phuong and the San Diego Zoo. Some of these aspects were discussed in the previous publication; others have been added since then and are represented in the Comparative Placentation web site (http://placentation). In human placentation, the blastocyst implants “interstitially”, i.e. deeply into the developing decidua. It is thus surrounded by endometrium/decidua and consequently, the developing free membranes develop villi as well. These villi subsequently atrophy and are found in the membranes of human placentas. In contrast, such atrophic villi are never found in the Cercopithecidae. Here, a secondary disk develops in most species, except for the baboon placenta.

The placenta of most ‘higher’ primates is hemochorial. That is to say, the villous trophoblast is surrounded by maternal blood that circulates in the intervillous space. The villous surfaces are covered by two layers of trophoblast, an inner cytotrophoblast layer (Langhans’ layer) that produces the outer layer of the multicellular syncytium. The latter cells make the ‘decisions’ of transplacental exchange, have lost the ability to divide their nuclei, secrete the hormones and often show signs of apoptosis (Benirschke *et al.*, 2006). From these cells also form the “syncytial knots” (or ‘buds’). The latter are regularly swept away in the maternal bloodstream and reach the maternal lung. Schmorl (1905) and Iklé (1961; 1964) have studied these elements in some detail and the latter author has estimated that as many as 150,000 syncytial elements are transported daily in the maternal blood. The knots are more numerous in preeclampsia and, especially, in eclampsia. In the capillaries of the lung these cells die and liberate “cell-free DNA” (ffDNA). This DNA is abundant in maternal blood during pregnancy but it soon disappears after delivery. Similar ffDNA is also found in rhesus gestations and in mice (Khosrotehrani *et al.*, 2004; Jimenez & Tarantal, 2003). This ffDNA has been useful for the prenatal diagnosis of fetal sex and, in humans, for other prenatal diagnostic tests.

MATERIALS AND METHODS

The microscopic slides of the 14 douc langur placentas, 6 Angolan colobus monkeys, 2 Delacour langurs, 2 Hatinh langurs, 1 Cat Ba langur, 20 hanuman langurs and 3 Francois' langurs were reviewed; measurements and photographs had previously been taken as was described by Benirschke (2008). Special attention was paid to the condition of the "free membranes" and of the placental floor. Moreover, observations on placental infarcts were made and their possible causes were reviewed. These observations are compared with human placentas and with the literature on Cercopithecidae.

In addition, the lung and uterus of one pregnant douc langur that had died from a general infection and *Pneumonyssis* infestation were studied. This animal was pregnant with a 2 cm fetus. All placentas were also screened for the presence of syncytial "knots" in the maternal intervillous blood.

RESULTS

With the exception of one placenta from a Hatinh langur, a red-shanked douc langur and one colobus monkey that had only a single disk, all other Colobine primates had two placental disks (Benirschke, 2008). The two disks are connected by free membranes in which major fetal blood vessels traverse that connect the two placental lobes. The organs are thus quite similar to those of the rhesus monkey placenta (Ramsey, 1975) and are the result of a superficial implantation that occurs in all of these species, as was also evident from the one early douc langur placenta studied. After implanting, the future membranes touch to the opposite side of the uterus in which a second disc is formed because the trophoblastic shell is still active and locally invasive. Baboons, while otherwise similar in most respects, generally have only a single disk (Hendrickx, 1971). Moreover, they are capable of hybridization with rhesus monkeys. Two baboon placentas were available for study in which a much smaller secondary disk had developed, most of which tissue, however, had atrophied and there were no atrophic villi in the membranes. It must also be said that not all placentas of rhesus monkeys have two disks. Chez *et al*. (1972) published a study that identified around 80% of rhesus monkey placentas to have two disks, the remainder had only one disk. He assumed this to be under genetic control. The main finding to be observed here again is the absence of atrophic villi in the free membranes of leaf monkeys. Such atrophic villi are regularly found in the membranes of human placentas which have a much deeper and a so-called 'interstitial' placental implantation. The absence of atrophied villi in all Cercopithecidae studied is probably due to their very superficial implantation, including that of the douc langur blastocysts (Fig. 1). The study of two very early leaf monkey implantations (*Presbytis obscura*) from Malaysia (Burton, 1980) had very similar features as those of this early douc langur gestation shown here (Fig. 2). This is markedly different in human placentation where the blastocysts invade considerably more deeply and assume an "interstitial" implantation. After the human blastocysts have implanted, the superficial defect is covered by a diminutive amount of decidua that is destined to become the 'decidua capsularis'. When the blastocyst subsequently expands, the amount of decidua increases in quantity and is reasonably thick in term membranes. It also has many spiral arterioles and these often participate in the changes referred to as 'atherosis'. This vascular change is believed to be typical of preeclampsia. It is dubious, however, that there is actually decidual proliferation (which is unlikely because of the strong influence of progesterone). It must be considered that much of the decidua capsularis is (in part at least) derived from the decidua vera of the opposite uterine side. Vascular casts have not been made to demonstrate

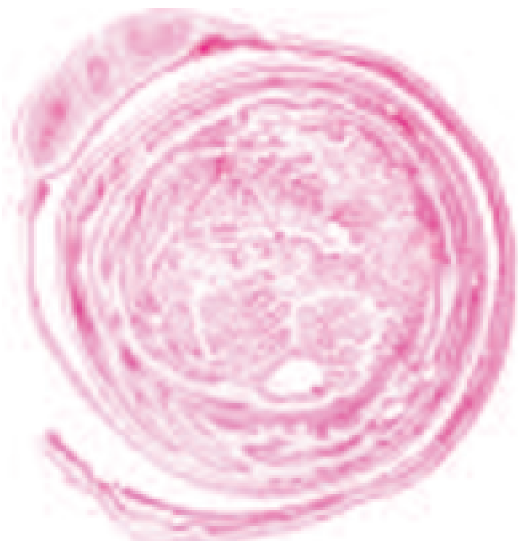

Fig. 1. Membrane roll prepared from the membranes of a douc langur at San Diego Zoo. There is virtually no decidua capsularis and no atrophied villi are present. The large 'bridging vessels' between the two placental lobes are seen at the top.

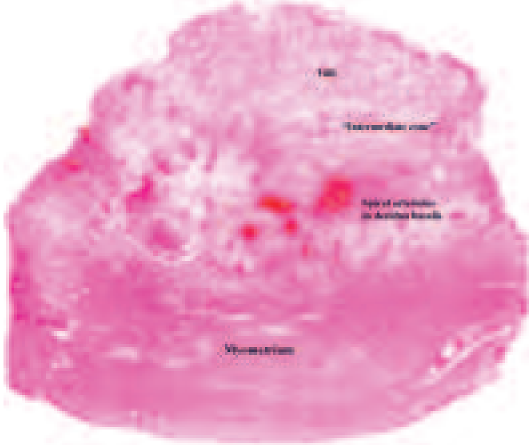

Fig. 2. Marginal infarct of a douc langur placenta from Cuc Phuong, Vietnam. The left portion of this placenta is degenerated and lacks maternal (and fetal) blood content.

Fig. 3. Placental implantation in the uterus of an early pregnant douc langur from the San Diego Zoo. The fetus was 2 cm long; the animal died from infection. The superficial implantation of this placenta is apparent and the decidualization of the basalis is indicated.

the vascular supply of this decidua capsularis and this topic is still unresolved.

One placenta from the San Diego Zoo autopsy files is of special interest. This pregnant adult died from infections, had numerous lung mites (*Pneumonyssis simicola*) and a pregnant uterus with a 2 cm fetus. While, in general, this placenta had the same superficial implantation as shown by Burton (1980) for Presbytis, the “intermediate zone” described by him was much less pronounced in this douc langur uterus. It contained only a small number of trophoblastic cells, it was much thinner, and had no degenerations. The endometrium beneath this region, however, was similarly hyperplastic although the glands were much less apparent than those previously described for *Presbytis*. Moreover, the tissue peripheral to the large spiral arterioles possessed the characteristics of human decidua (Fig. 2).

In at least one third of douc langur placentas a marginal infarct was found (Fig. 3). In human placentas, infarcts of the placenta are generally due to diseases occurring in the spiral arterioles of the decidua basalis. The most common lesion found in human placentas is the presence of altered blood vessel walls, so-called atherosis, i.e. a replacement of the muscular wall by fibrinoid and foamy, cholesterol–laden macrophages. This is most often seen in human preeclampsia but this disease presumably does not occur in cercopithecids. In contrast, the infarcts in the douc langur placentas were the result of thrombosis of these blood vessels that had occurred for as yet unknown reasons, not of atherosis.

All leaf monkey placentas had small numbers of syncytial “knots” in the intervillous maternal blood that clearly derived from the syncytial covers of the villi (Fig. 4 to 6). In the lung of one douc langur that died during pregnancy with an immature placenta, the pulmonary capillaries contain multinucleated cells (Fig. 7). Their exact nature is still speculative at this time but the finding suggests a trophoblastic origin.

DISCUSSION

The findings generally confirm earlier observations in the literature but leave open a few questions. The possibility of decidualization of the endometrium appears to be demonstrated in these animals’ pregnancies and comparative determination of progesterone levels in various species of Cercopithecidae should be a future mandatory investigative exercise. Perhaps more effort also needs to be made to rule out the existence of signs of preeclampsia in leaf-eating monkeys, as their placental infarcts are so frequent. Alternatively, the reason for thrombosis in spiral arterioles that underlies the infarcts needs to be explored.

Cell-free DNA (ffDNA) is now regularly found in human maternal blood plasma. Since the placental intervillous circulation and syncytiotrophoblast dissemination are so similar to those of human gestations it will be of interest to ascertain whether similar ffDNA exists in the maternal blood of leaf monkeys.

As was stated earlier (Benirschke, 2008), the placenta of the leaf monkeys is hemomonochorial with an intervillous circulation that is very similar to

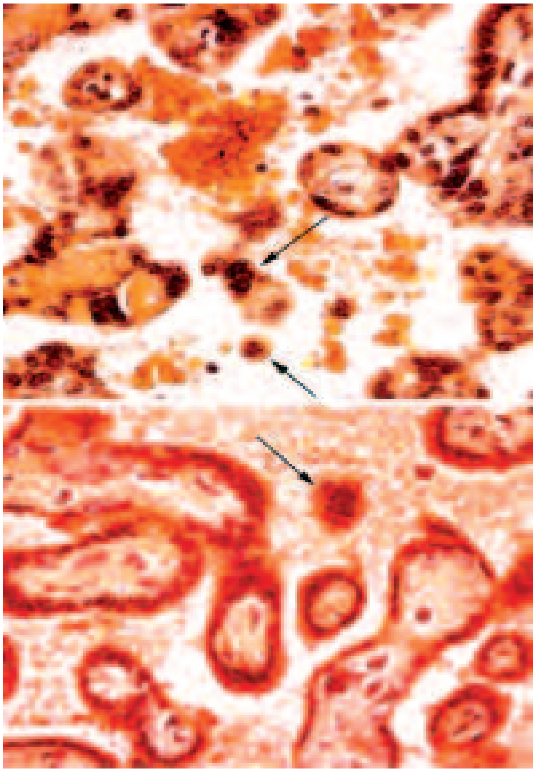

Fig. 4. Two views of different term douc langur placentas. Arrows point to the detached syncytiotrophoblast in the intervillous space, the presumed precursor of ‘cell-free DNA’.

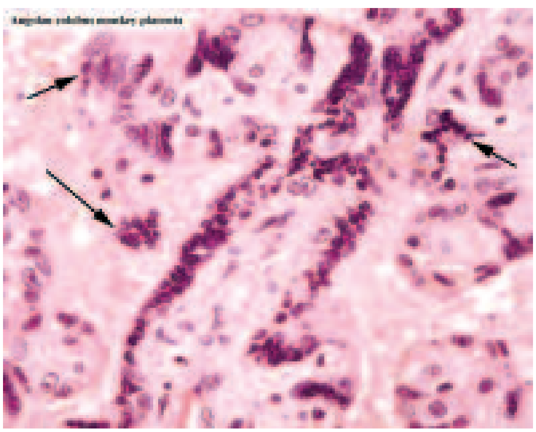

Fig. 5. Villi of term placenta in Angolan colobus monkey to show deporting syncytial knots. Arrows point at syncytial knots.

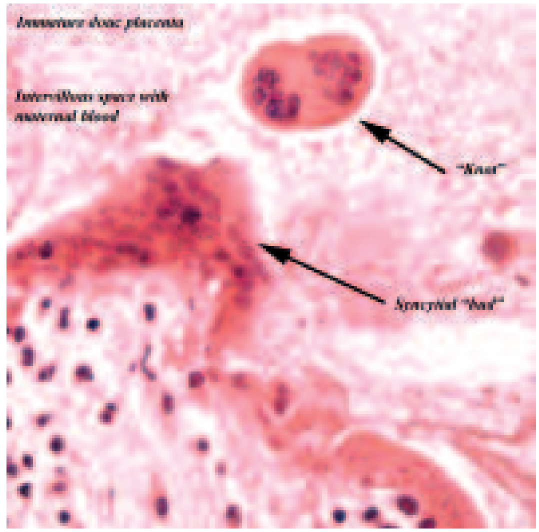

Fig. 6. Immature placenta of douc langur with syncytial knot.

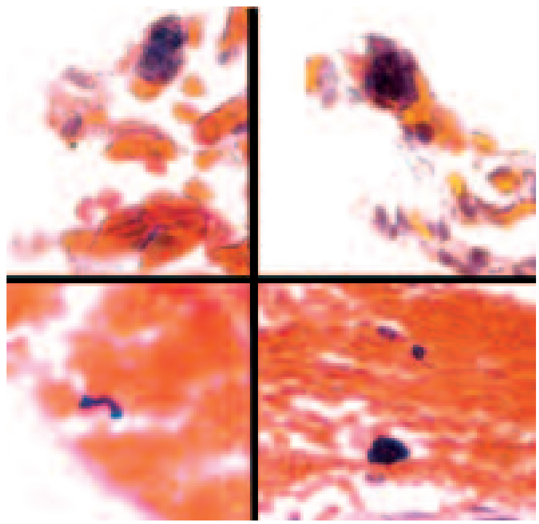

Fig. 7. Composite of pulmonary vessels of pregnant douc langur with presumptive syncytial knots.

the human placental blood flow. The maternal blood surrounds the villous syncytiotrophoblast and occasional syncytiotrophoblastic cells are found in the intervillous maternal blood (Fig. 4 to 6). Presumably they reach the maternal lung in a manner that is very similar to the transport of syncytial 'buds' in the human circulation. Here they are likely to be destroyed and the DNA is then 'liberated', appearing in the maternal blood as "cell-free DNA" (Lo *et al*., 1999; Iklé, 1961; Iklé, 1964; Jimenez & Tarantal, 2003; Khosrotehrani *et al*., 2004). ffDNA has been used in prenatal diagnosis of several human conditions and it may also be a cause of some maternal diseases of pregnancy. In rhesus, ffDNA has been useful in the prenatal diagnosis of fetal sex (Jimenez & Tarantal, 2003). This ffDNA disappears soon after the pregnancy terminates, as its life span is around 2 hours only. We know currently very little about its occurrence in most other nonhuman primates and the collection of maternal blood in pregnancies of leaf monkeys would be indicated in future studies. Moreover, it is essential that the nature of embolized possible trophoblast be studied with hCG-antibodies to verify its origin.

QUAN SÁT THÊM VỀ NHAU THAI CỦA CÁC LOÀI KHỈ ĂN LÁ

TÓM TẮT

Trong quá trình xem xét phần nhau thai của các loài voọc chà vá, chúng tôi có nhận thấy sự thiếu vắng các lông nhung đã bị teo nhỏ trong các màng tự do. Quan sát cho thấy thời kỳ đầu thai nghén của loài này, thai cấy bám vào thành bề mặt nhau thai. Tần suất và khả năng gây ra sẩy thai cũng được đánh giá và chúng tôi khuyến cáo tới các nghiên cứu trong tương lai về các loài khỉ ăn lá nên chú ý đến khả năng hiện diện của gen tế bào tự do trong quá trình di truyền từ mẹ.

REFERENCES

Benirschke, K. (2008): The placenta of Colobinae. Vietnamese J. Primatol. 1(2), 33-39.

Benirschke, K., Kaufmann, P. & Baergen, R. (2006): Pathology of the Human Placenta. 5th edition. Springer Verlag, New York.

Benirschke, K., Streicher, U. & Nadler, T. (2004): The placenta of leaf monkeys. In: Nadler, T., Streicher, U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam, pp. 144-146. Frankfurt Zoological Society, Hanoi.

Burton, G.J. (1980): Early placentation in the dusky leaf monkey (*Prebytis obscura*). Placenta 1, 187-195.

Chez, R.A., Schlesselman, J.J., Salazar, H. & Fox, R. (1972): Single placentas in the Rhesus Monkey. J. med. Primatol. 1, 230-240.

Hendrickx, A.G. (1971): Embryology of the Baboon. University of Chicago Press.

Iklé, F.A. (1961): Trophoblastenzellen im strömenden Blut. Schweiz. Med. Wochenschr. 91, 934-945.

Iklé, F.A. (1964): Dissemination von Syncytiotrophoblastzellen im mütterlichen Blut während der Gravidität. Bull. Schweiz. Akad. Med. Wissenschaft. 20, 62-72.

Jimenez, D.F. & Tarantal, A.F. (2003): Fetal gender determination in early first trimester pregnancies of rhesus monkeys (*Macaca mulatta*) by fluorescence PCR analysis of maternal serum. J. Med. Primatol. 32, 315-319.

Khosrotehrani, K., Wataganara, T., Bianchi, D.W. & Johnson, K.L. (2004): Fetal cell-free DNA circulates in the plasma of pregnant mice: relevance for animal models of fetomaternal trafficking. Hum. Reproduct. 19, 2460-2464.

Lo, Y.M.D., Zhang, J., Leung, T.N., Lau, T.K., Chang, A.M. & Hjelm, N.M. (1999): Rapid clearance of fetal DNA from maternal plasma. Am. J. Hum. Genet. 64, 218–224.

Ramsey, E.M. (1975): The Placenta of Laboratory Animals and Man. Holt, Rinehart and Winston.

Schmorl, G. (1905): Über das Schicksal embolisch verschlepperter Placentarzellen. Verh. Dtsch. Pathol. Gesellsch. 8, 39-46.

12

CHROMOSOMAL STUDIES OF LEAF-EATING PRIMATES

MARLYS L. HOUCK, KURT BENIRSCHKE, TILO NADLER, ULRIKE STREICHER, ROSCOE STANYON, AND OLIVER A. RYDER

SUMMARY

We compared the karyotypes and G-banding patterns of 10 taxa of langur including two *Pygathrix*, one *Rhinopithecus*, one *Semnopithecus*, and six *Trachypithecus* species/subspecies. The diploid chromosome number for all species studied was 2n=44 with 82 autosomal arms. The autosomes are largely conserved among all langurs studied with differences occurring primarily in the short arms. The X chromosome is completely conserved, but the Y chromosome appears in at least three different forms. The two subspecies of *P. nemaeus* are distinguished by inversions in the small arm of one autosome. G-banding is described for the first time in several langur taxa including *P. n. cinerea*, *T. delacouri*, *T. laotum ebenus*, and *T. l. hatinhensis*.

INTRODUCTION

Comparative cytogenetics is an important tool for clarifying phylogenetic relationships among species. The role of chromosomal rearrangements in molecular divergence and the speciation process is well documented (Navarro & Barton, 2003; Rieseberg & Livingstone, 2003). Karyotypes provide morphologic and banding pattern data essential for further analyses at the DNA level. Reproductive isolation and hybridization can also be usefully analyzed using chromosomal analyses. Although the Asian leaf-eating monkeys (Colobinae) have fairly conserved diploid numbers (all studied to date are 2n=44 with the exception of *Nasalis larvatus* which is 2n=48; see Schempp *et al*., 2008) fluorescence *in situ* hybridization (FISH) studies using human whole chromosome paints (WCP) have shown differences between *Pygathrix* (Bigoni *et al*., 2004) and *Trachypithecus* (Bigoni *et al*., 1997a; 1997b; Nie *et al*., 1998). It is important to know the underlying banding morphology of these species, yet G-banding has not been described for many langur taxa. Analysis of mitochondrial DNA sequences (Zhang & Ryder, 1998; Xing, 2005; Sterner *et al*., 2006) and chromosomal studies (Bigoni *et al*., 2004) support the reciprocal monophyly of African and Asian colobines. Mitochondrial DNA data support a monophyletic clade consisting of *Nasalis*, *Pygathrix*, and *Rhinopithecus* (Sterner *et al*., 2006). Finer resolution of the molecular phylogeny of this group is generally regarded to require analysis of additional taxa and incorporate more extensive sequence data, including nuclear gene sequences.

MATERIAL AND METHODS

The chromosomes of 63 langurs were studied, including 44 specimens of red-shanked douc langur (*Pygathrix n. nemaeus*), two grey-shanked douc langur (*P. n. cinerea*), three golden snub-nosed monkey (*Rhinopithecus roxellanae*), three Francois' langur (*Trachypithecus francoisi*), three Delacour's langur (*T. delacouri*), one Indochinese black langur (*T. laotum ebenus*), four Hatinh langur (*T. laotum hatinhensis*), one dusky leaf monkey (*T. obscurus*), one purple-faced langur (*T. vetulus*), and one northern plains grey langur (*Semnopithecus entellus*) (Table 1).

Table 1. Total number of individuals studied.

Species	Males	Females
Pygathrix nemaeus cinerea	1	1
Pygathrix n. nemaeus	17	27
Rhinopithecus roxellanae	1	2
Semnopithecus e. entellus	1	0
Trachypithecus delacouri	1	2
Trachypithecus laotum ebenus	1	0
Trachypithecus francoisi	1	2
Trachypithecus laotum hatinhensis	4	0
Trachypithecus obscurus	1	0
Trachypithecus vetulus	0	1

Heparinized whole blood (1.5 - 3.0 ml) and/or skin biopsies (approximately 5 mm^2) were collected from the animals during routine physicals, or post mortem. Skin biopsies were processed for fibroblast cell culture by a collagenase disaggregation technique (Houck *et al.*, 1994). Fibroblast cultures from most animals in the study are preserved in the Frozen Zoo® cell repository at the San Diego Zoo. Metaphase chromosomes were derived from fibroblast and/or lymphocyte cultures and banded using methods previously described (Kumamoto & Houck, 2001). G-band karyotypes were arranged following Bogart & Kumamoto (1978) after changing pairs 18 and 19 in their Fig. 2 to match Fig. 1 and 3 in same paper (Fig 1). Most samples were acquired from captive populations in the USA, except samples of *T. delacouri*, *T. l. ebenus*, *T. l. hatinhensis*, *P. n. cinerea*, one *P. n. nemaeus* and one *T. francoisi* which were collected from captive specimens at the Endangered Primate Rescue Center, Vietnam (Table 2), in accordance with CITES and United States regulations. CytoVision® software was used for image capture and karyotype analysis.

RESULTS AND DISCUSSION

This is the first description of G-bands in *P. n. cinerea*, *T. delacouri*, *T. l. ebenus* and *T. l. hatinhensis*. Chromosome complements were 2n=44 in all species and the number of autosome arms was constant at NAA=82, confirming previous reports for *P. n. nemaeus* (Bogart & Kumamoto, 1978; Hsu & Benirschke, 1975; Wurster & Benirschke, 1969), *R. roxellanae* (Chen *et al.*, 1979), *T. obscurus* (Hsu & Benirschke, 1971; Ponsa *et al.*, 1983), *T. francoisi* (Nie *et al.*, 1998), *T. vetulus* (Bigoni, 1995) and S. entellus (Chiarelli, 1963; Hsu & Benirschke, 1973; Ushijima *et al.*, 1964).

Table 2. Cell lines obtained from animals of the Endangered Primate Rescue Center, Vietnam.

Species	Males	Females
Pygathrix nemaeus cinerea	1	1
Pygathrix n. nemaeus	0	1
Trachypithecus delacouri	1	2
Trachypithecus laotum ebenus	1	0
Trachypithecus francoisi	0	1
Trachypithecus laotum hatinhensis	4	0

Fig. 1. G-banded karyotype of a male *P. n. cinerea* with heteromorphic pair 20 and 21.

All karyotypes consisted of 20 metacentric/submetacentric autosome pairs and one acrocentric/telocentric element (pair 20) that displays heteromorphism in *P. n. nemaeus*, where one chromosome of the pair can appear bi-armed. A marker chromosome (pair 21) with a nucleolus organizer region (NOR) identified previously in *P.n. nemaeus* (Bogart & Kumamoto, 1978; Zneimer et al., 1979, Bigoni *et al*., 2004) was seen in all species in this study. Bigoni *et al*. (2004) reported that human chromosomes 21 and 22 were associated with this marker chromosome in *P. n. nemaeus*. There appeared to be at least 12 entire autosomes and one q-arm conserved between the G-banded karyotypes of *Pyagthrix*, *Rhinopithecus*, *Trachypithecus* and *Semnopithecus*, however FISH results using HSA 6 and HSA 16 revealed differences between *T. delacouri* and *T. l. hatinhensis* that were not detected with G-banding (Fig 2), which is probably the result of a pericentric inversion. A complete FISH analysis on all taxa in this study using human whole chromosome paints and cloned DNA such as BACs (bacterial artificial chromosomes), as well as sequential banding to identify the specific chromosomes involved would more clearly identify any rearrangements.

In all species, the G-band pattern of the X chromosome was similar to that of the "original or

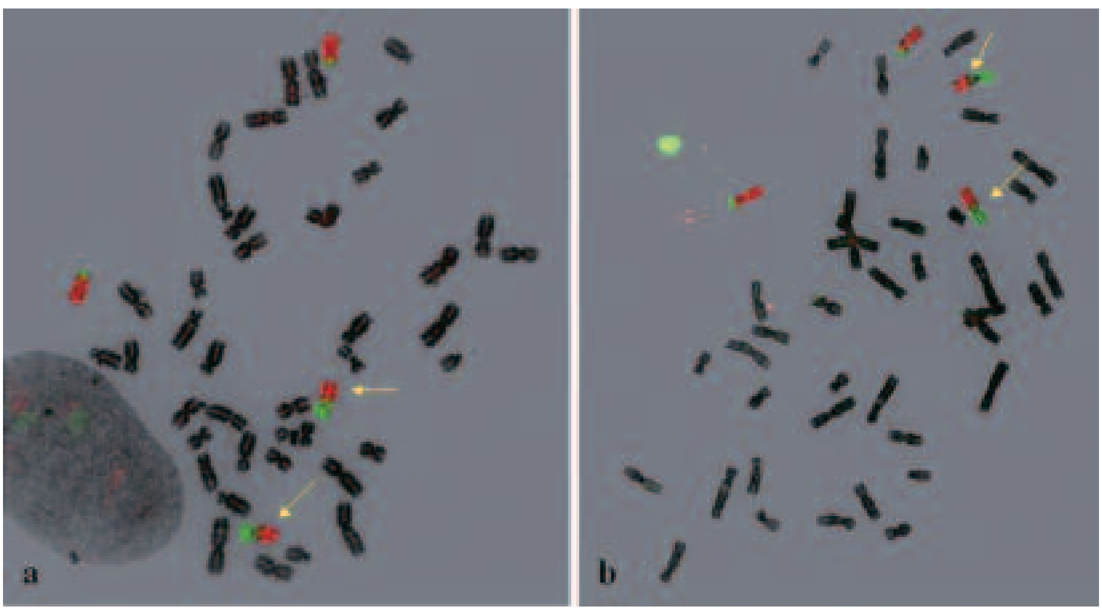

Fig. 2. Fluorescence in situ hybridization of human chromosome-specific painting probes for HSA6 (red) and HSA16 (green) on metaphase spreads of (a) *T. delacouri* and (b) *T. l. hatinhensis*. HSA6 painted to the entire long arm (q-arm) of *T. delacouri*, while in *T. l. hatinhensis* a small portion of the q-arm painted with HSA16, a difference not detected by G-banding.

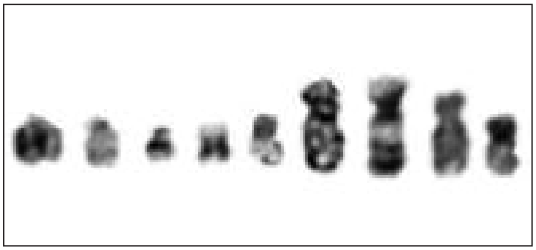

Fig. 3. Y chromosomes of (L-R): *P. n. nemaeus*, *P. n. cinerea*, *P. roxellanae*, *T .f. francoisi*, *T. delacouri*, *T. l. hatinhensis*, *T. l. ebenus*, *T. obscurus*, and *S. e. entellus*.

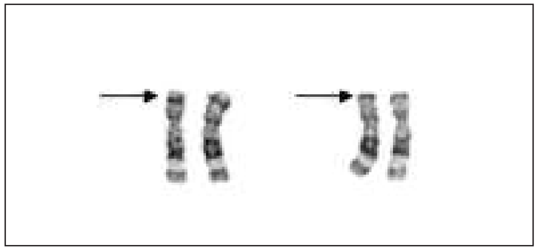

Fig. 4. Comparison of pair 2 showing light terminal band in short arm of *P. n. cinerea* (L) in contrast to the corresponding dark band in *P. n. nemaeus* (R).

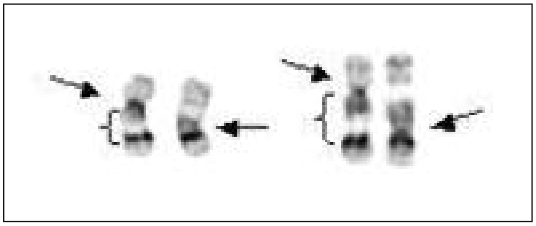

Fig. 5. Polymorphic pair 21 in *P. n. cinerea* (L) and *P. n. nemaeus* (R). All other langurs in this study were homozygous for the chromosomal morph presented on the right hand chromosome of each pair. Brackets indicate an area of probable pericentric inversion. Arrows denote centromere locations. The right hand chromosome of each pair is positioned in an inverted position with the centromere in the lower half of the chromosome, following convention for chromosomes with a secondary constriction (NOR region).

standard type" submetacentric X typical in most other primate species (Ohno, 1967; Pathak & Stock, 1974). The Y chromosome was the smallest acrocentric element in *Pygathrix*, *Rhinopithecus*, and *T. f. francoisi*, a small submetacentric (about the same size as the smallest autosome) in *T. l. hatinhensis*, *T. l. ebenus*, and *T. obscurus*, and a minute metacentric in *S. entellus* and *T. delacouri*. The morphology and G-banding differences among these taxa suggest that modifications and/or polymorphism of the Y-chromosome are taking place in these species (Fig 3). C-banding should be included in future studies to determine if the changes in Y chromosome morphology are heterochromatic.

One *P. n. nemaeus* was blood chimeric for 44,XX with a small population of 44,XY. No abnormalities were found after repeating G-band analysis on "Jack" the P. n. nemaeus with abnormalities previously reported (Bogart & Kumamoto, 1978; Benirschke *et al.*, 2004) indicating that the original abnormal findings were likely due to fibroblast cell culture artifact.

Both *P. n. cinerea* individuals were homozygous for a light terminal band in the small arm (p-arm) of pair 2, while all but one *P. n. nemaeus* was homozygous for a dark terminal band in the p-arm indicating a possible subspecies distinction. (Fig 4). A single *P. n. nemaeus* was heterozygous for the p-arm of this pair, potentially a subspecies hybrid. Sampling more *P. n. cinerea* individuals could provide confirmation of this potential subspecies difference. In addition, both *P. n. cinerea* were heterozygous for a polymorphism in pair 21 that appears to be a pericentric inversion, while the many *P. n. nemaeus* individuals could be either heterozygous for the polymorphism like cinerea, or homozygous for the "normal" form of pair 21 (Fig 5). All other langurs in this study were homozygous for the normal form.

Of particular future interest will be a study of the Cat Ba langur (*T. p. poliocephalus*) a species that has only recently been studied (Nadler *et al.*, 2003) and is completely isolated on an oceanic island.

CONCLUSIONS

Comparative cytogenetics using G-banding showed that the majority of the autosomes and the X chromosome appear conserved over 10 langur taxa studied. Morphology and G-band differences detected in the Y chromosomes suggest modifications and/or polymorphism of the Y-chromosome are taking place. Many autosomes were conserved across the 10 taxa, but p-arm differences were detected on some autosomes. Other differences not detected by G-banding (involving both the p- and q-arms) were identified by FISH painting. More detailed analysis with FISH using both chromosome paints and cloned DNA such as BACs (bacterial artificial chromosomes) is necessary to clearly define the specific differences between these langur taxa.

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NGHIÊN CỨU NHIỄM SẮC THỂ CỦA CÁC LOÀI LINH TRƯỞNG ĂN LÁ

TÓM TẮT

Chúng tôi đã so sánh các đặc tính nhiễm sắc thể karyotypes và kỹ thuật G-banding của 10 loài và phân loài voọc bao gồm hai loài *Pygathrix*, một loài *Rhinopithecus*, một loài *Semnopithecus* và sáu loài *Trachypithecus*. Số nhiễm sắc thể lưỡng bội cho tất cả các loài được nghiên cứu là 2n=44 với 88 nhánh nhiễm sắc thường. Các cá thể nhiễm sắc thường được di truyền rộng trong các loài voọc được nghiên cứu, có sự khác nhau xảy ra đầu tiên tại các nhánh nhiễm sắc thể thường ngắn. Nhiễm sắc thể X hoàn toàn được duy trì nguyên vẹn nhưng nhiễm sắc thể Y xuất hiện tối thiểu dưới ba hình thức khác nhau. Hai phân loài *P. nemaeus* được phân biệt bằng cách đảo ngược nhánh nhỏ của một thể nhiễm sắc bình thường. Lần đầu tiên kỹ thuật G-banding được dùng mô tả cho nhiều quẩn thể voọc gồm *P. n. cinerea*, *T. delacouri*, *T. laotum ebenus* và *T. l. hatinhensis*.

REFERENCES

Benirschke, K., Houck, M.L., Streicher, U., & Nadler, T (2004): Cytogenetic aspects of langurs. In: Nadler T, Streicher U, & Ha Thang Long (eds): Conservation of Primates in Vietnam; pp. 37-40. Frankfurt Zoological Society, Hanoi.

Bigoni, F. (1995): Omologia cromosomica e filogenesi nei primate: analisi molecolare e citogenetica. PhD dissertation, University of Genoa.

Bigoni, F., Koehler, U., Stanyon, R., Ishida, T. & Wienberg, J. (1997a): Fluorescence *in situ* hybridization establishes homology between human and silvered leaf monkey chromosomes, reveals reciprocal translocations between chromosomes homologous to human Y/5, 1/19, and 6/16, and delineates an X1X2Y1Y2/X1X1X2X2 sex chromosome system. Am. J. Phys. Anthropol. 102, 315-327.

Bigoni. F., Stanyon, R., Koehler, U., Morescalchi, A.M. & Wienberg, J. (1997b): Mapping homology between human and black and white colobine monkey chromosomes by fluorescence *in situ* hybridization. Am. J. Primatol. 42, 289-298.

Bigoni, F., Houck, M.L., Ryder, O.A. & Stanyon, R. (2004): Chromosome painting shows that the douc langur (*Pygathrix nemaeus*) has the most basal karyotype among Asian Colobinae, Int. J. Primat. 25, 679-688.

Bogart, M.H. & Kumamoto, A.T. (1978): Karyotype abnormalities in two primate species, *Pygathrix nemaeus* and *Lemur coronatus*. Folia Primatol. 30, 152-160.

Chen, Y., Luo, L., Shan, X. & Cao, X. (1979): The karyotype of the golden monkey (*Rhinopithecus r. roxellanae*). J. of Human Evol. 8, 597-602.

Chiarelli, B. (1963): Comparative morphometric analysis of primate chromosomes. III The chromosomes of the genera *Hylobates*, *Colobus* and *Presbytis*. Caryologia 16, 637-648.

Houck, M.L., Ryder, O.A., Vahala, J., Kock, R.A. & Oosterhuis, J.E. (1994): Diploid chromosome number and chromosomal variation in the white rhinoceros (*Ceratotherium simum*). J. of Hered. 85, 30-34.

Hsu, T.C. & Benirschke, K. (1971): *Presbytis obscurus* (Dusky langur) 2n=44. In: Hsu, T.C. & Benirschke, K. (eds): An Atlas of Mammalian Chromosomes, Vol 5, Folio 249. Springer-Verlag, New York.

Hsu, T.C. & Benirschke, K. (1973): *Presbytis entellus* (Entellus langur) 2n=44. In: Hsu, T.C. & Benirschke, K. (eds): An Atlas of Mammalian Chromosomes, Vol 5, Folio 349. Springer-Verlag, New York.

Hsu, T.C. & Benirschke, K. (1975): *Pygathrix nemaeus* (Douc langur) 2n=44 In: Hsu, T.C., Benirschke, K. (eds): An Atlas of Mammalian Chromosomes, Vol 9, Folio 450. Springer-Verlag, New York.

Kumamoto, A.T. & Houck, M.L. (2001): Cytogenetic identification of a hybrid owl monkey, *Aotus nancymaae* x *Aotus lemurinus griseimembra*. J. of Zoo and Wildlife Medicine 32(1), 130-133.

Nadler, T., Momberg, F., Nguyen Xuan Dang & Lormee, N. (2003): Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys. Fauna & Flora International-Vietnam Program and Frankfurt Zoological Society, Hanoi.

Navarro, A. & Barton, N.H. (2003): Chromosomal speciation and molecular divergence – accelerated evolution in rearranged chromosomes. Science 300, 321-324.

Nie, W., Liu, R., Chen, Y., Wang, J. & Yang, F. (1998): Mapping chromosomal homologies between humans and two langurs (*Semnopithecus francoisi* and *S. phayrei*) by chromosome painting. Chromosome Res. 6, 447-453.

Ohno, S. (1967): Sex Chromosomes and Sex-linked Genes. Springer-Verlag, Berlin.

Pathak, S. & Stock, A.D. (1974): The X chromosomes of mammals: karyological homology as revealed by banding techniques. Genetics 78, 703-714.

Ponsa, M., de Boer, L.E.M. & Egozcue, J. (1983): Banding patterns of the chromosomes of *Presbytis cristatus pyrrhus* and *P. obscurus*. Am. J. Primatol. 4, 165-169.

Rieseberg, L.H. & Livingstone, K. (2003): Evolution: Chromosomal speciation in primates. Science 300, 267-268.

Schempp, W., Munch, C., Roos, C. & Nadler, T. (2008): Chromosomal and molecular studies of a hybrid between red-shanked douc langur (*Pygathrix nemaeus*) and Hatinh langur (*Trachypithecus laotum hatinhensis*). Vietnamese J. Primatol. 1(2), 55-62.

Sterner, K.N., Raaum, R.L., Zhang, Y.-P., Stewart, C.-B. & Disotell, T.R. (2006): Mitochondrial data support an odd-nosed colobine clade. Mol. Phylogen. and Evol. 40, 1-7.

Ushijima, R.N., Shininger, F.S. & Grand, T. (1964): Chromosome complements of two species of primates: *Cynopithecus niger* and *Presbytis entellus*. Science 146, 78-79.

Wurster, D. & Benirschke, K. (1969): Chromosomes of some primates. Mamm. Chrom. Newslett. 10, 3-5.

Xing, J., Wang, H., Han, K., Ray, D.A., Huang, C.H., Chemnick, L.G., Stewart, C.-B., Disotell, T.R., Ryder, O.A., & Batzer, M.A. (2005): A mobile element based phylogeny of Old World monkeys. Mol. Phylogenet. Evol. 37(3), 872-880.

Zhang, Y.-P. & Ryder, O.A. (1998): Mitochondrial cytochrome b gene sequences of Old World monkeys: with special reference on evolution of Asian colobines. Primates 39(1), 39-49.

Zneimer, S., Kumamoto, A.T. & Benirschke, K. (1979): Banding patterns of the chromosomes of two langur species, *Pygathrix nemaeus* and *Presbytis entellus*: A comparative study. Chromosome Information Service 26, 19-21.

13

TAXON-SPECIFIC VOCAL CHARACTERISTICS OF CRESTED GIBBONS (*NOMASCUS* SPP.)

VAN NGOC THINH, TILO NADLER, CHRISTIAN ROOS, AND KURT HAMMERSCHMIDT

SUMMARY

We studied the vocal diversity of various wild crested gibbon populations (*Nomascus* spp.) to assess their taxonomic classification and to elucidate the distribution of taxa as well as their phylogenetic relationships. We recorded gibbon songs within 12 protected areas. 52 recorded groups were selected for analyses including 235 female great call phrases and 254 male multi-modulated phrases. Based on general acoustic features we were able to distinguish eastern black gibbon (*N. nasutus*) (Trung Khanh) and western black gibbon (*N. concolor*) (Muong La and Che Tao) from each other and from all other populations. The southern taxa were difficult to distinguish. Therefore, we performed discriminant function analyses, which could provide additional resolution. The results showed that northern white-cheeked gibbon (*N. leucogenys*) (Xuan Lien) and southertn white-cheeked gibbon (*N. siki*) (Phong Nha) were difficult to be separate, even with discriminant function analyses. In contrast, more southern *N. siki* populations (Da Krong, Phong Dien, Bach Ma and Chu Mom Ray) can clearly be discriminated from the Xuan Lien and Phong Nha populations as well as from yellow cheeked gibbons (*N. gabriellae*) (Phnom Prich, Ta Dung and Bi Doup-Nui Ba). In general, the study revealed that acoustic analysis could help to distinguish between crested gibbon populations and to confirm and verify phylogenetic relationships.

INTRODUCTION

Gibbons or lesser apes, family Hylobatidae, are distributed over wide ranges of South- and Southeast-Asia. They are well known for their duet songs and their monogamous social system (Geissmann *et al*., 2000). In early classifications, the family was divided into two genera, with one, *Symphalangus* including solely the siamang, and the other, *Hylobates* all the remaining species (e.g. Napier & Napier, 1967). However, chromosomal studies have shown that gibbons can be split into four major groups (*Nomascus*, *Symphalangus*, *Hylobates*, *Hoolock*), with all of them possessing a different diploid chromosome number (Prouty *et al*., 1983). Mitochondrial sequence data supported this division and proposed the classification of these four lineages as separate genera (Roos & Geissmann, 2001; Takacs *et al*., 2005). Both, *Symphalangus* and *Hoolock*, include only one species, but *Hylobates* and *Nomascus* are polytypic (Groves, 2001).

Especially for crested gibbons, which are endemic to the Indochinese bioregion (Vietnam, Laos, Cambodia, southern China), the number of taxa to be recognized, their phylogenetic relationships and their distribution areas are highly disputed. In early studies, all crested gibbon taxa were listed as subspecies of the single species *N. concolor* (Napier & Napier, 1967). Later on, some of them were elevated to species level (e.g. Geissmann *et al*., 2000; Groves, 2001; Roos, 2004). In the most recent classification, *N. nasutus*, *N. hainanus*, *N. concolor*, *N. leucogenys* and *N. gabriellae* are recognized as distinct species, and the subspecies of *N. concolor* were synonymized with the nominate form (Roos *et al*., 2007). Mitochondrial data have also shown that individuals morphologically classified as *N. siki* cluster either with *N. leucogenys* or *N. gabriellae* (Roos, 2004). However, karyotyped *N. siki* specimens, which show the typical chromosomal rearrangements for *N. siki* (Couturier & Lernould, 1991), form a sister lineage to *N. leucogenys* and do not cluster with *N. gabriellae* (Roos *et al*., 2007). Thus, the classification of *N. siki* individuals remains uncertain, but a division of *N. siki* into two taxa as supported by genetic and acoustic data might be appropriate (Konrad, 2004; Konrad & Geissmann, 2006). In the following, we will divide *N. siki* provisionally into a southern and a northern population.

To elucidate the taxon-identity of crested gibbons and to settle their distribution areas, various methods were applied. Due to similar inter-specific fur colouration, this characteristic is inappropriate to distinguish taxa. However, other methods such as karyotyping (Couturier & Lernould, 1991), (mitochondrial) DNA sequencing (Monda *et al*., 2007, Roos, 2004; Roos *et al*., 2007) or acoustic analyses (Konrad, 2004; Konrad & Geissmann, 2006; Geissmann, 1993; 2002a; 2002b; Haimoff, 1983; 1984) were successfully applied. In practice, karyotyping is problematic, because fresh blood or tissue samples are required, which are difficult to obtain from free-ranging animals. However, the PCR-based confirmation of chromosomal rearrangements using DNA extracted from faeces or other low-quality material might be a promising alternative (Carbone *et al*., 2009).

Besides genetic methods, acoustic studies could be a powerful tool to clarify the taxon-identity of gibbons and to describe phylogenetic relationships among taxa. In particular, gibbons produce songs with an innate and stereotyped pattern (Geissmann, 1993; 1995; 2002a; 2003; Geissmann *et al*., 2000; Haimoff, 1984; Marshall & Marshall, 1976; Groves, 1972; 2001; Schilling, 1984). In addition, the clear, elaborate and loud characteristics of their songs make it easy to record them in the wild.

In order to characterize the vocal diversity of crested gibbon populations and to further elucidate the distribution of taxa and their phylogenetic relationships, we collected songs from 12 populations representing 5 crested gibbon taxa. Vocal characteristics were analysed by qualitative and quantitative measurements and tested by discriminant function analyses.

MATERIAL AND METHODS

Survey locations and data collection

To collect song samples from wild gibbons, field surveys were conducted in 12 protected areas in 2007 and 2008 (Table 1, Fig. 1). Our major aim was to obtain data from all taxa, instead of a dense sampling from only one or a few taxa. Accordingly, we collected acoustic samples from *N. nasutus*, *N. concolor*, *N. leucogenys*, *N. siki* and *N. gabriellae*. The only species missing in our analysis was *N. hainanus*, the crested gibbon species endemic to Hainan Island, China.

Vocalization was recorded in the early morning using a “listening post” approach based on the method described by Brockelman & Ali (1987). When hearing calls, the time, direction and group composition was recorded with compass bearings on angle. With this information, it was possible to distinguish calls from different groups. Group positions were depicted on a map to enable changes in listening posts and to ensure the best coverage to obtain all groups in the observation area. When doubtful whether the same or a nearby group was recorded, the data were excluded from further analysis.

Vocalizations were recorded with a digital solid state recorder MARANTZ PMD 660; (Marantz, Japan; sampling rate: 44.1 kHz, 16 bit amplitude resolution) and a Sennheiser directional microphone (K6 power module and ME66 recording head with MZW66 pro windscreen; Sennheiser, Wedemark, Germany).

Acoustic analysis

For the analysis, 52 group samples consisting of 235 female and 254 male calls from 12 different populations were collected. Crested gibbon songs consist of phrases from both sexes. Males produce multi-modulated and females so-called great call phrases (Fig. 2). We considered male phrases as fully developed if they consisted of two or more notes. Female phrases were considered as fully developed if they consisted of six or more notes. The criteria we used to describe the general differences in song structure are listed in Table 2.

For subtle acoustic analysis we used AVISOFT SASLAB Pro (R. Specht, Berlin, Germany) to generate spectrograms and to calculate acoustic parameters. To find the point with maximum energy in the frequency spectrum we used the free reticule cursor tools of AVISOFT (frequency range: up to 500 kHz, frequency resolution: app. 8 Hz, time resolution:

Table 1. Taxa, collection sites and number of analysed groups and calls

No.*	Location	Province, Country	Longitude (N)	Latitude (E)	Taxon	Date of record	Analysed groups	Great calls	Male calls
1	Trung Khanh	Cao Bang, VN	220 51’ 10”	1060 42’ 58”	*N. nasutus*	09/2007	5	13	26
2	Che Tao	Son La, VN	210 42’ 30”	1040 06’ 26’	*N. concolor*	07/2007	2	9	14
3	Muong La	Son La, VN	210 35’ 14”	1040 16’ 18”	*N. concolor*	10/2008	4	8	12
4	Xuan Lien	Thanh Hoa, VN	190 57’ 01”	1050 00’ 18”	*N. leucogenys*	06/2007	4	14	17
5	Phong Nha	Quang Binh, VN	170 29’ 09”	1060 21’ 10”	*N. siki* North	08/2007	5	25	34
6	Da Krong	Quang Tri, VN	160 24’ 40”	1070 05’ 26”	*N. siki* South	10/2007	5	24	13
7	Phong Dien	Thua Thien Hue, VN	160 24’ 22”	1070 10’ 01”	*N. siki* South	10/2007	4	19	18
8	Bach Ma	Thua Thien Hue, VN	160 12’ 03”	1070 44’ 45”	*N. siki* South	11/2007	5	23	24
9	Chu Mom Ray	Kon Tum, VN	140 25’ 56”	1070 42’ 47”	*N. siki* South	11/2007	8	53	33
10	Phnom Prich	Mondulkiri, Cambodia	120 44’ 37”	1070 01’ 54”	*N. gabriellae*	12/2008	3	17	24
11	Ta Dung	Dak Lak, VN	110 52’ 51”	1070 57’ 27”	*N. gabriellae*	11/2008	2	11	19
12	Bi Doup-Nui Ba	Lam Dong, VN	120 11’ 37”	1080 41’ 06”	*N. gabriellae*	12/2007	5	19	20
Total							**52**	**235**	**254**

* Location numbers refer to those shown in Fig. 1; VN = Vietnam.

Fig. 1. Crested gibbon populations for which acoustic data were collected (for location numbers see Table 1).

16 ms). In total, we come up with 53 acoustic parameters describing the temporal and frequency structure of male and female gibbon phrases (Table 3 and 4). Descriptions how we measured the acoustic parameters are given in Fig. 3.

Statistical analysis

We conducted a discriminant function analysis (DFA) to test whether the songs of the nine populations, which could not be clearly separated by general acoustic description, could be assigned correctly. This was the case for *N. leucogenys*, *N. siki* and *N. gabriellae* populations (4-12 in Fig. 1, Table 1). Therefore, we used a subject of 205 songs from 41 different groups. We applied a stepwise DFA (SPSS 16) with all 53 acoustic parameters. The selection criterion for an acoustic parameter was p=0.05 to be entered and p=0.1 to be removed from the analysis. The assignment of songs to the different populations was cross-validated by the leaving-one-out method (Jacqueline & Willem, 2003), which involves leaving out each of the cases in turn, calculating the functions based on the remaining n–1 cases, and then classifying the left-out case.

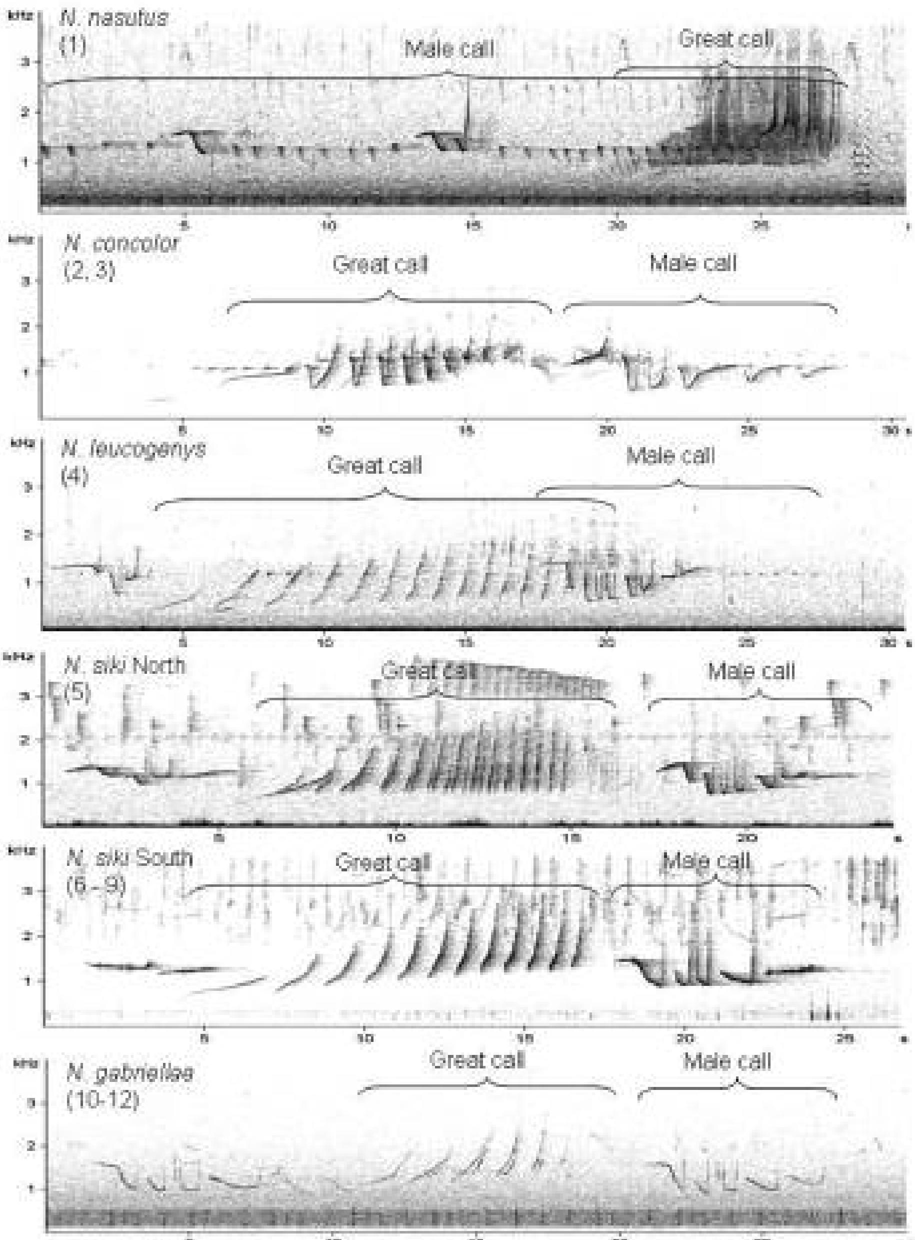

Fig. 2. Spectrograms of six crested gibbon taxa. Numbers in brackets refer to population numbers shown in Fig. 1 and Table 1.

Table 2. Qualitative criteria to describe crested gibbon taxa.

Taxa	Male call	Great call	Assigned populations
N. nasutus	• Booms absent. • Trough part of first note missing in sweep up frequency. No roll spears and initial part of second note start with short sweep up before sweeping down, then rapid changes of frequency modulation up to the last note. • Repeated staccato notes with short and rapid up-down sweeps. • Multi-modulated phrase immediately after first few notes of the great call.	• 8-12 notes and except the first 2-3 very rapid vibrato sounds. • All fundamental frequencies < 2.8 kHz. • Great call elements sweep up-down as spiral spring.	Trung Khanh
N. concolor	• Single booms during inflation of throat sac, staccato phrases and multi-modulated phrases. • First note start at high frequency (>1 kHz) and is of ascending, followed by notes with fast up-down modulation.	• 9-14 notes and except the first, ascending frequency only. • From second note fast down-up modulation.	Che Tao Muong La
N. gabriellae *N. siki* South *N. siki* North *N. leucogenys*	1a: Booms during inflation of throat sac. 1b: Booms absent during inflation of throat sac. 2a: Stable frequency at the beginning with fast down-up sweep at the end. 2b: Starts at low frequency then increasing with a fast down-up-sweep at the end. 2c: Starts low and holds to the end with stable frequency. 3a: Staccato regular. 3b: Staccato not regular. 3c: Staccato rare. 4a: Modulation of rolls very fast. 4b: Modulation of rolls fast. 4c: Modulation of rolls slow. 5a: Rolls on second and third note. 5b: Rolls only on second note. 5c: Rolls absent on second note.	6a: Series of 9-19 notes and Oo notes <4. 6b: Series of 8-15 notes. 6c: Series of 6-12 notes. 7a: Start frequency of notes low (<=600Hz). 7b: Start frequency of notes high (>600Hz). 8a: Start frequency across all notes constant. 8b: Start frequency across all notes ascending. Xuan Lien (1a, 2a, 3a, 4c, 5a, 6a, 7a, 8a)	Phong Nha (1ab, 2ab, 3b, 4c, 5b, 6b, 7a, 8a) Da Krong (1ab, 2ab, 3b, 4c, 5b, 6b, 7a, 8b) Phong Dien (1ab, 2c, 3c, 4c, 5b, 6b, 7b, 8ab) Bach Ma (1b, 2a, 3c, 4b, 5b, 6b, 7b, 8b) Chu Mom Ray (1b, 2a, 3c, 4b, 5b, 5c, 6c, 7b, 8b) Phnom Prich (1ab, 2b, 3c, 4a, 5bc, 6c, 7b, 8b) Ta Dung (1b, 2b, 3c, 4a, 5c, 6c, 7b, 8b) Bi Doup-Nui Ba (1b, 2a, 3c, 4a, 5c, 6c, 7b, 8b)

RESULTS

General difference in song structure of *Nomascus*

The population of *N. nasutus* in Trung Khanh and the populations of *N. concolor* in Muong La and Che Tao could be clearly indentified by the general acoustic characteristics of their songs (Fig. 2, Table 2). *N. leucogenys*, *N. siki* North and *N. siki* South had very similar song structures. *N. gabriellae* showed only minor differences to *N. leucogenys*, *N. siki* (Fig. 2).

N. nasutus females produce fast up-down sweeps like a spiral spring, with a vibrato sound on first two notes. Males produce staccato sounds during, before and after their multi-modulated phrases. All male notes start with almost unmodulated frequency, followed by a down sweep and a fast up sweep. Males of *N.concolor* produce

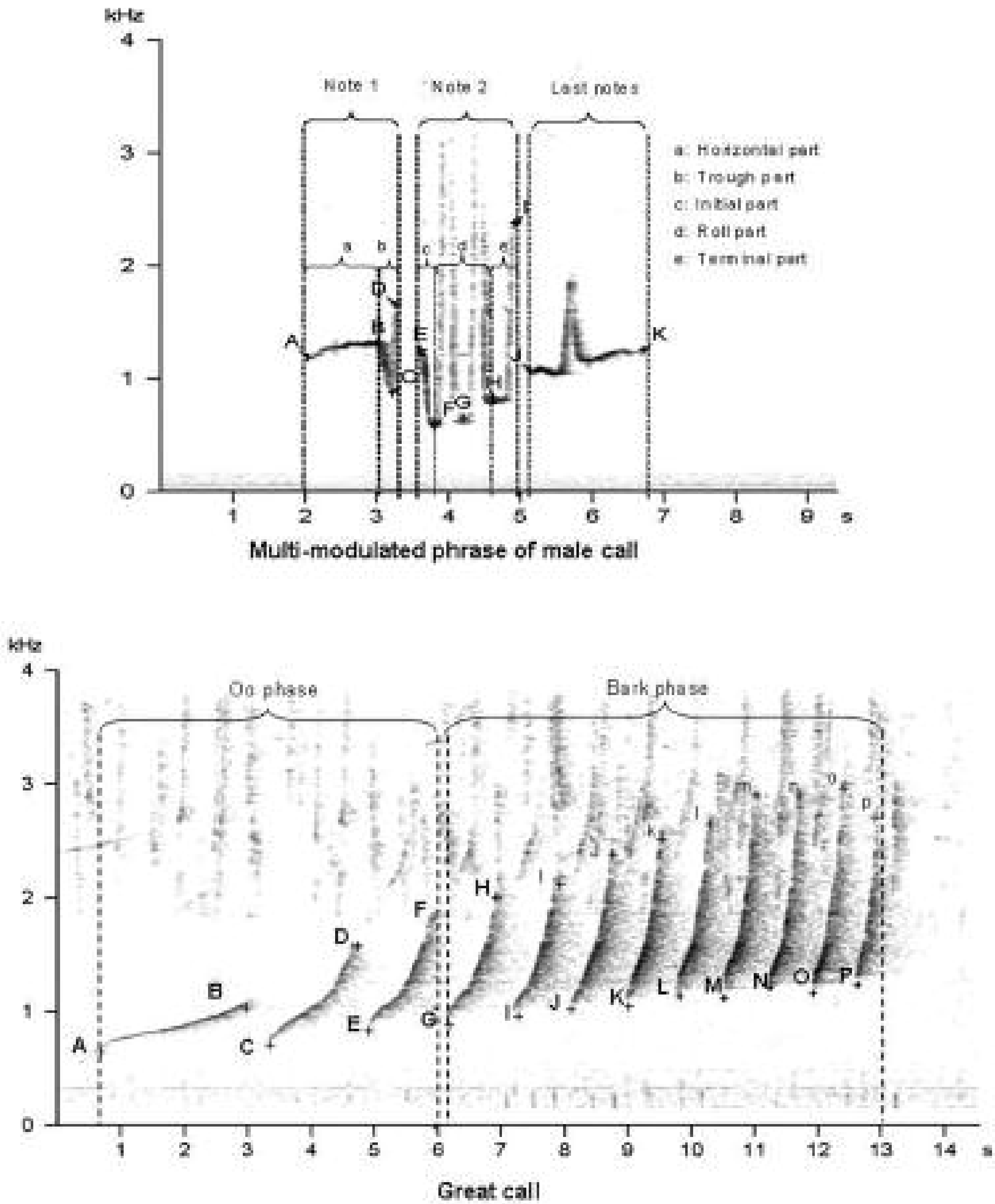

Fig. 3. Spectrogram describing acoustic parameter estimation. Letters mark points used to calculate acoustic parameter (see also Table 3 and 4).

their multi-modulated phrase immediately after the climax of female great call. The first note of male call has a slightly ascending characteristic, followed by notes with fast down-up modulation (Table 2, Fig. 2). *N. leucogenys*, *N. siki* and *N. gabriellae* are difficult to distinguish by listening. However, males of *N. leucogenys* gave regularly, loud staccato sounds, which appeared rarely in *N. siki* and were nearly absent in *N. gabriellae*. *N. leucogenys* could be better distinguished from *N. siki* and *N. gabriellae* by their great calls which had a longer duration and a faster frequency modulation in *N. leucogenys* as the great calls of *N. siki* and *N. gabriellae* (Table 2, Fig. 2).

Table 3. Explanations of acoustic parameters used in the acoustic analysis (DFA). Abbreviations A-P mark the points used to calculate acoustic parameters (see Fig. 3).

No.	Acoustic parameters	Description
Male call		
1	Duration of entire male phrase [s]	Time at (J – A)
2	Duration first note [s]	Time at (D – A)
3	Relative duration of first notes [%]	No. 2 in % of No. 1
4	Duration horizontal part [s]	Time at (B – A)
5	Relative duration horizontal part [%]	No. 4 in % of No. 2
6	Duration trough part [s]	Time at (D – B)
7	Relative duration trough part [%]	No. 6 in % of No. 2
8	Start frequency [Hz]	Frequency at A
9	Maximum frequency horizontal part (Hz)	Frequency at B/A
10	Minimum frequency [Hz]	Frequency at C or E or G
11	Frequency range [Hz]	Frequency at (A – E)
12	Duration of second note [s]	Time at (H – F)
13	Relative duration of second notes [%]	No. 12 in % of No. 1
14	Duration initial part [s]	Time at (F – E)
15	Relative duration initial part [%]	No.14 in % of No. 12
16	Duration roll part [s]	Time at (G - F)
17	Relative duration roll part [%]	No. 16 in % of No. 12
18	Duration terminal part [s]	Time at (H – G)
19	Relative duration terminal part [%]	No. 18 in % of No. 12
20	Start frequency of second note [Hz]	Frequency at E
21	Maximum frequency [Hz]	Frequency at E or F or G
22	Minimum frequency [Hz]	Frequency at E or H or G
23	Frequency range [Hz]	No. 21 – No. 22
24	Minimum frequency initial part [Hz]	Frequency at F
25	Frequency range initial part [Hz]	Frequency at (E – F)
26	Frequency range of trough roll part [Hz]	Frequency at (G – F)
27	Frequency range last trough roll part [Hz]	Frequency at (I - G)
28	Minimum frequency terminal part [Hz]	Frequency at G
29	Duration of the last notes [s]	Time at (J - I)
30	Relative duration of last notes [%]	No. 29 in % of No. 1

Table 3. Explanations of acoustic parameters used in the acoustic analysis (DFA). Abbreviations A-P mark the points used to calculate acoustic parameters (see Fig. 3).

No.	Acoustic parameters	Description
Great call		
1	Duration of entire great call [s]	Time at (p – A)
2	Number of notes	Total number of elements
3	Range of start frequencies [Hz]	Frequency at (P – A)
4	Number of Oo notes	Elements with frequency increase of <=1kHz/s
5	Duration of Oo phase [s]	Time at (F- A)
6	Relative duration of Oo phrase [%]	No. 5 in % of No. 1
7	Number of bark notes	Elements with frequency increase of >1kHz/s
8	Duration of bark phase [s]	Time at (p – G)
9	Relative duration of bark phrase [%]	No.8 in % of No.1
10	Duration of first note of Oo phrase [s]	Time at (B – A)
11	Duration of second note of Oo phrase [s]	Time at (D – C)
12	Duration of first note of bark phrase [s]	Time at (F – E)
13	Duration of last note of bark phrase [s]	Time at (p – P)
14	Frequency range of first note of Oo phrase [Hz]	Frequency at (B – A)
15	Frequency range of second note of Oo phrase [Hz]	Frequency at (D – C)
16	Frequency range of third note of Oo phrase [Hz]	Frequency at (F – E)
17	Frequency range of first note of bark phrase [Hz]	Frequency at (H – G)
18	First inter-note interval of Oo phrase [s]	Time at (C – B)
19	Second inter-note interval of Oo phrase [s]	Time at (E – D)
20	Last inter-note interval of bark phrase [s]	Time at (P – o)
21	First start freq range between second and first note of Oo phrase [Hz]	Frequency at (C – A)
22	Second start freq range between first note of bark and last note of Oo [Hz]	Frequency at (G – E)
23	First start freq range between last and previous note of bark phrase [Hz]	Frequency at F (G - H)

Discriminant function analyses of crested gibbon songs

We conducted a discriminant function analysis (DFA) of the nine population which could not be satisfyingly distinguished by general acoustic descriptions. The DFA was able to assign correctly 92.7 % of the 205 songs to the nine populations (Fig. 4). The accuracy of assignment ranged from 66.7% for Phnom Prich to 80.0% for Da Krong and Bach Ma populations to 100% for all other populations. The cross-validation achieved 80.5% of correct assignment. Four populations, Xuan Lien, Chu Mom Ray, Ta Dung and Bi Doup-Nui Ba, remained at 100 %. The populations Da Krong and Phnom Prich remained at 80,0% or 66.7%. Two other populations showed a slight decrease in the assignment accuracy (Phong Nha from 100% to 60%, Phong Dien from 100% to 50%). Misclassifications occurred only between neighbouring populations.

The DFA selected eight acoustic parameters to assign the songs to the respective populations. The eight acoustic parameters comprised characteristics from males and female calls. The scattergram (Fig. 4) showed the separation of the nine gibbon population according to the first and second discriminant functions, explaining 63.7 % and 15.7 % of the total variation. The first discriminant function, which mainly represents frequency characteristic of gibbon songs, separates the Xuan Lien and Phong Nha populations from Da Krong, Phong Dien, Bach Ma, Chu Mom Ray, and both from Phnom Prich, Ta Dung and Bi Doup-Nui Ba. The second discriminant function, which represents temporal features of gibbon songs, separates Da Krong, Phong Dien, Phong Dien, Bach Ma, Chu Mom Ray from all other populations.

DISCUSSION

Based on morphological, acoustic characteristics and genetic data, three (Groves, 1997), four (Geissmann, 1995; Geissmann, 2002a,b; Geissmann *et al.*, 2000) and recently even five species (Groves, 2001) have been identified in the genus *Nomascus*. The system of four species were also the subject of a phylogenetic analysis using vocal, fur coloration, and anatomical data, of which the vocal data produced the most reliable and best resolved tree (Geissmann, 2002a). In principle, these results confirm molecular results (Roos, 2004; Roos *et al.*, 2007; Takacs *et al.*, 2005). Disputed is the classification of *N. siki*. The taxon was variously classified as subspecies of either *N. leucogenys* or *N. gabriellae* (Geissmann, 1995; Geissmann *et al.*, 2000; Groves, 1993), but Groves (2001) proposed to classify the taxon as distinct species. Roos (2004) showed that *N. siki* representatives are paraphyletic,

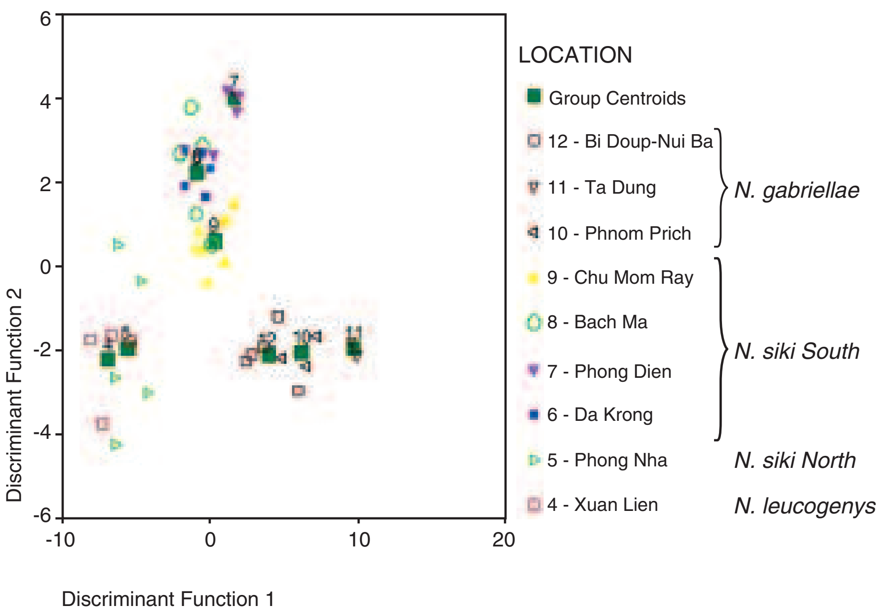

Fig. 4. Distribution of the different gibbon populations based on the scores of the first and second discriminant function.

with some forming a clade together with *N. leucogenys* and others with *N. gabriellae*. However, karyotyped *N. siki* specimens, which show the typical chromosomal rearrangements for *N. siki* (Counturier & Lernould, 1991), form a sister lineage to *N. leucogenys* and do not cluster with *N. gabriellae* (Roos *et al*., 2007).

In general, the acoustic analysis could confirm the relationships depicted by genetic data. Accordingly, we found a clear distinguishable song structure in *N. nasutus* and *N. concolor*, which separates them from each other and form the remaining populations. The difference in the song structure of the other four taxa/clades, *N. leucogenys*, *N. siki* North, *N siki* South and *N. gabriellae* is not well developed. Insofar, it was not possible to separate these taxa on general acoustic descriptions, indicating a close relationship between them, as it was also shown by molecular studies (Garza & Woodruff, 1992; Monda *et al*., 2007; Roos, 2004; Roos *et al*., 2007). The quantitative acoustic analysis revealed three distinctive clusters, with one including *N. leucogenys* and the northernmost *N. siki* population, one with solely southern *N. siki* populations, and finally, one with only *N. gabriellae*. Thus, the analysis showed that *N. siki* might be indeed paraphyletic, which supports genetic studies by Roos (2004). To elucidate the taxonomic status of various crested gibbon populations and specifically to clarify whether *N. siki* and the other a subspecies of *N. gabriellae*, further investigation are required.

CONCLUSIONS

1. Populations of eastern black gibbon (*N. nasutus*) (Trung Khanh) and western black gibbon (*N. concolor*) (Muong La and Che Tao) can clearly be differentiated in their song structure from one another and from all other populations.
2. Northern white-cheeked gibbon (*N. leucogenys*) in Xuan Lien and the northern *N. siki* population in Phong Nha have a similar acoustic structure and therefore, they form one acoustic cluster together.
3. Southern *N. siki* populations from Da Krong, Phong Dien, Bach Ma and Chu Mom Ray are highly correlated in stepwise discriminant function analyses and can be clearly separated from yellow-cheeked gibbon (*N. gabriellae*), northern white-cheeked gibbon (*N. leucogenys*) and the northern *N. siki* population (Phong Nha).
4. Yellow-cheeked gibbon (*N. gabriellae*) populations (Phnom Prich, Ta Dung and Bi Doup-Nui Ba) are highly correlated and differ in their song pattern from all other taxa.
5. The acoustic results are in agreement with genetic data and hence, show that subtle acoustic analysis could help to confirm and verify phylogenetic relationships.

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ĐẶC ĐIỂM ÂM HỌC NỔI BẬT TRONG PHÂN LOẠI CÁC LOÀI VƯỢN ĐEN CÓ MÀO (*NOMASCUS* SPP.)

TÓM TẮT

Việc nghiên cứu sự đa dạng về âm học của các quần thể vượn có mào khác nhau ngoài tự nhiên nhằm đánh giá về phân loại và làm sáng tỏ thêm về vùng phân bố cũng như những mối quan hệ phát sinh chủng loài. Tiếng hót của vượn được thu âm từ 12 vùng khác nhau đại diện cho tất cả các loài thuộc giống vượn có mào. Với 52 đàn vượn đã thu âm tiếng hót được sử dụng để phân tích quang phổ, bao gồm 235 tiếng hót lớn của con cái và 254 pha chuyển giọng liên tục của con đực. Căn cứ vào những đặc tính cơ bản về âm học và quang phổ, loài *N. nasutus* (Trùng Khánh) và loài *N. concolor* (Mường La và Chế Tạo) có sự khác biệt rất rõ giữa chúng cũng như đối với các quần thể khác còn lại. Tuy nhiên, các loài phân bố về phía Nam thì rất khó phân loại với nhau, do vậy việc phân tích biệt số (discriminant function analyses) được áp dụng để làm sáng tỏ sự phân loại giữa chúng. Kết quả cho thấy, quần thể *N. leucogenys* (Xuân Liên) và *N.siki* (Phong Nha) không phân biệt được với nhau, thậm chí khi phân tích biệt số. Ngược lại, các quần thể của *N. siki* về phía Nam (Đa Krông, Phong Điền, Bạch Mã và Chư Mom Ray) lại khác biệt rất rõ với quần thể Xuân

Liên và Phong Nha cũng như khác biệt với các quần thể *N. gabriellae* (Phnôm Prích, Tà Dựng và Bi Doup - Núi Bà). Nhìn chung, nghiên cứu này đã đưa ra kết quả rằng âm học có thể giúp phân biệt giữa các quần thể vượn có mào đồng thời tái khẳng định cũng như xác minh những mối quan hệ phát sinh chủng loài vượn giống *Nomascus*.

REFERENCES

Brockelman, W.Y. & Ali, R. (1987): Methods of Surveying and Sampling Forest Primate Populations. In: Marsh, C.W. & Mittermeiner, R.A. (eds.): Primate Conservation in the Tropical Rain Forest; pp. 23-62. Alan R. Liss, New York,

Carbone, L., Mootnick, A.R., Nadler, T., Moisson, P., Ryder, O., Roos, C. & Jong, P.J. (2009): A Chromosomal Inversion Unique to the Northern White-Cheeked Gibbon. *PLoS ONE* 4(3), e4999.

Couturier, J. & Lernould, J-M. (1991): Karyotypic Study of Four Gibbon Forms Provisionally Considered as Subspecies of *Hylobates* (*Nomascus*) concolor (Primates, Hylobatidae). Folia Primatol. 56, 95-104.

Garza, J.C. & Woodruff, D.S. (1992): A phylogenetic study of the gibbons (Hylobates) using DNA obtained non-invasively from hair. Molecular Phylogenetics and Evolution 1, 202–210.

Geissmann, T. (1993): Evolution of Communication in Gibbons (Hylobatidae). PhD Dissertation, University Zurich.

Geissmann, T. (1995): Gibbon Systematics and Species Identification. Int. Zoo News 42, 467-501.

Geissmann, T. (2002a): Duet-splitting and the Evolution of Gibbon Songs. Biological Reviews 77, 57-76.

Geissmann, T. (2002b): Taxonomy and evolution of gibbons. In: Soligo, C., Anzenberger, G. & Martin, R.D. (eds.): Anthropology and Primatology into the Third Millennium; pp. 28–31. Wiley-Liss, New York,

Geissmann, T. (2003): Vergleichende Primatologie. Springer-Verlag, Berlin and Heidelberg.

Geissmann, T., Nguyen Xuan Dang, Lormee, N. & Momberg, F. (2000): Vietnam Primate Conservation Status Review. Part 1: Gibbon. Fauna & Flora International, Hanoi.

Groves, C.P. (1972): Systematics and Phylogeny of Gibbons. In: Rumbaugh, D.M. (ed.): Gibbon and Siamang; pp. 1-89. Karger, Basel and New York.

Groves, C.P. (1997): Taxonomy and phylogeny of primates. In: Blancher, A., Klein, J. & Socha, W.W. (eds.): Molecular Biology and Evolution of Blood Group and MHC Antigens in Primates; pp. 3–23. Springer-Verlag, Berlin.

Groves, C.P. (2001): Primate Taxonomy. Smithsonian Institution Press, Washington DC.

Haimoff, E.H. (1983): Gibbon Songs: An Acoustical, Organizational, and Behavioural Analysis. PhD Dissertation, Cambridge University.

Haimoff, E.H. (1984): Acoustic and Organizational Features of Gibbon Songs. In: Preuschoft, H., Chivers, D.J., Brockelman, W.Y. & Creel, N. (eds.): The Lesser Apes. Evolutionary and Behavioural Biology; pp. 333-353. Edinburgh University Press, Edinburgh.

Jacqueline, J.M. & Willem J.H. (2003): SPSS Categories® 13.0SPSS Inc; pp. 1-371. Chicago.

Konrad, R. (2004): Vocal Diversity and Taxonomy of the Crested Gibbons (Genus *Nomascus*) in Cambodia. Diploma Thesis. University Zürich.

Konrad, R. & Geissmann, T. (2006): Vocal Diversity and Taxonomy of *Nomascus* in Cambodia. Int. J. Primatol. 27(3), 713-745.

Marshall, J. T. & Marshall, E.R. (1976): Gibbons and their Territorial Songs. Science 193, 235-237.

Monda, K., Simmons, R.E., Kressirer, P., Su, B. & Woodruff, D.S. (2007): Mitochondrial DNA Hypervariable Region-1 Sequence Variation and Phylogeny of the Concolor Gibbons, *Nomascus*. Am. J. Primatol. 69, 1-22.

Napier, J.R. & Napier, P.H. (1967): A Handbook of Living Primates. Academic Press, London.

Prouty, L.A., Buchanan, P.D., Pollitzer, W.S. & Mootnick, A.R. (1983): *Bunopithecus*: A genus-level taxon for the hoolock gibbon (*Hylobates hoolock*). Am. J. Primatol. 5, 83-87.

Roos, C. & Geissmann, T. (2001): Molecular Phylogeny of the Major Hylobatid Divisions. Molecular Phylogenetics and Evolution 19, 486-494.

Roos, C. (2004): Molecular Evolution and Systematics of Vietnamese Primates. In: Nadler, T, Streicher, U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 23-28. Frankfurt Zoological Society, Hanoi.

Roos, C., Vu Ngoc Thanh, Walter, L. & Nadler, T. (2007): Molecular Systematics of Indochinese Primates. Vietnamese J. Primatol. 1(1), 41-53.

Schilling, D. (1984): Song Bouts and Duetting in the *concolor* Gibbon. In: Preuschoft, H., Chivers, D.J., Brockelman, W.Y. and Creel, N. (eds.): The

Lesser Apes. Evolutionary and Behavioural Biology; pp. 390-403. Edinburgh University Press, Edinburgh.
Takacs, Z., Morales, J.C., Geissmann, T. & Melnick, D.J. (2005): A Complete Species-Level Phylogeny of the Hylobatidae based on Mitochodrial ND3-ND4 Gene Sequences. Molecular Phylogenetics and Evolution 36, 456-467.

Behavior and Ecology

Chapter III

14

PLANT DIET OF LONG-TAILED MACAQUES (*MACACA FASCICULARIS*) IN A FRAGMENTED FOREST IN SOUTHEAST THAILAND

JANYA JADEJAROEN, ARNUPARP YHAMDEE, AND SANSANEE SIRILAK

SUMMARY

Two groups of long-tailed macaques (*Macaca fascicularis*) live in a 54.4 ha fragment of mixed deciduous forest located on the Si Racha Campus of Kasetsart University in Southeast Thailand. The forest is surrounded by local communities, private business areas, temple and roads. The Royal Forest Department of Thailand gave permission to Kasetsart University to use the forest for educational and conservation purposes in 2005. During 2008 we assessed the number of macaques and their plant diet in each month in their home range. We found two troops of macaques with 109 and 17 members, respectively. Fifty-four species (31 families) of plants eaten by them were identified including ten species of grasses (Gramineae) and 8 species of Leguminosae. Mature and young leaves averaged 52% (range 40–¬70%) of all the 54 diet species in the rainy season while the average of fruits, flowers, and seeds was 48% (range 30–60%). Mature leaves alone comprised approximately 30% of food species in the cool dry (Dec–Feb), early rainy (Mar–May) and late rainy (Sep–Nov) seasons, while it decreased to 10% in the mid-rainy season (Jun–Aug) when young leaves and fruits were more available. In March, August, and October the leaves of the herb *Christia vespertilionis* (L.f.) Bakh.f. (Leguminosae: Papilionoideae) were found to be chewed and discarded on the forest floor by adult monkeys. This plant species has been studied in Vietnam for its antimalarial activity.

INTRODUCTION

Habitat fragmentation and destruction are major threats to wildlife in Thailand, as in many other countries. Forested areas in Thailand have decreased from 70% of the total country area to less than 20% in 40 years (NESDB, 2007). This has led to national concern for biodiversity conservation and management. One of the targets of the current (10th) National Economic and Social Development Plan in protecting natural resources and biodiversity is to maintain at least 18% of the land area in conservation forest.

Chonburi is a somewhat hilly province in south-eastern Thailand (approx. 120 km from Bangkok) along the gulf coast, with fast-growing petrochemical, manufacturing, and transportation industries, including the deep-water harbour Laem Chabang. The province is confronted with many environmental problems including fragmentation and degradation of hill and forest habitats.

This study was carried out in a 54 ha forest fragment called Khao Namsap (Khao = hill or mountain) adjacent to the Si Racha campus of Kasartsart University in Chonburi (Fig. 1). In 2005 the Royal Forest Department of Thailand gave permission to the University to use the forest for educational and conservation purposes. The hill has also been announced by the province as part of Plant Genetic Conservation Project under the Royal Initiation of Her Royal Highness Princess Maha Chakri Sirindhorn to protect plants and wildlife.

Fig. 1. Location of the study area “Khao Namsap”, Kasetsart University, Si Racha Campus, Chonburi Province, Thailand (13º7’ N; 100º55’ E). (Google Earth, accessed April 20, 2008.)

The forest contains a natural population of the long-tailed macaque (*Macaca fascicularis*), a species common in most lowland areas of the country in scrub forest and mangroves (Lekagul & McNeely, 1988) (Fig. 2). Habituated or semi-tame populations of this species also occur in at least 74 locations at religious shrines, especially on limestone outcrops, in Thailand (Aggimarangsee & Brockelman, 1992; Malaivijitnond, 2008). The average size of these colonies is close to 200 individuals (Malaivijitnond, 2008). The nearest other reported population is approximately 2 km to the north, on a small hill close to the beach. These two groups are now separated from each other by a 6-lane highway and industrial and residential communities.

Although this macaque is not endangered by any criteria, it is facing habitat loss, inbreeding, or outbreeding depression due to hybridization with other macaque species in many areas (Malaivijitnond, 2008). Therefore, this study was designed to investigate the population size of long-tailed macaques and their diet throughout the year in order to evaluate their chances of survival in this habitat fragment, and to develop management recommendations that may be applied to other colonies in a similar situation.

Fig. 2. Group of long-tailed macaques (*Macaca fascicularis*).

Photo: Tilo Nadler

MATERIAL AND METHODS

Study site

The study area, Khao Namsap, is a 54.4 ha fragment of mixed deciduous forest virtually on the University campus (13º7' N and 100º55' E) as shown in Fig. 1. The elevation of the hill is 50–190 m asl. Average maximum and minimum temperatures from 2006 to 2007 were 31.5 and 24.7ºC, respectively. Annual rainfall in the same period averaged 1,333 mm. The climate is divided into four seasons: cool dry (Dec–Feb), early rainy (Mar–May), mid-rainy (Jun–Aug) and late rainy (Sep–Nov). The field study on long-tailed macaques and their plant diets was conducted from January to December 2008.

In Khao Namsap, 129 species (116 genera of 46 families) of plants were found in 50 survey plots (10 m × 10 m). Species with the highest densities were *Atalantia monophylla* (DC.) Correa, *Bauhinia bracteata* (Graham ex Benth.) Baker, *Diospyros bejaudii* Lecomte, and *Antidesma ghaesembilla* Gaertn. with 212, 144, 96 and 64 trees/ha, respectively (Khopai, 2007). Seventy-three species of birds were recorded (Duengkae, 2007).

Khao Namsap covers a very limited area with no streams or other water sources. The west side of the hill is occupied by the university campus, while the north and east sides border local communities, private businesses, a temple, and roads. Human-induced fires usually occur during the cool dry season each year, and are usually set to stimulate growth of new leaves of "pak wan-pa" (*Melientha suavis* Pierre), an edible shrub. Such fires reduce the food resources of the monkeys and often bring them into conflict with humans outside their habitat.

Observation methods

The macaques were followed and observed with binoculars every month during 2008 a total of 27 times for approximately 200 hours. The number of groups, group size, and age-sex structure were noted. Age-sex classes were recorded as adult male, adult female, sub-adult male, sub-adult female, juvenile male, juvenile female, and infant.

While following and observing monkeys in each month, plants and their parts eaten by the monkeys were recorded, photographed, and collected for species identification. The numbers and species eaten, parts eaten, and percentages of eaten parts were compared among the seasons.

RESULTS

Population of long-tailed macaques

Two groups of macaques could be clearly identified. The total number of monkeys in Khao Namsap is approximately 130. The larger group (group 1) had approximately 109 individuals and the smaller group (group 2) had 17 members (Table 1). Group 1 had 25 adult monkeys (9 males and 16 females) and the second had five adults (1 male and 4 females). At each observation, some members of the large group were usually hidden in the trees or dense vegetation, and thus could not be aged and sexed accurately.

A possible additional group of five males was seen just once for about six hours in August; therefore we are not certain about its status.

Plant diet

Fifty-four species of plants (52 genera, 31 families) in the study area were eaten by long-tailed macaques (Table 2). These were dominated by ten species of grasses/bamboos (Gramineae) and eight species of legumes. The monkeys fed on only 16 species in the cool dry season (Dec–Feb) but 29 species in the late rainy season (Sep–Nov).

During the cool dry season, large *Bombax anceps* trees were frequently visited by the monkeys (Fig. 3). They fed on the large flowers and seeds of young fruits of this species. A vine species, *Bauhinia bracteata*, was eaten from the end of the cool dry season to the rainy season (Feb–Aug). This species provided young leaves, bark, and also seeds (Fig. 4).

Table 1. Age and sex classes of the two groups of long-tailed macaques (*Macaca fascicularis*) at Khao Namsap.

Group	AdM	AdF	SubM	SubF	JuvM	JuvF	JuvUnk	Inf	Unk	Total
1	9	16	4	4	17	5	17	12	25	109
2	1	4	-	-	8	-	-	4	-	17
Total	**10**	**20**	**4**	**4**	**25**	**5**	**17**	**16**	**25**	**126**

AdM = Adult Male, AdF = Adult Female, SubM = Sub-adult Male, SubF = Sub-adult Female, JuvM = Juvenile Male, JuvF = Juvenile Female, JuvUnk = Juvenile of unknown sex, Inf = Infant, Unk = Unknown age and sex.

Table 2. List of plant taxa and their parts eaten by long-tailed macaques (*Macaca fascicularis*) lived at Khao Namsap, Chonburi Province from January to December, 2008.

No.	Family	Scientific name	Part eaten	Cool dry		Early rainy			Mid-rainy			Late rainy			
				J	F	M	A	M	J	J	A	S	O	N	D*
1	Amaranthaceae	*Alternanthera sessilis* (L.) DC. var. *sessilis*	leaves, flowers										x		x
2	Anacardiaceae	*Spondias pinnata* (L. f.) Kurz	fruit								x	x			
3	Annonaceae	*Uvaria cordata* (Dunal) Alston	leaves	x											
4	Apocynaceae	*Holarrhena pubescens*	leaves		x									x	
5	Asclepiadaceae	*Toxocarpus villosus* (Bl.) Decne.	leaves				x								
6	Basellaceae	*Basella alba* L.	leaves, flowers										x	x	
7	Bombacaceae	*Bombax anceps* Pierre var. *cambodiense* (Pierre) Robyns	flowers, seeds of young fruit	x	x	x									x
8	Capparaceae	*Capparis grandis* L.f.	young leaves										x	x	
9	Commelinaceae	*Commelina diffusa* Burm.f.	leaves				x								
10	Connaraceae	*Connarus semidecandrus* Jack	aril	x	x	x	x								
11	Cucurbitaceae	*Coccinia grandis* (L.) Voigt	leaves, flowers, fruit							x	x				
12	Dioscoreaceae	*Dioscorea oryzetorum* Pr. & Burk.	flowers, fruit		x								x	x	x
13	Ebenaceae	*Diospyros bejaudii* Lecomte	young leaves						x	x					
14	Ebenaceae	*Diospyros montana* Roxb.	fruit												x
15	Euphorbiaceae	*Antidesma ghaesembilla* Gaertn.	fruit								x				
16	Euphorbiaceae	*Phyllanthus emblica* L.	leaves, fruit	x									x	x	x
17	Flacourtiaceae	*Hydnocarpus ilicifolia* King	leaves, seeds							x	x	x	x	x	x
18	Gramineae	*Axonopus compressus* (Sw.) Beauv.	leaves, culm								x				
19	Gramineae	*Brachiaria mutica* (Forssk.) Stapf	culm								x		x		
20	Gramineae	*Dactyloctenium aegyptium* (L.) P. Beauv.	leaves, seeds											x	x
21	Gramineae	*Eleusine indica* (L.) Gaertn.	leaves, seeds								x		x		
22	Gramineae	*Imperata cylindrica* Beauv.	culm										x		
23	Gramineae	*Melinis repens* P. Beauv.	leaves, culm				x	x	x						
24	Gramineae	*Panicum maximum* Jacq.	culm, flowers, seeds							x	x	x	x	x	
25	Gramineae	*Sporobolus indicus* (L.) R. Br. var. *flaccidus* (Roem. & Schult.) Veldk.	leaves, culm				x						x	x	
26	Gramineae	*Urochloa panicoides* P. Beauv. var. *pubescens* (Kunth) Bor	leaves, culm								x	x	x		
27	Gramineae	*Zoysia matrella* (L.) Merr.	leaves, culm										x		
28	Guttiferae	*Cratoxylum cochinchinense* (Lour.)	seeds									x			
29	Lauraceae	*Tamarindus indica* L.	leaves, fruit	x	x	x	x						x	x	x
30	Leguminosae, Caesalpinioideae	*Bauhinia bracteata* (Graham ex Benth.) Baker	young leaves, phloem (bark), seeds		x	x	x	x	x	x	x				
31	Leguminosae, Caesalpinioideae	*Dialium cochinchinensis* Pierre	fruit	x											x
32	Leguminosae, Caesalpinioideae	*Peltophorum dasyrachis* (Miq.) Kurz	leaves, seeds						x						
33	Leguminosae, Mimosoideae	*Leucaena leucocephala* (Lmk.) De Wit	young leaves, seeds				x	x	x					x	
34	Leguminosae, Papilionoideae	*Abrus precatorius* L.	leaves										x		
35	Leguminosae, Papilionoideae	*Centrosema pubescens* Bth.	leaves, flowers				x								
36	Leguminosae, Papilionoideae	*Christia vespertilionis* (L.f.) Bakh.f.	leaves			x					x		x		
37	Leguminosae, Papilionoideae	*Mucuna pruriens* (L.) DC.	young leaves									x			
38	Loranthaceae	*Dendrophthoe pentandra* (L.) Miq.	young leaves			x									
39	Melastomataceae	*Memecylon edule* Roxb. var. *ovatum* Bn.	leaves			x									x
40	Opiliaceae	*Cansjera rheedii* J.F. Gmel.	young leaves			x			x						x
41	Opiliaceae	*Melientha suavis* Pierre	young leaves				x								
42	Opiliaceae	*Urobotrya siamensis* Hiepko	young leaves			x									
43	Rhamnaceae	*Ventilago denticulata* Willd.	young leaves			x									
44	Rutaceae	*Atalantia monophylla* (DC.) Correa	young leaves		x					x				x	
45	Rutaceae	*Glycosmis pentaphylla* (DC.) Correa	leaves, fruit							x					
46	Rutaceae	*Murraya paniculata* (L.) Jack	young leaves							x					
47	Sapindaceae	*Lepisanthes tetraphylla* (Vahl) Radlk.	fruit							x					
48	Simaroubaceae	*Harrisonia perforata* (Blanco) Merr.	leaves			x									
49	Solanaceae	*Capsicum frutescens* L. var. *frutescens*	fruit										x		
50	Sapotaceae	*Mimusops elengi* L.	seeds											x	
51	Tiliaceae	*Microcos paniculata* L.	fruit										x	x	
52	Verbenaceae	*Vitex limonifolia* Wall.	leaves, fruit			x							x		
53	Verbenaceae	*Vitex trifolia* L.	leaves								x	x	x		
54	Vitaceae	*Tetrastigma siamense* Gagnep. & Craib	leaves			x						x			

Fig. 3. Long-tailed macaques (*Macaca fascicularis*) feeding on seeds of young fruit in a *Bombax anceps* tree.

In the late rainy season eight species of grass were consumed (Table 2). The grass *Panicum maximum*, which was dispersed mostly in burnt areas, was fed on for its flowers, seeds, and culms (Fig. 5).

The monkeys fed on various parts of other plants including mature leaves of ten species, young leaves of ten species, fruits of seven species, and leaves and culms of five grass species. They ate the mature leaves of *Uvaria cordata*, *Centrosema pubescens* and *Vitex trifolia*. Species whose young leaves were eaten were *Diospyros bejaudii*, *Ventilago denticulata* and *Murraya paniculata*. Fruits eaten included those of *Diospyros montana*, *Lepisanthes tetraphylla*, *Dialium cochinchinensis*, and *Microcos paniculata*. Other dietary parts were flowers, especially of *B. anceps*, bark of *B. bracteata* and arils of *Connarus semidecandrus*.

Considering the main parts of plants (young leaves, mature leaves, flowers, fruit and seeds) eaten by the macaques, mature and young leaves made up to 70% (16 of all the diet species) in the late-rainy

Fig. 4. Long-tailed macaque (*Macaca fascicularis*) feeding on bark of *Bauhinia bracteata*.

Fig. 5. Long-tailed macaque (*Macaca fascicularis*) feeding on seeds of *Panicum maximum.*

season, with an average of 52% (range 40–70%) for all months of the year. The average of fruits, flowers, and seeds combined was 48% (range 30–60%) (Fig. 6). Mature leaves alone made up approximately 30% of species consumed in the cool dry (Dec–Feb), early rainy (Mar–May) and late rainy (Sep–Nov) season, while it decreased to 10% in the mid-rainy season (Jun–Aug) when fruits and young leaves were more available. Young leaves were consumed most in early rainy and mid-rainy seasons with 30% in each. In the mid-rainy season, one species of flower and seven species of fruits were consumed. Seeds (3–4 species) were eaten in all seasons.

Interestingly, we saw that some adult males chewed the leaves of *Christia vespertilionis* (Leguminosae, Papilionoideae) and discarded the chewed wads on the forest floor (Fig. 7). We observed this behavior in March, August and October or early to late rainy season. The wads were approximately 1.5 × 3 cm in size and dark green.

DISCUSSION

Long-tailed macaques (*Macaca fascicularis*) are

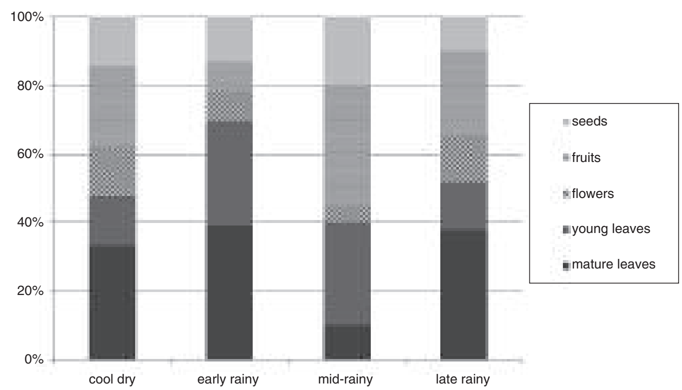

Fig. 6. Percentages of mature leaves, young leaves, flowers, fruit and seeds eaten by long-tailed macaques (*Macaca fascicularis*) in each season: cool dry (Dec–Feb), early rainy (Mar–May), mid-rainy (Jun–Aug) and late rainy (Sep–Nov), by long-tailed macaques at Khao Namsap.

Fig. 7. Wads of *Christia vespertilionis* (approx. 1.5 ×3 cm) chewed by long-tailed macaques (*Macaca fascicularis*) at Khao Namsap and left on the forest floor in March, August and October, 2008.

known to be distributed throughout Southeast Asia in habitat types ranging from primary forest, disturbed and secondary forests, riverine and coastal mangrove forests, to villages, towns, cities, recreation parks and temples (Lekagul & McNeely, 1988; Malaivijitnond & Hamada, 2008; Malaivijitnond *et al*., 2005). Although they are highly adaptable, their natural habitats are declining in both quantity and quality. In Thailand, 39 of 74 reported macaques were living in temples or sacred places (Malaivijitnond & Hamada, 2008). The two groups on Khao Namsap also live on a hill near a temple. Usually, Thai people do not disturb animals or encroach on their habitats inside or near religious places, but such places are very small and fragmented.

The population size of the two groups in the study area was approximately 130 monkeys while the average number in the other 74 locations reported by Malaivijitnond & Hamada (2008) was 200. The total population of long-tailed macaques is relatively large in comparison with many other endangered primate species in the region or the world. However, the severe fragmentation of the species population leads to more severe habitat destruction and degradation and, in addition, to inbreeding. Hybridization also occurs in some areas where other species of macaques are released in or near their colonies. Therefore, studies on the ecology of these populations and further genetic research are needed to provide knowledge useful for conservation and management.

Being an omnivorous species, the monkeys feed on a variety of foods such as fruit, leaves, crabs and other invertebrates, small animals, food from people, crops, and garbage. The groups at Khao Namsap are now isolated from the nearest neighboring groups (Malaivijitnond & Hamada, 2008). Because of their restricted habitat, the two groups have no access to the shore and its food resources. Instead, they increasingly come down on the roads to scrounge edible materials from trash or beg for food from local villagers and travelers, especially during the cool dry season. They also look for water in surrounded areas.

Khao Namsap has been disturbed by fires every year which further limits the monkeys' living and foraging area. Opening up areas increases drought and soil erosion problems (Neary & Overby, 2006). During the cool dry and early rainy seasons, monkeys sometimes exploited crops such as mangos, jackfruit, bananas, tamarinds and cassava from the university campus and outside community. After the beginning of rain in early 2008, young leaves became more available, especially in May and June. In the same period, regrowth of grasses and other pioneer species in burnt areas provided some food for the monkeys.

Of the 54 plant species eaten by the monkeys, ten were not in the list of flora made by Khopai (2007). Of the 129 species listed by her it is estimated that 90 species could be consumed by the monkeys here (J. F. Maxwell, pers. comm.). This illustrates that there should be more plant surveys and studies of phenology. Plant distribution and vegetation structure should also be studied so that better plans for habitat preservation and food species conservation can be made.

Ecologically, the macaques control populations of their food plants by exploiting them and possibly by dispersing their seeds. During the field studies we found that some of their fecal matter contained seeds. We collected some of these and started experiments on germination. In the field, we also noticed germinated seeds in their dung piles.

One herb species, *Christia vespertilionis*, was accidentally found in the form of left wads of leaves chewed and discarded by the monkeys. Local people use extracted substances of this plant as an insect repellent for their crops and as a repellent against flies in jars of fermenting fish and other foods. The plant has also been studied for its antimalarial activity (Nguyen-Pouplin *et al*., 2007). The results showed that it can inhibit the growth of *Plasmodium falciparum* but unfortunately had high toxicity to mammalian cells. Lowland gorillas, chimpanzees, and bonobos also use plants for self-medication, apparently to reduce internal parasites, repel insects and perhaps treat other illnesses (Dupain, 2002;

Huffman & Hirata, 2004; Huffman *et al.*, 1996; Kuroda, 1997). Thus, chewing the leaves and discarding the wads of *C. vespertilionis* by long-tailed macaques at Khao Namsap might be an adaptation of monkeys to learn and use natural resources for themselves.

Although Khao Namsap is only a small fragment of forest, it has an importance far beyond its size. It provides biodiversity resources not only for local people but also serves as a valuable natural laboratory for the University. Further studies in ecological and related aspects should be carried out to safeguard this value for the future.

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CHẾ ĐỘ ĂN THỰC VẬT CỦA KHỈ ĐUÔI DÀI (*MACACA FASCICULARIS*) TẠI MỘT KHU RỪNG CÓ SINH CẢNH BỊ TÁC ĐỘNG Ở PHÍA NAM THÁI LAN

TÓM TẮT

Hai đàn khỉ đuôi dài (*Macaca fascicularis*) sống trong một khu rừng hỗn giao cây rụng lá với diện tích 54.4ha nằm trong khu Si Racha của trường Đại Học Kasetsart ở phía Nam Thái Lan. Bao quanh khu rừng là các vùng cộng đồng địa phương, các doanh nghiệp tư nhân, đền thờ và đường giao thông. Chi cục Lâm nghiệp Hoàng gia Thái Lan cho phép Trường Đại học sử dụng rừng này vào mục đích bảo tồn và giáo dục từ năm 2005. Trong suốt năm 2008 chúng tôi đã xác định số lượng của các loài khỉ và chế độ dinh dưỡng thực vật vào mỗi tháng trong các khu vực cư ngụ của chúng. Chúng tôi tìm thấy hai đàn khỉ với số lượng lần lượt là 109 và 17 cá thể. Thức ăn của chúng bao gồm 54 loài (31 họ) thực vật được xác định trong đó có 10 loại cỏ (Gramineae) và 8 loại cỏ Leguminosae. Vào mùa mưa, các lá cây già và non chiếm trung bình 52% (dãy 40 – 70%) của tất cả 54 loài có chế độ ăn lá cây trong khi đó loại thức ăn hoa quả và hạt giống đạt mức trung bình là 48% (dãy 30 – 60%). Các lá cây già duy nhất xấp xỉ đạt 30% các loại thức ăn trong mùa khô và lạnh (từ tháng 12 đến tháng 2), mùa mưa đầu mùa (từ tháng 3 – tháng 5), và mùa mưa cuối mùa (tháng 9 – tháng 11). Trong khi đó các lá cây gia tăng 10% vào mùa mưa giữa mùa (tháng 6 – tháng 8) trong khi các lá cây và trái cây non đang phát triển. Các con khỉ lớn thường nhai và xả vỏ của các loại lá cây cỏ *Christia vespertilionis* (L.f.) Bakh.f. (Leguminosae: Papilionoideae) lên thảm rừng thường thì vào thàng 3, tháng 8 và tháng 10. Các loài thực vật này đã được nghiên cứu ở Việt Nam cho việc chế dược phẩm chống sốt rét.

REFERENCES

Aggimarangsee, N. (1992): Survey for semi-tame colonies of macaques in Thailand. The Natural History Bulletin of the Siam Society 40, 103–166.

Aggimarangsee, N. & Brockelman, W.Y. (2005): Monkey-human interactions in Thailand. Am. J. Physical Anthropology (Suppl.) 40, 62–63.

Altman, J. (1974): Observational study of behavior: sampling methods. Behavior 49, 227–267.

Andresen, E. (1999): Seed dispersal by monkeys and the fate of dispersed seeds in Peruvian rain forest. Biotropica 31(1), 145–158.

Borries, C., Larney, E., Kreetiyutanont & Koenig, A. (2002): The diurnal primate community in a dry evergreen forest in Phu Khieo Wildlife Sanctuary, Northeast Thailand. The Natural History Bulletin of the Siam Society 50(1), 75–88.

Duengkae, P. (2007): Bird species diversity at Si Racha Campus, Kasetsart University and Khao-Kaset Forest Area. Final Report. Kasetsart University Research and Development Institute.

Duengkae, P. (2007): Survey on wildlife species diversity in Khao-Kaset Forest Area at the Si Racha Campus, Kasetsart University. Final Report. Kasetsart University Research and Development Institute.

Dupain, J., Elsacker, L., Nell, C., Garcia, P., Ponce, F. & Huffman, M. A. (2002): New Evidence for Leaf Swallowing and *Oesophagostomum* Infection in Bonobos (*Pan paniscus*). Int. J. Primatol. 23(5), 1053–1062.

Geissmann, T., Njiman, V. & Dallmann, R. (2006): The fate of diurnal primates in southern Sumatra. Gibbon Journal 2, 18–24.

Huffman, M.A. & Hirata, S. (2004): An experimental study of leaf swallowing in captive chimpanzees: insights into the origin of a self-medicative behavior and the role of social learning. Primates 45, 113–118.

Huffman, M.A., Page, J.E., Shukdeo, M.V.K., Gotoh, S., Kalunde, M.S., Chandrasari, T. & Towers, G.H.N. (1996): Leaf-swallowing by chimpanzees: Abehavioral adaptation for the control of strongyle nematode infections. Int. J. Primatol. 17(4), 475–503.

IUCN (2008): 2008 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 15 April 2009.

Khopai, O. (2007): The Study of Plant Species Composition and Structural Characteristics in Si Racha Campus, Kasetsart University and Khao-Kaset Forest Area. Final Report. Kasetsart University Research and Development Institute.

Kuroda, S. (1997): Possible Use of Medicinal Plants by Western Lowland Gorillas (*G. g. gorilla*) and Tschego Chimpanzees (*Pan t. troglodytes*) in the Ndoki Forest, and Pygmy Chimpanzees (*P. paniscus*) in Wamba. In: Proceeding of the Sixth International Symposium on Traditional Medicine in Toyama, pp 155-162.

Lekagul, B. & McNeely, J.A. (1988): Mammals of Thailand. 2nd Edition. Darnsutha Press, Bangkok.

Lucas, P.W. & Corlett, R.T. (1998): Seed dispersal by long-tailed macaques. Am. J. Primatol. 45, 29–44.

Malaivijitnond, S., Lekprayoon, C., Tandavanittj, N., Panha, S., Cheewatham, C. & Hamada, Y. (2007): Stone tool usage by Thai long-tailed macaques (*Macaca fascicularis*). Am. J. Primatol. 69, 227–233.

Malaivijitnond, S. & Hamada, Y. (2008): Current Situation and Status of Long-tailed Macaques (*Macaca fascicularis*) in Thailand. The Natural Journal of Chulalongkorn University 8(2), 185–204.

Malaivijitnond, S., Hamada, Y., Varavudhi, P. & Takenaka (2005): The current distribution and status of macaques in Thailand. The Natural Journal of Chulalongkorn University (Suppl.) 1, 35–45

Neary, D.G. and Overby, S.T. (2006): Wildfire and post-fire erosion impacts on forest ecosystem carbon and nitrogen: An analysis. Forest Ecology and Management.

NESDB (National Economic and Social Development Board) (2007): The 10th National Economic and Social Development Plan.

Nguyen-Pouplin, J., Tran, H., Tran, H., Phan, T.A., Dolecek, C., Farrar, J., Tran, T.H. Caron, P., Bodo, B. & Grellier, P. (2007): Antimalarial and cytotoxic activities of ethnopharmacologically selected medicinal plants from South Vietnam. J. Ethno-Pharmacology 109 (3), 417–427.

Tianpech, P., Swatsitang, P. & Tanpanich, S. (2008): Antioxidant capacity and nutritional values of Pak-Wanpa (*Melientha suavis* Pierre.). Journal of Science Khon Kaen University (Suppl.) 36: 75–82.

Thawornwong, L. (2006): Project on Khao Kaset grid system. Final Report. Kasetsart University Research and Development Institute.

Yeager, C.P. (1996): Feeding ecology of the long-tailed macaque (*Macaca fascicularis*) in Kalimantan Tengah, Indonesia. Int. J. Primatol. 17(1), 51–62.

15

SEASONAL EFFECTS ON FEEDING SELECTION BY DELACOUR'S LANGUR (*TRACHYPITHECUS DELACOURI*) IN VAN LONG NATURE RESERVE, VIETNAM

CATHERINE WORKMAN AND LE VAN DUNG

SUMMARY

The 'Critically Endangered' Delacour's langur (*Trachypithecus delacouri*) of northern Vietnam lives in an environment where both temperature and rainfall show high seasonal fluctuation. Here we describe temporal changes in the food availability and diet of the Delacour's langur on Dong Quyen Mountain in Van Long Nature Reserve, Vietnam between August 2007 and July 2008. We collected daily data on relative humidity, rainfall, and temperature as well as bimonthly monitoring of two plant phenology transects. Behavioral data were collected using the focal animal sampling method (*n*=350 hours) on seven unhabituated langur groups. During the study period, total annual rainfall was 1375 mm, with 89% of rain falling between May-October (wet season). Availability of plant parts changed across the year with young and mature leaves the most available across all months. No variation exists between wet and dry seasons, but monthly changes are evident. Temperature, rainfall, young leaf availability, and feeding breadth were lowest from December to February. Young leaves never comprised less than 35% of the diet. Young leaf consumption peaked in April (89.9%) and was lowest in August (35.1%). Across months, there were no significantly positive relationships between the consumption and availability of young leaves, mature leaves, fruit, or flowers. Despite the lack of significance in these relationships, however, there are interesting patterns in the availability and consumption of plant parts over the months. We conclude that young leaf availability throughout the year - coupled with the lack of hunting - is allowing the rebound of the Dong Quyen Mountain langur population.

INTRODUCTION

Plant phenological patterns impact on seasonal changes in primate diets, ranging, habitat use, and ultimately reproduction (White, 1998). Seasonal variation in colobine diets is well-studied, yet dietary data on the limestone langurs of Southeast Asia are still emerging. Limestone karst is a distinct habitat and therefore characterizing the diet of langurs inhabiting limestone forests is important to understanding the total range of colobine dietary diversity. Further, temperature and rainfall in limestone langur habitat fluctuates widely across seasons.

The limestone langurs of the genus *Trachypithecus* include six allopatric taxa: white-headed langur (*T. leucocephalus*), endemic to China, Francois' langur (*T. francoisi*), of Vietnam and China, Delacour's langur (*T. delacouri*) and Cat Ba langur (*T. poliocephalus*), endemic to Vietnam, Lao langur (*T. laotum*), endemic to Laos, and Hatinh langur (*T. hatinhensis*) of Laos and Vietnam. Researchers have studied the diet and feeding behavior of white-headed langur in China (Huang *et al*., 2000; Li *et al*., 2003; Li & Rogers, 2006) yet systematic studies on the feeding ecology of the five other taxa in this monophyletic group have not yet been conducted.

Delacour's langurs inhabit an unusually harsh environment in Vietnam where they move and forage on rough, sparsely vegetated karst formations. Currently, about 200 individuals in 50-57 groups remain in 18 isolated subpopulations. Populations occur in four provinces in northern Vietnam, comprising an area of 5,000 km^2, of which actual locales comprise 400 km^2 (Nadler, 2004; Nadler, pers. comm.). Due to small and isolated subpopulations, high historic hunting pressure, and the difficulty of working on rugged limestone topography, Delacour's langurs are not well habituated to observers and cannot be studied for long periods of time. All dietary information on this primate has come from anecdotal observations and from captive studies (O'Brien *et al*., 2006; Le Van Dung, 2007).

Northern Vietnam is characterized by hot, wet summers and cold, drier winters. From China south to 18 degrees latitude, temperatures and rainfall are seasonal (Sterling *et al*., 2006). Broadly speaking, a hot, wet, humid summer lasts from May to October and a less-humid, cold winter with light rain lasts from November to April. Vietnam's cold winter weather is caused by winds blowing from Siberia south to Australia, while the summer monsoon is caused by warm, wet winds coming up from the Gulf of Thailand and the Indian Ocean (Sterling *et al*., 2006). Late winter and early spring in the north is often characterized by a misting and light drizzle as the humidity rises.

In this study we present data on the diet and feeding behavior of Delacour's langurs on Dong Quyen Mountain in Van Long Nature Reserve from August 2007 through July 2008. Seasonal differences in feeding and the relationship between plant part availability and feeding preference was investigated.

MATERIAL AND METHODS

Study Site

Research was conducted at the Dong Quyen karst mountain of Van Long Nature Reserve (20º20'55"N, 105º48'20"E) Ninh Binh Province, northern Vietnam, about 80 km South of Hanoi. Van Long Nature Reserve (VLNR) is a wetland. In the south-eastern part of the reserve, marshes fragment the mountain ranges into separate limestone island blocks. The primary study site is one such 265 ha block, Dong Quyen, which rises from 1 m to 328 m elevation (Fig. 1).

The dominant vegetation at VLNR is a mixture of mostly evergreen and some deciduous forest on limestone and arenaceous hills, of which the highest peak is 428 m asl. (Nguyen Ngoc Quynh, 2001). No plant species or family dominates the flora at VLNR. Vegetation on Dong Quyen Mountain is comprised of woody trees and shrubs (43.5%), herbs (25.4%), climbers (29.7%), and grasses (1.4%).

Feeding Ecology of Delacour's Langurs

Data were collected from August 2007-July 2008. We pushed a bamboo boat through the wetland each morning, scanning Dong Quyen and collecting data whenever we located a group of langurs (Fig. 2 and 3). We knew the approximate location of groups from previous survey work. We observed seven groups for information on diet, but we concentrated our searching and observation efforts on three groups that were most visible. When one of these three groups could not be found, we looked for another group. We collected data on adult males, adult females, females with dependent young, and subadults. Focal animals were chosen randomly each day, based on which langur group was encountered. Few langurs were able to be identified confidently as individuals, and therefore data collection focused on rotation of age and sex class.

When we encountered a langur group, we used the instantaneous focal individual sampling method (Altmann, 1974) to record data for as long as possible (n=21,012 min.; 200 days). We used Canon 18x50IS binoculars and a Bushnell Trophy 20-60x65 spotting scope, from an average distance of between 50-400 m. As at Fusui Nature Reserve, China, VLNR's topography is characterized by steep cliffs which caused langur groups to be frequently out of sight (Li *et al*., 2003) and which did not permit following the same group every day (Li & Rogers, 2006). However, the boat allowed quick responses to langur movements compared to slow and dangerous travel on the karst. In addition, langurs were not fully habituated at VLNR, but would tolerate closer approach (<10 m) by humans in the boat. On several occasions CW was able to come within 10 meters of two of the groups.

We measured feeding effort rather than food intake and therefore all dietary data are expressed as a percentage of feeding records (Li & Rogers, 2006). The feeding effort method is consistent with that of most other studies of colobine behavioral ecology (Davies, 1984; Oates, 1977; Li & Rogers, 2006; Stanford, 1991; Struhsaker, 1975). Feeding was recorded as any occasion when a langur took or moved vegetation towards its mouth, ingested,

Fig. 1. Dong Quyen Mountain in Van Long Nature Reserve, the study site.

Photo: Tilo Nadler.

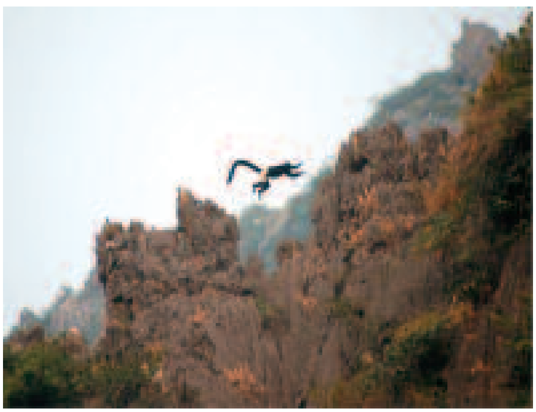

Fig. 2. The rough and sparsely vegetated karst formation is the habitat of Delacour's langur (*Trachypithecus delacouri*) in Van Long Nature Reserve.

Photo: Catherine Workman.

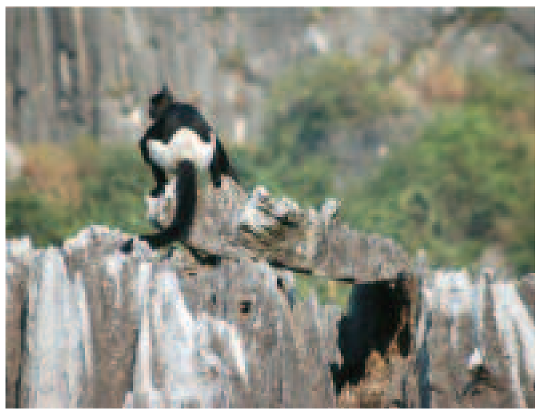

Fig. 3. The leader of a Delacour's langur group observes the area during the members of the group foraging.

Photo: Catherine Workman.

masticated, or swallowed food (Fashing, 2001) (Fig. 4). When a focal animal was feeding, the species and plant part (young leaves, mature leaves, unripe fruit, ripe fruit, flowers, buds, stems, and seeds) consumed was noted. When an animal was feeding but the plant item could not clearly be seen, the item was classified as unidentified.

Throughout the course of the project, unknown foods eaten by the Delacour's langurs were identified by Nguyen The Cuong (Institute for Ecology and

Fig. 4. A Delacour's langur female (*Trachypithecus delacouri*) - to identify on the white pubic patch - feeding on a climber.

Photo: Catherine Workman.

Biological Resources) and Nguyen Manh Cuong (Cuc Phuong National Park) using collected samples and digital photographs. CW spent June and July 2007 learning to identify the plant species. Langurs on Dong Quyen consumed four plant species that could not be identified, although these species only contributed 0.26% to the total annual diet.

Phenology of Plant Parts

We collected data on relative humidity, rainfall, and temperature for 394 days from July 2007-July 2008. To produce a quantitative measure of plant part availability, we monitored 187 plants in two phenology transects on the mountain. Due to the karst topography, transects were not straight lines. Transect 1 was 230 m, covering an elevation of 92 m. Transect 2 was 361 m covering an elevation of 124 m. We scored all plants within 5 m of the transect as climbers, herbs, shrubs, or trees. We recorded plant species, height and DBH where applicable. Transects were monitored bimonthly and scored for the presence or absence of young and mature leaves, flowers, and ripe and unripe fruit.

In 2006, CW and the Institute for Ecology and Biological Resources recorded 145 plant species on Dong Quyen Mountain (unpublished data). At the time the study began, the specific food plants consumed by Delacour's langurs were unknown and therefore specific food plant species were not monitored.

RESULTS

Climate and Phenology of Plant Part Availability

From August 2007-July 2008, the mean maximum temperature was 31ºC, and the mean minimum was 13ºC (n=394, range=9-37ºC). Relative humidity ranged from 39% to 91% with a mean of

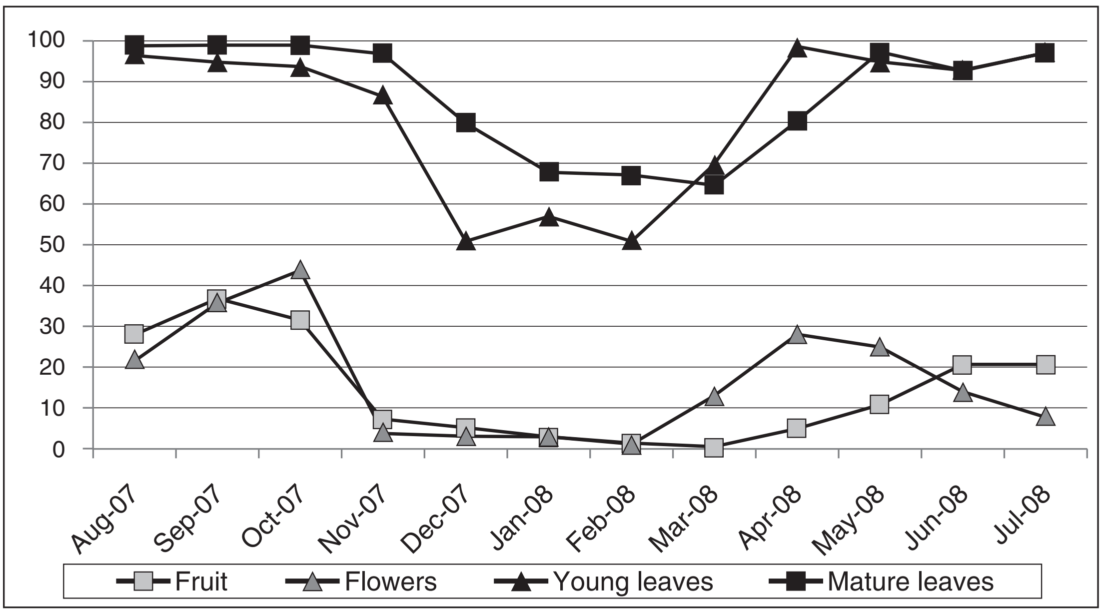

Fig. 5. Phenological changes in the availability of plant parts from August 2007-July 2008.

75%. Total annual rainfall during the study period was 1375.62 mm, with 89% of rain falling between May-October. We recognized a wet and dry season based on this distribution.

Plant parts showed seasonal availability (Fig. 5). Young and mature leaves were the most available parts throughout the year. The lean months were December-February, when mean temperatures and young leaf availability were the lowest. The availability of all plant parts was lowest during this time, and many deciduous trees lost their leaves completely. Nearly 100% of plants had young and mature leaves in the wet season of May-October with a decrease of both recorded in November. After decreased leaf production in the winter months, young leaves started to increase in March while mature leaves were observed in increasing abundance in April. Flowers were most abundant during May through October with peak abundance in October. Fruit was generally most available in July-October with almost no ripe or unripe fruit during January, February, and March. Along with flowers, peak fruit abundance was October 2007.

Annual Dietary Composition: Plant Parts

The general plant types in the langurs' diet included trees and shrubs (45.2%), climbers (52.4%), and one herb species (2.4%) (Table 1). The langurs fed on the following plant parts: young leaves, mature leaves, unripe fruit, ripe fruit, flowers, leaf buds, flower buds, seeds, and stems (Table 2). Langurs were never observed eating any animal or invertebrate matter, although juvenile and subadult langurs were seen chasing squirrels on a few occasions. Langurs drank water, both from the wetland and from karst bowls.

Data on plant part consumed were available for 94.9% of the total feeding records. Leaves comprised the majority of the langurs' diet (78.7%). More than half of the annual diet was young leaves (58.25%) and 20.45% were mature leaves. The top four plant species were the most important sources of leaves, although langurs fed on the leaves of many woody and non-woody plants. Leaves were eaten from all but four (*Lantana camara*, *Cocculus sarmentosus*, *Taxillus* sp., and *Eriobotrya bengalensis*) of the 42 eaten species. From these four species, langurs ate only the unripe fruit. There were no species for which langurs ate the mature leaves but not the young leaves; however, there were several species for which langurs ate young leaves but were never seen ingesting mature leaves. Thus, the langur diet was mostly folivorous.

Table 1. Vegetation type of plants consumed by Delacour's langurs.

Vegetation Type	Number of species	Percentage of total species
Tree	16	38.1
Shrub	3	7.1
Herb	1	2.4
Climber	22	52.4

Table 2. Annual feeding records by plant part consumed by Delacour's langurs.

Plant part	Percentage of annual diet
Young leaves	58.25
Mature leaves	20.45
Unripe fruit	9.23
Flowers and flower buds	5.15
Leaf buds	0.99
Seeds	0.6
Stems	0.25
Ripe fruit	0.08
Unidentified items	5

Non-leaf items combined to account for less than 20% of the langurs' diet. Fruit made up 9.3% of the diet, 0.08% of which was ripe fruit. The majority of the fruit that the langurs consumed was that of *Lantana camara*; langurs ate only the fruit – and almost exclusively the unripe fruit- of this plant, which was the fifth most frequently consumed plant species (7.2%). Flowers comprised 4.85% of the diet, followed by seeds (0.6%), stems (0.25%), leaf buds (0.99%), and flower buds (0.3%). The majority of the flowers that the langurs consumed were from *Broussonetia papyrifera* and *Alangium kurzii*. Seeds and shoots were only eaten from one plant species each: *Derris tonkinensis* and *Pothos repens*, respectively. Therefore, langurs concentrated on leaves.

Annual Dietary Composition: Plant Species

Data on species consumed were available for 67.4% of all feeding records (n=3,986). Langurs were observed feeding from a total of 42 species belonging to at least 36 genera and 24 families (Table 3). Sixteen plant species each contributed at least 1% of the annual feeding records, and these species together constituted at least 93.6% of the total feeding records (Table 4). Therefore, langurs were selective for plant species.

The top four plant species, from three different families, comprised over half (55.7%) of the langurs' annual feeding records, and the ten most frequently-consumed species together made up at least 83.8% of the feeding records. The langurs fed most frequently on the young leaves, mature leaves, and flowers of *Broussonetia papyrifera* (22.2%), followed by the young and mature leaves of *Wrightia macrocarpa* (13.4%), and the young leaves, mature leaves, and flowers of *Alangium kurzii* (11.1%). The young leaves, mature leaves, and unripe fruit of Ficus microcarpa comprised at least 9.2% of the langurs feeding records, and no other plant species contributed more than 8% of the total feeding records. Langurs selectively ate plant species.

Temporal Patterning of Feeding Behavior: Plant Parts

While young and mature leaves comprised more than three-fourths of the langurs' annual feeding records, variation existed across months in the contribution of different plant parts to the feeding records. There is a general lack of variation in dietary composition between wet and dry seasons (Fig. 6). Comparing the dry and wet seasons, langurs ate young leaves (62.9 vs. 55.5%), mature leaves (18.1 vs. 23.3%), fruit (9 vs. 9.5%), seeds (1.1 vs. 0%), and flowers (7.6 vs. 2.4%). These differences are not statistically significant, but monthly variation is evident. Feeding on young leaves peaked at 89.8% in April, and reached its lowest at 35.1% of the feeding records in August. Young leaves accounted for at least 35% of feeding records in all 11 months of feeding analyses. No other plant part contributed more than 39% of any month's feeding records. While mature leaves were eaten in every month, the langurs' consumption of mature leaves varied extensively, peaking at 38.2% in September, but reaching a low of 2.9% in April, when young leaf consumption was highest. Thus, langurs selectively chose young leaves over mature leaves.

Fruit consumption also varied greatly. Fruit consumption reached a high of 21.1% in July 2008, while the langurs did not eat any fruit in February. Seed consumption was absent from all months except February, when it accounted for 17.8% of feeding records. One solo male (seemingly a migrating male) was observed eating the seeds of *Derris tonkinensis* growing on rocks at the base of Dong Quyen. Flowers were absent from feeding records during five months and accounted for <1% in

Table 3. Plant species consumed by Delacour's langurs on Dong Quyen Mountain.

Family	Genera	Species	Family	Genera	Species
Alangraceae	1	1	Malpighiaceae	1	1
Apocynaceae	1	1	Menispermaceae	3	3
Araceae	1	1	Moraceae	3	4
Caesalpinaceae	1	1	Oleaceae	1	1
Combretaceae	2	2	Rosaceae	2	2
Convolvulaceae	2	2	Rubiaceae	2	2
Dioscoreacea	1	1	Rutaceae	2	2
Ebenaceae	1	1	Sterculiaceae	1	1
Euphorbiaceae	5	6	Uderbenaceae	1	1
Fabaceae	1	1	Urticaceae	1	1
Flacourtiaceae	1	1	Verbenaceae	1	1
Loxanthaceae	1	1	Unidentified families	4	4

Table 4. Species contributing at least 1% of annual feeding records consumed by Delacour's langurs, ranked in order of percent contribution.

Rank	Family	Species	Parts Eaten[1]	Percent Annual Feeding Records	Cumulative Percent	Months Consumed[2]
1	Moraceae	*B. papyrifera*	yl, ml, fl	22.2	22.0	10
2	Apocynaceae	*W. macrocarpa*	yl, ml, fl	13.4	35.4	9
3	Alangraceae	*A. kurzii*	yl, ml, fl, lb	11.1	46.5	9
4	Moraceae	*F. microcarpa*	yl, ml, uf, rf	9.2	55.7	9
5	Uderbenaceae	*L. camara*	uf	7.2	62.9	6
6	Euphorbiaceae	*A. tiliaefolia*	yl, ml	6.7	69.6	6
7	Fabaceae	*D. tonkinensis*	yl, ml, fl, lb, se	4.8	74.4	7
8	Convolvulaceae	*I. bonii*	yl, ml, fl, lb, st	4.3	78.7	4
9	Oleaceae	*L. verticillata*	yl, ml, uf, lb	2.7	81.4	6
10	Ebenaceae	*D. mollis*	yl, ml, uf	2.4	83.8	6
11	Rubiaceae	*G. tonkinensis*	yl, ml, uf	2.2	86	3
12	Euphorbiaceae	*M. philippensis*	yl, ml, uf	1.9	87.9	7
13	Euphorbiaceae	*B. retusa*	yl	1.8	89.7	2
14	Urticaceae	*D. squamata*	yl	1.8	91.5	2
15	Malpighiaceae	*H. lucida*	yl	1.1	92.6	1
16	Menispermaceae	*S. rotunda*	yl, ml, uf	1	93.6	5

[1] yl=young leaf, ml=mature leaf, uf=unripe fruit, rf=ripe fruit, fl=flower, lb=leaf bud, st=stem, se=seed.
[2] Out of a total of 11 months (January not included in annual diet).

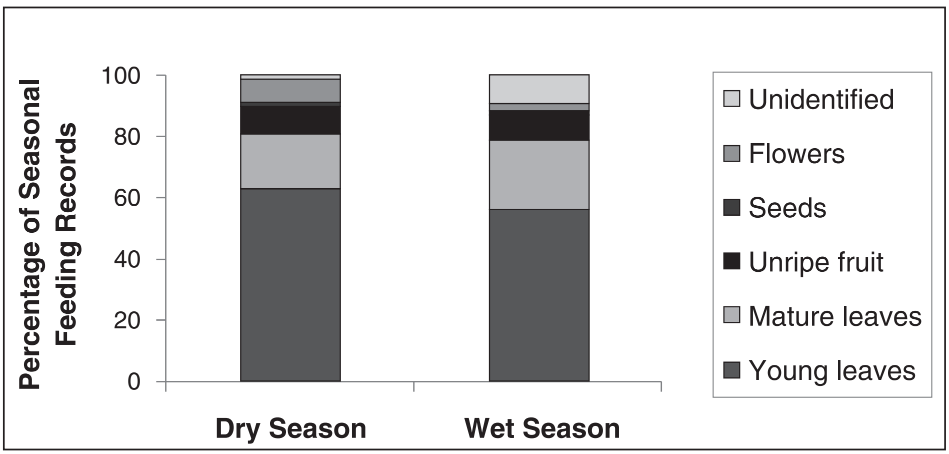

Fig. 6. Seasonal consumption of plant parts for Delacour's langurs (*Trachypithecus delacouri*) at Van Long Nature Reserve.

two more. Flower consumption was highest in March, comprising 27.4% of the diet. Unidentified plant parts accounted for less than 8% of the feeding records in all months except for August, when 35.3% of eaten foods were unidentified. The temporal variation of the consumption of different plant parts therefore does not appear to simply reflect seasonality.

Temporal Patterning of Feeding Behavior: Plant Species

Although the top 16 plant species together comprised at least 93.6% of the langurs'annual feeding records, their inclusion was quite variable on a monthly basis. None of the species eaten by langurs were consumed in all 11 months included in these analyses (Table 4). *Broussonetia papyrifera* was the only species consumed during 10 months. It comprised at least 42.4% of the feeding in March, a substantially higher percentage than any other plant species' contribution to any month's feeding records. Langurs consumed the other most important species - *Wrightia macrocarpa*, *Alangium kurzii*, and *Ficus microcarpa* – during nine months. No other species was eaten in more than seven months. Thus, while no one species was eaten in all months, *B. papyrifera* was eaten in the most months.

Clear seasonal patterns existed in the langurs' consumption of four of the top five consumed species: *Broussonetia papyrifera*, *Wrightia macrocarpa*, *Alangium kurzii*, and *Lantana camara*, but not of *Ficus microcarpa* (Fig. 7). While the langurs used *Ficus microcarpa* fairly consistently across seasons (slightly more during the wet season), they fed with much greater frequency on *Broussonetia papyrifera* and *Wrightia macrocarpa* during the dry season, although these differences are not significant. The langurs' consumption of *Alangium kurzii* displayed the greatest seasonal disparity, contributing 25% of the wet season feeding records, but significantly less, only 4.6%, during the dry season (p=0.0003). The fifth most prevalent food species, *Lantana camara*, only contributed 3.4% of the diet during the wet season but contributed more than 10% of the diet during the dry season. The langurs therefore selected plant parts from their most important species on a seasonal basis.

The sixth through ninth most prevelant food species - *Alchornia tiliaefolia*, *Derris tonkinensis*, *Ipomoea bonii*, and *Linociera verticillata* - each contributed at least 10% of the feeding records during one month of the year and showed clear seasonal patterns. *Ipomoea bonii* was eaten almost exclusively during the dry season, while *Alchornia tiliaefolia* and *Linociera verticillata* were more frequently eaten during the wet season. Nine months of the year, *Derris tonkinensis* accounted for less than 2% of the feeding records. In February, however, it comprised a substantially higher percentage to the diet than any other plant species. Further, *D. tonkinensis* was the only seed that we observed the langurs consume. Annually, however,

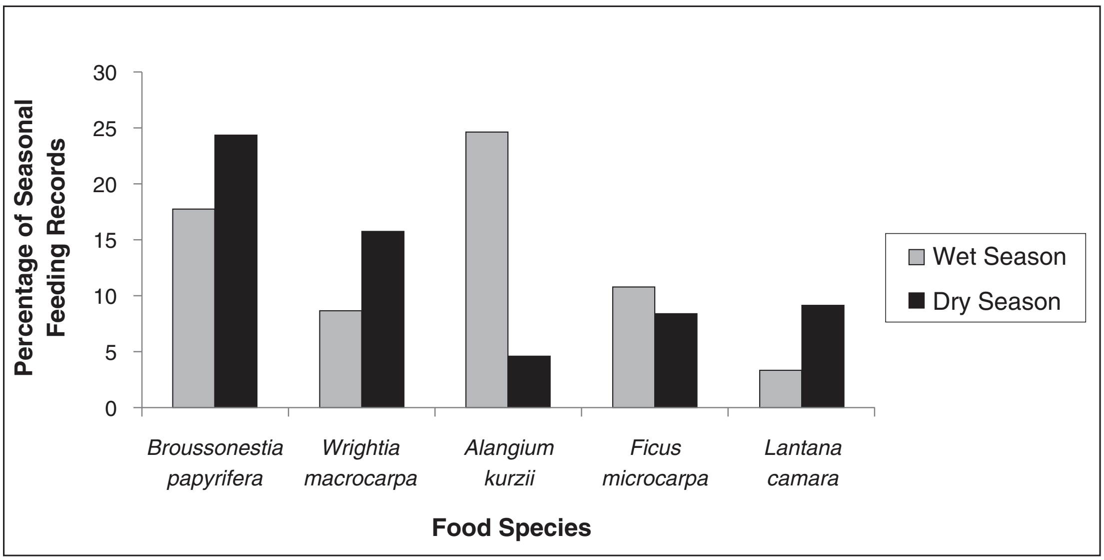

Fig. 7. Seasonal consumption of Delacour's langurs' five most important species.

these species were a small percent of the langurs' diet (Table 4).

Plant Part Availability and Selection

The temporal consumption of different plant parts was not tied to the availability of those plant parts in the habitat, over the 11 month period. Across months, there were no significantly positive relationships between the consumption and availability of young leaves (r_s=0.188, p=0.574, N=11), mature leaves (r_s=0.445, p=0.169, N=11), fruit (r_s=0.370, p=0.258, N=11), or flowers (r_s=0.305, p=0.355, N=11). Despite the lack of significance in these relationships, however, there are interesting patterns in the availability and consumption of plant parts over the months (Fig. 8).

In addition to reaching peak consumption in April, young leaf consumption and availability were most closely correlated in December, February, March and April. Young leaf availability was lowest during December and February. As leaf bud and young leaf availability rose in March and April, langur consumption similarly rose. Availability and consumption of young leaves then diverged in the summer months (June, July, August), a time when unripe fruit consumption rose. Young leaves were therefore preferred throughout the year.

Unripe fruit consumption rose along with availability in May-July. In November and December, however, unripe fruit consumption also spiked, at a time when overall fruit availability was low in the habitat. November was the month of peak consumption of *Lantana camara*, a species whose fruit was eaten exclusively. When fruit was most available (August-October), consumption was near its lowest. Both availability and consumption of fruit bottomed out in February-April. Mature leaf consumption showed a small spike in February, corresponding to a time when young leaf availability was lowest (Fig. 4). Mature leaves contributed their smallest amount to the langur diet during March-May when young leaf availability was peaking. Thus, mature leaf and fruit consumption rose only at times of the year when young leaf availability or consumption declined.

The number of plant species that the langurs consumed also varied across months, and these patterns seemed to loosely reflect seasonality. Feeding breadth was lowest in February, with five species contributing to the feeding records, and peaked with 19 species contributing to the feeding record in April. The large number of plant species eaten in April may reflect that many plants had new growth during this month. The langurs, therefore, ate a wide variety of food species when their preferred food item was at its peak. Feeding breadth was also high in May-July 2008, and July was when many of

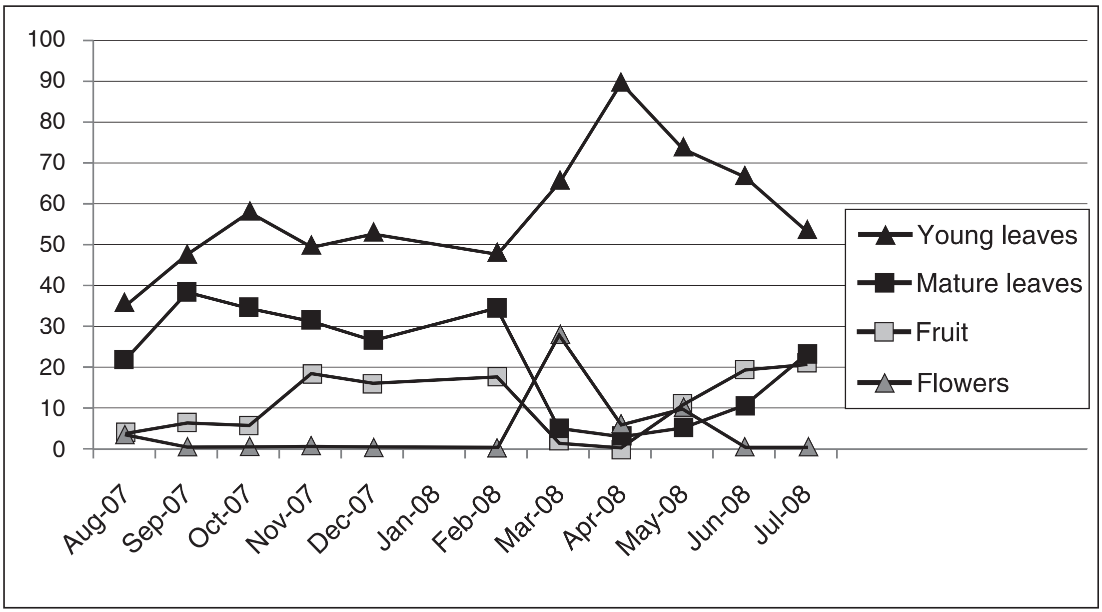

Fig. 8. Monthly changes in the proportions of different plant parts in the diet of Delacour's langurs (August 2007-July 2008).

the lesser important food species were consumed. High feeding breadth during these summer months also corresponds to an increase in the amount of unripe fruit in the diet. The number of food items consumed narrowed during the winter months, when overall availability of food items decreased. Thus, monthly feeding breadth seemed to fluctuate in part with young leaf availability.

DISCUSSION

Delacour's langurs fed on 42 of 145 plant species at Van Long Nature Reserve from August 2007-July 2008. Leaves comprised the overwhelming majority of the Delacour's langur diet and young leaves contributed the greatest proportion to the diet annually and across months and seasons. The top 16 of 42 species eaten by langurs at Van Long comprised more than 93% of the diet. We recognize the data presented here may not provide a complete dietary profile of this species because the habitat's steep cliffs limited our observations (Li & Rogers, 2006).

Comparisons with other colobines

Table 5 compares the diet of Delacour's langurs with other Asian langurs. The limestone langurs white-headed langur (*Trachypithecus leucocephalus*) and Delacour's langur (*T. delacouri*) are among the most folivorous of the Asian colobines. Only proboscis monkeys (*Nasalis larvatus*) Hose's langur (*Presbytis hosei*) eat as much foliage as the limestone langurs (74%, 78% respectively) (Boonratana, 1994; Mitchell, 1994). The degree of folivory of the limestone species is similar to that of the most highly folivorous *Colobus* sp. in Kibale National Park, for whom leaves comprise 78.5-94% (Harris & Chapman, 2007) or 80-92% of the diet (Wasserman & Chapman, 2003). In

Table 5. Dietary comparison between Delacour's langurs (*Trachypithecus delacouri*) and other Asian colobines.

Species	L	YL*	ML	FL	F/S	O	Source
Trachypithecus delacouri	79.7	59.2	20.5	5.1	9.3	5.9	this study
T. leucocephalus	83.3	74.9	8.4	2.4	7.7	2.2	Li *et al.*, 2003
T. leucocephalus	89	75.2	10.5	2.7	6.1	2.2	Li and Rogers, 2006
T. auratus	56	46	<10	14	32	8	Kool, 1993
T. pileatus	53	11	42	7	34	1	Stanford, 1991
T. johnii	52	25	27	9	25	6	Oates *et al.*, 1980
T. obscurus	58	36	22	7	35		Curtin, 1980
T. vetulus	60	20	40	12	28		Hladik, 1977
Presbytis rubicunda	37	36	1	11	49	2	Davies, 1994
P. siamensis	35	24	11	6	56	2	Curtin, 1980
P. hosei	78	45	5	3	19		Mitchell, 1994
Pygathrix nigripes		54.6		14.6	29.3	1.5	Duc *et al.*, 2009
Nasalis larvatus	74	73	<1	8	11	8	Boonratana, 1994
N. larvatus	52	41	11	3	40	5	Yeager 1989
Rhinopithecus roxellana	24				29.4	41.4	Guo *et al.*, 2007
R. bieti	34					69	Ding and Zhao, 2004

L=Total leaves; YL=young leaves; ML=mature leaves; FL=flowers; F/S=fruit and/or seeds; O=other or unidentified items
*Young leaves includes leaf buds.

fact, when mature and young leaves are combined for comparison, both of the limestone langurs are more folivorous than any of the other Asian species for which data are known.

In a recent review chapter, Kirkpatrick (2007) described Asian colobines as feeding predominantly on young leaves, supplementing with seeds and fruits. Indeed, several Asian colobine species depend on substantial contributions from seeds at certain times of the year (Yeager & Kool, 2000). For example, seed consumption by maroon langur (*Presbytis rubicunda*) reached an extreme of 87% of the diet in one month at Sepilok, Borneo (Davies, 1991). However, both Delacour's langurs and white-headed langurs include comparatively small proportions of seeds in their diet (0.6% and 0.4%, respectively). Delacour's langurs ate the seeds of *Derris tonkinensis* during a winter month when young leaves were at their lowest abundance, but the contribution of seeds to the diet - even at their peak contribution in February - was only 17.8%. Further, the overall contribution of fruit is dramatically low (less than 1/3 the amount) compared to other *Trachypithecus*' diets (Table 5). Li & Rogers (2006) suggested this might be due to a lack of suitable or seasonally available fruit in the limestone karst environment, and that langurs would eat more fruit if more fruit were available. While our study supports this hypothesis for limestone karst environments, fruit abundance needs to be quantified to clarify whether karstic environments have lower fruit and seed productivity. During November and December, *Lantana camara* seemed to be most available in the habitat and accounted for the second-greatest proportion of the diet after *Broussonetia papyrifera*, suggesting a preference for this fruit when available.

Seasonality of diet and switching between plant parts is associated with availability. For example, proboscis monkeys eats mostly young leaves but switches to fruits when young leaves are not available (Boonratana, 1994). The limestone langurs show less drastic seasonal variation than other colobines, however. In southern China, the white-headed langur shows a preference for young leaves, even in winter (Li, 2000; Li *et al*., 2003). The Delacour's langurs' similar fidelity to young leaves seems to be made possible by the availability of young leaves throughout the year. In all months, young leaves contributed the greatest percentage to the diet of Delacour's langurs at VLNR, never falling below 35%. Asynchronous flushing of young leaves throughout the year provides consistent edible foliage and might contribute to high primate folivore biomass (Ripley, 1979). At VLNR, asynchronous flushing of preferred young leaves – along with cessation of hunting in 2001 - may explain the quick rebound of the langur population on Dong Quyen Mountain. Delacour's langurs supplemented their young leaf consumption with mature leaves, but - like other langurs - they fed to the exclusion of the most consistently available item in the habitat: mature leaves (Kool, 1993).

The mostly folivorous diet of Delacour's langurs - as well as of white-headed langur - may also be explained by the kinds of trees present on limestone karst. Dong Quyen Mountain is unlike many Southeast Asian forests because it is not dominated by Dipterocarps but neither are leguminous trees abundant, an inverse relationship in SE Asia (Waterman *et al*., 1988). No plant family or species dominates the flora at either VLNR or Fusui Nature Reserve, China (Li *et al*., 2003). Vegetation communities growing over limestone are distinct in species composition from other forest types (Sterling *et al*., 2006). It may be that the absence of the dipterocarps' relatively indigestible foliage (Waterman *et al*., 1988) and the absence of exploitable leguminous seeds contribute to high folivory, especially of young leaves, by langurs living on limestone.

The narrowness of Delacour's langur diets is amplified when compared to that of *Rhinopithecus*. The Yunnan snub-nosed monkey (*Rhinopithecus bieti*) shows extreme dietary diversity, as they eat fungi, squirrels, underground storage organisms, terrestrial herbaceous vegetation, and snow (C. Grueter, pers. comm.). Lichens account for 50-67% of Yunnan snub-nosed monkey and golden snub-nosed monkey (*Rhinopithecus roxellana*) feeding records (Li, 2006), and Yunnan snub-nosed monkey ingest bamboo leaves and fir tree lichens as a large part of their diet, with a mere 12% contribution from young leaves (Wu, 1993; Yang & Zao, 2001; Xiao *et al*., 2003; C. Grueter, pers. comm.). Delacour's langurs were never observed ingesting invertebrates, animal matter, or lichens. In addition, Delacour's langurs differ from white-headed langur in that they were not observed licking the karst to collect insects or lichens (Li *et al*., 2003).

The selectivity of food plants by Delacour's langurs in this study has been shown for several colobines. White-headed langur eats just under 1/3 of available species (50 of 164 species) in Fusui Nature Reserve, China (Li *et al*., 2003), the same proportion eaten by Delacour's langurs at VLNR. Other Asian langurs also show feeding selectivity.

Purple-faced langur (*Trachypithecus vetulus*) in Sri Lanka feed on only 28 of 61 plant species (Hladik, 1977) and the capped langur (*Trachypithecus pileatus*) feeds on just 35 of 140 plant species at Madhupur, Bangladesh (Stanford, 1991). The mean number of plant species in the diet of 26 African colobine species listed by Kirkpatrick (2007) is 52. In southern China, white-headed langurs consumed 42 food plant species, the same amount in this study (Huang *et al*., 2000). The difference in this selectivity is that the majority of young leaves eaten by white-headed langurs were chosen mostly from uncommon trees (Li *et al*., 2003), yet Delacour's langurs did not focus on rare plants.

CONCLUSION

The most important plant species in the diet of Delacour's langur at VLNR during August 2007-July 2008 were not plants endemic to limestone habitats. At the Endangered Primate Rescue Center in northern Vietnam, Delacour's langur, Lao langur, Hatinh langur, and Cat Ba langur eat the leaves, bark, flowers, and fruit from more than 100 species, but less than 10% of these are typical limestone species (T. Nadler, pers. comm.). Despite these captive data, one of the several hypotheses proposed to account for the current use of and distribution on limestone karst by these colobine taxa is a dependence on endemic limestone food plant species. Our data do not support this hypothesis. Intense hunting pressure precludes a solely ecological explanation of limestone langur distribution and abundance on karst habitats, a similar ecological conundrum to that of African primate communities (Struhsaker, 1999). However, we suspect that a combination of karst as refuge habitat (Li & Rogers, 2005) as well as the use of caves and rock ledges for thermoregulation is the primary reason Delacour's langurs are now found almost exclusively on limestone karsts. Unfortunately, while karst is unsuitable for agriculture, accelerated limestone blasting for cement production threatens the remaining unprotected karst areas and their fragmented langur populations.

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NHỮNG ẢNH HƯỞNG CỦA CÁC MÙA ĐẾN VIỆC LỰA CHỌN THỨC ĂN CỦA VOỌC MÔNG TRẮNG (*TRACHYPITHECUS DELACOURI*) TẠI KHU BẢO TỒN ĐẤT NGẬP NƯỚC VÂN LONG, VIỆT NAM

TÓM TẮT

Voọc mông trắng (*Trachypithecus delacouri*), là loài cực kỳ nguy cấp sinh sống ở phía Bắc Việt Nam trong sinh cảnh sống có những thay đổi thất thường về nhiệt độ và lượng mưa theo mùa. Trong khuôn khổ tài liệu này, chúng tôi mô tả sự thay đổi nhiệt độ ảnh hưởng đến lượng thức ăn và chế độ ăn uống của loài voọc mông trắng tại núi Đồng Quyển thuộc Khu bảo tồn đất ngập nước Vân Long, Việt Nam từ tháng 8 năm 2007 đến tháng 7 năm 2008. Chúng tôi đã tiến hành thu thập dữ liệu hàng ngày về độ ẩm, lượng mưa, nhiệt độ, đồng thời tiến hành giám sát hai tuyến thức ăn thực vật hai lần trong một tháng. Sử dụng phương pháp thu thập thông số của động vật được lựa chọn (n=350 giờ) nhằm ghi nhận dữ liệu về thái độ loài cho bảy đàn voọc không thích nghi với khí hậu. Trong suốt tiến trình nghiên cứu ghi nhận được tổng lượng mưa hàng năm là 1,375mm, trong đó 89% lượng mưa xảy ra từ tháng 5 đến tháng 10 (mùa mưa). Trữ lượng thực vật thay đổi suốt năm, trong đó lá non và lá già hầu như có sẵn trong các tháng. Không thấy có sự biến đổi lớn giữa mùa mưa và mùa khô nhưng lại thấy rõ sự thay đổi giữa các tháng. Nhiệt độ, lượng mưa, nguồn

thức ăn lá non và nguồn thức ăn dồi dào cho loài lại thấp nhất từ tháng 12 đến tháng 2. Lá non luôn chiếm ít hơn 35% trong tổng số chế độ dinh dưỡng của loài. Động vật ăn lá non nhiều nhất vào tháng tư (chiếm 89.9%) và thấp nhất vào tháng 8 (chiếm 35.1%). Không có tháng nào trong năm thể hiện được mối quan hệ tích cực có ý nghĩa giữa chế độ ăn uống và trữ lượng sẵn có của lá non, lá già, trái cây hay hoa. Mặc dù thiếu đi ý nghĩa của các mối quan hệ này, vẫn có một vài điểm đáng quan tâm về trữ lượng sẵn có và chế độ dinh dưỡng của loài qua các tháng. Chúng tôi kết luận rằng với nguồn lá non luôn sẵn có trong cả năm, cùng với hoạt động săn bắt ngày càng giảm đi sẽ là dấu hiệu tích cực cho quần thể voọc mông trắng ở núi Đồng Quyển có cơ hội tăng trưởng trở lại.

References

Altmann, J. (1974): Observational study of behavior: Sampling methods. Behaviour 49, 227–267.

Boonratana, R. (1994): The ecology and behavior of the proboscis monkey (*Nasalis larvatus*) in the Lower Kinabatangan, Sabah. PhD thesis, Mahidol University, Bangkok.

Chengming Huang, Youbang Li, Qihai Zhou & Fuwen Wei (2004): A study on the behaviour of cave-entering and leaving and selection of sleeping sites of a Francois' langur group (*Trachypithecus francoisi*) in China. In: Nadler, T., Streicher, U., Ha Thang Long. (eds.): Conservation of primates in Vietnam; pp. 137-143. Frankfurt Zoological Society, Hanoi.

Curtin, S.H. (1980). Dusky and banded leaf monkeys. In: Chivers, D.J. (ed.): Malayan Forest Primates; pp. 107-145. Plenum Press, London.

Davies, A.G. (1984): An ecological study of the red leaf-monkey (*Presbytis rubicunda*) in the dipterocarp forest of northern Borneo. PhD thesis, University of Cambridge, England.

Davies, A.G. (1991): Seed-eating by red leaf monkeys (*Presbytis rubicunda*) in dipterocarp forest of northern Borneo. Int. J. Primatol. 12, 119–143.

Ding, W., & Zhao, Q.K. (2004): *Rhinopithecus bieti* at Tacheng, Yunnan: Diet and daytime activities. Int. J. Primatol. 25, 583–598.

Fashing, P.J. (2001): Feeding ecology of Guerezas in the Kakamega Forest, Kenya: The importance of Moraceae fruit in their diet. Int. J. Primatol. 22, 579–609.

Guo, S., Li, B. & Watanabe, K. (2007): Diet and activity budget of *Rhinopithecus roxellana* in the Qinling Mountains, China. Primates 48,268–276.

Harris, T.R. & Chapman, C. A. (2007): Variation in diet and ranging of black and white colobus monkeys in Kibale National Park, Uganda. Primates 48(3), 208-221.

Hoang Minh Duc, Baxter, G.S., Page, M.J. (2009): Diet of *Pygathrix nigripes* in southern Vietnam. Int. J. Primatol. 30,15–28.

Huang, C.M., Sun, R.Y., Xue, Y.G., Wei, S.L., Li, Y.B. (2000): The research on dietary and feeding time budget of white-headed leaf monkey. Acta Anthropol Sin 19(1), 65–72.

Kirkpatrick, R.C. (2007): The Asian colobines: diversity among leaf-eating monkeys. In: Campbell, C.J., Fuentes, A., MacKinnon, K.C., Panger, M. & Bearder, S.K. (eds.): Primates in Perspective; pp. 186-200. Oxford University Press, New York.

Kool, K.M. (1993): The diet and feeding behavior of the silver leaf monkey (*Trachypithecus auratus sondaicus*) in Indonesia. Int. J. Primatol. 14(5), 667-700.

Le Van Dung (2007): Feeding ecology and behavioral of Delacour's langurs at the semi- wild area in Endangered Primate Rescue Center. Thesis, Vietnam National University Hanoi.

Li, Z. (2000): The socioecology of white-headed langurs, *Presbytis leucocephalus*, and its implications for their conservation. PhD thesis, The University of Edinburgh, Scotland.

Li, Z.Y., Wei, Y. & Rogers, M.E. (2003): Food choice of white-headed langurs in Fusui, China. Int. J. Primatol. 24(6), 1189-1205.

Li, Z.Y. & Rogers, M.E. (2005): Are limestone hills a refuge or essential habitat for white-headed langurs in Fusui, China? Int. J. Primatol. 26(2), 437-452.

Li, Z.Y. & Rogers, M.E. (2006): Food items consumed by white-headed langurs in Fusui, China. Int. J. Primatol. 27(6), 1551-1567.

Mitchell, A.H. (1994): Ecology of Hose's langur, *Presbytis hosei*, in mixed logged and unlogged dipterocarp forest of northeast Borneo. PhD thesis, Yale University, New Haven.

Nguyen Ngoc Quynh (2001): Natural protected area: Van Long Wetland in Gia Vien, Ninh Binh. Hanoi, Vietnam.

Oates, J.F. (1977): The guereza and its food. In: Clutton-Brock, T.H. (ed.): Primate Ecology; pp. 276–321. Academic Press, London.

O'Brien, J.A., Ulibarri, L., Wright, B.W., Wright, K.A., Covert, H.H. & Nadler, T. (2006): A preliminary analysis of the mechanics, chemistry, and color of leaves ingested by four colobines species in Vietnam. Amer. J. Phys. Anthropol. 26, 140.

Ripley, S. (1979): Environmental grain, niche diversification, and positional behavior in Neogene primates: an evolutionary hypothesis. In: Morbeck M.E, Preuschoft H., & Gomberg N. (eds.): Environment, behavior and morphology: dynamic interactions in primates; pp. 37-74. Gustav Fischer, New York.

Rodman, P.S. (1978): Diets, densities, and distributions of Bornean primates. In: Montgomery G.G. (ed.): The ecology of arboreal folivores; pp. 465-478. Smithsonian Institution Press, Washington DC.

Ruhiyat, Y. (1983): Socio-ecological study of *Presbytis aygula* in west Java. Primates 24, 344-359.

Stanford, C.B. (1991): The capped langur in Bangladesh: behavioral ecology and reproductive tactics. S. Karger, Basel.

Sterling, E.J., Hurley, M.M. & Le Duc Minh. (2006): Vietnam: a natural history. Yale University Press, New Haven and London.

Struhsaker, T.T. (1975): The red colobus monkey. University of Chicago Press, Chicago.

Wasserman, M.D. & Chapman, C.A. (2003): Determinants of colobine monkey abundance: the importance of food energy, protein and fibre content. J. Anim. Ecol. 72, 650-659.

Waterman, P.G., Ross, J.A.M., Bennett, E.L. & Davies, A.G. (1988): A comparison of the floristics and leaf chemistry of the tree flora in two Malaysian rain forests and the influence of leaf chemistry on populations of colobine monkeys in the Old World. Biological J. Linnaean Society 34, 1-32.

Yeager, C.P. (1989): Feeding ecology of the proboscis monkey (*Nasalis larvatus*). Int. J. Primatol. 10(6), 497-530.

Yeager, C.P., & Kool, K. (2000): The behavioral ecology of Asian colobines. In: Whitehead, P.F. & Jolly, C.J. (eds.): Old world monkeys; pp. 496–521. Cambridge University Press, Cambridge.

16

FEEDING ECOLOGY OF YUNNAN SNUB-NOSED MONKEYS (*RHINOPITHECUS BIETI*) IN THE SAMAGE FOREST, BAIMAXUESHAN NATURE RESERVE, CHINA

CYRIL C. GRUETER, DAYONG LI, BAOPING REN, AND FUWEN WEI

SUMMARY

We provide data of an 18 month field study on the feeding ecology of Yunnan snub-nosed monkeys (*Rhinopithecus bieti*), a “Critically Endangered” colobine endemic to China. *Rhinopithecus bieti* inhabit probably the most extreme of all colobine habitats, living at the edge of the Himalaya Massif at altitudes above 3,000 m. The climate at the study site Samage is very seasonal and the habitat is made up montane mixed deciduous broadleaf and conifer forest. Lichens dominated the diet of the monkeys in all seasons, but the proportional representation of lichens varied from 51% in spring to 88% in winter. The lichen-based diet was complemented with seasonal plant phenophases, viz. young foliage in spring, fruit in summer/autumn, and mature leaves in autumn. Seasonal dietary shifts and a narrow diet spectrum as a result of overall food scarcity in winter are hallmarks of the feeding ecology of *Rhinopithecus bieti* at Samage. 94 plant species were found to be incorporated into the diet of the study group. As demonstrated by feeding records, the tree *Acanthopanax evodiaefolius* (Araliaceae) was the single most important food species, followed by *Sorbus* spp. (Rosaceae), and *Acer* spp. (Aceraceae). Investigation of feeding remains, however, indicate that bamboo *Fargesia* spp. was the major plant species in the diet. Other notable food items recorded in this study were tubers, mushrooms, mammalian flesh, and snow. Different populations of *Rhinopithecus bieti* vary considerably in their dietary strategies; this variability is attributable to differences in habitat composition, the latter being driven by altitude, latitude, precipitation and temperature. While Yunnan snub-nosed monkeys may be rather flexible with regard to their feeding strategies (as evidenced by considerable intraspecific differences in diet), the long term survival of this population can in all probability only be guaranteed if critical resources (lichens, bamboo shoots, deciduous broadleaf trees of Araliaceae, Rosaceae, and Aceraceae) can be preserved and protected from anthropogenic use.

INTRODUCTION

The four species of snub-nosed langurs (*Rhinopithecus brelichi*, *R. avunculus*, *R. roxellana*, *R. bieti*), systematically belonging to the monophyletic odd-nosed colobines, are large-bodied, stocky and semi-terrestrial leaf monkeys with markedly differing habitat requirements: the grey snub-nosed monkey (*Rhinopithecus brelichi*) is associated with subtropical-temperate mixed deciduous and evergreen broadleaf forests in NE Guizhou/China (Bleisch *et al*., 1993; Wu *et al*., 2004; Xiang *et al*., 2009), the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) inhabits tropical-subtropical evergreen broadleaf forests on limestone formations in N Vietnam (Le *et al*., 2007), and the golden snub-nosed monkey (*Rhinopithecus roxellana*) ranges mostly in mixed deciduous broadleaf/conifer forests in Central/SW China (Li *et al*., 2002; Tan *et al*., 2007). The diet of these taxa reflects their association with particular biota; the diet of *Rhinopithecus brelichi* is composed of leaves, fruits, seeds and flowers, with a conspicuous preponderance of leaf buds in winter (Bleisch & Xie, 1998). *Rhinopithecus roxellana* feed on leaves, fruits and seeds, buds, bark and lichens, with the latter three items being of significant importance in winter (Guo *et al*., 2007; Kirkpatrick *et al*., 1999; Li, 2006; Su *et al*., 1998). Seasonal differences in dietary composition are a characteristic of these temperate-living colobines. The diet of the more tropical *Rhinopithecus avunculus* is a mix of leaves, fruits and seeds (Boonratana & Le, 1998; Le *et al*., 2007).

The fourth species, the Yunnan snub-nosed monkey (*Rhinopithecus bieti*), is 'extreme' in terms of its ecological adaptations. This species has a highly restricted distribution between the upper Yangtze and Mekong rivers in the biodiversity hotspot of the Hengduan Mountains in NW Yunnan (Long *et al*., 1994). The habitat is mostly mixed deciduous broadleaf/conifer or pure conifer forest. The monkeys are not territorial and travel in large bands of up to 410 members (Grueter *et al*., 2008; Kirkpatrick *et al*., 1998). So far, the feeding ecology of *Rhinopithecus bieti* has been investigated in detail at three sites: two in the northern sector of the distributional range (Kirkpatrick, 1996; Xiang *et al*., 2007), and one in the southern sector (Ding & Zhao, 2004). Kirkpatrick (1996), in his pioneering work, noted that lichens constitute a large portion of the diet, and that plant foods are of secondary importance. Studies in areas of greater productivity and plant species richness (lower altitude and latitude, higher rainfall) found that plant foods are of at least equal importance to lichens in some seasons. In this chapter, we briefly highlight the key findings of a prolonged field study on the feeding ecology of a population of *Rhinopithecus bieti* in the Samage Forest (within Baimaxueshan Nature Reserve) (cf. also Grueter *et al*., in review; Grueter *et al*., in press)). *Rhinopithecus bieti* are a first class protected animal in China, listed on Appendix I of the IUCN (IUCN, 2007). Given the dire conservation status with a maximum of 2,000 individuals left in the wild (cf. Long & Wu, 2008)), the present findings are important for comprehending the species' resource requirements and carrying capacity of the habitat and thus have implications for conservation management.

METHODS

We conducted the present study in the Samage Forest near the village of Gehuaqing (27°34'N, 99°17'E) in Yunnan's Baimaxueshan National Nature Reserve (Fig. 1). Samage is named after Mt. Samage (4,100 m) and lies mostly within Weixi County. The habitat is characterized as highland temperate forest with a clear altitudinal zonation of vegetation types. Vegetation types at Samage were divided into six broad categories: mixed coniferous and deciduous-broadleaf forest (at 2,900 – 3,600 m), sub-alpine George's fir forest (3,500 – 4,000 m), montane sclerophyllous oak forest (3,200 – 3,500 m), subtropical evergreen broadleaf forest (2,500 – 3,000 m), Yunnan pine forest (2,500 – 3,100 m), as well as cattle pastures at various elevations. In terms of basal area, 77% of the trees at Samage are evergreen and 23% deciduous. Umbrella bamboos (*Fargesia* spp.) and rhododendrons form an important element of the underbrush in all vegetation types. Some forest areas are still primary, but commercial logging activities in the past and ongoing selective tree cutting has had a disruptive effect on the physiognomy of the forest. The habitat of the monkeys at this locality ranges from 2,600 m to 4,000 m and includes all major vegetation types, with mixed forest being the most commonly used ecotype and clear-cuts being unsuitable habitat for *Rhinopithecus bieti*. The semi-habituated focal group of *Rhinopithecus bieti* is composed of ca 410 members (Grueter, 2009).

The climate is extremely seasonal and influenced by the summer monsoon, resulting in sunny and dry winters with freezing nights and moderately warm summers with frequent downpours. Annual rainfall was 1,004 mm, and mean annual temperature was 14.3°C at 2,448 m (or

Fig. 1. Map showing the location of Baimaxueshan Nature Reserve and the study site Gehuaqing in Yunnan Province, People's Republic of China.

ca 10°C within the core area of the monkey group's main range). Snowfall was most intense in February. By January, all deciduous trees were bare as a result of natural leaf shedding.

CCG collected data on diet composition on 116 days over a 20 month period between September 2005 and July 2007. The rugged terrain with steep-sided ravines and impenetrable undergrowth (bamboo etc.) made tracking difficult, and thus distance observations (median distance to group: 200 m) from prominent topographical features such as rocky outcropping with help of a spotting scope were the methods of choice.

We took scans of all visible animals at 15 or 30 min intervals, depending on the number of individuals in view. For every subject being scanned, we recorded age, sex, and activity. Scan records of feeding behaviour also included the specific food item, i.e. lichens, young leaves, mature leaves, winter buds, flowers/flower buds, bark, pith, fruit, seeds, invertebrates, snow, fungi, water, bamboo shoots, and tuber. If we were unable to identify the tree species or genus by eye, we attempted to collect some samples from that feeding tree or a nearby tree of the same taxon for later identification. The behaviour of every animal scanned was considered to be an instantaneous sample. The practice of alternating between 15 and 30 min scan intervals yielded two data sets. We thus analyzed the two data sets separately and then calculated a grand mean. Proportions of the different food items in the diet were calculated for each month and each season.

During forest walks outside scan sessions, we recorded all partially consumed and discarded foods on the forest floor with tooth marks or other signs of having been handled by the monkeys. We used evidence from such feeding sign as a complementary measure to estimate diet composition. Observational sampling was usually biased toward arboreal feeding, so the importance of terrestrial foods such as bamboo shoots was likely underrepresented in scans.

The composition of the forest was investigated via stratified random sampling, i.e. we subdivided the forest into five distinct forest types (Mueller-Dombois & Ellenberg, 1974). The different strata are described fully in Li *et al*., (2008). We established a total of 67 plots of 20 m x 20 m each. The distribution of plots among the available vegetation types was based on the proportional availability of different vegetation types within the central part of the study area. We determined the availability of vegetation types through reconnaissance surveys and a GIS vegetation map. Within each stratum, we placed plots with an objective of sampling at different altitudinal belts (200 m intervals). Within these belts, we laid out plots along existing trails using a random walk procedure (Li *et al*., 2008).

Following Kirkpatrick (1996), we included only trees with a girth >40 cm. We identified all trees (n = 1,851) in the plots and measured girth using a forestry tape and later converted it to diameter at breast height (DBH). Tree density per plot was converted to number of trees per hectare. Basal area per tree is the cross-sectional area of a tree at breast height and was calculated by the following formula: BA = (.5 * DBH)2 * π.

The degree to which animals are selective in their choice of food tree species can be estimated by calculating a selection index (Krebs, 1999). This index compares the proportion of feeding observations of a plant species with the relative abundance of the species concerned as estimated from the botanical plots. Basal area is used to express the relative species crown biomass and potential food abundance, and the selection index is calculated from the formula: $W_i = O_i/P_i$, where W_i is the selection index, O_i the percentage of feeding observations for species i, and P_i the percentage of total basal area accounted for by species *i*. $W_i > 1$ indicates preference, $W_i < 1$ avoidance.

RESULTS

This study recorded 80 tree species of 23 families in the botanical plots in the Samage Forest. The family Pinaceae was the dominant plant family based on both basal area (46%) and stem density (37%). As estimated by basal area, the three dominant tree species at Samage were *Abies georgei* (13.3%), *Cyclobalanopsis* cf. *gambleana* (13.0%), and *Picea likiangensis* (12.5%). As estimated by stem density, the three dominant tree species were *Abies georgei* (14.8%), *Pinus yunannensis* (11.3%), and *Rhododendron rubiginosum* (8.4%). The discrepancy between basal area and stem density is probably the result of *Cyclobalanopsis* trees having trunks of relatively large diameter and *Rhododendron rubiginosum* trees having relatively small trunks.

The results on dietary composition of the study group are founded on a total of 2,674 feeding records that included information on the identity of the ingested food item. By averaging monthly proportional representations of particular food items, lichens were found to comprise the bulk of the annual diet, followed by young foliage and fruit (Fig. 2).

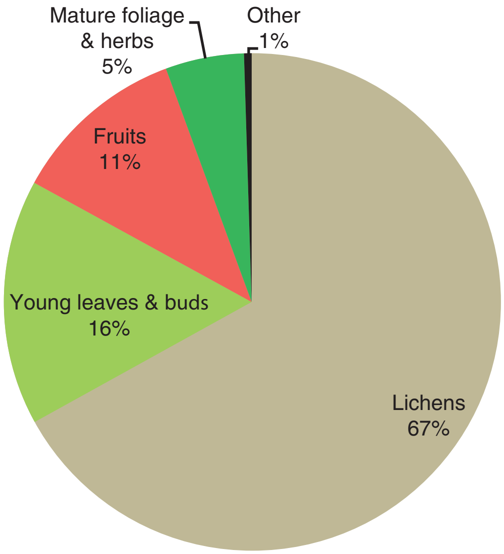

Fig. 2. Annual composition of the diet of a group of Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) in the Samage Forest near Gehuaqing, China.

Fig. 4. The lichens most frequently ingested by Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) at Samage/Gehuaqing is *Usnea longissima* (family Usneaceae), colloquially referred to as "Methuselah's Beard".

Photo: Cyril C. Grueter.

There were clear seasonal differences in diet composition (Fig. 3). Lichens (Fig. 4) dominated the diet in all seasons, but the proportional representation of lichens varied from 51% in spring to 88% in winter. The proportional consumption of lichens was significantly different between the dry and wet season ($F = 9.972$, $p = 0.005$; Table 1). The importance of young leaves and fruit in the diet fluctuated in line with the phenological availability of these phases across the year. The proportion of mature and young leaves varied significantly among the four seasons (mature leaves: $p = 0.003$; young leaves: $p = 0.009$; Table 2). Young leaves were the second most important food

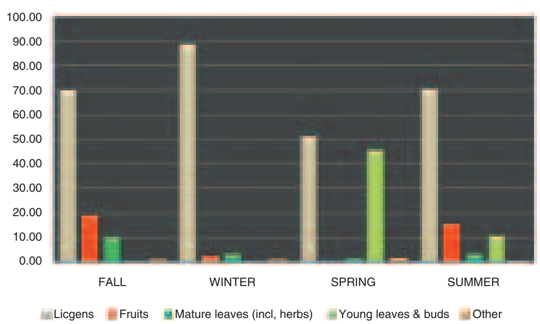

Fig. 3. Seasonal differences in diet composition of a group of Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) in the Samage Forest.

Table 1. Differences in proportional representation of specific foods in the diet of Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) at Samage between the dry and wet season (One-way ANOVA, df = 1). The dry season is Oct-Mar, the wet season is Apr-Sep.

Plant item	F	P
Lichens	9.972	**0.005**
Buds	3.876	*0.065*
Fruit	0.532	0.475
Mature leaves	0.884	0.360
Young leaves	10.368	**0.005**
Flowers	2.663	0.120
Herbs	0.548	0.469

Table 2. Differences in proportional representation of specific foods in the diet of Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) at Samage across the four seasons spring (Mar, Apr, May), summer (Jun, Jul, Aug), autumn (Sep, Oct, Nov), and winter (Dec, Jan, Feb) (One-way ANOVA, df = 3). Values in bold denote significant differences, values in italics denote statistical trends (0.10 >p>0.05).

Plant item	F	P
Lichens	2.817	*0.072*
Buds	1.075	0.388
Fruit	2.919	*0.066*
Mature leaves	6.869	**0.003**
Young leaves	5.516	**0.009**
Flowers	2.646	*0.084*
Herbs	0.977	0.428

item in spring, comprising 45% of the diet. There was also a statistically significant difference in feeding on young leaves between the dry and wet season ($F = 10.368$, $p = 0.005$). Fruit was the second most important food item in summer and autumn, comprising 15% and 18% of the diet, respectively. The diversity of food species was highest in April with 32 species and 38 items and October with 34 species and 38 items (Fig. 5).

At least 94 species (woody plants, shrubs, herbs and vines) and 38 families contributed to the diet of *Rhinopithecus bieti* at Samage. The family

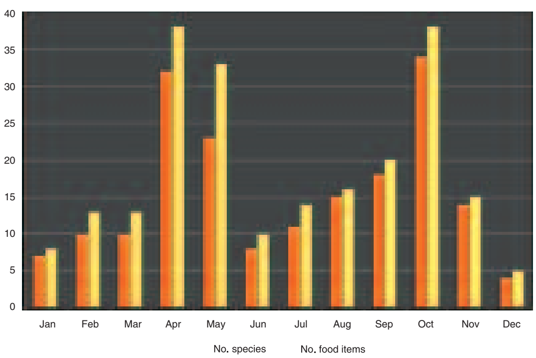

Fig. 5. Diversity of food species and food items of Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) at Samage across the year.

Table 3. Number of species eaten of each plant family by Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) at Samage.

Plant family	No. species
Rosaceae	17
Caprifoliaceae	7
Ericaceae	6
Aceraceae	5
Hydrangeaceae	4
Fagaceae	3
Liliaceae	3
Ranunculaceae	3
Urticaceae	3
Gramineae	3
Betulaceae	3
Lauraceae	3
Araliaceae	2
Cornaceae	2
Balsaminaceae	2
Cruciferae	2
Salicaceae	2
Oleaceae	2
Compositae	2
Lardizabalaceae	2
Aquifoliaceae	2
Juglandaceae	1
Bretschneideraceae	1
Celastraceae	1
Clethraceea	1
Balanophoraceae	1
Berberidaceae	1
Orobanchaceae	1
Schisandraceae	1
Tiliaceae	1
Leguminosae	1
Loranthaceae	1
Actinidiaceae	1
Vitaceae	1
Sabiaceae	1
Saxifragaceae	1
Cupressaceae	1
Pinaceae	1

Rosaceae provided the animals with the largest number of food species, viz. 17, followed by Caprifoliaceae and Ericaceae (Table 3). Araliaceae contributed to the largest number of feeding records (47%), followed by Rosaceae (23.1%), Aceraceae (7.7%), Gramineae (5.5%) and Juglandaceae (4.5%). The top ten food tree species (Table 4) accounted for >90% of the total feeding time on plant foods. As evinced by feeding records, *Acanthopanax evodiaefolius* was the single most prominent food species (Table 4), followed by *Sorbus* spp., *Acer* spp., *Sorbus* cf. *thibetica*. As evinced by feeding remains, bamboo *Fargesia* spp. were the most important plant species in the diet, followed by *Acanthopanax evodiaefolius*, *Sorbus* cf. *thibetica*, *Sorbus* spp. (Table 5). Derived from the selection indices, the most preferred plant species were *Pterocarya delavayi*, *Padus obtusata* and *Acanthopanax evodiaefolius* (Table 4).

Most of the frequently taken fruits were usually ingested wholly. The small size of most fruits, e.g. the pome Sorbus and the drupes *Acanthopanax* and *Cornus*, made extraction of seeds probably uneconomical. A percentage of the seeds may pass through the digestive tract intact. Seeds were extracted and fruit flesh discarded only in a few species, e.g. *Euonymus theifolius*. *Acanthopanax* and *Sorbus* fruits were usually picked off directly with the teeth without involvement of the hands. The monkeys consumed both mature and immature fruits of the top food species.

Mature leaves were chosen and ingested from both deciduous and evergreen trees, but only a few woody species were important sources of mature leaves, i.e. the deciduous *Philadelphus delavayi*, *Sorbus* spp., *Acanthopanax evodiaefolius* and the evergreen *Ilex* sp.. For some species, only petioles were eaten (e.g. *Bretschneidera sinensis*), for others only the leaf blades (e.g. *Stranvaesia davidiana*) and for yet others both leaf blades and petioles (e.g. *Acanthopanax evodiaefolius*).

The snub-nosed monkeys fed on subterranean parts of *Boschniakia himalaica* and *Balanophora involucrata*. They spent a considerable amount of time unearthing unidentified tubers (hidden food items). We observed juveniles and females eating snow in winter, but only on rare occasions. We recorded a case of predation on bird eggs. One individual was seen feeding on the flesh of an unidentified flying squirrel (Sciuridae). The monkeys drank water from terrestrial water sources such as small ponds and streams. Active drinking at ponds and slow-flowing streams takes place regularly. We observed them biting into mushrooms in the Autumn. We also saw them removing the bark of dead fallen and standing trees (mostly *Abies georgei*) and disassembling rotten and brittle tree stumps. While we never clearly saw an individual actually eating an insect, these latter observations may indicate foraging on invertebrates. We witnessed feeding on bamboo (*Fargesia* spp.) leaves in all seasons. Bamboo shoots (*Fargesia* spp.) were consumed in large quantities in summer.

DISCUSSION

The dietary strategy of *Rhinopithecus bieti* in the Samage Forest can be summarized as one of feeding on abundant lichens year-round and complementing the diet with plant phenophases of deciduous broadleaf trees, i.e. consuming immature leaves in spring and fruits and mature leaves in summer/autumn. These findings are generally in line with those of a previous study of *Rhinopithecus bieti* at Tacheng (Ding & Zhao, 2004) and *Rhinopithecus roxellana* (Li, 2006). After a long food-poor winter period during which they relied extensively on protein-poor lichens as a fallback resource (cf. also (Ding & Zhao, 2004; Kirkpatrick, 1996; Xiang *et al*., 2007), food availability and dietary diversity increased dramatically in spring when trees started producing new protein-rich foliage. Mature leaves do not form a major part of the annual diet, but are important in autumn when they are eaten together with fruits from deciduous angiosperms.

Detritus found in the group‘s foraging path indicates that bamboo leaves (both immature and mature) are consumed perennially and shoots become an increasingly important ingredient of the monkeys’ diet from late spring onwards (cf. (Ding & Zhao, 2004; Yang & Zhao, 2001)). Extensive use of bamboo (shoots and leaves) is an uncommon strategy in primates, restricted to those Old World Monkey species living in central-south Asian and central-east Africa in montane forests, viz. Tibetan macaques (*Macaca thibetana* (Zhao, 1996)), Himalayan langurs (*Semnopithecus schistaceus* (Sayers & Norconk, 2008)), ‘golden monkeys’ (*Cercopithecus mitis kandti* (Twinomugisha *et al*., 2006)), mountain gorillas (*Gorilla beringei beringei* (Vedder, 1984)), and bamboo lemurs (*Hapalemur* spp. (Tan, 1999)).

Our study confirmed that mushrooms are consumed in autumn. Mycophagy sensu stricto (excluding lichen) is a common dietary strategy only in Goeldi’s monkeys (*Callimico goeldii* (Hanson *et al*., 2003)), but otherwise an occasional strategy for a few temperate and tropical primates, e.g. Japanese macaques (*Macaca fuscata* (Wada &

Table 4. Number of feeding records for the 10 top-ranked identified plant food species of Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) at Samage.

Rank	Species	Family	No. feeding records	Selection index
1	*Acanthopanax evodiaefolius*	Araliaceae	437	22.3
2	*Sorbus* spp.[2]	Rosaceae	142	10.6
3	*Acer* spp.[3]	Aceraceae	72	2.7
4	*Sorbus* cf. *thibetica*	Rosaceae	59	5.4
5	*Fargesia* spp.[4]	Gramineae	51	NA[1]
6	*Pterocarya delavayi*	Juglandaceae	42	82.1
7	*Cornus macrophylla*	Cornaceae	17	2.1
8	*Padus obtusata*	Rosaceae	14	41.0
9	*Tilia* cf. *chinensis*	Tiliaceae	11	1.3
10	*Litsea chunii*	Lauraceae	8	7.2

[1] Shrub.

[2] Includes *Sorbus oligodonta*, *S. rufopilosa*, *S. rehderiana*, *S. monbeigii*, *S. hupehensis*, and *S. macrantha*; distinguishing among these species was difficult.

[3] Includes *Acer laxiflorum*, *A. mono. A. hookeri*, *A. caesium*, and *A. caudatum*; distinguishing among these species was difficult.

[4] Includes *Fargesia* cf. *melanostachys* and *F.* cf. *dura*. Identifying bamboos to species level was not possible.

Table 5. The ten top-ranked plant food species of Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) at Samage, as evidenced from feeding traces.

Rank	Species	Family	Score
1	*Fargesia* spp.	Gramineae	104
2	*Acanthopanax evodiaefolius*	Araliaceae	71
3	*Sorbus* cf. *thibetica*	Rosaceae	23
4	*Sorbus* spp.[1]	Rosaceae	20
5	*Cornus macrophylla*	Cornaceae	11
6	*Cyclobalanopsis* cf. *gambleana*	Fagaceae	4
7	*Pterocarya delavayi*	Juglandaceae	3
8	*Padus obtusata*	Rosaceae	3
9	*Ilex* sp.	Aquifoliaceae	3
10	*Bretschneidera sinensis*	Bretschneideraceae	2

[1] Includes *Sorbus oligodonta*, *S. rufopilosa*, *S. rehderiana*, *S. monbeigii*, *S. hupehensis*, and *S. macrantha*; distinguishing among these species was difficult.

Ichiki, 1980)), green monkeys (*Chlorocebus sabaeus* (Harrison, 1984)), bonobos (*Pan paniscus* (Bermejo *et al*., 1994)), and *Rhinopithecus roxellana* (Kirkpatrick & Gu, 1999). Judging from the bite marks, *Rhinopithecus bieti* at Samage often did not eat the whole fungus, but left a substantial portion untouched. This may be related to the supposition that some fungi cause gastrointestinal distress (e.g. *Gomphus floccosus*).

Acorn feeding was observed only once in this study; this low rate of occurrence is surprising given that other studies highlight the preponderance of acorn in the diet of both *Rhinopithecus bieti* (Xiang *et al*., 2007; Zhong *et al*., 1998) and *Rhinopithecus roxellana* (Tan *et al*., 2007). Low visibility at Samage may impede detectability of foraging for acorns in leaf litter on the forest floor.

Feeding on vertebrate matter is most unusual among colobines. There is one published case of a male grey leaf monkey (*Presbytis hosei*) raiding the nest of a babbler and eating the eggs and perhaps one young hatchling (Goodman, 1989). *Rhinopithecus bieti* seem to be partly faunivorous, as demonstrated by records of cannibalism (Xiang & Grueter, 2007) and the incident of ingestion of flesh from a mammal presented here. Moreover, a rodent skull was once discovered in fecal droppings (Yang & Zhao, 2001).

Digging up USOs (underground storage organs) - as demonstrated in this study - is a form of extractive foraging (Sayers, 2008). Feeding on bamboo shoots also requires a certain amount of manipulative skill: the monkeys break off the shoots with their hand, discard the sheaths with teeth before eating the juicy center. That *Rhinopithecus bieti* are skilled extractive foragers had already been noted by (Zhong *et al*., 1998). They observed that acorns were eaten by peeling the nut, and eating the kernel while discarding the shell.

The habitat of *Rhinopithecus bieti* is characterized by a more or less successive drop in altitude toward the south of the geographical range. In line with this reduction in altitude and latitude from north to south, temperature, precipitation and botanical richness increase (Long *et al*., 1994). The monkeys live in predominantly coniferous forests in the cold high-latitude regions of their geographical range and in more mixed forests in the warmer and more southern regions. The number of plant species in the diet of *Rhinopithecus bieti* populations is positively correlated with the mean annual habitat temperate (r_s = 0.900, p = 0.037) and negatively correlated with mean altitude (r_s = -0.900, p = 0.037). Hence, environmental conditions explain the different dietary spectra of populations, with more northern populations having a more species-poor diet and southern populations having a more species-rich diet. When we compare the high-latitude site Wuyapiya (28°30') in the north with the lower latitude site Samage (27°34') to the south, there is an apparent striking variation in environmental parameters (Kirkpatrick, 1996; Grueter, 2009): the mean annual temperature at Wuyapiya is 0.9° as compared to 10.3° at Samage. The mean altitude of the respective study group is ca 4,100 m at Wuyapiya and ca 3,200 m at Samage. The basal area of Abies georgei is 53% at Wuyapiya and only 13% at Samage. There are 22 tree species at Wuyapiya and 80 at Samage. Moreover, fruit resources are scarce at Wuyapiya and represent a minor portion of the diet (0.1 %), but a considerable portion at Samage (11%); on the other hand, lichens comprise a larger percentage of the diet at Wuyapiya (86% vs. 67% at Samage). An analogous situation exists in African black-fronted duikers (*Cephalophus nigrifrons*): in the fruit-poor Virunga Mountains, lichens contributed importantly to the diet (Plumptre, 1991), while in the lowland tropical rain forest, black-fronted duikers are mainly frugivorous (Dubost, 1984).

As to the use of particular plant families, a total of 38 plant families provided *Rhinopithecus bieti* at Samage with food. An additional 11 families have been recorded by other scientists at other localities. For *Rhinopithecus avunculus*, 39 plant families have been recorded, for *Rhinopithecus roxellana* 37, and for *Rhinopithecus brelichi* 33 (Table 6). These results imply that the more subtropical taxa *Rhinopithecus brelichi* and *Rhinopithecus avunculus* feed on a smaller number of plant species, but this result may have been simply a fact of differential observation conditions and sampling effort. The diet of the four taxa of *Rhinopithecus* shows partial overlap, but also deviates; the deviation is likely due to differing habitat characteristics and distribution of plant families. Eight families are part of the diet of all four *Rhinopithecus* species, viz. Aceraceae, Araliaceae, Fagaceae, Lauraceae, Oleaceae, Rutaceae, Sabiaceae, and Tiliaceae.

Pointing out essential food resources of an endangered taxon such as *Rhinopithecus bieti* and assessing whether dietary preferences are narrow or whether there is ecological flexibility associated with diet are crucial for survival assessment. Incorporation of feeding ecology data should be an integral part of any environmental impact assessment plan. Whenever some sort of habitat alteration or wildlife management is planned, feeding

Table 6. A list of all plant families that contribute to the diet of the 4 *Rhinopithecus* species. Data come from Ding & Zhao (2004), Grueter (2009), Guo *et al.*, (2007), Huo (2005), Kirkpatrick (1998), Kirkpatrick & Gu (1999), Le *et al.* (2007), Le & Boonratana (2006), Li (2001; 2006), Xiang *et al.* (2007).

Families	***R. avunculus***	***R. roxellana***	***R. bieti***	***R. brelichi***
Aceraceae	■	■	■	■
Actinidiaceae		■	■	■
Anacardiaceae	■	■		■
Annonaceae	■			
Apocynaceae	■			
Aquifoliaceae			■	■
Araliaceae	■	■	■	■
Asclepiadaceae	■			
Balanophoraceae			■	
Balsaminaceae		■	■	
Berberidaceae		■	■	
Betulaceae		■	■	■
Bignoniaceae	■			
Bretschneideraceae			■	
Burseraceae	■		■	
Buxaceae				■
Caprifoliaceae		■	■	■
Celastraceae		■	■	■
Clethraceae			■	■
Clusiaceae	■			
Compositae		■	■	
Cornaceae		■	■	■
Cruciferae			■	
Cucurbitaceae				■
Cupressaceae			■	
Cyperaceae			■	
Daphniphyllaceae				■

Families	***R. avunculus***	***R. roxellana***	***R. bieti***	***R. brelichi***
Dennstaedtiaceae			■	
Diapensiaceae			■	
Dilleniaceae	■			
Ebenaceae	■			
Elaeagnaceae				■
Elaeocarpaceae	■			
Ericaceae		■	■	■
Euphorbiaceae	■	■		
Fabaceae / Leguminosae	■	■	■	
Fagaceae	■	■	■	■
Flacourtiaceae				■
Gramineae	■	■	■	
Grossulariaceae		■	■	
Guttiferae	■			
Hydrangeaceae		■	■	
Juglandaceae		■	■	■
Icacinaceae	■			
Iridaceae			■	
Lardizabalaceae		■	■	■
Lauraceae	■	■	■	■
Liliaceae		■	■	■
Loranthaceae			■	
Magnoliaceae		■		■
Marantaceae	■			
Meliaceae	■			
Menispermaceae				■
Mimosaceae	■			

Families	*R. avunculus*	*R. roxellana*	*R. bieti*	*R. brelichi*
Moraceae				
Musaceae				
Myrtaceae				
Oleaceae				
Orchidaceae				
Orobanchaceae				
Oxalidaceae				
Pinaceae				
Primulaceae				
Ranunculaceae				
Rosaceae				
Rutaceae				
Sabiaceae				
Salicaceae				
Sapindaceae				
Sapotaceae				
Sarcospermaceae				
Saxifragaceae				
Schisandraceae				
Staphyleaceae				
Styracaceae				
Symplocaceae				
Tetracentraceae				
Theaceae				
Thymelaeaceae				
Tiliaceae				
Verbenaceae				
Vitaceae				
Ulmaceae				
Umbelliferae				
Urticaceae				

ecology data have the potential to predict a population's response to such actions, and harmful effects can be mitigated if key resources have been identified and are left unharmed (Caro, 1998; Clemmons & Buchholz, 1997; Litvaitis, 2000). There exist plans to establish a local breeding colony of *Rhinopithecus bieti*, and data on relative diet composition are of vital importance for successful *ex situ* management (Lambert, 2007).

We have previously demonstrated that *Rhinopithecus bieti* at Samage exhibit an overriding preference for mixed deciduous broadleaf and conifer forest over other forest types (Li *et al.*, 2008). The present results substantiate that preferred food tree species are mostly deciduous angiosperms such as *Acanthopanax* that are located within this ecotype, which should be the major target of conservation efforts. Some deciduous trees offering seasonally valuable foods have been decimated locally, e.g. *Pterocarya delavayi*, and - given their high importance as food resources - should receive strict protection. Human activities encroaching upon the monkeys' food resources and thereby bringing about a decreased yield should be controlled more rigorously. Potential sources of competition are goats/sheep foraging on acorns in winter, and villagers scouring the forest for mushrooms and bamboo shoots.

A most striking aspect of this species' dietary ecology is that it is highly dependent on lichens, especially in winter when leafy and fruity material is not available. Lichens are organisms that grow very slowly (Kirkpatrick, 1996). It has been proposed that lichens in these fragmented forests might suffer from overharvesting and also environmental changes associated with air pollution (Grueter *et al.*, in press) and possibly global warming (cf. Press *et al.*, 1998). The monkeys' ability to adapt to habitats with more plant foods and less lichen food enhances the survival chances for this iconic primate (cf. Ding & Zhao, 2004). In theory, they could switch to plant alternatives in winter such as bark and buds, but it is unknown if they could actually survive with a significantly reduced quantity of lichens.

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MỘT SỐ ĐẶC ĐIỂM SINH THÁI DINH DƯỠNG CỦA VOỌC MŨI HẾCH YUNNAN (*RHINOPITHECUS BIETI*) Ở RỪNG SAMAGE, KHU BẢO TỒN THIÊN NHIÊN BAIMAXUESHAN, TRUNG QUỐC

TÓM TẮT

Chúng tôi cung cấp dữ liệu của 18 tháng nghiên cứu về tập tính sinh thái dinh dưỡng của loài voọc mũi hếch Yunnan (*Rhinopithecus bieti*), một loài đặc hữu "Cực kỳ Nguy cấp" của Trung Quốc. Vooc mũi hếch (*Rhinopithecus bieti*) có lẽ phân bố ở những vùng núi rất cao so với sinh thái của các loài voọc, tại ranh giới giáp với dãy Himalaya ở độ cao trên 3,000 m. Vùng nghiên cứu Samage là nơi có thời tiết theo mùa và sinh thái là vùng núi lá rộng nhiệt đới và rừng thông. Địa y ở đây chiếm ưu thế về nguồn thức ăn cho voọc mũi hếch ở tất các các mùa, mật độ địa y biến đổi từ 51% vào mùa xuân đến 88% vào mùa đông. Bổ sung thêm nguồn thức ăn cho loài này, ngoài địa y là các loài thực vật theo mùa có lá vào mùa xuân, quả vào mùa hè hay mùa thu và lá vàng vào mùa thu. Những thay đổi nguồn thức ăn theo mùa và sự thu hẹp dần nguồn thức ăn dẫn đến khan hiếm nguồn thức ăn vào mùa đông là những dấu hiệu cho nghiên cứu dinh dưỡng của vọoc mũi hếch (*Rhinopithecus bieti*) ở vùng Samage trong nghiên cứu này. 94 loài thực vật được ghi nhận là nguồn cung cấp cấp thức ăn cho voọc mũi hếch. Như đã giải thích về ghi nhận các nguồn dinh dưỡng, loài *Acanthopanax evodiaefolius* (Araliaceae) là loài thực vật cung cấp nguồn thức ăn quan trọng nhất, tiếp theo là loài Sorbus spp. (Rosaceae), và Acer spp. (Aceraceae). Những điều tra nguồn dinh dưỡng khác đã chỉ ra rằng loài trúc *Fargesia* spp. cũng là loài thực vật chính cung cấp thức ăn cho voọc. Các loại thức ăn khác nữa được ghi chép trong nghiên cứu này là các loài thực vật có củ, nấm, côn trùng và tuyết. Các quần thể khác nhau của *Rhinopithecus bieti* thay đổi khác nhau về cách kiếm ăn và ăn các nguồn thức ăn khác nhau. Sự khác biệt này có thể là do sự khác nhau về môi trường sinh thái, tiếp đến là do độ cao và xích đạo, lượng mưa và nhiệt độ. Trong khi voọc mũi hếch Yunan thay đổi thích nghi với nguồn dinh dưỡng (đây là bằng chứng được xem là khác biệt phụ thuộc vào nguồn thức ăn) để duy trì sự sống cho vooc mũi hếch Yunan, các loài thực vật cung cấp thức ăn then chốt như địa y, trúc, những loài thực vật lá rộng Araliaceae, Rosaceae, và Aceraceae cần phải được bảo tồn và bảo vệ của con người.

REFERENCES

Bermejo, M., Illera, G. & Sabater, P.J. (1994): Animals and mushrooms consumed by bonobos (*Pan paniscus*): New records from Lilungu (Ikela), Zaire. Int. J. Primatol. 15, 879-898.

Bleisch, W., Cheng, A.S., Ren, X.D. & Xie, J.H. (1993): Preliminary results from a field study of wild Guizhou snub-nosed monkeys (*Rhinopithecus brelichi*). Folia Primatol. 60, 72-82.

Bleisch, W. & Xie, J.H. (1998): Ecology and behavior of the Guizhou snub-nosed langur (*Rhinopithecus brelichi*). In: Jablonski, N.G. (ed.): The Natural History of the Doucs and Snub-Nosed Monkeys; pp. 217-241. World Scientific Press, Singapore.

Boonratana R. & Le, X.C. (1998): Preliminary observations of the ecology and behavior of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in Northern Vietnam. In: Jablonski N.G. (ed): The Natural History of the Doucs and Snub-Nosed Monkeys; pp. 207-217. World Scientific Press, Singapore.

Caro, T. 1998. The significance of behavioral ecology for conservation biology. In: Caro T. (ed.): Behavioral Ecology and Conservation Biology; pp. 3-62. Oxford University Press, Oxford.

Clemmons, J.R. & Buchholz, R. (1997): Linking conservation and behaviour. In: Clemmons, J.R. & Buchholz, R. (eds.): Behavioral Approaches to Conservation in the Wild; pp. 3-22. Cambridge University Press, Cambridge.

Ding, W. & Zhao, Q.-K. (2004): *Rhinopithecus bieti* at Tacheng, Yunnan: Diet and daytime activities International. Int. J. Primatol. 25, 583-598.

Dubost, G. (1984): Comparison of the diets of frugivorous forest ruminants of Gabon. J. Mammalogy 65, 298-316.

Goodman, S.M. (1989): Predation by the grey leaf monkey (*Presbytis hosei*) on the contents of a bird's nest at Mt. Kinabalu Park, Sabah. Primates 30, 127-128.

Grueter, C.C. (2009): Determinants of Modular Societies in Snub-nosed Monkeys (*Rhinopithecs bieti*) and other Colobines (Ph.D. dissertation). University of Zurich. Zurich, Switzerland.

Grueter, C.C., Li, D., Ren, B., Wei, F. & van Schaik, C.P. (in review): Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) at Samage, China: Dietary profile in relation to spatial availability of plant resources and its socioecological implications.

Grueter, C.C., Li, D., Ren, B., Wei, F., Xiang, Z. & van Schaik, C.P. (in press): Fallback foods of temperate-living primates: A case study on snub-nosed monkeys. Am. J. Phys. Anthropol.

Grueter, C.C., Li, D., van Schaik, C.P., Ren, B., Long, Y. & Wei, F. (2008): Ranging of *Rhinopithecus bieti* in the Samage Forest, China. I. Characteristics of range use. Int. J. Primatol. 29, 1121-1145.

Guo, S., Li, B. & Watanabe, K. (2007): Diet and activity budget of *Rhinopithecus roxellana* in the Qinling Mountains, China. Primates 48, 268-276.

Hanson, A.M., Hodge, K.T. & Porter, L.M. (2003): Mycophagy among primates. Mycologist 17, 6-10.

Harrison, M.J.S. (1984): Optimal foraging strategies in the diet of the green monkey, *Cercopithecus sabaeus*, at Mt. Assirik, Senegal. Int. J. Primatol. 5, 435-471.

Huo, S. (2005): Diet and habitat use of *Rhinopithecus bieti* at Mt Longma, Yunnan (Ph.D. dissertation). Chinese Academy of Sciences. Kunming Institute of Zoology, Kunming.

IUCN (2007): IUCN Red List of Threatened Species. http://www.iucnredlist.org.

Kirkpatrick, R.C. (1996): Ecology and Behavior of the Yunnan Snub-nosed Langur (*Rhinopithecus bieti*, Colobinae) (Ph.D. dissertation). University of California, Davis.

Kirkpatrick, R.C. (1998): Ecology and behavior in snub-nosed and douc langurs. In: Jablonski N.G. (ed): The Natural History of the Doucs and Snub-Nosed Monkeys; pp. 155-190. World Scientific Press, Singapore.

Kirkpatrick, R.C. & Gu, H.J. (1999): Ecology and conservation of golden monkeys *Rhinopithecus roxellana* at Baihe Nature Reserve (Min Mountains, Sichuan).

Kirkpatrick, R.C., Gu, H.J. & Zhou, X.P. (1999): A preliminary report on Sichuan snub-nosed monkey (*Rhinopithecus roxellana*) at Baihe Nature Reserve. Folia Primatol. 70,117-120

Kirkpatrick, R.C., Long, Y.C., Zhong, T. & Xiao, L. (1998):. Social organization and range use in the Yunnan snub-nosed monkey *Rhinopithecus bieti*. Int. J. Primatol. 19,13-51.

Krebs, C.J. (1999): Ecological Methodology. Addison-Wesley-Longman.

Lambert, J.E. (2007): Primate nutritional ecology: feeding biology and diet at ecological and evolutionary scales. In: Campbell, C.J, Fuentes, A., MacKinnon, K.C., Panger, M. & Bearder, S.K. (eds): Primates in Perspective; pp. 482-495. Univ Press, New York: Oxford.

Le, K.Q., Duc, N.A., Tai, V.A., Wright, B.W. & Covert, H.H. (2007): Diet of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in the Khau Ca area, Ha Giang Province, Northeastern Vietnam. Vietnamese J. Primatol. 1 (1), 75-83.

Le, X.C. & Boonratana, R. (2006): A Conservation Action Plan for the Tonkin Snub-Nosed Monkey in Vietnam. http://www.primate-sg.org/TSMAP.htm.

Li, D., Grueter, C.C., Ren, B., Long, Y., Li, M., Peng, Z. & Wei, F. (2008): Ranging of *Rhinopithecus bieti* in the Samage Forest, China. II. Use of land cover types and altitudes. Int. J. of Primatol.

Li, Y. (2001): The seasonal diet of the Sichuan snub-nosed monkey (*Rhinopithecus roxellana*) in Shennongjia Nature Reserve, China. Folia Primatol. 72, 40-43.

Li, Y. (2006): Seasonal variation of diet and food availability in a group of Sichuan snub-nosed monkeys in Shennongjia Nature Reserve, China. Am. J. Primatol. 68, 217-233.

Li, Y., Stanford, C. & Yang, Y. (2002): Winter feeding tree choice in Sichuan snub-nosed monkeys (*Rhinopithecus roxellanae*) in Shennongjia Nature Reserve, China. Int. J. Primatol. 23. 657-675.

Litvaitis, J. (2000): Investigating food habits of terrestrial vertebrates. In: Boitani, L. & Fuller, T. (eds.). Research Techniques in Animal Ecology, pp. 65-190. Columbia University Press, New York.

Long, Y. & Wu, R. (2008): Latest survey results: populations and home ranges of the Yunnan snub-nosed monkey (*Rhinopithecus bieti*). Primate Eye:Abstract #854.

Long, Y.C., Kirkpatrick, C.R. & Zhongtai, Xiaolin (1994):. Report on the distribution, population, and ecology of the Yunnan snub-nosed monkey (*Rhinopithecus bieti*). Primates 35, 241-250.

Mueller-Dombois, D. & Ellenberg, H. (1974): Aims and Methods of Vegetation Ecology. John Wiley & Sons, New York.

Plumptre, A.J. (1991): Plant-Herbivore Dynamics in the Birungas (Ph.D. thesis): University of Bristol.

Press, M.C., Potter, J.A., Burke, M.J.W., Callaghan, T.V. & Lee, J.A. (1998): Responses of a subarctic dwarf shrub heath community to simulated environmental change. J. Ecology 86, 315-327.

Sayers, K. (2008): Optimal Foraging on the Rood of the World: A Field Study of Himalayan Langurs. Kent State University.

Sayers, K. & Norconk, M. (2008): Himalayan *Semnopithecus entellus* at Langtang National Park, Nepal: Diet, activity patterns, and resources. Int. J. Primatol. 29, 509-530.

Su, Y., Ren, R., Yan, K., Li, J., Zhou, Y., Zhu, Z., Hu, Z. & Hu, Y. (1998): Preliminary survey of the home range and ranging behavior of golden monkeys (*Rhinopithecus roxellana*) in Shennongjia National Natural Reserve, Hubei, China. In: Jablonski N.G. (ed): The Natural History of the Doucs and Snub-Nosed Monkeys; pp. 255-268. World Scientific Press, Singapore.

Tan, C.L. (1999): Group Composition, home range size, and diet of three sympatric bamboo lemur species (genus *Hapalemur*) in Ranomafana National Park, Madagascar. Int. J. Primatol. 20, 547-566.

Tan, C.L., Guo, S. & Li, B. (2007): Population structure and ranging patterns of *Rhinopithecus roxellana* in Zhouzhi National Reserve, Shaanxi, China. Int. J. Primatol. 28, 577-591.

Twinomugisha, D., Chapman, C., Lawes, M., Worman, C. & Danish, L. (2006): How does the golden monkey of the Virungas cope in a fruit-scarce environment? In: Newton-Fisher, N., Notman, H., Paterson, J. & Reynolds, V. (eds): Primates of Western Uganda.

Vedder, A. (1984): Movement patterns of a group of free-ranging mountain gorillas (*Gorilla gorilla beringei*) and their relation to food availability. Am. J. Primatol. 7:73-88.

Wada, K. & Ichiki, Y. (1980): Seasonal home range use by Japanese monkeys in the Shiga Heights. Primates 21, 468-483.

Wu, G., Wang, H., Fu, H., Zhao, J. & Yang, Y. (2004): Habitat selection of Guizhou golden monkey (*Rhinopithecus roxellanae brelichi*) in Fanjing Mountain Biosphere Reserve, China. J Forest Res (Harbin) 15, 197-202.

Xiang, Z.-F. & Grueter, C.C. (2007): First direct evidence of infanticide and cannibalism in wild snub-nosed monkeys (*Rhinopithecus bieti*). Am. J. Primatol. 69, 249-254.

Xiang, Z.-F., Huo, S., Xiao, W., Quan, R.-C. & Grueter, C.C. (2007): Diet and feeding behavior of *Rhinopithecus bieti* at Xiaochangdu, Tibet: Adaptations to a marginal environment. Am. J. Primatol. 69, 1141-1158.

Xiang, Z.-F., Nie, S.-G., Lei, X.-P., Chang, Z.-F., Wei, F.-W. & Li, M. (2009): Current status and conservation of the gray snub-nosed monkey *Rhinopithecus brelichi* (Colobinae) in Guizhou, China. Biol Conserv 142, 469-476.

Yang, S.J., Zhao, Q.K. (2001): Bamboo leaf-based diet of *Rhinopithecus bieti* at Lijiang, China. Folia Primatol. 72, 92-95.

Zhao, Q.-K. (1996): Etho-ecology of Tibetan macaques at Mount Emei, China. In: Fa, J. & Lindburg, D. (eds:): Evolution and Ecology of Macaque Societies; pp. 263-289. Cambridge University Press, New York.

Zhong, T., Xiao, L., Kirkpatrick, R. & Long, Y. (1998): A brief report on Yunnan snub-nosed monkeys, *Rhinopithecus bieti*, at Bamei in Northern Yunnan Province, China. Primate Conservation 18, 76-80.

17

TIME BUDGET AND ACTIVITY OF RED-SHANKED DOUC LANGURS (*PYGATHRIX NEMAEUS*) IN HIN NAMNO NATIONAL PROTECTED AREA, LAO PDR

PHAIVANH PHIAPALATH AND PONGTHEP SUWANWAREE

SUMMARY

A change in time budget can be caused by both threats on animals as well as a change in habitat quality. We studied two un-habituated groups of red-shanked douc langurs (*Pygathrix nemaeus*) through scan sampling in Hin Namno National Protected Area (NPA), Khammouane Province in Lao People's Democratic Republic (hereafter Laos). The two groups were labeled G1, which consisted of 17 individuals, and was located at Camp 5 Nam Pasai, where there is much human presence. The second group, G2 had 39 individuals and was located at Camp 4 Nam Khoum, which has low frequency of human activity. These two groups were situated about 5 km apart from each other. Within each group we identified six target animal classes: adult female, adult male, sub-adult, juvenile, infant 2 and infant 1. We recorded scan samples at 30-minute intervals to study the species' time budget in the wild. Group observations were conducted from March 2007 to June 2008 with 8,837 records made of the species with respect to their daily activities. Combined results from the two groups show that feeding (29.47%) was the highest proportion of time used, then social activity (14.89%) including grooming and playing; inactive mode counts (14.17%); foraging (13.36%); sleeping (11.89%); traveling (9.81%) and other (6.40%). Red-shanked douc langurs behaved slightly different between the dry season and wet season. Besides the change in seasons more human pressure, especially in terms of hunting, was an important factor to determine changes in their daily activities. Group 1 experienced more human pressure and had a higher recorded travel time and inactivity, especially 'look-out' monitoring for threats during the dry season, which allowed for less time sleeping.

Social activity was mainly comprised of self-grooming 43.34%; solitary play 21.84%; chase play 15.8%, whilst a range of other activities made up the final percentages. Surprisingly partner grooming covered only 11.91% of the time budget, which is considered low.

In conclusion, feeding covers the highest percentage of the species time budget, whilst a high proportion of social activity is spent in self-grooming, but with a low proportion of partner grooming. Their time budget and activity is not influenced much by season per se, but more by the degree of human pressure, which occurs during the dry season.

INTRODUCTION

Hin Namno NPA probably supports the highest number of primate species in Laos (Phiapalath & Suwanwaree, 2007), and is particularly important for the conservation of red-shanked douc langurs and Hatinh langurs (*Trachypithecus hatinhensis*) (Timmins & Khounboline, 1996; Timmins & Duckworth, 1999; Walston & Vinton, 1999). The red-shanked douc langur is considered high priority in terms of conservation needs, and is classified in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and listed as "Endangered" in the IUCN Red List of Threatened Species. (IUCN, 2008). However, scientific studies of the species have rarely been undertaken in the wild, and of those none are studies on this species in limestone habitat. The red-shanked douc langur is endemic to Southeast Asia, and today the species cannot be found elsewhere in the world besides Laos, Vietnam (Nadler *et al*., 2003) and Cambodia (Rawson & Roos, 2008). Laos supports the highest population of red-shanked douc langurs (Timmins & Duckworth, 1999), when combining Nakai-Nam Theun NPA and Hin Namno NPA. Distribution of this species in Laos ranges from the central to southern provinces. Hin Namno is a contiguous area under legal protection in Laos where red-shanked douc langurs are found in limestone habitat (Fig. 1). In Hin Namno we found three different forms of red-shanked douc langurs, locally known as *Khadeng napan* – langurs with the largest body size, *Khadeng kang* - those of medium body size, and *Khadeng kok* – langurs with the smallest body size. These three different forms are found in separate groups, and the differences are quite well distinguished and well understood by local hunters.

Fig. 1. Red-shanked douc langur (*Pygathrix nemaeus*) in limestone area.

Photo: Tilo Nadler.

It is important to understand the species behavior and time budget activities within the limestone forest, as part of understanding the species' distribution and threats. Obtaining this kind of data can provide baseline data for further studies on the species and additional to information for conservation activities.

Changes in behavior can be based upon habitat quality (Li & Rogers, 2004), temperature (Li & Rogers, 2005), level of human disturbance and other factors (Brokelman & Srikosmatara, 1993). External factors shaping the animal's behavior, such as environmental change, habitat change, population size and food availability, all affect differences in social behavior and social structure (Siex, 2004). Therefore, it is presumed that when the proportion of time used for travel and inactivity are higher, this can be interpreted as a result of a decline in either habitat quality or an increase in the level of human disturbance.

MATERIAL AND METHODS

Study area

The study area of Hin Namno NPA (Fig. 2) is a forested limestone area, located in central Laos, Khammouane Province, with an area of 869 km^2 (200-1000 m asl). Vegetated outcrops characterize its cover with bushes covering the top. The lower layers and foothills have a much greater density of medium to tall trees. The flat ground area is dominated by closed canopy evergreen forest, hill evergreen and mixed deciduous forests.

Hin Namno NPA includes 22 villages totalling about 7,240 inhabitants. Adjoining the area of Hin Namno, across the international border with Vietnam, is Phong Nha-Ke Bang National Park a World Heritage site, which makes this the largest limestone area in Southeast Asia under legal protection.

Study groups

Our main objective was to study the behavioral activities of red-shanked douc langurs with a hypothesis that the species behavior is affected by season (wet season and dry season). We examined behavior in terms of activity budget, threat response, sleeping, detection and habitat use. However, this paper mainly presents results on time budget, with additional information on other activities of the species evidenced through this study. Two study groups were selected in areas which supported better field conditions and where it was possible to

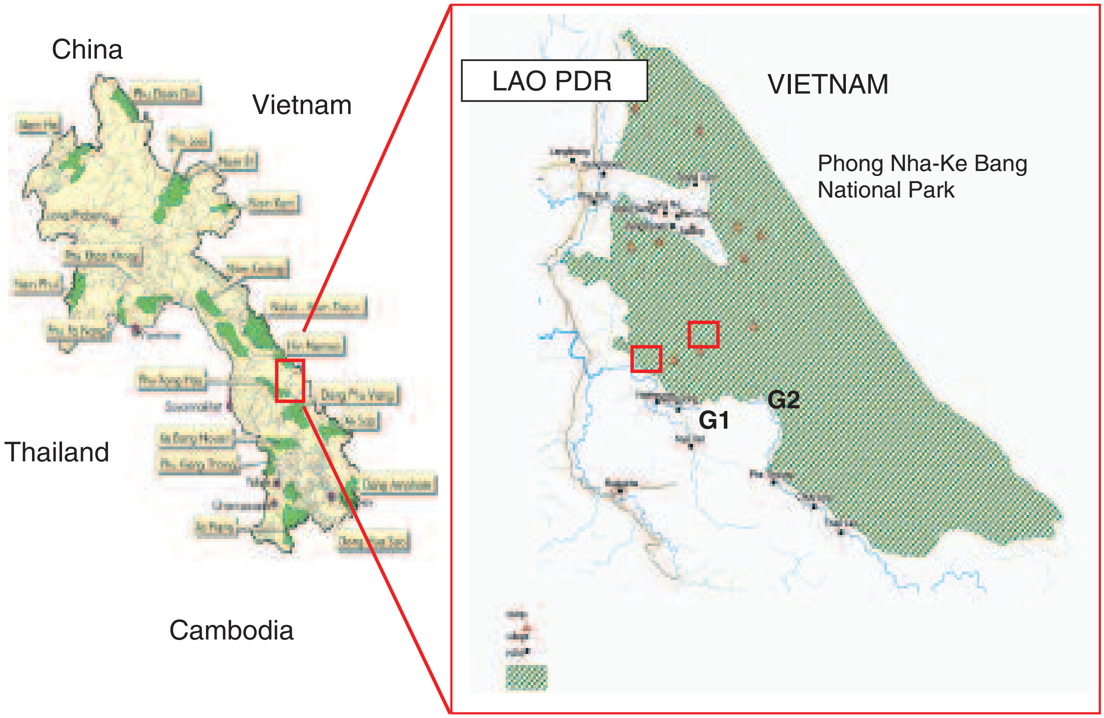

Fig. 2. Map of Hin Namno National Protected Area and locations of the studied groups.

follow the animals. Group 1 (G1) was at Camp 5 Nam Pasai (17°26´N–105°53´E) and consisted of 17 individuals, identified in March 2007; Group 2 (G2) was located at Camp 4 Nam Khoum (17°24´N–105°50´E) and consisted of 39 individuals, identified in July 2007 (Fig. 2). These two groups were *Khadaeng kang* (individuals with medium body size). Based on Phiapalath & Suwanwaree (2008), G1 resided in an area suffering high levels of human disturbance (ranking 2nd highest in terms of threat level out of 10 study plots), while G2 was located in central Hin Namno in an area of lower human disturbance (ranking 4th). These two groups were located about 5 km apart from each other. Neither group was habituated because of hunting activity occurring in the area. In this connection, it has been well reported that animal habituation would not be successful (Brokelman & Srikosmatara, 1993). In each group, we identified six target animal classes to observe, in accordance with age classes: adult male (AM), adult female (AF), sub-adult (SA), juvenile (JU), infant 2 (between 6 months and 1.5 years), and infant 1 (under 6 months). In order to determine the time budget, it was necessary to classify the animals' proportional use of time in different categories, such as inactive, sleeping, feeding, foraging, social, and traveling. 'Inactivity' was recorded when they were found standstill (such as on sentry), but excluded sleeping. The type of social activity was recorded, such as various modes of playing, grooming, antagonism, sex etc.

Observations and methods

Our observations were conducted and recorded from March 2007 to June 2008, in 30-minute scan sampling for all target animals (adult male, adult female, sub-adult, juvenile, infant 2 and infant 1). Observation with binoculars using rangefinders was conducted from hidden locations in trees and amongst large stones and rock cover. The average distance from observers to the animals was 27 m. Sometimes, we were able to observe the animals from as close as 10 m, particularly during the wet season. The animals became more habituated to our team after we had followed them for weeks at a time. The distance to which the animals fled to escape was about 100 m to 200 m away from the original site of the alert.

At the start of the survey, we used only one team to observe G1 at C4, but after G2, at C5, was identified in July 2007, we expanded to two survey teams. We each spent about 5 to 7 days per group, per month - a total of 128 days, or 718 hours of detection from 162 days of effort. Data was recorded on Excel sheets to show proportions of activity budget which the animals used. These two groups were then compared regarding the activity budget to determine if the level of threat from human disturbance made any significant changes to their behavior.

RESULTS

Red-shanked douc langurs in their limestone habitat showed certain differences in activity budget between the two study groups and between seasons (dry season and wet season) although these were not statistically significant, it was likely dependent upon the level of human disturbance. From the observations of these groups (*N*=8,837 as the records of the species on activity budget), the study shows that feeding counts for 29.47% of their time, which was the highest proportion of their time used; then social activity (14.89%) which included mainly self-grooming, partner grooming and playing (Fig. 3). Inactivity and travel were likely an indication of habitat quality and level of threat or human pressure, as indicated by G1 – the group having suffered more exposure to threat subsequently spent more time for inactivity and travel, especially during the dry season (Fig. 4).

Clearly, human pressure is an important factor influencing changes in the species' activity budget pattern. G1 spent more time traveling compared to G2, and had more time of inactivity, especially the time used for sentry/monitoring for threat, due to the need for more watchfulness during feeding times. These differences were clearer between these groups during the dry season, in which an increased number of people enter the area for hunting and other purposes (Fig. 4). Additionally, G1's percentage of time spent sleeping was less. Social activity was another interesting result, in which for G1 we observed the use of their social activities mainly for self-grooming (43.34%), followed by solitary play (21.84%), chasing play (15.80%), etc, and surprisingly partner grooming (11.91%) was unusually low. We found quite often that male-female grooming was observed at rest time before taking a nap, and in the late afternoon. Among the age class of juveniles and infants, more time was used for this kind of social activity compared to other age classes. Chasing play between sub-adult, juvenile and young infants was often observed at about 10:00 am and at 16:00 pm, during times of rest.

During these times adults stayed close and watched the group members playing. During this time, while adults usually groom, the young were found at play. Social playing was also well observed in the early morning, before taking a nap, and sleeping in the late afternoon.

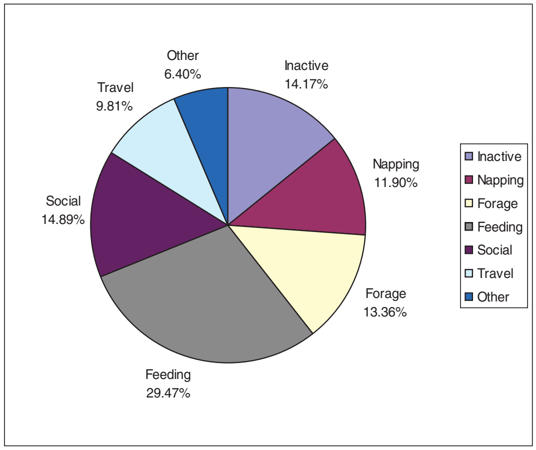

Fig. 3. Time budget of red-shanked douc langurs (*Pygathrix nemaeus*).

Fig. 5 shows some differences between the age classes of the study animals. Adults, especially adult males, used more time to monitor activity for threats compared to any other age class in the group, while juveniles and infants have more social activity, especially play, than other age classes. Infants in class 1 (of an age less than six months) were observed to have the lowest times for activities including feeding.

DISCUSSION

Many primates use the highest proportion of their time for feeding and resting. In accordance with Lippold (1995) diurnal and arboreal animals, as with most colobines, spend at least 50% of the day feeding in the wild. However, this is not the case for the red-shanked douc langurs in the Hin Namno limestone habitat, as they use only 29.47% of their time for feeding. Although the proportion of time consuming leaves is somewhat higher than for fruits (except during the wet season when fruits make up the mainstay of their diet), the foraging of fruits takes more time than leaves because some fruits e.g *Castanopsis* sp. need to be cracked open with the teeth before eating. The animals either eat the fruit pulp, the seeds, or both, while for some food types they eat major parts of tree species including bud, leaf, fruit (such as Dok khamma *Paranephelium spirei*), *Ficus* sp. and *Khoypha*. Amongst these species, *Ficus* is considered as a stable food of primates because it provides fruits over the year and across seasons (Yimkhao, 2005). Social activity is observed throughout the day

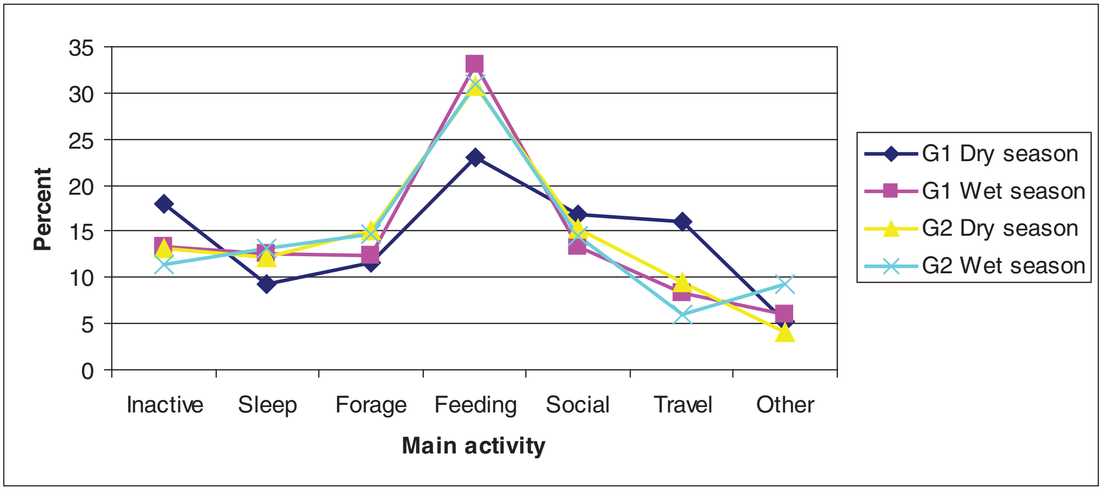

Fig. 4. Comparison of red-shanked douc langur time budget by season.

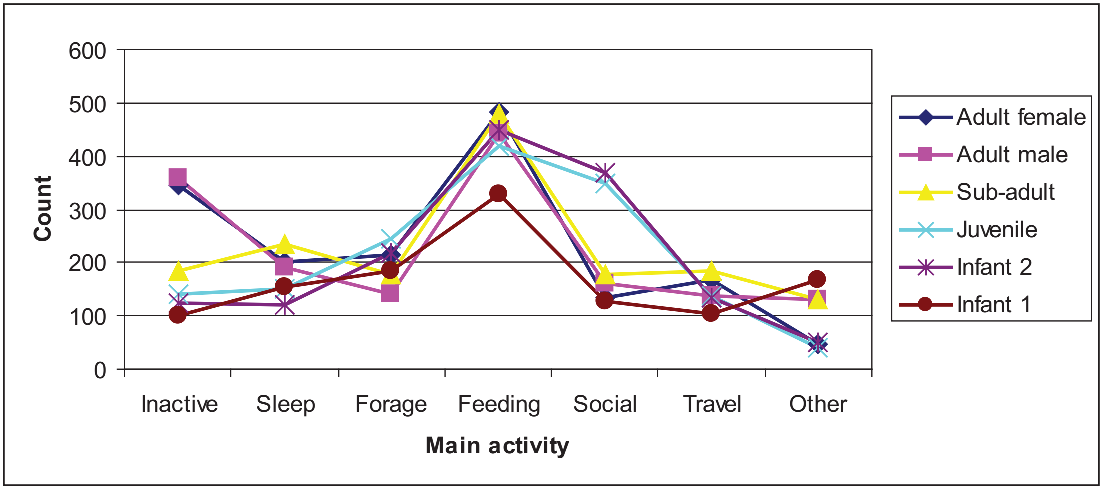

Fig. 5. Comparison of red-shanked douc langur activity budget by age classes.

amongst the group, as some animal's feed others may groom and play (mostly solitary play and chasing play). While, antagonism was rarely observed in the group of red-shanked doucs, occasionally we found that an adult male chased a sub-adult male away from an adult female (one without an infant). Sleep in the context of our study also includes a nap at mid-day and in the night-time, but a rest or break from feeding is excluded from this count. During sleep, adult males generally sit or lie at a higher position than others in the group however, sometimes in the vicinity of adult females. The recent study on black-shanked douc langurs in Vietnam shows that they prefer to rest and conduct social contact on rocks (Nadler, 2008) but this has not yet been observed in red-shanked doucs in Hin Namno. This is reflected in a similar study of white-headed langurs (*Trachypithecus leucocephalus*), where limestone formations were used only for refuge (Li & Rogers, 2005) as whenever there was an absence of humans, the animals descend to the flat ground area.

Inactivity was recorded when the animals stopped, and remained generally motionless. We often observed the group members stop feeding and listen to a suspected threat very carefully. This was frequently observed amongst the group members during the dry season and also with a higher frequency amongst adult males. An interesting activity result was the ravel times of the red-shanked doucs which show differences from other primate species. The red-shanked doucs generally have an established route (Lippold, 1998) and always follow the first animal. This mode of transportation was observed during our study. It was also reported by hunters that in spite of the first animal being shot, in many cases, the remaining group members still follow that same route or trees that the first one leapt to and from. Leaping or jumping is most used for red-shanked douc langurs locomotion as they often jump from the different levels of the canopy. Sometimes they can jump as far as 15-20 m from the higher canopy to the lower canopy. Arboreal quadrupedalism is another mode of travel that they use, which is often observed where trees support open branches. Brachiation is occasionally noticed especially when they encounter humans and immediately before they start leaping. We recorded that they use several modes of travel depending on external factors and conditions.

Seasonal changes did not impact on the overall time budgets of white-headed langurs it did however amongst different age classes (Li & Rogers, 2004). This is similar to the current study of red-shanked doucs in Hin Namno, where, during the dry season (although the seasonal difference is not significant), the difference in time budget used for travel is likely due to seasonal food scarcities (Li & Roger, 2004) and human pressure. Also, the amount of playing time amongst young white-headed langurs was influenced by habitat quality (Li & Rogers, 2004). Not only does habitat quality influence young white-headed langurs, but in China where a group was found in a low quality habitat had a high proportion of feeding time and a low proportion of playing time (Li & Rogers, 2004). During the dry season in Hin Namno, this is likely the same situation for the red-shanked douc langurs, as food resources are less abundant. There is also increased human pressure due to better access to the animals and less agricultural duties in the fields of local villages. Due to this seasonal threat, red-shanked doucs are observed to move around the limestone mountains cluster and they reside from the mid to upper limestone hills a majority of the time. They shift from one limestone hill cluster to another, generally every 3-5 days, before returning to the previous cluster. During the dry season there is a somewhat lower amount of time spent in napping while they had to use more time to monitor and watch for threats because of the constant threat from human encroachment. Therefore, human disturbance is one factor leading to changes in the animals' time budget pattern and which is more obvious in red-shanked douc langurs during the dry season, and recorded especially for G1.

Although reports indicate that there is a high level of grooming in the social activity of most langurs, red-shanked doucs langurs in the wild have a low frequency of grooming as seen in our study. Grooming between adult females and adult males is occasionally noticed during rest periods. However, self-grooming is observed with a high frequency and happens throughout the day including feeding time. Chasing play between sub-adult, juvenile and young infants is often observed however rarely was there physical contact observed. Juveniles and young Infants particularly like playing for extended periods, including the early morning, before taking a nap and sleeping in evening. While other group members are sleeping the young still carry on with solitary play and forage amongst the group locale. It may be part of safeguarding other members from threat. Also, it is observed that there is no fighting among group members, only a few cases of antagonism when an adult male chases a sub-adult male who comes close to adult female (without a baby). However, no fighting is observed because the sub-adult male runs away submissively. The chase by adult male ends immediately after adult-male is away from the adult female. Although we found red-shanked doucs langurs feeding in the same tree, there was no fighting, as has been observed with other primates.

The activity budget showed differences between the groups in the area suffering from high disturbance (G1) compared to that with low disturbance (G2). The animals have to adjust to the interference from people by pausing for a short period each time they feed, then moving to another tree. Where their travel route is close to a human track they have to be very careful and travel more quickly to keep the risk of being hunted down. In this regard, it is much similar to the report of the white-headed langur study (Li & Rogers, 2005). The activity of G1 during the dry season recorded less time than usual for napping but more time for inactivity. Although they are feeding they still have to monitor for threats. The system is like "move-monitor-forage-monitor-feed-monitor-move-monitor". Often, in the monitoring mode they look below and backwards. From this observation, we are able to better position ourselves and thereby observe the animals from the side of the group direction, which provided closer, better observation.

Although, the differences in the animals' behaviors were not significant between these two groups, which could be because these two groups, according to Phiapalath & Suwanwaree (2008), have only two different ranking position of threats (just in rank 2nd and 4th for G1 and G2 respectively).

However, the differences between these groups are clear during the dry season because of the higher number of hunters that enter the area when local villagers are free from the crop season duties.

Amongst the age classes adult males pay attention to monitoring threats more than other group members. The adult male is the group leader and tries to take care and watch out for the group. Juveniles and infants like playing more than other group members. This might be part of natural selection, and with this connection we assumed that this age class is assigned as a safety guard during napping time. Infant 1 (less than six months old) is observed to have the lowest proportion of feeding activity compared to other classes. Infant 1 is often observed within their mothers' chest area. When infants become old enough to be weaned they are still within the mother's reach in case of any threat. It has been observed however that sometimes when the infant is feeding out of the reach of its mother and the animals sense humans, the mother sometimes escapes without the infant in hand. This is considered abnormal in comparison with other primate species.

In conclusion, red-shanked douc langurs spend a major amount of their time feeding (29.47%) social, inactive and forage activity types respectively. For social activity, self-grooming is the highest proportion of time used for the species while partner grooming is considerably low. Adults, especially adult males spend the highest amount of time in inactivity – especially to monitor for threats and take care of the group, while the young use more time for social activity – mainly playing. Inactivity as well as travel are likely indications of habitat quality and level of threat or human pressure as indicated by G1 – the group of having suffered from higher threat spent more time for inactivity and travel, especially evident during the dry season. During the wet season they prefer to live in the foothill areas, whereas they prefer the mid to upper limestone hill during the dry season. They spend more time in inactivity and travel during the dry season, which is clearer in G1 (with the higher level of human pressure). As a whole, the behavior activity of the species is not of any significant difference between seasons, but amongst age classes and activity mode. Adults spend more than other group members for inactivity, while this is very low amongst the young. By contrast, adults spent less proportions of time in social activity. For the limestone habitat of Hin Namno, we have quite clear observations of the animals during the wet season when the animals descended to feed in the foothills and flat ground areas.

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QUỸ THỜI GIAN VÀ HOẠT ĐỘNG CỦA LOÀI CHÀ VÁ CHÂN ĐỎ (*PYGATHRIX NEMAEUS*) TẠI KHU BẢO TỒN QUỐC GIA HIN NAMNO, CHDCND LÀO

TÓM TẮT

Quỹ thời gian có thể bị thay đổi bởi hai nguyên nhân là các mối đe dọa tới động vật và chất lượng sinh cảnh sống bị thay đổi. Chúng tôi tiến hành nghiên cứu hai đàn chà vá chân đỏ (*Pygathrix nemaeus*) không thích nghi (tập tính ứng xử tự nhiên kém) qua nghiên cứu lựa chọn tại Khu bảo tồn Hin Namno, tỉnh Khammouane tại Lào. Có hai đàn G1 gồm 17 cá thể sinh sống tại Trại số 5 Nam Pasai chịu tác động của con người nhiều hơn trong khi đàn G2 gồm 39 cá thể tại Trại số 4 Nam Khoum ít chịu tác động của con người. Hai đàn này sống tách biệt cách nhau khoảng 5km. Trong mỗi đàn chúng tôi phân làm 6 loại cá thể bao gồm con cái trưởng thành, con đực trưởng thành, con đang trưởng thành, con nhỏ và sơ sinh 2 và sơ sinh 1. Chúng tôi ghi lại các thông số sau mỗi lần 30 phút về quỹ thời gian hoạt động của

loài ở ngoài tự nhiên. Chúng tôi đã thu được các hoạt động về tập tính hành vi của loài trong quỹ thời gian hoạt động ở ngoài tự nhiên, để xem thử liệu chúng có phụ thuộc theo mùa hay không. Các quan sát đàn được tiến hành từ tháng 3 năm 2007 đến tháng 6 năm 2008 (N=8,837) – tổng số ghi nhận của loài về các hoạt động hàng ngày. Các kết quả của 2 đàn này chỉ ra rằng ăn uống (29.47%) chiếm tỉ lệ sử dụng thời gian cao nhất; tiếp đến là các hoạt động xã hội (14.89%) bao gồm chuốt lông và chơi đùa; hoạt động tĩnh chiếm (14.17%) hầu hết là quan sát, theo dõi; lấy thức ăn (13.36%); ngủ (11.89%); đi lại (9.81%) và (6.40%) cho các hoạt động còn lại. Chà và chân đỏ hành xử khá khác nhau giữa hai mùa khô và mùa mưa. Mặt khác, việc chịu tác động của con người là nhiều hơn, đặc biệt săn bắt là yêu tố chính dẫn đến một vài thay đổi trong các hoạt động hàng ngày của chúng. Đàn 1 chịu nhiều ảnh hưởng của con người hơn nên có thời gian đi lại và hoạt động tĩnh đặc biệt là theo dõi mối đe dọa nhiều hơn vào mùa khô và tập tính ngủ ít hơn. Hoạt động xã hội chủ yếu là tự chuốt lông (43.34%) ; chơi (21.84%) và chơi đuổi bắt (15.8%), vv... trong lúc chuốt lông cho nhau chỉ chiếm (11.91%), chiếm tỉ lệ khá thấp. Tóm lại, ăn uống chiếm tỉ lệ lớn nhất trong quỹ thời gian của loài trong lúc hoạt động xã hội có tỉ lệ cao ở tự chuốt lông và thấp ở chuốt lông. Những thay đổi theo mùa không ảnh hưởng nhiều đến quỹ thời gian và hoạt động của động vật nhưng chúng lại chịu ảnh hưởng bởi sự tác động của con người trong suốt mùa khô.

REFERENCES

Brokelman, W.Y. and Srikosmatara, S. (1993): Estimation of density of gibbon groups by use of loud songs. Am. J Primatol. 29, 93-108.

IUCN (2008): 2008 Red-list of Endangered Species. www.redlist.org.

Lippold, L.K. (1995): Distribution and conservation of the douc langur (*Pygathrix nemaeus*) in Vietnam. Asian Primates 4, 4-6.

Lippold, L.K. (1998): Natural History of Douc Langurs. In: Jablonski N.G. (ed.): The natural history of the doucs and Snub-nosed Monkeys; pp. 191-206. World Scientific Publishing, Singapore.

Li, Zhaoyuan & Rogers M.E. (2004): Habitat Quality and Activity Budgets of White-Headed Langurs in Fusui, China. Int. J. Primatol. 25 (1), 41-54.

Li, Zhaoyuan & Rogers, M.E (2005): Are Limestone Hills a Refuge or Essential Habitat for White-Headed Langurs in Fusui, China? Int. J. Primatol. 26 (2), 437-452.

Nadler, T. (2008): Color variation in black-shanked douc langurs (*Pygathrix nigripes*) and some behavioural observations. Vietnamese J. Primatol. 2, 71-76.

Nadler T., Momberg F., Nguyen Xuan Dang & Lormee N. (2003): Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys. Fauna & Flora International-Vietnam Program and Frankfurt Zoological Society, Hanoi.

Nguyen Manh Ha (2006): Some observation on the Hatinh Langur, *Trachypithecus laotum hatinhensis*, in North Central Vietnam. Primate Conservation 21, 149-154.

Phiapalath, P. & Suwanwaree, P. (2007): Preliminary census study of Red-shanked douc langur and other primates in Hin Namno, Khammoaune, Lao PDR. Poster presented at Thai Wildlife Conference, Kasetsart University, Thailand. Dec 2007.

Phiapalath, P. & Suwanwaree, P. (2008): Wildlife threat, hunting and trade in north-western HinNamno National Protected Area and Na Phao Lao-Vietnam checkpoint, Lao PDR. Paper presented in “Knowledge Networks and Regional Development in the Greater Mekong Subregion and Asia - Pacific”, Kunming, China.

Rawson, B. & Roos, C. (2008): A new primate species record for Cambodia: *Pygathrix nemaeus*. Cambodia J. Natural History 1, 7-11.

Siex, K.S. (2004): Alterations in Social behaviour and structure in response to population compression in the Zanzibar red colobus (*Procolobus kirkii*). Wildlife Conservation Society and Conservation International – Africa Program. (Unpubl. report).

Timmins, R.J. & Khounboline, K. (1996): A Preliminary wildlife and habitat survey of Hin Namno National Biodiversity Conservation Area, Khammouane Province, Lao PDR. Wildlife Conservation Society, Vientiane. (Unpubl. report).

Timmins, R.J. & Duckworth, J.W. (1999): Status and Conservation of Douc Langurs in Laos. Int. J. Primatol. 20, 469-489.

Walston, J. & Vinton, M. (1999): A Wildlife and habitat surveys of Hin Namno National Biodiversity Conservation Area and adjacent areas, Khammouane Province, Lao PDR. WWF Lao. (Unpubl. report).

Yimkao, P. (2005): Ecology and conservation of the white handed gibbon Hylobates lar in a tropical seasonal deciduous forest in Mae Hong Sone, Northern Thailand. Master thesis. Faculty of Graduate Studies, Mahidol University.

18

REPRODUCTION OF RED-SHANKED DOUC LANGURS (*PYGATHRIX NEMAEUS*) AT DUSIT ZOO, THAILAND

NUNTANIT KULCHAROEN AND YONGCHAI UTARA

SUMMARY

Red-shanked douc langurs (*Pygathrix nemaeus*), has long been exhibited at Dusit zoo. There were 12 individuals (7,5) at Dusit zoo in 1997, but due to translocation of some individuals to other zoos, by 2002, there were three individuals. However, in 2003, five individuals were donated to the zoo. They were divided into three breeding groups of 1,1; 1,2 and 1,2 adults, respectively. Subsequently, the dietary regime was modified and increased to include more than 20 varieties of feed, consisting mainly of mixed vegetables, fruits, grain, hard-boiled eggs and herb varieties. Nutrional balance and better choice of diet was created by feeding twice a day, *ad libitum*. Breeding has become routinely successful after dietary changes and recently (October 2008) the population has increased to 31 doucs, (10,21 including 5,12 adults and 5,9 juveniles) with 5 breeding groups. Retrospective analysis of birth data shows that the species is not a seasonal breeder and birth occurs year round. From 22 birth records, the shortest birth interval was nine months and the longest was 26 months. Mating occurs when the youngest male or female reached three years and six months of age. In summary, the success of breeding red-shanked douc langurs in captivity depends on several factors such as reproduction management planning, animal health care, nutritional management and behavioral enrichment.

INTRODUCTION

Dusit Zoo's predecessor was the Zoological Park Organization under the Royal Patronage of H.M. the King. Formerly, Dusit Zoo was a part of the Dusit Royal Garden Palace with the local name of "*Khao Din Wana*" which was set up by King Rama V as his private botanical garden. It then became a public zoological park named "Dusit Zoo" on March 18, 1938. Management objectives have since focused on providing education, research, ex-situ conservation as well as public recreation. There are diverse animals both from Thailand and other countries, now totaling more than 300 species and 2,000 individuals. Dusit zoo is a very popular city zoo with more than two million visitors per year.

Red-shanked douc langurs (*Pygathrix nemaeus*) occur in east-central Lao PDR, northern and central Vietnam and has recently been recorded in northern Cambodia (Rawson & Roos, 2008). This species is believed to have undergone a decline of more than 50% in the last three generations (based on a generation length of 10-12 years), due to forest loss and hunting, and the decline is predicted to continue at the same rate or slightly higher in the next 30-35 years. The species is listed as "Endangered" on the IUCN Red List (IUCN, 2008) and on Appendix I of CITES (CITES, 2008).

Red-shanked douc langurs have long been exhibited at Dusit zoo. There were 12 individuals in December 1997, yet only three individuals (two males and one female) remained in 2002. In 2003, five individuals (one male and four females) were donated to the zoo to provide eight founders (three males and five females). From a breeding plan and with nutritional management, the population has increased to 31 individuals, (10,21 including 5,12 adults and 5,9 juveniles) with five breeding groups (Fig. 1).

MATERIAL AND METHODS

Enclosures

An exhibit of ten primate enclosures was built in 1996, to include the red-shanked douc langurs (Fig. 2). The enclosure was divided into two sections the indoor enclosure and outdoor exhibit. The indoor enclosures are 2.6 x 4.4 x 2.3 m and the outdoor exhibit ranges from 8.0 x 5.3 x 6.8 m to 8.0 x 7.4 x 6.8 m with environmental enrichments including jumping ropes and branches of different sizes.

Diet

As the animals had previously been fed no more than ten ingredients, an increased menu and range of food with more varities of ingredients enhanced the animals' choice and therefore nutritional balance.

- Feeding *ad libitum* twice a day, at 9.00 am and 3.00 pm.
- Feeding of more than 20 varities of diet, consists of vegetables, fruits, grain, hard- boiled eggs and several kinds of herb. There are many types of foliage offered for them such as *Angasana sp.*, *Ficus sp.*, lead tree and roselle leaves.
- Dietary supplements provided with mixed minerals and vitamins.

Fig. 1. Red-shanked douc langur female (*Pygathrix nemaeus*) with juvenile.

Photo: Tilo Nadler.

Population

In 2003, there were eight individuals (three adult males and five adult females) and divided into three breeding groups with 1,1; 1,2 and 1,2 individuals respectively. In 2005, there were two adult females donated and one adult female translocated from Songkhla zoo. Additionally, one juvenile was donated in 2006.

HEALTH MANAGEMENT

Identification

Juvenile douc was implanted with an interscapular microchip (AVID™) and marked with a tattoo on the inner thigh.

Annual check

Doucs were anesthetized (Ketamine 10 mg + Xylazine 1 mg per kg. of body weight, maintained with Isofurane 2%) for the annual check.

Check list comprised of:

Chest x-ray
TB test (old mammalian tuberculin) intradermal test in the eyelid
Blood sample
CBC & Blood parasite check
Deworming with Pyrantel Palmoate 10mg/kg PO (repeated per three weeks)
Antibody booster for hepatitis A and B
Fecal Examination
Rectal palpation (check prostate gland in adult male)

RESULTS AND DISCUSSION

Reproduction

The first offspring was born on 28 April 2003 from the donated female. In total, 22 individuals were born from April 2003 to July 2008 (Table 1). Retrospective analysis of 22 births shows that the species is not seasonal breeder and births occur all year round, with peaks in March, April and September. The average birth intervals is 16 months (n = 22) shorter than the report of Ruempler (1998) that showed the average birth intervals of douc langurs at Cologne zoo to be 24 months (n = 24), the shortest birth interval was 9 months and the longest was 26 months. Female No.18 gave birth three times, and all to males, whilst female No.20 gave 2 births to females only. The sex ratio of this group for male : female is 41 : 59 (Fig. 3).

There are two breeding pairs from the second generation of doucs. Sexual behavior started at three years for both sexes, and they reached maturity between three years six months to four years old. Mating occured when the youngest male and female were three years six months old. Males produce their first offspring at four and five years old and females produce their first offspring at four years one month and four years three months old. While Lippold (1989) showed data from 6 females at the age of first reproduction with a mean of four years and eight months old, and from eight males, the mean age for first siring t offspring was five years and seven months old.

Fig. 2. Douc langur enclosure at Dusit Zoo.
Photo: Tilo Nadler.

Health

Cystitis is common amongst adult males. Sick animals show abdominal cramp and stiff gait, dermatitis in the lower abdominal area, urinary incontinence, and fetid odor

After restraining with a net, examination through rectal palpation found hypertrophic prostate glands. The treatment includes washing of the affected skin area with a Chlorhexidine scrub, then wiping of the skin with a dry towel. It is then recommended to use baby powder talc (hypoallergenic) to keep the infected area dry. Finally, provide Enrofloxacin (Baytril™ 50mg/ml) 10 mg/kg of body weight once daily through intramuscular injection in the lateral thigh, for a period of 14 days. Finesterine 1.25 mg (Proscar 5mg/tabs) can be provided once daily to decrease the size of the prostate gland.

Fig. 3. Largest breeding group, with 1 male 3 females and 5 offspring.
Photo: Nuntanit Kulcharoen.

Record of health status:

- One alpha male (No.16) died from gastro-enteritis.
- One alpha male (No.14) was paralysed through a stroke, and then treated with acupuncture (Fig. 4).
- Two alpha males (No. 14 and No. 23) suffered from cystitis cause by prostate gland hypertrophy.

Table 1. Population of red-shanked douc langurs (*Pygathrix nemaeus*) at Dusit zoo.
(Data record from January 2003 to October 2008). KKOZ = Khao Kheow Open Zoo; SKZ = Songkhla Zoo.

House No.	Sex	Date of Bird	Date of arrival	Sire	Dam	Birth type	Note
14	M	11-Nov-95	-	890L01	910014	Captive Born	Dusit Zoo
16	M	Unknown	24-Nov-95	-	-	Wild born	Translocated from KKOZ and death on 5 Mar 07
19	F	Unknown	10-Sep-02	-	-	Unknown	Donation, Adult
20	F	Unknown	10-Jan-03	-	-	Unknown	Donation, Adult
18	F	Unknown	20-Apr-03	-	-	Unknown	Donation, Adult
21	M	28-Apr-03	-	16	19	Captive born	Dusit zoo
22	F	Unknown	22-Jun-03	-	-	Unknown	Translocated from SKZ
23	M	Unknown	30-Jun-03	-	-	Unknown	Donation, Adult
24	F	Unknown	30-Jun-03	-	-	Unknown	Donation, Adult
25	F	Unknown	30-Jun-03	23	24	Unknown	Donation, death16 Jul 03
26	F	1-Aug-03	-	16	20	Captive Born	Dusit zoo
27	F	19-Mar-04	-	23	22	Captive Born	Dusit zoo
28	F	23-Mar-04	-	23	24	Captive Born	Dusit zoo
29	M	16-Apr-04	-	14	18	Captive Born	Dusit zoo
30	M	25-Sep-04	-	16	21	Captive Born	Dusit zoo
31	F	25-Jun-05	-	14	20	Captive Born	Dusit zoo
32	F	Unknown	20-Aug-05	-	-	Unknown	Donation, Adult
33	F	Unknown	29-Sep-05	-	-	Unknown	Donation, Adult
34	M	21-Nov-05	-	14	18	Captive Born	Death on 29 Jun 07
35	F	20-Dec-05	-	23	22	Captive Born	Death on 26 Jan 06
36	F	4-Jan-06	-	16	19	Captive Born	Dusit zoo
37	M	23-May-06	-	23	24	Captive Born	Dusit zoo
38	F	28-Jul-06	-	16	32	Captive Born	Dusit zoo
39	M	27-Sep-06	-	23	22	Captive Born	Dusit zoo
40	F	Unknown	30-Sep-06	-	-	Unknown	Translocated from SKZ
41	F	Unknown	1-Nov-06	-	-	Unknown	Donation , Young
42	F	9-Nov-06	-	16	19	Captive Born	Dusit zoo
43	M	4-Mar-07	-	14	18	Captive Born	Dusit zoo
44	F	3-Aug-07	-	16	19	Captive Born	Dusit zoo
45	M	25-Sep-07	-	23	24	Captive Born	Dusit zoo
46	F	10-Oct-07	-	23	40	Captive Born	Dusit zoo
47	M	2-Feb-08	-	23	22	Captive Born	Dusit zoo
48	F	22-Apr-08	-	29	28	Captive Born	Dusit zoo
49	F	22-Jun-08	-	21	27	Captive Born	Dusit zoo
50	F	24-Jul-08	-	21	33	Captive Born	Dusit zoo

- One female miscarried in the first quarter, on two occasions.
- Two young died from pneumonia, one male (No.34) died at one year and eight months, and one female (No.35) died at one month old.

CONCLUSION

- 22 red – shanked doucs were born at Dusit zoo between April 2003 – July 2008.
- The population has increased from 3:5 to 10:21 douc (5:12 adults and 5:9 juveniles) with five breeding groups.
- Retrospective analysis of birth data shows that the species is not seasonal breeder and birth occurs year round, usually at night or early morning.
- From 22 birth records, the shortest birth interval was 9 months and the longest was 26 months.
- The youngest sire was four years and six days old and the youngest dam was four years and one month old.
- The success of breeding red-shanked doucs in captivity depends on several factors including breeding and management planning, animal health care, nutritional management and behavioral enrichment.

Fig. 4. The paralysed douc langur alpha male being treated with acupuncture.
Photo: Nuntanit Kulcharoen.

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SINH SẢN LOÀI VỌOC CHÀ VÁ CHÂN ĐỎ (*PYGATHRIX NEMAEUS*) TẠI VƯỜN THÚ DUSIT, THÁI LAN

TÓM TẮT

Loài chà vá chân đỏ (*Pygathrix nemaeus*) từ lâu đã được chăm giữ tại vườn thú Dusit, Thái Lan. Có 12 cá thể (7,5) tại vườn thú vào năm 1997, sau đó chúng được đưa đến các vườn thú khác và chỉ còn lại 3 cá thể vào năm 2002. Nhưng đến năm 2003, vườn thú được tặng thêm 6 cá thể khác. Chúng được chia thành 3 nhóm sinh sản tương ứng với 1.1, 1.2 và 1.2 con trưởng thành. Sau đó, thực đơn dinh dưỡng được tăng lên với hơn 20 loại thức ăn khác nhau bao gồm rau quả, trái cây, ngũ cốc, trứng luộc và thảo mộc. Chúng được cho ăn ngày hai lần và được ăn tùy ý nhằm tăng cường sở thích và cân bằng chế độ dinh dưỡng. Gây nuôi sinh sản đã thu được nhiều thành công lặp lại sau khi có những thay đổi về chế độ ăn uống và gần đây vào tháng 10 năm 2008, quần thể loài đã tăng lên 10.21 vọoc chà vá chân đỏ (5.12 con trưởng thành và 5.9 con non) với 5 đàn sinh sản. Phân tích trước đây về số liệu sinh sản đã chỉ ra rằng loài này không phải là loài sinh sản theo mùa mà có thể sinh quanh năm. Từ 22 lần ghi nhận về sự sinh sản của chúng, khoảng cách sinh ngắn nhất là 9 tháng và dài nhất là 26 tháng. Giao phối xảy ra khi con đực và con cái đến 3 năm 6 tháng tuổi. Tóm lại, việc gây nuôi sinh sản thành công chà vá chân đỏ phụ thuộc vào nhiều yếu tố như kế hoạch quản lý gây nuôi, chăm sóc sức khỏe loài, quản lý chế đố dinh dưỡng và cải thiện hành vi đối xử với loài.

REFERENCES

CITES (2008): http://www.cites.org/eng/app/appendices.shtml. Downloaded 24. June 2008.

IUCN (2008): IUCN Red-list of Threatened Species. http://www.iucnredlist.org/ details.php /39826. Downloaded 20. October 2008.

Lippold, L.K. (1989): Reproduction and survivorship in douc langurs *Pygathrix nemaeus*. Int. Zoo Yearbook. 28, 252-255.

Rawson, B. & Roos, C. (2008). A new primate species record for Cambodia: *Pygathrix nemaeus*. Cambodia J. of Natural History (1) 7-11.

Ruempler, U. (1998): Husbandry and breeding of Douc langurs at Cologne Zoo. Int. Zoo Yearbook. 36, 73-81.

19

BEHAVIOURAL DEVELOPMENT IN CAPTIVE RED-SHANKED DOUC LANGURS (*PYGATHRIX NEMAEUS*)

CHARLENE YEONG, CHIA TAN, AND LUCIA MEIJER

SUMMARY

The behavioural development of five infant red-shanked douc langurs (*Pygathrix nemaeus*) has been studied at Singapore Zoo from birth up to 18 months. Each infant was sampled up to four days per week and daily observations consisted of one to three one-hour sessions. Instantaneous data were collected on infant activity, presence of physical contact with the mother, and distance from the mother at two-minute intervals. Behavioural landmarks were also recorded as they emerged. Infants exhibited little activity after birth, but began showing interest in their environs and started to make brief exploratory excursions away from their mothers, and tasted solids within the first month. Social play and consumption of solids began in the second month, followed by independent travel in the second or third month. Mothers provided the majority of care and restricted their infants from venturing out of contact only during the first few months. As early as five months, mothers started rejecting infants from suckling, which became increasingly more intense after 12 months. Weaning was observed in only two of the five infants due to changes in group composition. One infant, housed in an off-exhibit den with a small family group, showed anomalous and accelerated development compared to the others. The development of the infants was possibly affected by maternal care style, group composition and physical environment.

INTRODUCTION

A hallmark of primates is the extended ontogeny from infancy to adulthood (Stanford *et al*., 2006). Infancy, in particular, is one of the most dangerous and crucial life stages for primates (Altmann, 1980). Primate infants are born relatively altricial and highly dependent on their mothers for a long time compared to other mammals of similar body size (Charnov & Berrigan, 1993; Martin & MacLarnon, 1988; Nicolson, 1987; Western, 1979). Because of the long period of postnatal development, a greater investment by the mother is required, which is energetically costly (Altmann & Samuels, 1992; Gittleman & Thompson, 1988; Lee *et al*., 1991). One way to better understand the interactions between primate life histories and socioecology is through studies of behavioural development. Although behavioural development has been widely researched across the primate order (see references in MacKinnon, 2007; Nicholson, 1987; Rasmussen & Tan, 1992), only a small number of studies, both field and captive included, have provided the complete trajectories that span the entire infancy from birth to the development of independence. With regard to the Asian colobine taxa, the behavioural development literature is scant; merely a handful of studies (e.g. Horwich, 1974; Jay, 1963; Li *et al*., 2005; Zhao *et al*., 2008) have tracked the development of infants throughout the period, which in Old World monkeys often extends into the second year of life.

The red-shanked douc langur (*Pygathrix nemaeus*) is one of the three species of douc langurs currently recognized (Roos *et al.*, 2007). It is listed as "Endangered" (IUCN, 2008) with natural populations found in Vietnam and Laos (Brandon-Jones *et al.*, 2004; Nadler *et al.*, 2003), and was recently discovered in Cambodia (Rawson & Roos, 2008). Challenging conditions and past political instability have hindered long-term, field studies of this species (Kirkpatrick, 1998; Lippold, 1998). There is also a paucity of zoo-based studies, since historically douc langurs have been difficult to maintain and breed in captivity (Heldstab, 1988; Hill, 1964; Janssen, 1994; Ruempler, 1998). A greater understanding of the biology, especially reproduction and development, is critical to the long-term conservation of red-shanked douc langurs and the other more threatened member of the genus.

The Singapore Zoo over the years has successfully managed two breeding groups of red-shanked douc langurs in two different housing situations. Due to the stable environment, high visibility and habituation to humans, the conditions are ideal for longitudinal studies. Previously, Brockman (1976) described the relationships of two red-shanked douc langur mother-infant dyads at the San Diego Zoo. The aim of this study was to augment that information, focusing on developmental milestones of five infants from birth up to 18 months. Furthermore, we concentrated on age-related changes in mother-infant contact, suckling, and locomotor and social play as indices of development of physical independence and socialization. Such information provides the basis for analyses of mother-infant interactions and maternal effects on behavioural development.

MATERIAL AND METHODS

Subjects

Five mother-infant dyads housed at the Singapore Zoo were observed. The five infants were born between April 2005 and August 2006 (Table 1). They came from two groups and were maintained in separate areas - one on display and the other off-exhibit. The display group comprised between six and nine individuals during the study period. In total, there was one adult male, three adult females, three juveniles and five infants, of which four (two males and two females) were included in the study. The off-exhibit group contained a total of four animals – one adult male, one adult female, one juvenile female and one male infant (focal animal).

Housing

The display group was maintained on a 755 m^2 outdoor, water-moated, naturally vegetated island. Two 8 m tall shelters were linked to live and artificial trees by artificial vines. 10 x 3 x 3.5 m overnight dens were situated in the middle of the island. The off-exhibit group was maintained in a primate complex in a 5 x 2.5 x 3.5 m den, divided by a guillotine door. About half of the den was exposed to the weather, and the other half was sheltered, and a 1.4 x 1.4 x 1.7 m plywood triangular box served as a rest area. The dens were covered in a stainless steel mesh with natural branches used as climbing structures.

Diet

The feeding behaviour of both groups comprised primarily of browsing from a variety of plants. The diet consisted of three main plant types *Acalypha siamensis*, *Leucaena leucocephala* and *Morus alba*. A number of other species of browse were offered. This varied on a daily basis, dependent on their availability. Examples of such browse are provided in Table 2. Their diet was also supplemented with white bread sprinkled with Nutroplex® multi-vitamin liquid, fruits (banana, apple/pear) and vegetables (long

Table 1. Douc langur infants (*Pygathrix nemaeus*) included in the study between April 2005 and January 2007.

Infant	Sex	Date of birth	Mother	Location	Study Duration (wk)
SK	M	22-Apr-05	NH (multiparous)	Exhibit	29[a]
SE	F	19-Jul-05	VO (multiparous)	Exhibit	72+
HC	M	26-Aug-05	BA (multiparous)	Off-exhibit	72
TU	M	1-May-06	CI (multiparous)	Exhibit	72+
TB	F	18-Aug-06	NH (multiparous)	Exhibit	72+

[a] Observations ended due to infant's death.

Table 2. Types of browse offered to the douc langurs (*Pygathrix nemaeus*).

Family	Scientific name
Regular browse	
Euphorbiaceae	*Acalypha siamensis*
Fabaceae	*Leucaena leucocephala*
Moraceae	*Morus alba*
Examples of browse that were dependent on availability	
Anacardiaceae	*Mangifera* spp.
Clusiaceae	*Garcinia mangostana*
Fabaceae	*Baphia nitida*
Fabaceae	*Pterocarpus indicus*
Lauraceae	*Cinnamomum iners*
Loganiaceae	*Fagraea fragans*
Malvaceae	*Hibiscus* spp.
Meliaceae	*Khaya* spp.
Moraceae	*Ficus* spp.
Myrtaceae	*Syzygium* spp.

beans, sweet potato, carrot, corn). Additionally, they were given rice balls mixed with egg, ground meat, cod liver oil and Mazuri® primate pellets. The total diet was divided into about four or five feeding times a day.

Sampling and recording methods

Focal animal sampling was carried out on the infants (Altmann, 1974). Each infant was sampled up to four days a week and daily observations consisted of one to three one-hour sessions. The sessions generally took place during mid-morning, mid-day, and mid-afternoon. Instantaneous time recording was carried out at two-minute intervals. The infants' activity in addition to locomotor (exploratory) play, social play, physical contact with mother and distance to mother were recorded. Suckling behaviour was also recorded and it was assumed that when infants were attached to the nipple, they were suckling. Infants' developmental landmarks and interactions with their mothers and other group members were noted as they emerged.

Data analysis

The data was recorded into a notebook or Dell Axim X50 personal digital assistant and entered into Microsoft Excel. Data points that the infants were obscured or not in sight, or which the observations were interrupted, were discarded. Data across four weeks were pooled into monthly data.

RESULTS

Developmental landmarks

The developmental landmarks for the five infants are displayed in Table 3. Within the first two weeks of birth, infants showed interest in their surroundings by looking at inanimate objects and actions of other group members, as well as reaching out for objects. Within the same period, they also started making awkward attempts to move away from their mothers. Mothers almost always held back their infants with a firm grasp around the torso or a limb at this time. However by the fifth week, infants were actively spending time away from their mothers and engaging in solitary, locomotor play, which included various forms of behaviour such as squirming,

Table 3. Developmental landmarks of the five douc langur infants (*Pygathrix nemaeus*).

Landmarks	SK (♂)	SE (♀)	HC (♂)	TU (♂)	TB (♀)	Range (weeks)
Interest in surroundings	1	1	1	2	1	1-2
Initiate to get away from mother	2	2	1	1	2	1-2
Actively moving away from mother, engaging in locomotor play	5	3	3	4	3	3-5
Tasting solids	5	3	7	4	3	3-7
Eating solids	9	9	10	11	8	8-11
Independent travel	12	14	8	9	13	8-13
Social play	17	5	17	7	4	4-17
Rejected by mother from suckling	21	17	25	31	42	17-42
Last time seen suckling	No data	71	60	No data	No data	60-71

Fig. 1 and 2. Juvenile douc langur (*Pygathrix nemaeus*) three months old.

Photo: Tilo Nadler.

hopping on the spot, climbing, brachiating, jumping and quadrupedal or bipedal walking or running.

Between the third and seventh week, they started tasting solid food, such as leaves, petioles, bark, fruit and vegetables. Items were placed in their mouths and manipulated, but no conscious ingestion of food was observed until about eight to 11 weeks of age. Food items were young leaves or fresh corn. At this stage, only small amounts were consumed (Fig. 1 and 2).

Infants started to travel independently of their mothers by quadrupedal walking or climbing between eight and 13 weeks. They began engaging in social play with other group members, in particular juveniles, between four to 17 weeks after birth. Wrestling, play-biting and chasing were involved.

The age at which mothers first rejected their infants from suckling differed widely – between 17 and 42 weeks (Fig. 3 and 4). Mothers rejected their infants by leaning away from them, lying ventrally against a branch or object, aggressively staring at them or moving away from them. Infants were rarely physically pulled or pushed away from their mothers' ventrum. Infants often vocalised loudly while shaking their heads from side to side when they were rejected. Rejection from suckling became more frequent and intense after 48 weeks. Weaning was observed in only two of the five infants (HC and SE) at 60 and 71 weeks from birth respectively. This milestone could not be observed in the other three due to the death of one infant (SK) at 29 weeks of age. The other two infants (TU and TB) continued to suckle beyond 18 months of age.

Mother-infant physical contact

All infants displayed a decline in the amount of time spent in physical contact with their mothers over time (Fig. 5). This physical contact was highest in the first two months, but also had the most noticeable decrease during this period. The decline was less sharp after the first two months, and individual

Fig. 3 and 4. Juvenile douc langur (*Pygathrix nemaeus*) nine months old.

Photo: Tilo Nadler.

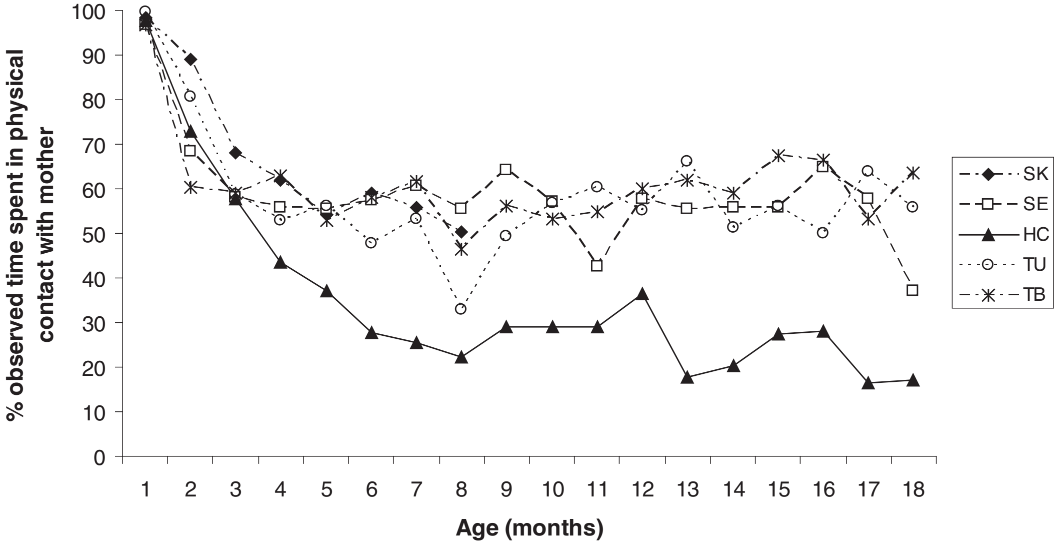

Fig. 5. Percentage of time juvenile douc langurs (*Pygathrix nemaeus*) spent in physical contact with mother.

variation started to be more noticeable. HC and SE spent increasingly less time with their mothers until they spent only 17% and 37% of their time respectively in contact with their mothers when they were weaned. TU and TB's physical contact with mother fluctuated around 60% at about 12 months from birth.

Suckling

Infants were observed to suckle only from their mothers. Only one infant (HC) displayed an overall decline in suckling behaviour between birth and weaning (16 months). Fluctuations were observed in the others, and a sharp drop was noticed in one (SE) in the last month before weaning. Suckling for two infants (TU and TB) appeared to increase overall to about 55% of observed time for each of them (Fig. 6).

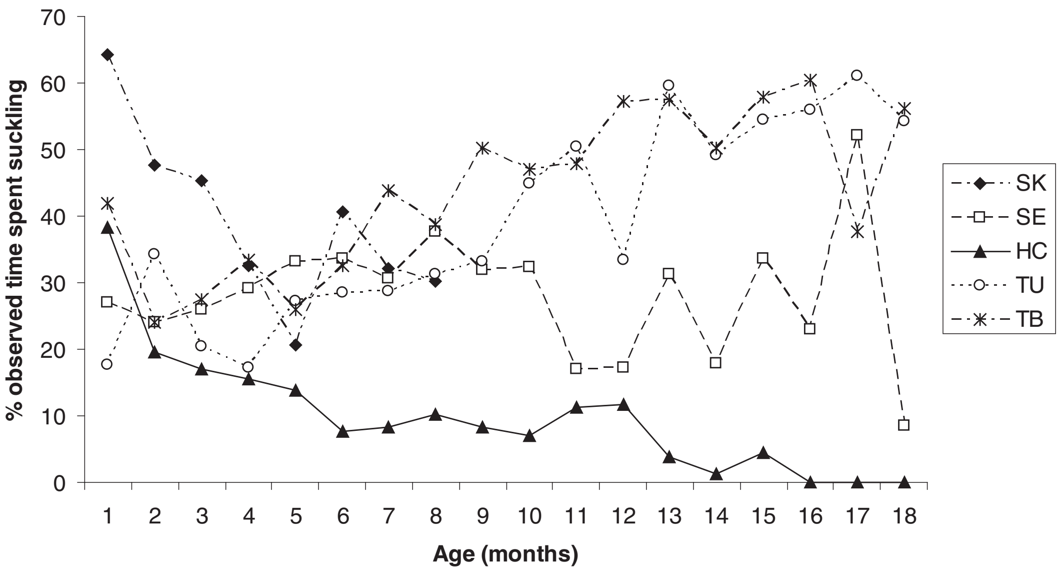

Fig. 6. Percentage of time juvenile douc langurs (*Pygathrix nemaeus*) spent suckling on mother.

Locomotor (exploratory) play

Most douc langur infants displayed a marked increase in locomotor play in the second month. Locomotor play generally started to drop at about five or six months after birth, although the opposite was true for HC (Fig. 7). HC was most involved in locomotor play, and TB the least. Locomotor play included squirming, hopping on the spot, climbing, jumping, brachiating and quadrupedal or bipedal walking or running, occasionally with eyes closed. Play behaviour occasionally took place on or near the ground, but more frequently for HC than the other infants.

Social play

The amount of time spent in social play is displayed in Fig. 8. All infants showed little or no social play in the first month, but there were marked increases by the second or third month for four of the five infants. One particular infant (TU) was engaged in more social play than the others. TB also social played comparatively often, but HC did not engage in social play much or at all until the sixth month. SE, HC and TB social played only about 2-5% of observed time at 18 months from birth. In almost all instances, social play took place between or within infants and juveniles. Adults were very rarely engaged or interested. Social play included wrestling, play biting and chasing.

DISCUSSION

The developmental milestones of infant *P. nemaeus* in this study are generally consistent with those described in Brockman (1976). This is not surprising since both are zoo-based studies of the same species. Like Brockman (1976), we also observed individual differences among the infants. These were evident in HC's distinctive development, and the continuation of suckling observed in TU and TB after the death of the adult male in the group. Due to the small sample size, these differences could not be statistically tested. Nevertheless, the stages of behavioural development of *P. nemaeus* are comparable to those described in other Asian colobine species (Horwich, 1974; Jay, 1963; Li *et al.*, 2005; Zhao *et al.*, 2008). Below we comment on the individual variations in behavioural development and the interactions between infants and mothers.

In this study, infants started tasting solid foods by the seventh week and started consuming solids between eight and 11 weeks. This is consistent with the 60 days observed by Brockman & Lippold (1975) but earlier than the 12 weeks reported by Hollihn (1973). Conversely, other studies have reported

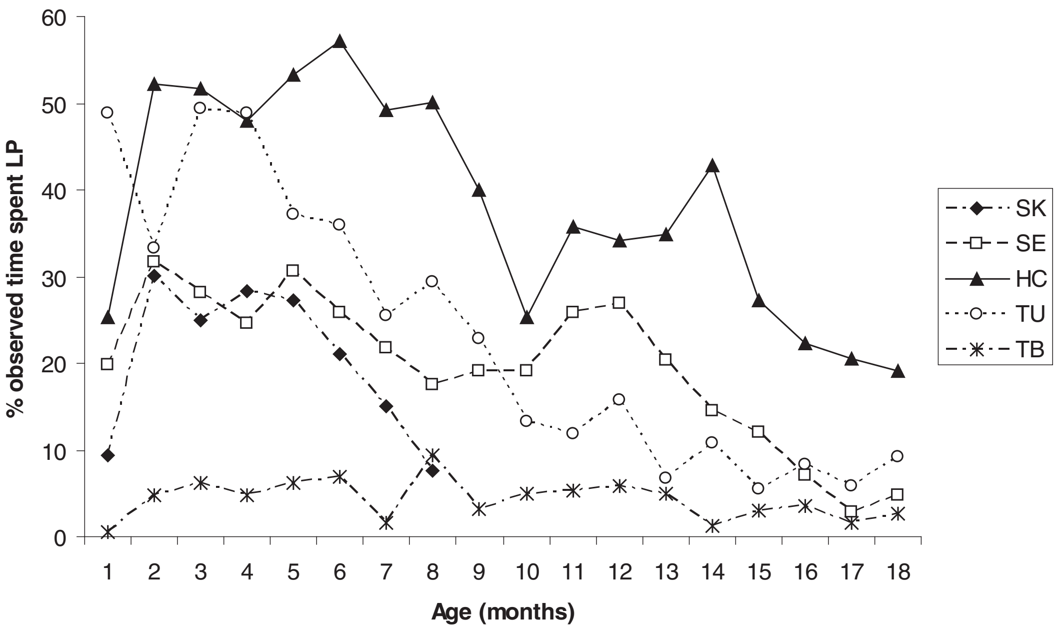

Fig. 7. Percentage of time juvenile douc langurs (*Pygathrix nemaeus*) spent in locomotor (exploratory) play. These included squirming and hopping on the spot, climbing, jumping, quadrupedal or bipedal walking or running.

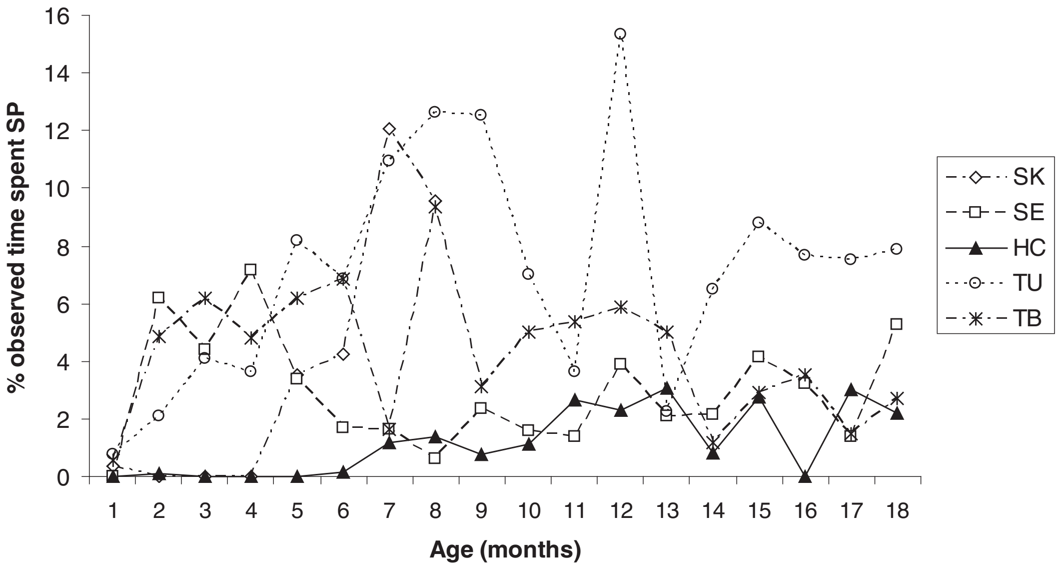

Fig. 8. Percentage of time juvenile douc langurs (*Pygathrix nemaeus*) spent in social play with group members, mostly juveniles. Actions included wrestling, play biting and chasing.

consumption of solids as early as the 16th day (Hafner, pers. observ., in Hill, 1972). This discrepancy could be because we differentiated between tasting and conscious feeding of solids, but this was not the case in the previous studies. In addition, small amounts of food could have been ingested when infants tasted the solid foods that we could not observe. The actions involved in food tasting were similar to that described by Dolhinow & Murphy (1982).

Brief exploratory forays, independent of their mothers, by infants within two weeks of birth were consistent with previous studies (Hick, 1972), and also with another colobine, *Semnopithecus* (formerly *Presbytis*) *entellus* (Dolhinow & Murphy, 1982). Play behaviour observed in this study was consistent with the description by Kavanagh (1978). The actions employed in locomotor play, such as climbing, brachiating, jumping and quadrupedal running, were also utilised later on in social play. Most infants showed a marked increase in locomotor play in their second month, which then generally declined with age. This complemented an increase in social play between the first and third months. However, a greater amount of variation was observed for social than for locomotor play. HC was consistently most involved in locomotor play and least involved in social play compared to the other infants. This was likely to be a result of group composition and environment. He was maintained in the off-exhibit den with his parents for most of the 72 weeks. An older juvenile female was removed from this group in his third month and he had no other group members to play with apart from his parents. Even though he was maintained in a smaller area relative to the island exhibit, he was able to utilise relatively more three-dimensional space of his den, such as the mesh sides and top. TU, which was in the exhibit group, generally social played the most, and was fairly frequently engaged in locomotor play. TB consistently locomotor played the least, but was fairly highly engaged in social play. The locomotor repertoire by infants was also similar to that observed by Workman & Covert (2005), including that of suspensory movements, playing with eyes closed and playing on or near the ground. All infants, during their exploratory or social play, did so on or near the ground occasionally, in particular HC. This could be due to a predator-free environment, and, in HC's case, maximising the use of a small space to play in. This suggests that play – exploratory and social – is highly influenced by individual variation, physical environment and group composition.

The infants only suckled from their mothers, which is compatible with that found in the majority of mother-infant literature (Nicolson, 1987). However, there was a wide variation in time spent suckling across infants in this study. This could be due to individual differences in infants and mothers, which also affected the onset of weaning. Data in which the mother-infant dyads were out of sight, or when the infants' positions on their mothers were obscured and ambiguous, were discarded. Therefore, the actual duration spent suckling could possibly be greater than that reflected in the results, particularly in the first one or two months from birth. During this time, it was particularly difficult to pinpoint the position of infants on their mothers due to their small size and tendency for mothers to rest or nurse their infants in a sheltered area, and to slump over their infants, obscuring them, while doing so.

Along a similar vein, the age of weaning was also highly variable in the four infants that survived to the end of the 72 weeks. HC was not the first infant to be rejected by his mother, BA, but he was the first infant to be weaned, at 16 months. This suggests that the onset of rejection is not a reliable indication of age of weaning. Overall, HC suckled less than the other infants. Correspondingly, he also spent markedly less time in physical contact with his mother. He was the only one to display a clear, generally steady decline for these two parameters. He was weaned about two months before the birth of the next offspring, which was not included in this study. For most of the study period, HC was housed alone in the off-exhibit dens with his parents. This provides support for the finding that small family groups comprising of parents and one offspring are likely to accelerate maternal rejection and weaning (Lippold, 1989). Furthermore, in yellow baboons (*Papio cynocephalus*), infants with mothers who were "less tolerant of suckling" and were less involved with physical contact were also weaned earlier (Altmann, 1980).

SE was the first to be rejected, and was the second to be weaned, at 71 weeks. Even though her suckling frequency fluctuated greatly between 12 – 18 months of age, physical contact with her mother remained consistently high. During this period, she often rested close or next to her mother even if she was not suckling.

SK was also one of the first infants to be rejected, at 21 weeks. However, SK's younger sibling, TB, was the last one to be rejected at 42 weeks. In TB and the other similar age infant, TU, suckling remained constant around 55%, and physical contact with mother around 60% for both TB and TU beyond 72 weeks. This is very likely to be a result of the death of the dominant, breeding male in the group, with no replacement. Without the subsequent offspring, their mothers, NH and CI, did not consistently reject TB and TU from suckling, thus delaying their independence.

Douc langur mothers have previously been reported to lie down to prevent their infants from climbing ventrally (Kavanagh, 1978). This was also observed in this study. Rejection was also achieved by leaning against a diagonal or vertical object, turning away and actively moving away from the infant. Only rarely did mothers physically pull or push their infants away from their ventrum.

In white-headed langurs (*Trachypithecus leucocephalus*), captive infants are weaned at a much earlier age (six months) compared to their wild counterparts (19 – 21 months) (Zhao *et al*., 2008). The differences may be dietary-related. It is possible that captive douc langurs tend to develop and gain independence faster than their wild counterparts.

The diet of the douc langurs in the Singapore Zoo approximates their natural diet as best as possible, and while differences in maternal investment may exist between this group and wild populations, the differences are unlikely to be as dramatically different. Nonetheless, food availability and nutrition condition has implications for *in-situ* conservation and captive management, such as when caring for orphaned young, during park management, transfers and introductions of group members and collection planning.

In sum, infant development is influenced by a host of factors; in particular, maternal behaviour has been noted to be a significant determinant (Altmann, 1978, 1980; Dolhinow & Murphy, 1982; Förster & Cords, 2002; Hinde & Spencer-Booth, 1967; Lee, 1984; Nash, 1978). Maternal behaviour may be shaped by the experience, ranking, temperament and personality of the mother, and individual mothering styles can vary widely with some characterized as restrictive while others as *laissez-faire* (Altmann, 1980; Fairbanks, 1996). Additionally the social environment, in aspects such as group size, composition, and the presence of kin, has been suggested to affect maternal behaviour and infant development (Berman *et al*., 1997; Förster & Cords, 2005; Maestripieri, 1994; Silk, 1991; Spencer-Booth, 1968). Indeed, the social organizations of Asian colobines are especially important since allomothering is a prevalent phenomenon in these species (see references in MacKinnon, 2007; Nicholson, 1987; Yeager & Kool, 2000). Another notable factor that can influence rearing behaviour and infant development is the physical environment, which can be vastly different between naturalistic and captive settings. Current findings suggest that maternal style and physical environment appear to play a major role in douc langurs' development. Group composition also may be a contributing factor. These results have implications for *ex-situ* management of this species and other closely related species. Intact social groups should be a priority, as well as an environment that encourages the development of locomotor and social skills.

As ecological and social processes are likely to impact the behavioural development of free-ranging douc langurs differently, detailed data from the field are needed to provide comparisons to the results found in this study. Future studies should also focus on maternal and allomaternal interactions to shed more light on the variability of infant development.

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SỰ PHÁT TRIỂN HÀNH VI CỦA CHÀ VÁ CHÂN ĐỎ (*PYGATHRIX NEMAEUS*) TRONG ĐIỀU KIỆN NUÔI NHỐT

TÓM TẮT

Một nghiên cứu về phát triển hành vi của 5 cá thể chà vá chân đỏ (*Pygathrix nemaeus*) sơ sinh từ khi sinh ra cho đến 18 tháng tuổi tại Vườn thú Singapore. Mỗi cá thể sơ sinh được kiểm tra bốn ngày một lần đồng thời tiến hành quan sát chúng liên tục từ một đến ba giờ mỗi ngày. Chúng tôi đã thu thập được dữ liệu tức thời về hoạt động của cá thể sơ sinh, sự tiếp xúc cơ thể với con mẹ và khoảng cách với con mẹ cứ mỗi hai phút một lần. Chúng tôi cũng ghi nhận được những dấu hiệu tiêu biểu về hành vi ứng xử. Con con rất ít hoạt động sau khi sinh nhưng bắt đầu quan tâm đến môi trường sống xung quanh rồi dần tiến đến có những cuộc khám phá ngắn xa con mẹ và bắt đầu nếm thức ăn đặc trong suốt tháng đầu tiên. Hoạt động xã hội và ăn thức ăn đặc bắt đầu diễn ra từ tháng thứ hai cùng với di chuyển độc lập từ tháng thứ ba và thứ tư. Con mẹ chăm sóc và hạn chế con của chúng di xa khỏi mẹ chỉ trong một vài tháng đầu tiên. Khi bước sang năm tháng tuổi, con mẹ bắt đầu giảm không cho con chúng bú và giảm dần khi con chúng sau 12 tháng tuổi. Việc thôi cho con bú chỉ được quan sát được hai trong số năm con nhỏ do những thay đổi trong thành phần đàn. Một con con, sinh sống trong một hang kín cùng với một đàn nhỏ khác, sẽ thể hiện những hành động ứng xử không có quy tắc so với những con khác. Phát triển ở con con có khả năng chịu nhiều ảnh hưởng từ cách chăm sóc của con mẹ, thành phần đàn và môi trường sinh sống. Nghiên cứu này được Tổ chức Amerman, Tổ chức Gia đình Offield, Các Khu Bảo tồn Động Thực vật hoang dã Singapore và Hội Động vật học San Diego tài trợ.

REFERENCES

Altmann, J. (1974): Observational Study of Behaviour: Sampling Methods. Behaviour 49, 227-267.

Altmann, J. (1978): Infant Independence in Yellow Baboons. In: Burghardt, G.M. & Bekoff, M. (eds.): The Development of Behavior: Comparative and Evolutionary Aspects. Garland STPM Press, New York.

Altmann, J. (1980): Baboon Mothers and Infants. Harvard University Press, Cambridge.

Altmann, J. & Samuels, A. (1992): Costs of Maternal Care: Infant Carrying in Baboons. Behavioral Ecology and Sociobiology 29, 391-398.

Berman, C.M., Rasmussen, K.L.R. & Suomi, S.J. (1997): Group Size, Infant Development and Social Networks in Free-ranging Rhesus Monkeys. Animal Behaviour 53, 405-421.

Brandon-Jones, D., Eudey, A.A., Geissmann, T., Groves, C.P., Melnick, D.J., Morales, J.C., Shekelle, M. & Stewart, C-B. (2004): Asian Primate Classification. Int. J. Primatol. 25(1), 97-164.

Brockman, D.K. (1976): The Douc Langur (*Pygathrix nemaeus nemaeus*) Mother-Infant Dyad at the San Diego Zoo. Master thesis, San Diego State University.

Brockman, D.K. & Lippold, L.K. (1975): Gestation and Birth of a Douc Langur (*Pygathrix nemaeus nemaeus*) at San Diego Zoo. Int. Zoo Yearbook 15: 126-129.

Charnov, E.L. & Berrigan, D. (1993): Why Do Female

Primates Have Such Long Lifespans and So Few Babies? Evolutionary Anthropology 1, 191-194.

Dolhinow, P. & Murphy, G. (1982): Langur monkey (*Presbytis entellus*) development: the first 3 months of life. Folia Primatol. 39(3-4): 305-31.

Fairbanks, L.A. (1996): Individual Differences in Maternal Style: Causes and Consequences for Mothers and Offspring. Advances in the Study of Behavior 25, 579-611.

Förster, S. & Cords, M. (2002): Development of Mother-infant Relationships and Infant Behavior in Wild Blue Monkeys (*Cercopithecus mitis stuhlmanni*). In: Glenn, M.E. & Cords, M. (eds.): The Guenons: Diversity and Adaptation in African Monkeys; pp. 245-272. Kluwer Academic/Plenum Publishers, New York.

Förster, S. & Cords, M. (2005): Socialization of infant blue monkeys (*Cercopithecus mitis stuhlmanni*): allomaternal interactions and sex differences. Behaviour 142, 869-896.

Gittleman, J.L. & Thompson, S.D. (1988): Energy Allocation in Mammalian Reproduction. American Zoologist 28, 863-875

Heldstab, A. (1988): Management and Disease Problems in Douc Langurs at the Basle Zoo. Proceedings of the American Association of Zoo Veterinarians Annual Conference; pp. 184-187.

Hick, U. (1972): Breeding and Maintenance of Douc Langurs *Pygathrix nemaeus nemaeus* at Cologne Zoo. Int. Zoo Yearbook 12, 98-103.

Hill, W.C.O. (1964): The Maintenance of Langurs (Colobidae) in Captivity: Experiences and Some Suggestions. Folia Primatol. 2, 222-231.

Hill, C. (1972): Infant Sharing in the Family Colobidae Emphasizing *Pygathrix*. Primates 13(2), 195-200.

Hinde, R.A. & Spencer-Booth, Y. (1967): The Behaviour of Socially Living Rhesus Monkeys in their First Two and a Half Years. Animal Behaviour 15, 169-196.

Hollihn, U. (1973): Remarks on the Breeding and Maintenance of Colobus Monkeys *Colobus guereza*, Proboscis Monkeys *Nasalis larvatus* and Douc Langurs *Pygathrix nemaeus* in Zoos. Int. Zoo Yearbook 13, 185-188.

Horwich, R.H. (1974): Development of Behaviors in a Male Spectacled Langur (*Presbytis obscurus*). Primates 15, 151-178.

IUCN (2008): 2008 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 30 March 2009.

Jay, P. (1963): Mother-infant Relations in Langurs. In: Rheingold, H.L. (ed.): Maternal Behavior in Mammals; pp. 282-304. John Wiley and Sons, Inc., New York,

Janssen, D.L. (1994): Morbidity and Mortality of Douc Langurs (*Pygathrix nemaeus*) at the San Diego Zoo. Proceedings of the American Association of Zoo Veterinarians Annual Conference; pp. 221-226.

Kavanagh, M. (1978): The Social Behaviour of Doucs (*Pygathrix nemaeus nemaeus*) at San Diego Zoo. Primates 19(1), 101-114.

Kirkpatrick, C.R. (1998): Ecology and Behaviour in Snub-nosed and Douc Langurs. In: Jablonski, N.G.(ed.): The Natural History of the Doucs and Snub-nosed Monkeys; pp. 155-190. World Scientific Publishing Co., Singapore.

Lee, P.C. (1984): Early Infant Development and Maternal Care in Free-ranging Vervet Monkeys. Primates 25(1), 36-47.

Lee, P.C., Majluf, P. & Gordon, I.J. (1991): Growth, Weaning and Maternal Investment from a Comparative Perspective. J. Zool. London 225, 99-114.

Li, Y.-H., Li, B.-G. & Tan, C.L. (2005): Behavioral Development within One-year-old Individuals of Sichuan Snub-nosed Monkeys *Rhinopithecus roxellana* in the Qinling Mountains. Acta Zoologica Sinica 51, 953-960 (Chinese with English abstract).

Lippold, L.K. (1989): Reproduction and Survivorship in Douc Langurs *Pygathrix nemaeus* in Zoos. Int. Zoo Yearbook 28, 252-255.

Lippold, L.K. (1998). Natural History of the Doucs. In: Jablonski, N.G. (ed.): The Natural History of the Doucs and Snub-nosed Monkeys; pp. 191-206. World Scientific Publishing Co., Singapore.

MacKinnon, K.C. (2007): Social Beginnings: the Tapestry of Infant and Adult Interactions. In: Campbell, C.J., Fuentes, A., MacKinnon K.C., Panger, M. & Bearder S.K.: Primates in Perspective; pp. 571-591. Oxford University Press, New York.

Maestripieri, D. (1994): Mother-infant Relationships in Three Species of Macaques (*Macaca mulatta*, *M. nemestrina*, *M. arctoides*). I. Development of the Mother-infant Relationship in the First Three Months. Behaviour 131(1-2), 75-96.

Martin, R.D. & MacLarnon, A.M. (1988): Comparative Quantitative Studies of Growth and Reproduction. Symposia of the Zoological Society of London 60, 39-80.

Nadler, T. Momberg, F., Nguyen Xuan Dang & Lormee, N. (2003): Vietnam Primate Conservation Status Review. Part 2: Leaf Monkeys. Frankfurt Zoological Society and Fauna & Flora International-Indochina

Programme, Hanoi.

Nash, L.T. (1978): The Development of the Mother-infant Relationship in Wild Baboons (*Papio anubis*). Animal Behaviour 26, 746-759.

Nicolson, N. (1987): Infants, Mothers, and Other Females. In: Smuts, B., Cheney, D.L., Seyfarth, R.M., Wrangham, R.W. and Struhsaker, T.T.(eds.): Primate Societies; pp. 330-342. University of Chicago Press, Chicago.

Rasmussen, D.T. & Tan, C.L. (1992): The Allometry of Behavioral Development: Fitting Sigmoid Curves to Ontogenetic Data for Use in Interspecific Allometric Analyses. J. Human Evolution 23, 159-181.

Rawson, B. & Roos, C. (2008): A New Species of Primate for Cambodia: *Pygathrix nemaeus*. Cambodian J. Natural History 1(1):7-11.

Roos, C., Vu Ngoc Thanh, Walter, L. & Nadler, T. (2007): Molecular Systematics of Indochinese Primates. Vietnamese J. Primatol. 1(1), 41-53.

Ruempler, U. (1998): Husbandry and Breeding of Douc Langurs (*Pygathrix nemaeus nemaeus*) at Cologne Zoo. Int. Zoo Yearbook 36, 73-81.

Silk, J. B. (1991). Mother-infant Relationships in Bonnet Macaques: Sources of Variation in Proximity. International Journal of Primatology 12: 21-38.

Spencer-Booth, Y. (1968): The Behaviour of Group Companions Toward Rhesus Monkey Infants. Animal Behaviour 16, 541-557.

Stanford, C., Allen, J.S. & Antón, S.C. (2006): Biological Anthropology: The Natural History of Humankind. Pearson Prentice Hall, New Jersey.

Western, D. (1979): Size, Life-history and Ecology in Mammals. African J. Ecology 17(4), 185-204.

Workman, C. & Covert, H.H. (2005): Learning the Ropes: the Ontogeny of Locomotion in Red-shanked Douc (*Pygathrix nemaeus*), Delacour's (*Trachypithecus delacouri*) and Hatinh langurs (*Trachypithecus hatinhensis*) I. Positional Behaviour. Am. J. Physical Anthropology 128, 371-180.

Yeager, C.P. & Kool, K. (2000): The Behavioral Ecology of Asian Colobines. In: Whitehead, P.F. & Jolly, C.J. (eds.): Old World Monkeys; pp. 496-521. Cambridge University Press, Cambridge.

Zhao, Q., Tan, C.L. & Pan, W. (2008): Weaning Age, Infant Care and Behavioral Development in *Trachypithecus leucocephalus*. Int. J. Primatol. 29(3), 583-591.

HOME RANGE SIZE AND DENSITY OF YELLOW-CHEEKED GIBBONS (*NOMASCUS GABRIELLAE*) IN DIFFERENT FOREST TYPES WITHIN CAT TIEN NATIONAL PARK, VIETNAM

MARINA KENYON, DAVID CHIVERS, AND VO THANH BINH

SUMMARY

The home range size of the yellow-cheeked gibbon (*Nomascus gabriellae*) was investigated in the semi-evergreen lowland forests of Cat Tien National Park, an area disturbed by war, logging and hunting. Four study areas were selected based on forest type (varying structurally and compositionally), with observations from January 2004 to December 2005. In each intensive study area, the average home range size was consistent, but between forest types there was a wide variation, ranging from 16.72 ha in the "evergreen forest", 51.86 ha in "semi-evergreen" forest and 60.50 ha in the "bamboo" area. As gibbon populations throughout Vietnam are threatened by hunting and habitat loss (Hoang *et al*., 2005) with national parks being no exception (Geissmann *et al*., 2007), the study of their ecology is vital to develop baseline knowledge of a species never studied before in Vietnam. By developing an understanding of the relationship between forest type and home range size important conservation measures can be recommended to safeguard the remaining population from extinction and to encourage recovery.

INTRODUCTION

There is no information available for the home range size of yellow-cheeked gibbons (*Nomascus gabriellae*) in the lowland semi-evergreen forests of Vietnam. In general home range size of gibbons varies between species (O'Brien *et al*., 2004; Ellefson, 1974; Whitten, 1982; Chivers, 1974) and within species. Kloss' gibbon (*Hylobates klossii*) (Tenaza, 1975), has a home range size average between 20-40 ha for gibbons, excluding the crested gibbons (*Nomascus* sp.). The home ranges of crested gibbons are mostly above 70 ha, with the western black gibbon (*N. concolor*) ranging from 44 to 200 ha (Lan, 1989, Sheeran *et al*., 1998) and both the Hainan gibbon (*Nomascus hainanus*) and the northern white-cheeked gibbon (*N. leucogenys*) estimated up to 500 ha (Liu *et al*., 1987; Hu *et al*., 1989; Chan *et al*., 2005). It is not clear whether such large home ranges are natural for the crested gibbons in seasonal high-altitude forests, compared to the more humid forests of other gibbons, or a consequence of disturbed habitat and low densities. The remaining crested gibbon populations, especially in the northern regions, are generally only found at higher elevations as most forests below 2200 m asl have been cleared for agriculture through generations of selective logging (Jiang *et al*., 2006). At this altitude tree diversity is reduced, so even in the areas of good-quality primary forest with continuous canopy, high gibbon densities are not found; however, home ranges can still be over 100 ha (Fan *et al*., 2006). These surviving populations confined to higher elevations are considered the natural "sink" (Cowlishaw & Dunbar 2000). Thus, although representative of the remaining populations, they are not likely to have been representative of the original distribution before extensive forest loss.

MATERIAL AND METHODS

Study site

Cat Tien National Park (CTNP) is located in South Vietnam, 150 km North of Ho Chi Minh City on the southern edge of the Annamite mountain region, one of the few areas of lowland forest remaining in Vietnam. It covers an area of 70,549 ha. CTNP is divided into two sectors. The southern Cat Tien sector has had over 30 years of Government protection while the northern Cat Loc sector has only been protected since 1992. A 10 km densely-populated band of agricultural land separates the two sections (Fig. 1). In 2002 CTNP was declared a Biosphere Reserve and more recently as a Ramsar site and a nominee for a World Heritage site.

The climate of CTNP is classified as tropical monsoon with a dry season from November to December and a rainy season from March to April when rainfall exceeds 300 mm/month. Average annual temperatures are 26.2ºC with little fluctuation, with maximum temperatures reaching 35ºC and minimum temperatures of only 18ºC.

The national park is located at the foothills of the central highlands where the topography varies greatly. The northern Cat Loc region is dominated by hills (200-600 m asl) with flat tops and is the source of the Dong Nai River. Further South, the altitude is 200-300 m asl in the Cat Tien section with moderate slopes and streams feeding the Bau Sau wetlands. The river plain around the Dong Nai River, at an altitude of 130 m asl, is prone to flooding in the wet season.

Roughly half of the forest has been replaced by bamboo re-growth on abandoned agricultural fields. Evergreen forests are found in the northwest and southwest of Cat Loc, and the southwest and southeast Cat Tien. Most of these parts have been selectively logged at least once resulting in low species richness. Semi-evergreen forest is found in the northeast of Cat Tien, where the soil is not as deep and is prone to drying. The upper storey of *Lagerstroemia* forms a closed canopy, whereas the middle storey is more fragmented and open. The under storey is very species rich, with a denser ground cover of rattan, creepers and grasses. “Mixed” forest is found where incomplete burning has opened up the canopy, released nutrients and allowed the growth of bamboo. This is the dominant vegetation of the East and South portions of Cat Tien.

Methods

Field work was carried out from January 2004 to December 2005. Four study areas were selected based on the presence of gibbons, forest type and logistic feasibility;

- Da Mi - Dominated by “semi-evergreen” forest, dominant families Lythraceae, Myrtaceae and Dipterocarpaceae,
- Bau Sau - Dominated by “evergreen” forest, dominant families Sterculiaceae, Ebenaceae and Bambuseae
- Ben Cau - Dominated by “bamboo” forest, dominant families Bambuseae, Fagaceae and Myrtaceae
- Headquarter - Similar forest to Da Mi, but without contiguous neighbours

The area to the headquarter enabling a comparison to see if density of gibbons was limiting home-range size (Fig. 2).

An experienced forest ranger was trained as an assistant for the full period of the study. When data collection started in the intensive studies, VTB would monitor a neighbouring gibbon group, allowing more information on more groups. In Bau Sau a second ranger joined the team to assist in the field for the duration of the study in Bau Sau. Seven days out of each month a researcher would arrive before dawn at a known listening post. When the groups called the researcher would approach the group quickly, correctly identify the group and take a GPS point. The group was then followed for as long as possible while feces was collected and calls were recorded. The GPS points were mapped using the program “Map Source”.

Following the animals from dawn to dusk enable rapid identification of gibbon home ranges. In most populations, 90% of the final size of the home range can be found within 11-21 days (Bartlett 1999; Kakati, 2004). Once the locations are established for a group with travel paths, the home-range can be drawn using minimum convex polygons (MCP), joining the furthest known points that each group travelled (Bartlett, 1999; Whitten, 1982). Without full-day follows, as in this study, territory size can be estimated with lines of best fit drawn through the points where territorial disputes are observed (Gittins, 1979) as well as the call locations.

The definition of home range is “the total area in which the gibbon regularly travels”. Territory size is an area within the home range, which is actively defended to the exclusion of all others. This does not

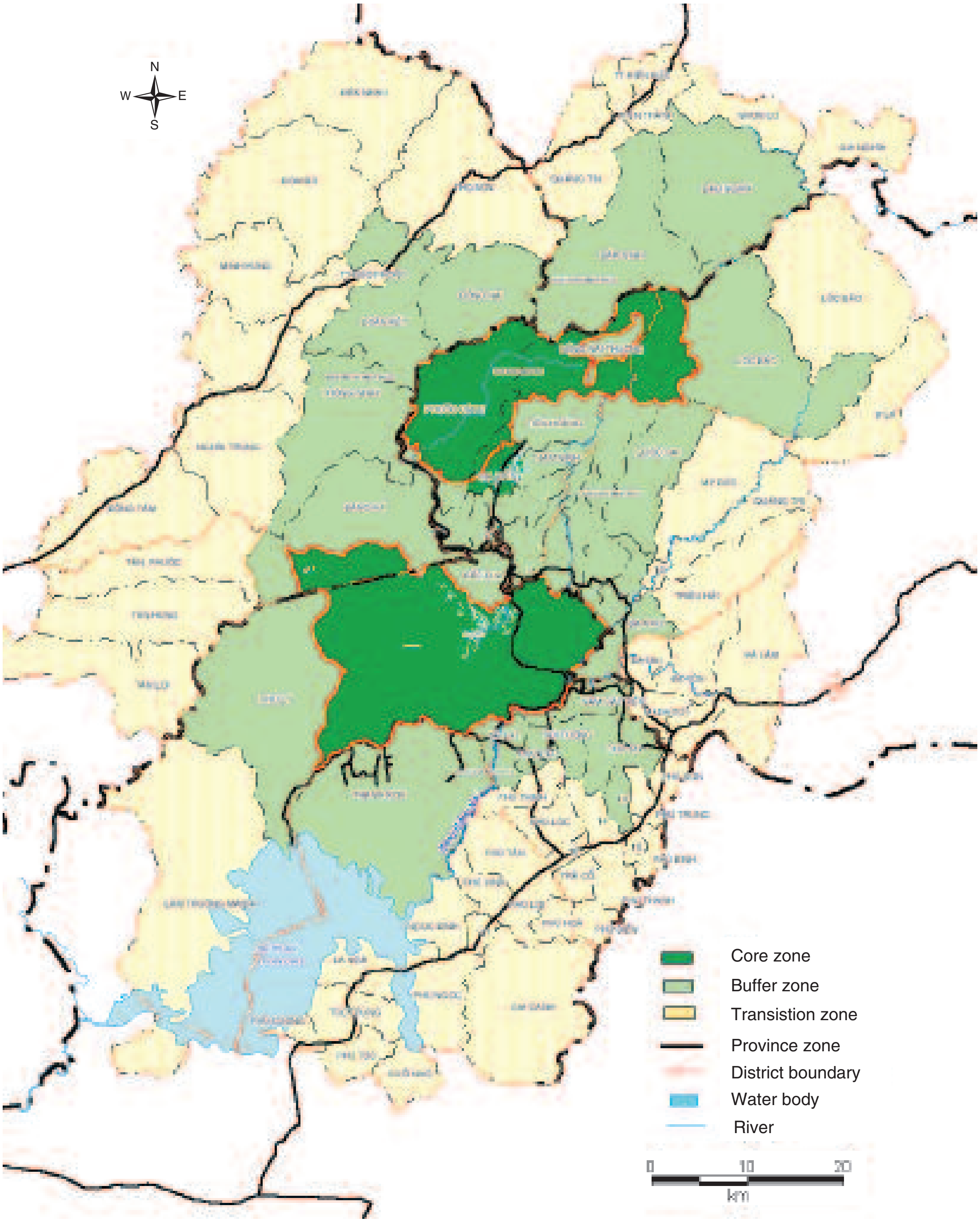


Fig. 1. Cat Tien National Park and the surrounding buffer zone. (Source: Cat Tien National Park, Technical Department).

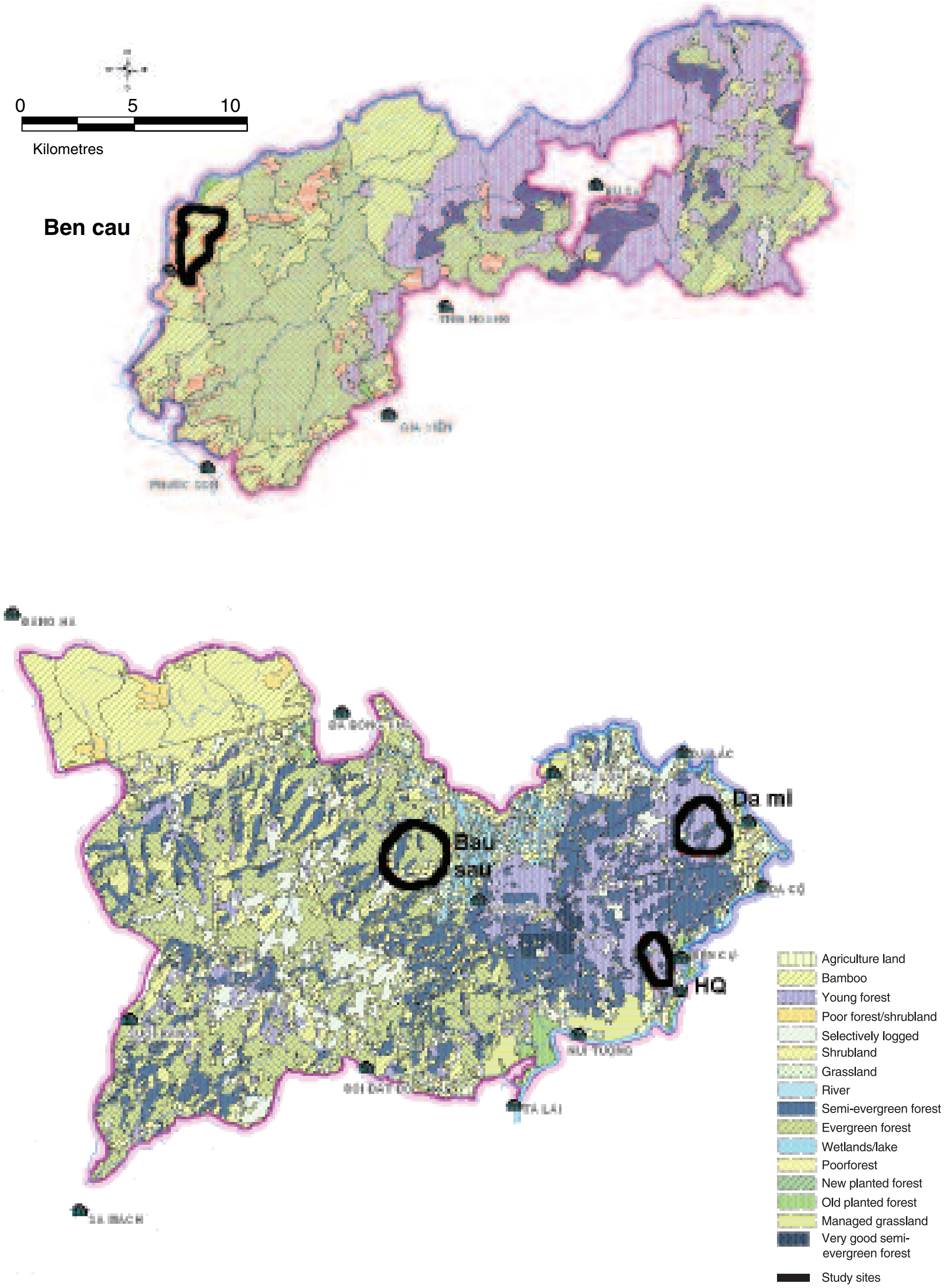


Fig. 2. Location of the 4 study sites in Cat Tien National Park: Da Mi, Bau Sau, HQ and Ben Cau (with the main forest types identified).

imply an area of exclusive use, but an area of the home range, such as specific feeding trees, which at times, are actively defended. These areas will often be visited by other groups when a neighbour is too far away to detect intrusion. The area of exclusive use (AEU) can be estimated by calculating the area within each home range delineated by the borders of the home ranges of all neighbouring groups.

Data analysis

Non-parametric statistics were used because a majority of the variables had non-normal distributions. Significance was set at $p<0.05$ unless otherwise stated.

RESULTS

Density based on home-range mapping

Within CTNP, four areas of intensive study were established, based on forest habitat and the presence of gibbons (Table 1).

Number of survey days to establish territory size

It took between 27-78 days to establish territories based on observations, call locations and disputes. Territory is considered the area actively defended in which no other gibbons were seen to call. Home range size included call locations that overlapped with neighbouring groups. Without full-day ranging data, the estimates are only minimum figures. The group “HQ1” had the slowest acquisition of territory size. One explanation could possibly be because there was only one neighbour to enforce territorial boundaries against and thus was not as critical as compared with areas accompanied by many neighbours, such as “Da Mi 3” (Fig. 3).

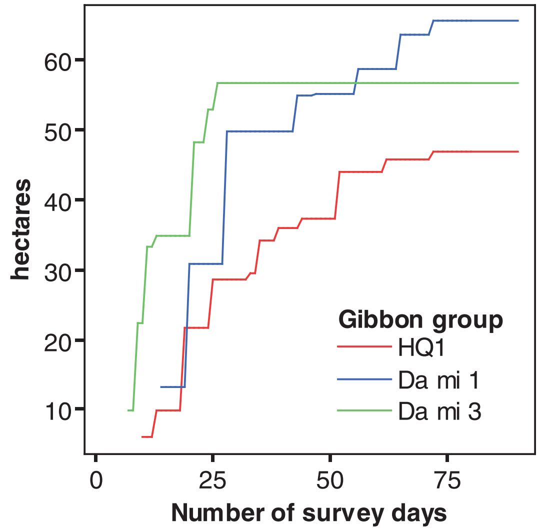


Fig. 3. Number of survey days to estimate territory size, based on call location and boundary encounters from the three main gibbon groups studied.

Estimated territory and home range based on range mapping

Da Mi range mapping

The area of Da Mi was monitored monthly (excluding Aug-Sept 2004) for the full two years, providing the most accurate estimation of territory and home range size for four groups out of the 10 located in the study area (Fig. 4).

The study area was at the edge of the forest, with the habitat to the east consisting of scrub, while north, south and west remained high-quality continuous forest within the National Park. Territory

Table 1. The four study sites within CTNP.

Site	Forest type	Topography and altitude	Number of survey days	Number of gibbon groups	Hunting
Da Mi	Semi-evergreen	Flat (120-160m asl)	173	10	high
HQ	Semi-evergreen	Flat (120-160m asl)	101	2	low
Bau Sau	Evergreen	Hills (200-350m asl)	71	16	high
Ben Cau	Bamboo	Hills (200-400m asl)	77	2	high

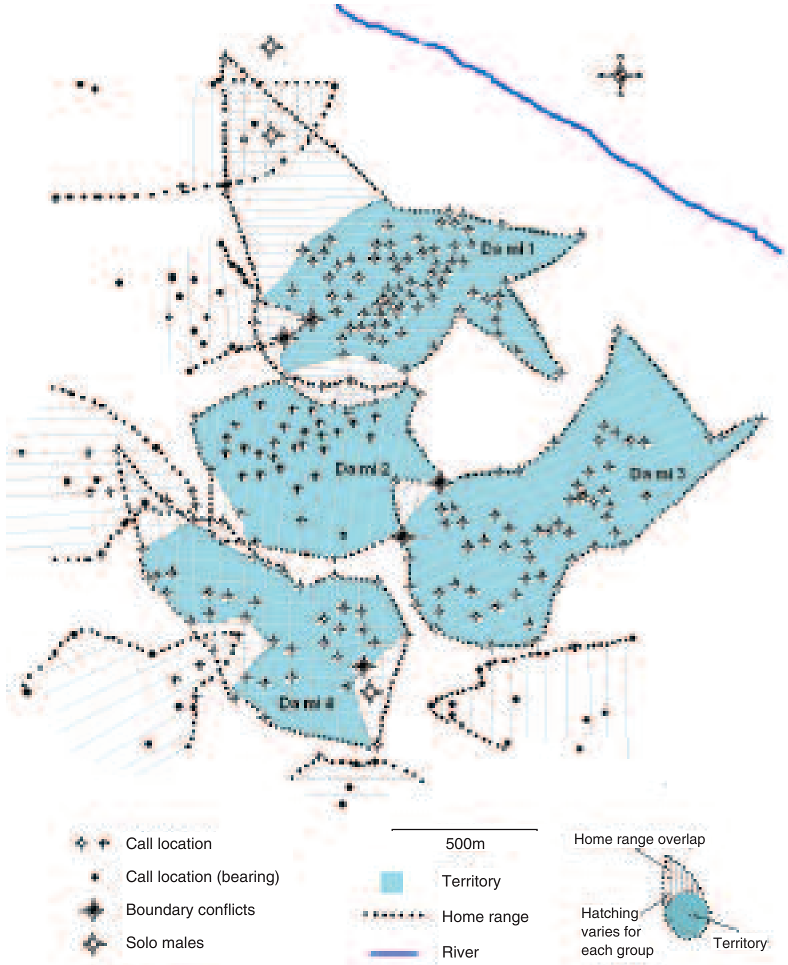


Fig. 4. Gibbon group territories in Da Mi, based on observed call location and boundary battles.

size shown is based on the exclusive area from which one group called and boundary disputes. Estimation of home range size included all call points and observations that overlapped with other groups (Table 2). Areas not used by the gibbons are not removed, since full-day follows were not possible and the use of such areas could not be determined accurately.

The four groups varied in estimated territory, from 31.60 to 54.50 ha, and estimated home range from 41.12 to 61.40 ha, with a percentage of home range overlap from 3 to 35%. Surprisingly the smallest area contained the largest group size of 6 ("Da Mi 4"), often found in conflict with macaques and was generally very nervous. Group size for all four groups was above the mean for the Park of 4.5.

From the total intensive study area of 284 ha in Da Mi, 4 groups were present with 6 neighbouring groups, allowing for an average of 71 ha available for each group. Although the animals were found to only use 51 ha on average, attaining a density of 1.43 groups/km².

Headquarters range mapping

"HQ1" start their territory just 700 m north-west from the main Head-quarters of the Park, possibly one of the best protected areas from hunting, due to the closeness of HQ to the "*Kiem lam*" Forest Protection Department (FPD). Furthermore, it is an important location for researchers and tourists who visit the park, providing a constant presence in the area that deters local hunters.

Table 2. Territory size and known overlaps for Da Mi.

Gibbon group	Group size	Home range (ha)	Territory (ha)	Territory % of Home range	Home range overlap (ha)	Home range overlap (%)
Da Mi 1	5	61.40	40.80	66.45	20.60	33.55
Da Mi 2	5	41.12	36.90	89.74	4.22	010.26
Da Mi 3	6	55.93	54.50	97.44	1.43	2.56
Da Mi 4	6	48.98	31.60	64.52	17.38	35.48
$\bar{x}$ (±s.e)		51.86 (± 8.79)	40.95 (± 9.79)	79.54 (±8.27)	10.91 (± 9.49)	20.46 (±8.27)

As no overlap was seen (Fig. 5) , based on calling locations and follows between "HQ 1" and the family to the north "HQ 2", the territory and home range estimate are the same (Table 3).

Based on the census area of 1 km² of available forest, the density is lower than Da Mi with 1 group/km² of available forest. It is believed that the family has only recently formed and set up a territory in the area in 2002 (G. Polet pers. comm.).

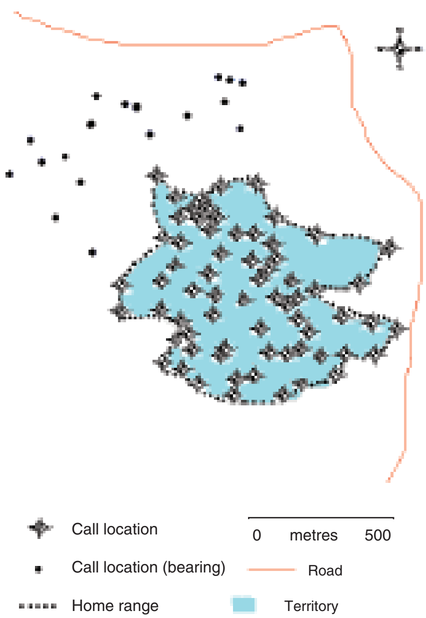


Fig. 5. Gibbon group territory in HQ, based on observed call locations.

Bau Sau range mapping

Bau Sau is located two hours walking distance from the nearest ranger station, an area seldom patrolled by rangers. The area proved to be an unexpected puzzle. Running to a location from a group calling the day before and expecting to find the same group, we repeatedly met with new groups. A large degree of overlap was found between neighbouring groups (37-64%), which had not been seen in the other areas so far (Fig. 6).

The survey area was of similar size to the other areas, yet we found 8 different established groups, ranging from 3-6 individuals/group, defending territories. Based on groups meeting on boundaries, the edges of the territories were marked out fairly accurately for "Bau Sau 1", with all neighbouring groups found, and "Bau Sau 2" based on boundary conflicts and forest availability. The two most robust estimates of territory size (Table 4) range from 7.79 to 15.50 ha, with a mean of 11.64 ha.

Home range size differed 4 fold from the "semi-evergreen" forest area, suggesting much more compression of groups. The habitat in this area is less continuous, with pockets of good forest, surrounded by rattan. Home range size is tentatively estimated at a mean of 16.72 ha, but from a total census area of 178 ha (1.78 km²) containing 8 groups, a density of 4.49 groups/km², with an average potential territory for each group of 22.25 ha. This is based on the use of all surface area land available, not taking into account unsuitable habitat.

Table 3. Territory size and known overlap in HQ.

Gibbon group	Home range (ha)	Group size	Territory (ha)	Territory % of Home range	Home range overlap (ha)	Home range overlap (%)
HQ 1	48.10	4	48.10	0	0	0

Table 4. Territory size and known overlap in Bau Sau.

Gibbon group	Group size	Home range (ha)	Territory (ha)	Territory % of Home range	Home range overlap (ha)	Home range overlap (%)
Bau Sau 1	14.21	6	7.79	54.82	6.42	45.18
Bau Sau 2	19.24	5	15.50	80.57	3.74	19.44
$\bar{x}$ (±s.e)	6.72 (± 3.56)		11.64 (± 5.45)	67.70 (±12.88)	5.09 (± 1.91)	32.31 (±12.87)

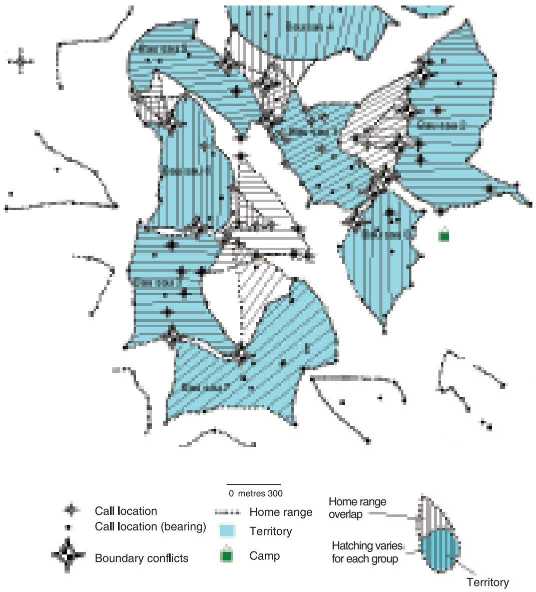


Fig. 6. Gibbon group territory in Bau Sau, based on call locations and boundary battles.

Ben Cau range mapping

Ben Cau, situated in northern Cat Loc sector of the Park, has only been part of the Park since 1992, with a ranger station located next to the forest from 2002. Composed of steep, bamboo-filled slopes, interspersed with pockets of evergreen trees, it was initially thought that two groups lived here, but it became apparent that it was just one, with a young male dispersing. The forest is confined to a linear tract (Fig. 7) due to agriculture and the river to the west and cashew plantation to the east. Forest disturbance is high, with the local ethnic minorities laying snare lines. Local people also collect bamboo shoots, selectively log large trees (*Afzelia xylocarpa*) for building material, in addition to burning sections of forest to allow expansion of cashew plantations, constantly reducing the gibbon's available forest.

The estimated territory size is 44.6 ha (Table 5), with an observed area of overlap (27% of home-range) with the neighbouring group to the north, increasing the home-range estimate to over 60 ha. No permanent group was found in the available forest to the south, an area with little protection and known hunting.

An estimate of density, based on forest availability from the 100 ha (1 km²), is one group/km². Even though the forest is classified as poor habitat, the density is equal to the area near HQ and Da Mi, where forest is considered better for gibbons.

Average territory and home range size in Cat Tien National Park

From all four intensive study sites, mean territory and home range size is estimated for the whole park (Table 6), group and individual density for each area and the whole park (Table 7).

DISCUSSION

What is shown from this study are those conditions influencing home range and territory size, even within 20 km, can vary largely with densities ranging from 1.65 groups/km²/HR (one group/km²/survey area) to 5.98 groups/km²/HR (4.49 groups/km²/survey area).

Table 5. Territory size and known overlap in Ben Cau.

Gibbon group	Home range (ha)	Territory (ha)	Territory % of Home range	Home range overlap (ha)	Home range overlap (%)
Ben cau 1	60.50	44.60	73.72	13.10	21.65

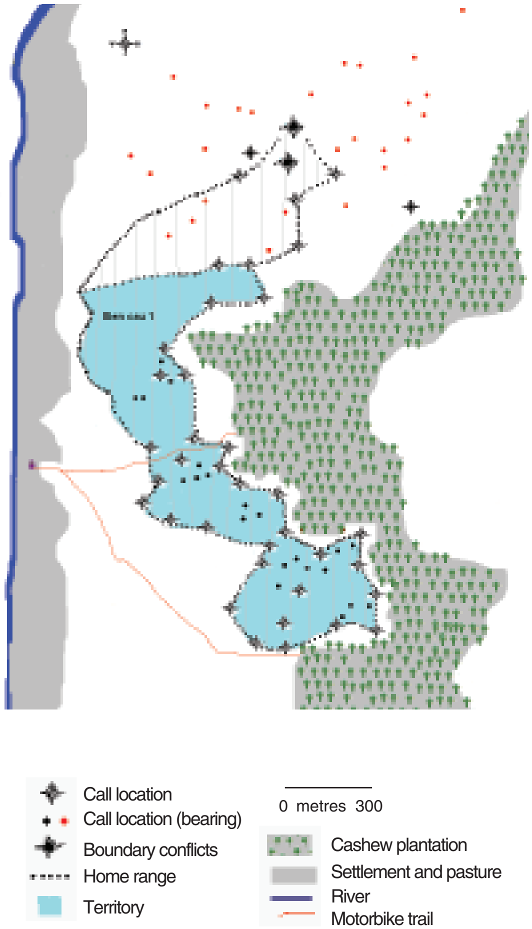


Fig. 7. Gibbon group territory in Ben Cau, based on call locations (observed and bearings) and boundary battles.

Interestingly, 3 sites are similar in home range size (Da Mi, HQ and Ben Cau), even though Ben Cau is dramatically different in habitat type. Only the area of Bau Sau has different densities, showing high group compression. In CTNP, when conflict behaviour was assessed, a bias for greater conflict in the higher density area was found. On 30% of the survey days (n=71) in Bau Sau, either vocal or conflict behaviour was noted, while in all other areas this was observed less than 5% of days (Da Mi n=173, HQ n=101, Ben Cau n=77). Territorial aggression is considered to be a density-dependent phenomenon (Whitten 1982); hence more aggression occurs, where gibbons are more crowded.

Comparison of *Nomascus gabriellae* densities in Cat Tien National Park with other gibbon species

Based on range mapping the mean density for yellow-cheeked gibbons in CTNP was 1.98 (±1.69) groups/km², while based on the survey area (this including unoccupied areas) a higher density of 2.91 (±2.05) groups/km² based on home range size. Thus, the park is on the threshold for low gibbon densities laid down by Brockelman & Srikosamatara (1993). These densities are lower than for most other gibbon species (excluding *Nomascus*), on average ranging from 2-5 groups/km² (Chivers, 1984), although more frequent surveys in sub-optimal habitats, such as this study, are finding low densities (Cheyne *et al*., in press). Even though the average for CTNP was low, areas within the Park of very high density do exist. In the evergreen forest of Bau sau, densities of 4.49 groups/km²/survey area and 5.98 (±2.05) groups/km²/HR were discovered. These are comparable to the high density estimates for pileated gibbons (*H. pileatus*) at a similar latitude (Srikosamatara, 1980). It is difficult to compare densities of gibbons in this region, especially to other gibbon species, due to recent history of war and the repeated use of defoliants.

Comparison of *Nomascus gabriellae* densities in Cat Tien National Park with other *Nomascus* species

A greater similarity of densities from CTNP is found when data are directly compared within the genus *Nomascus*. The northern black gibbons are generally found at densities of below 1 group/km², ranging from 0.43-0.82 groups/km² (Sheeran *et al*., 1988; Haimoff *et al*., 1986), while the southern white-cheeked species live at slightly higher densities of

Table 6. Mean home range and exclusive territory within CTNP.

Area CTNP n=8	Home range (ha)	Territory (ha)	Territory % of Home range	Home range overlap (ha)	Home range overlap (%)
$\bar{x}$ (±s.e)	41.70 (±16.71)	36.96(±18.29)	78.41(±5.79)	8.37(±7.69)	21.02 (±5.75)
Range	14.21-61.40	7.79-54.50	64.52-100	0-20.6	0-45.2

Table 7. Density, based on available forest and actual home range.

Area	Census area km²	Number of group	Group density /km²/survey area	Home range ha	Individual density /km²/survey area	Group density /km²/H	Individual density /km²/HR
Da Mi	2.84	4	1.43	51.86 (± 8.79)	6.45	1.93	8.69
HQ	1.00	1	1.00	48.10	4.5	2.08	9.36
Bau Sau	1.78	8	4.49	16.72 (± 3.56)	20.21	5.98	26.91
Ben Cau	1.00	1	1.00	60.50	4.5	1.65	7.44
$\bar{x}$ **CTNP** (±s.e)		14	**1.98 (±1.69)**	**41.70 (±16.71)**	**8.92 (±7.59)**	**2.91 (±2.05)**	**13.10 (±9.24)**

1.3 groups/km² in Bach Ma National Park, Vietnam and 1.47 groups/km², for yellow-cheeked gibbons in eastern Cambodia. The highest density in CTNP is considerably greater than the highest density found in eastern Cambodia for yellow-cheeked gibbons of 3.73 groups/km² (Traeholt *et al*., 2006).

Thus the data from range mapping in CTNP from the selected sites, agree with the higher densities for this southern species of *Nomascus* in the lower latitudes. Lower densities with increasing latitude are expected, as the tropical evergreen rain-forest belt, unparalleled in complexity, diversity and abundance of plant and animal species, give way to more seasonal forests with climatic extremes (Chivers, 1974; Haimoff *et al*., 1986).

Yellow-cheeked gibbon home range

The mean home range size in CTNP of 41.7 ha was similar to western black gibbons in Xiaobahe at 44-49 ha (Lan, 1989), but significantly less than a habituated group of the subspecies *N. c. jingdongenis* with a home range of 151 ha (Fan & Jiang, 2007) or the eastern black gibbon ranging up to 500 ha (Liu *et al*., 1987), in poor habitat and with no neighbours. It is generally accepted that if density is low then the home range size will naturally expand (Wilson & Wilson, 1975). This expansion could possibly be beyond the size necessary to supply enough resources for the gibbons (Raemaekers, 1978). Due to low densities and few neighbours, gibbons could range more frequently further outside their normal limits. This may well be the case in the three areas of Da Mi, Ben Cau and HQ, especially in HQ, surrounded by available unoccupied habitat, which is often found to be sub-optimal (MacKinnon & MacKinnon, 1977). On the contrary, surrounding "HQ 1" is good-quality forest, albeit full of large groups of noisy tourists, which may make this area less attractive. It is suggested that an upper-threshold of the yellow-cheeked gibbon home range size has been reached in these areas.

The ultimate expansion of a gibbon home range should be limited by the ability to defend. Firstly, if the area is too large, the ability to travel around an area, keeping intruders out, is severely compromised. Additionally, it is crucial that the gibbon group communicates with the local community, letting neighbouring groups know of the continued occupation of the home range and its boundaries. This provides information on pair bonds, group size and dispersing sub-adults. Secondly, the gibbons need to have a good knowledge of the food resources in the area, and the location and pattern of fruiting, which is compromised by ranging over an increasingly larger and lesser-known area. The forests of CTNP are far less seasonal and more diverse than those found in the more northern latitudes enabling sufficient resources throughout the seasons from a smaller area.

Animal species that have a narrow range of food items in their diets, relying on food resources in higher trophic levels, have less energy available in the habitat and, consequently, occur at lower densities (Robinson & Redford, 1986). Gibbons are known to be adaptive; the degree of adaptability influenced by intrinsic characteristics such as body size and dietary diversity (Johns, 1983). Thus, agile gibbons (*H. agilis*), for example are found to have similar territory sizes in disturbed and undisturbed sites (Gittins, 1979). Lar gibbon (*H. lar*) densities recovered in Malaysia Peninsula just 6 years after logging, while, at the same sites, high mortality (related to lack of ability to adapt) was observed in juvenile banded langurs (*Presbytis femoralis*) and dusky langurs (*Trachypithecus obscurus*) (Johns &

Johns, 1995). In the bamboo forests of Ben Cau, gibbons were surviving, with no evidence to support lower breeding rates, since birth intervals were similar to those of the animals in the evergreen and semi-evergreen forest. Thus, there is no evidence yet of high-energy expenditure in the larger home range compromising population recovery. The absence of black-shanked doucs in the Ben Cau region in the "bamboo" may be partly explained by the fact they are primarily leaf-eaters, eating small tender leaves, especially *Ficus* fruit, leaves and buds (Lippold, 1998), and do not possess the dietary flexibility to survive.

The adaptability of species to change their diet appears to be a greater factor in home-range size than the presence of competing species, forcing the expansion of home-range sizes, as suggested by MacKinnon & MacKinnon (1977). The larger home range of Ben Cau has less competitors, while the small home ranges at Bau Sau contained high densities of doucs, macaques and hornbills. Equally, the argument that territory size of a large group would be larger than that of a small group (MacKinnon & MacKinnon, 1977) is not supported; generally, if there may be enough food for one gibbon, there is enough for six (Whitten, 1980).

Even though the large home ranges seem to have reached a natural upper threshold, similar in very different forest types, what is surprising are the extremely small home ranges found in Bau Sau. At high densities the territory would be expected to become smaller, until a minimum is reached which contains just enough resources for the group's survival. It is suggested that this is the case in Bau Sau, existing at minimum territory size and likewise maximum possible densities, without compromising survival and fecundity. In Bau Sau, group size and birth interval were comparable to the other areas, hence there is no indication that resources are limiting at such high density. Although only 30 years from extreme habitat disturbance (Westing, 1971), the population may have only recently recovered to this level. Gastro-intestinal parasite surveys indicate greatest pressure is in this high density area of Bau Sau.

Possible justification that the density is at an upper threshold is when the frequency of aggressive encounters is considered. In Kloss gibbons, adult males at Sirimuri (with home ranges of only 7 ha) were reported fighting in the trees and even on the ground (Tenaza, 1975). Encounters involving arboreal displays and short chases between opposing males at dawn were often observed, but, at other sites, with home ranges of 34 ha, no aggression was seen (Whitten, 1982). Hence it was concluded territorial aggression to be a density-dependent phenomenon (Whitten, 1982). Kloss gibbons with the smallest home range and greatest aggression were in the most limited forest (Tenaza, 1975). This does not agree with the high density in Bau Sau, as it is not an isolated fragment, with gibbons able to disperse north, east and west from the survey area, especially as neighbouring areas had lower densities. In fact, the other three areas of Da Mi, HQ and Ben Cau all had greater limits on forest availability due to rivers, cashew plantations and settlements.

Protection due to proximity to a ranger station, distance from the park boundary, and very difficult terrain with solid walls of rattan for the terrestrial hunter, may all have contributed to the high density in this area. This indicates that natural home ranges of yellow-cheeked gibbons at this latitude could potentially have been smaller than the average 41.7 ha of the Park today, and were more likely to be around the 20 ha level.

This minimum home range threshold is very small, giving rise to one of the highest gibbon biomass recorded, contributed to by the large size of crested gibbons (on average 2 kg heavier than other gibbons) and larger groups than the average gibbon (4.5). Gibbon biomass, (excluding crested gibbons) varies from 30-100 kg/km^2 based on home-range size (Chivers, 1984), with the large-bodied siamangs (*S. syndactylus*) with 97 kg/km^2/HR and silvery gibbons (*H. moloch*) with small home ranges of 17 ha with a biomass of 98 kg/km^2/HR. The lowest density was Lar gibbons (*H. lar*) in home ranges of 55 ha with a biomass of only 29 kg/km^2/HR, living sympatrically with siamangs. Thus, the yellow-cheeked gibbon at Bau Sau ("evergreen" forest) is one of the highest biomass estimates found for gibbons. Yellow-cheeked gibbons in this study, from range mapping, vary from 28.55 to 101.23 kg/km^2, with the overall mean of 52.58 kg/km^2, compared to 46.80-124.55 kg/km^2/HR, with an overall mean of 76.27 kg/km^2/HR.

GIỚI HẠN VÙNG SỐNG VÀ MẬT ĐỘ CỦA VƯỢN MÁ HUNG (*NOMASCUS GABRIELLAE*) Ở CÁC KIỂU RỪNG KHÁC NHAU TRONG VƯỜN QUỐC GIA CÁT TIÊN, VIỆT NAM

TÓM TẮT

Giới hạn vùng sống của loài vượn má hung (*Nomascus gabriellae*) đã được điều tra ở các khu rừng nửa rụng lá đất thấp ở Vườn Quốc gia Cát Tiên, một khu vực đã bị tác động bởi chiến tranh, khai thác và săn bắt. Bốn khu vực nghiên cứu được lựa chọn dựa trên cơ sở kiểu rừng (cấu trúc và thành phần loài khác nhau), tiến hành quan sát từ tháng 01 năm 2004 đến tháng 12 năm 2005. Trong mỗi khu vực nghiên cứu, diện tích trung bình không bị biến động. Tuy nhiên, giữa các kiểu rừng có sự biến động lớn, giao động từ 16,72 ha ở rừng thường xanh, 51,86 ha ở rừng nửa rụng lá và 60,50 ha ở rừng tre nứa. Trong khi quần thể vượn ở khắp Việt Nam bị đe dọa bởi nạn săn bắt và môi trường sống bị thu hẹp (Hoang *et al*., 2005), thì các vườn quốc gia cũng không ngoại lệ (Geissmann *et al*., 2007). Nghiên cứu sinh thái về vượn là cần thiết nhằm tăng thêm hiểu biết về phạm vi, ranh giới của một loài mà ở Việt Nam chưa từng được nghiên cứu. Bằng cách tăng thêm hiểu biết về mối quan hệ giữa các kiểu rừng và giới hạn vùng sống, các giải pháp bảo tồn loài có thể đề xuất nhằm bảo vệ quần thể đó tránh khỏi sự tuyệt chủng và khuyến khích phục hồi.

REFERENCES

Bartlett, T. (1999): Feeding and ranging behaviour of the white-handed gibbon (*Hylobates lar*) in Khao Yai National Park, Thailand. PhD thesis, Department of Anthropology. Saint Louis, Washington University.

Brockelman, W. & Srikosamatra, S. (1993): Estimation of density of gibbon groups by use of loud song. Am. J. Primatol. 29, 93-108.

Chan, B. & Fellowes, J. (2005): Hainan gibbon status survey and conservation action plan- Version 1. Hanoi.

Cheyne, S., Thompson, C., Philips, A. & Hill, R. (in press): Density and population estimate of gibbons (*Hylobates agilis albibarbis*) in the Sebangau National Park, Indonesia.

Chiver, D. (1974): The siamang in Malaya: a field study of a primate in tropical rain forest. Karger, Basel.

Chivers, D. (1984): Feeding and ranging in gibbons: a summary. In: Preuschoft, H., Chivers, D. Brockelman, W. & Creel, N. (eds.): The Lesser Apes: Evolutionary and Behavioural Ecology; pp. 267-281. Edinburgh University Press, Edinburgh.

Cowlishaw, G. & Dunbar, R. (2000): Primate Conservation Biology. University of Chicago Press.

Ellefson, J. (1974): A natural history of white-handed gibbons in the Malayan Penninsular. In: Rumbaugh, R. (ed.): Gibbon and Siamang; pp. 1-136. Karger, Basel.

Fan, P. & Jiang, X. (2007): Sleeping sites, sleeping trees, and sleep-related behaviours of black crested gibbons (*Nomascus concolor jingdongensis*) at Mt. Wuliang, Central Yunnan, China. American J. Primtol. 69, 1-12.

Fan, P., Liu, C. & Jiang, X. (2006): Can a group elicit duets from its neighbours? A field study on the black-crested gibbon (*Nomascus concolor jingdogensis*) in Central Yunnam, China. Folia Primatologica 78, 186-195.

Geissmann, T., Hoang, T., Trung, L. &Tallents, L. (2007): A brief survey for crested gibbons in Bach Ma National Park, central Vietnam. Gibbon Journal 3, 43-49.

Gittins, S. (1979): The behaviour and ecology of the agile Gibbon (*Hylobates agilis*). University of Cambridge. Cambridge.

Haimoff, E., Yang, H., He, S. & Chen, N. (1986): Census and survey of wild black crested gibbons (*H. concolor concolor*) in Yunnan Province, China PRC. Folia Primatologica 46, 205-214.

Hoang, M., Khanh, T., Thuong, H. & Long, B. (2005): Primate Conservation in Quang Nam Province, Central Vietnam. Troung Son, WWF report 58.

Hu, T., Xu, H. & Yang, D. (1989): The studies on ecology in *Hylobates leucogenys*. Zoological Research 10, 61-67.

Jiang, X., Luo, Z., Zhao, S., Li, R. & Liu, C. (2006): Status and distribution pattern of black crested gibbon (*Nomascus concolor jingdongensis*) in Wuliang Mountains, Yunnan, China: implication for conservation. Primates 26, 264-271.

Johns, A. (1983): Ecological effects of selective logging in a west Malaysian rain-Forest. PhD thesis. Sub-Department of Veterinary Anatomy. Cambridge University, Cambridge.

Johns, A. & Johns, B. (1995): Tropical forest primates and logging: long-term coexistence? Oryx 29, 205-211.

Kakati, K. (2004): Impact of Forest Fragmentation on the hoolock Gibbon in Assam, India. PhD thesis, University of Cambridge, Cambridge.

Lan, D. (1989): Preliminary study on the group composition, behaviour and ecology of the Black Gibbons (*Hylobates concolor*) in south-west Yunnan. Zoological Research 10, 119-126.

Lippold, L.K. (1998): Natural History of Douc Langurs. In: Jablonski N.G. (ed.): The natural history of the doucs and Snub-nosed Monkeys; pp. 191-206. World Scientific Publishing, Singapore.

Liu, Z., Zhang, Y., Jiang, H. & Southwick, C. (1989): Population structure of *Hylobates concolor* in Bawanglin Nature Reserve, Hainan, China. Am. J. Primatol. 19, 247-254.

Liu, Z., Zhang, Y., Liu, Y., Chou, T., Manry, D. & Southwick, C. (1987): Field report on the Hainan Gibbon. Primate Conservation 8, 49-50.

MacKinnon, J. & MacKinnon, K. (1977): The formation of a new gibbon group. Primates 18, 701-708.

O'Brien, T., Kinnaird, M., Nurchayo, A., Iqbal, M. & Rusmanto, M. (2004): Abundance and distribution of sympatric gibbons in a threatened Sumatran rainforest. Int. J. Primatol. 25: 267-284.

Raemaekers, J. (1978): Changes through the day in the food choice of wild gibbons. Folia Primatologica 30, 194-205.

Robinson, J. & Redford, K. (1986): Body size, diet and population density of Neotropical forest mammals. The American Naturalist 128, 665-680.

Sheeran, L., Yongu, Z., Poirier, F. & Dehua, Y. (1998): Preliminary report on the behaviour of the Jingdong black gibbon (*Hylobates concolor jingdongensis*). Journal of Biodiversity 5, 113-125.

Srikosamatara, S. (1980): Ecology and behaviour of the pileated gibbon (*Hylobates pileatus*) in Khao Soi Dao Wildlife Sanctuary, Thailand. PhD thesis, Madihol University, Bangkok.

Tenaza, R. (1975): Territory and monogamy among Kloss' gibbons (*Hylobates klossii*) in Siberut Island, Indonesia. Folia Primatologica 24, 60-80.

Traeholt, C., Bonthoeun, R., Virak, C., Samuth, M. & Vutthin, S (2006): Song Activity of the Pileated Gibbon, *Hylobates pileatus*, in Cambodia. Primate Conservation 21, 139-144.

Westing, A. (1971): Ecological effects of Military Defoliation on the Forests of South Vietnam. BioScience 21, 893-898.

Whitten, A. (1980): Arenga fruit as a food for gibbons. Principles 24, 143-146.

Whitten, A. (1982): Home range use by Kloss gibbons (*Hylobates klossi*) on Siberut island, Indonesia. Animal Behaviour 30, 182-198.

Wilson, C. & Wilson, W. (1975): The influence of selective logging on primates and some other animals in East Kalimantan. Folia Primatologica 23, 245-274.

FEEDING ECOLOGY OF NORTHERN WHITE-CHEEKED GIBBONS (*NOMASCUS LEUCOGENYS*) IN A SEMI-WILD ENCLOSURE AT THE ENDANGERED PRIMATE RESCUE CENTER, CUC PHUONG NATIONAL PARK, VIETNAM

NGUYEN XUAN NGHIA, NGUYEN XUAN DANG, TILO NADLER, AND LE VAN DUNG

SUMMARY

A study was conducted between October 2006 to September 2007 of the feeding ecology of two northern white-cheeked gibbons (*Nomascus leucogenys*) which have been kept in captivity and released into a semi-wild enclosure at the Endangered Primate Rescue Center (EPRC), Cuc Phuong National Park, Vietnam. The released gibbons were observed to eat young leaves of 16 species, flowers of one species, fruits of 12 species and buds of two species. Phenological monitoring of 580 trees of 81 species inside the enclosure shows that young leaves are available throughout the year with highest abundance from March to July, while flowers occur mainly from March to May and fruits occur also mainly from March to May. As the gibbons feed mostly on fruits, April and May can be assumed to be the best time in terms of natural food supply. A daily activity time budget of the two white-cheeked gibbons was observed in 2007 using the focal animal observation method. Out of total 8360 observation minutes the gibbons spent the largest proportion of time sitting & lying (42.2%), followed by feeding (19.2%), traveling (18.5%), grooming (8.9%), watching (8.8%), playing (1.3%) and singing (1.2%). In comparison with the captive northern white-cheeked gibbons at the EPRC, the gibbons in the semi-wild conditions spent less time (42.2%) sitting & lying and more time (19.2%) feeding. This can be explained by the fact that in the semi-wild enclosure, the gibbons spend time not only eating food provided by a keeper, but also for searching and taking natural food from the trees. This study shows that the semi-wild enclosure at the EPRC can provide released gibbons with certain natural habitat requirements such as food sources, safe refuge, and provide the basic activities that help the released gibbons to obtain certain re-adaptation to the natural habitat, such as successful search for food in wild trees, and allowing free movement between trees, including brachiation. However, food sources, seasonal food availability and space for gibbon activities are limited and therefore restrict the re-adaptation capacity of released gibbons.

INTRODUCTION

The northern white-cheeked gibbon is highly threatened with extinction in the wild. The species is listed in the 2008 IUCN Red List of Threatened Species as “Critically Endangered”. Formerly two subspecies were recognized: the northern white-cheeked crested gibbon (*N. l. leucogenys*) (Fig. 1 and 2), and the southern white-cheeked gibbon (*N. l. siki*) but recently placed as valid species (Groves, 2001). Northern white-cheeked gibbons occur in Northern Laos, Northwest and North-central Vietnam. In China, the taxon was previously reported in Xishuangbanna National Nature Reserve, South Yunnan Province, but is now most probably extirpated (Nadler *et al*., 2007). In Vietnam, Northern white-cheeked gibbons were recorded West and South of the Black River (Song Da) (Geissmann *et al*., 2000). At present, its population is extremely low

Fig. 1. Northern white cheeked gibbon (*Nomascus leucogenys*), male.
Photo: Tilo Nadler.

Fig. 2. Northern white cheeked gibbon (*Nomascus leucogenys*), female.
Photo: Tilo Nadler.

and highly fragmented with no subpopulation of more than 50 individuals (Nadler *et al*., 2007).

In Vietnam, the northern white-cheeked gibbon is listed in the Vietnam Red Data Book as "Endangered" (Ministry of Science and Technology & Vietnam Academy of Sciences and Technology, 2007), and protected on the highest level under the wildlife protection law (Government of Vietnam, 2006).

Very little is known about diet and feeding behavior of the white-cheeked gibbons. Le Hien Hao (1973) reported remains of fruits, leaf, buds, and flowers found in the species' stomach content. Pham Nhat (2002) provides a list of 59 plant species that the gibbon used as food. Tallents (2002) conducted a short study on three captive northern white-cheeked gibbons housed at the Endangered Primate Rescue Center and provided some data on their activity budget, feeding, locomotion, and vocalization. Nguyen Xuan Nghia (2006) reported - based on his study on captive white-cheeked gibbons at the EPRC - the gibbons ate fruits, roots and leave of 28 cultivated and 8 wild plants species. The food consumption in captivity ranges from 1,126.8 g/day in August to 1,900.7 g/day (fresh matter) in March. The diet and feeding ecology of white-cheeked gibbons is poorly studied. Further appropriate knowledge on feeding and feeding ecology can help improve effective conservation measures for the species.

The Endangered Primate Rescue Center was established to provide a home for endangered primates confiscated from illegal wildlife trade. The EPRC has shown great success in keeping many confiscated primates; and several species have successfully bred under captive conditions. One of the main goals of the EPRC is the reintroduction of captive bred primates. As a part of these programs, two semi-wild enclosures of 2 ha and 5 ha have been constructed within an area of secondary evergreen forest, to train captive primates for the reintroduction process. Five northern white-cheeked crested gibbons (1 males, 4 females) have been kept in these semi-wild enclosures since 1999. Enclosure number 1 is home to two females, while enclosure number 2 is home to three individuals (1 male, 2 females).

From January to December 2007, we conducted a study on the feeding ecology of two northern white-cheeked gibbons in the semi-wild enclosure 1. The aim of this study was to identify how well semi-wild habitats provide a complete dietary resource base for released gibbons and how the gibbons exploit the resources that are available to them in these habitats.

Specific objectives were:

- to identify plant species and their parts that the gibbons select for food within the semi-wild enclosures.
- to sample plant species within the enclosure and compare to existing lists of plant species exploited by white cheeked gibbons in the wild.
- to provide a phenological assessment of potential food plants within the semi-wild enclosure
- to study the gross daily activity pattern of the released gibbons under semi-wild conditions.
- to estimate the proportion of time spent feeding out of the total daily activity budget.

MATERIALS AND METHODS

Study site

The semi-wild enclosure was established in 1997 (Fig. 3). The enclosure encompasses a two hectare hill area, surrounded by an electrical fence. The limestone hill of 30 m high is covered by secondary evergreen forest. The forest consists of trees and bushes between 5 to 10 m high and only a few prominent trees of 20 to 40 cm in diameter. The ground story is dense with small plants and lianas. Between the hill and the surrounding electrical fence, there is a 10 to 15 m gap that is covered with 1.5 m high grass. Along the fence, the grass is regularly cut to form a 1.5m barrier. Within the semi-wild facility, there is a mesh-wire cage (3.5 x 5.5 x 3.5 m) furnished with ropes and bamboo poles. One side of the cage facing the hill has a slide door just beyond the ceiling. A bamboo pole connects this door with the closest tree. The cage is to provide food for gibbons and keep them for necessary interventions. The gibbons are given food (variety of fruits and roots of cultivated plants) in the cage twice a day, at 9:00 to 9:30 am and 2:00 to 2:30 pm. When the food is given, the gibbons are locked inside the cage for about 15 to 30 min. During the study two female white-cheeked gibbons have been housed in the semi-wild enclosure:

- Gibbon Polly, who arrived at EPRC on 30th September 1994 (about 1 year old), released into semi-wild enclosure in May 2004.

Fig. 3. Semi-wild enclosure at the Endangered Primate Rescue Center, Cuc Phuong National Park, Vietnam.
Photo: Nguyen Xuan Nghia.

- Gibbon Lisa, who also arrived at EPRC on 30th September 1994, released into semi-wild enclosure in May 2004.

Inside the semi-wild enclosure, there are also kept three Delacour's langur (*Trachypithecus delacouri*) and four barking deer (*Muntiacus muntjak*).

METHODS

Study of daily activity budget and feeding activity

Continuous focal animal sampling method (Altmann, 1974; Peterson, 2001) was used to collect data on gross daily activity pattern and for estimating the proportion of time spent foraging and feeding (Fig. 4). Observational samplings were conducted from March to December 2007 with four consecutive days per month, 2 days per gibbon, alternatively. The gibbons usually awoke between 5:00 to 5:30 am and began their calls (singing) before 6:00 am, however, it was too dark to observe the gibbon at that time. The observation of each focal animal started from 6:00 to 7:00 am, and ended 4:30 to 5:00 pm when the individuals prepared for sleep. The sampling period was 20 minutes, with a 10 minute rest after each sampling period. If the animal went out of sight, a note of "hidden of view" was recorded together with the time out of view. The time of the next observational period was to be noted to the nearest second on previously prepared check-sheets. The following activities were recorded: singing, feeding, traveling, watching, grooming, playing, sitting/lying and sleeping.

When feeding was observed, the plant species and food items the gibbon fed upon were recorded.

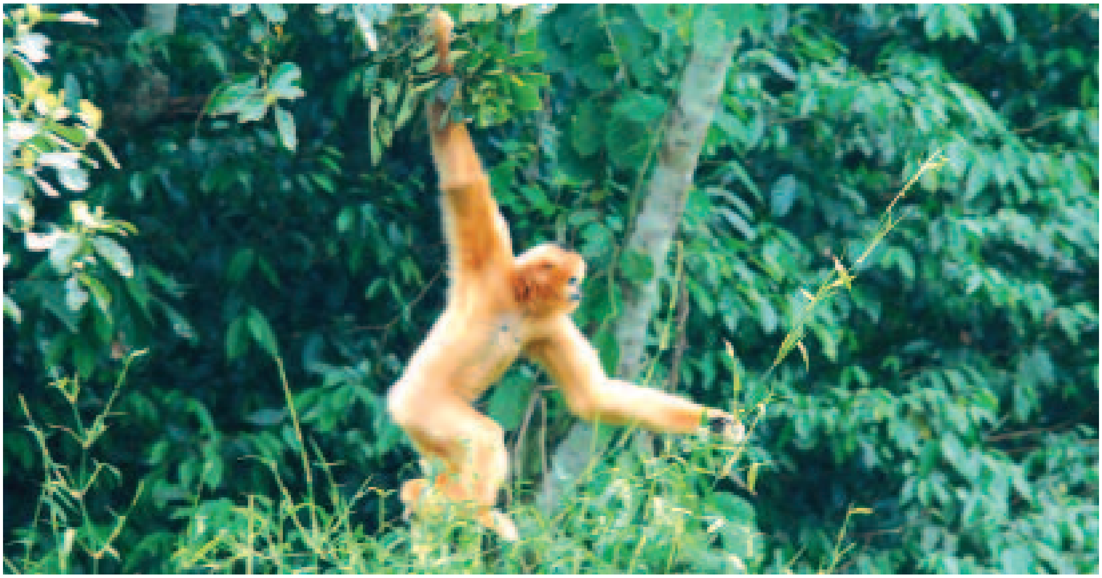


Fig. 4. Northern white-cheeked gibbon, female (*Nomascus leucogenys*) feeding on trees at the semi-wild enclosure. *Photo: Tilo Nadler.*

Feeding is any occasion during which the gibbon plucked food items, pulled food items towards its mouth, ingested, masticated, or swallowed. All food trees were marked and specimens were taken for species identification.

The gibbons at the semi-wild enclosure have been acquainted to people's presence; therefore there was no need for a habituation period, however, during sampling the observer always attempted to keep out of the animal's sight as much as possible. The proportion of time each animal spends in each activity can be calculated using the following formula:

$$M_a / M_t$$

M_a: number of minutes in the study activity; M_t: the total number of minutes the animal was observed.

Phenological assessment of potential food plants

In order to assess potential food availability and seasonal changes in food abundance the phenological assessment method (Silver et al., 1998) was used. The semi-wild enclosure area was divided into 8 sectors, in each sector, all trees of ≥ 10 cm diameter at breast height (DBH) were tagged, identified, and measured.

The total tree coverage of each species was calculated using the following formula:

$$Ci = \sum BAi$$

Ci: coverage of species i; BAi: basal area of tree of species i.

Relative abundance of each species was calculated using the following formula:

$$RCi = \sum BAi / \sum C_{all}$$

RCi: a relative coverage of species i; BAi: a basal area for species i; C_{al}: a coverage for all species.

Data on white-cheeked gibbon food from the wild is lacking Therefore all marked trees were phenologically monitored. Once a month, each marked tree was inspected for the presence of mature leaves, young leaves, fruit, and flowers. An abundance score was assessed for each tree part ranging from 0-3, as following:

- A score of 0 corresponds to complete absence of that plant part
- A score of 1 is recorded when that part encompassed <25% of the crown.
- A score of 2 is recorded when that part encompassed >25% and <50% of the crown.
- A score of 3 is recorded when that part encompassed >50% of the crown

A monthly food abundance index (MAI) for each plant part can be calculated using following formula:

$$MAI_i = AvMAS \times RCi$$

MAIi: monthly food abundance index of plant part for species i; AvMAS: Average monthly abundance score of the plant part; RCi: relative coverage of species i.

A monthly abundance index (MAIp) for each plant part for all study species in the enclosure can be calculated using the following formula:

$$MAI_p = \sum MAI_i$$

MAIp: monthly abundance index of plant part p; MAIi: monthly abundance index of that plant part for species i.

RESULTS

Food plants of WCG in Semi-wild enclosure

Through direct observation of gibbon feeding activity, 28 plant species were recorded as food plants for gibbons (Table 1). Within these species, the gibbons eat young leaves of 16 species, flowers of one species, fruits of 12 species and buds of two species. Additionally, the gibbons were also observed to feed on insects and their larvae.

Pham Nhat (2002) reported 59 food plant species for northern white-cheeked gibbons, consisting of 31 wild species and 28 cultivated species. Only one species of his list (*Ficus lacor*) appears on our list. This indicates that the gibbons can use a wide range of food plants. The low number of food plant species recorded at the semi-wild enclosure is possibly because of low abundance of fruit-bearing plants here.

Phenological assessment of plants

In total, 580 trees of 81 species were tagged and phenologically monitored. Within these species, 18 species have been identified as food plants for the gibbons and most of these are species of the highest abundance (RCi > 2.9). Total monthly abundance indices (MAIp) of young leaves, flower and fruits of all monitored species are shown in Table 2.

The results indicate that young leaves are available throughout the year with the highest abundance from March to July, while flowers occur mainly from March to May, and fruits similarly occur mainly from March to May (Fig. 5). The resources of potential food (leaves, flowers, fruits) for the gibbons at the semi-wild enclosure are most abundant in the period from March to June. However, the gibbons feed mostly on fruits (Pham Nhat, 2002; Nguyen Xuan Nghia, 2006), therefore, April and May is the best time for the gibbons in terms of food resources.

Daily activity time budget

During the study period the observed gibbons at the semi-wild enclosure appeared to have the following activity agenda:

The gibbons sleep in trees between 4:30 and 5:00 pm to 5:00 am the following day. They usually wake up at 5:00 to 5:15 am and start to call (sing) at clear sunrise 5:20 to 6:00 am depending on weather. After that, they move out for feeding and other activities around the enclosure. About 8:30 am, they come back to the cage to wait for food provisioning from the animal keeper. The food is given between 9:00 to 9:30 am, and the gibbons are locked in the cage for 10-15 min. to eat the food. After finishing the food inside the cage, the gibbons go out again. They rest on trees at about 12:00 to 1:00 pm, and then start again for various activities. At about 2:00 pm they come back to the cage to wait and get their afternoon meal. After that, they travel for about an hour and move to their sleeping trees at about 3:00 to 3:30 pm and stay there for sleeping. They start to sleep again at 4:30 to 5:00 pm.

In general, the gibbons are active from 5:30 to 6:00 am until 4:00 to 5:00 pm, about 10 to 11 hours/day. Table 3 shows the ethogram for the gibbons at the semi-wild enclosure.

The daily time budget of the two gibbons at the semi-wild enclosure is shown in Table 4.

The two females, Lisa and Polly, formed a pair and usually go together for their activities; however, there is some difference in their activity budget. In comparison with Lisa, Polly spent more time for resting and less time for grooming and playing. The time amount spent for feeding and traveling is not much different. The time amount spent for feeding of both females is highest in April and May. This possibly relates to highest monthly abundance index of food (especially fruits) at the semi-wild enclosure in these months (Fig. 6).

In general, the gibbons spent the largest proportion of time for sitting & lying (42.2%), followed by feeding (19.2%), traveling (18.5%), grooming (8.9%) watching (8.8%), playing (1.3%) and singing (1.2%) (Fig. 7).

To our knowledge there are no observations on the activity budget of white-cheeked crested gibbons in the wild. Studies of Tallents (2002) and Nguyen Xuan Nghia (2006) on captive gibbons at the EPRC show that the gibbons spent between 5:00 am and 5:00 pm, about 58-60% of the time for resting and about 6-12% of the time for feeding. Our study shows that the gibbons at the semi-wild area spent less time (42.2%) for resting and more time (19.2%) for feeding. This is because except time spent for eating food in a cage, the gibbons also spent also their time searching and taking natural food from the wild.

DISCUSSION

The vegetation at the semi-wild enclosures consists of secondary growth dominated by bushes and trees of less than 10 m high. This vegetation is obviously not a suitable habitat for white-cheeked gibbons, which inhabit mostly intact primary forest or

Table 1. Plant species used as food by northern white-cheeked gibbons (*Nomascus leucogenys*) at the Endangered Primate Rescue Center's semi-wild enclosure.

No.	Scientific name	Family	Eaten parts
1.	*Saraca dives* Pierre, 1899	Caesalpiniaceae	Young leaves, flowers
2.	*Vitex stylosa* Dop, 1928	Verbenaceae	Young leaves
3.	*Streblus laxiflorus* (Hutch.) Corn. 1962	Moraceae	Young leaves, green fruits
4.	*Streblus macrophyllus* Blume, 1856	Moraceae	Young leaves, green fruits
5.	*Bauhinia touranensis* Gagnep.1912	Fabaceae	Young leaves
6.	*Melia azedarach* L. 1753	Meliaceae	Green fruits
7.	*Acacia pennata hainanensis* (Hayata) I. Nielsen, 1980	Fabaceae	Young leaves
8.	*Ficus lacor* Buch.-Ham. 1827	Moraceae	Young leaves, green fruit
9.	*Randia fasciculata* (Roxb.) DC. 1830	Rubiaceae	Young leaves
10.	*Alpinia malaccensis* (Burm. f.) Rosc. 1807	Zingiberaceae	Young leaves, buds
11.	*Bambusae* sp.	Poaceae	Buds
12.	*Mallotus barbatus* Muell.-Arg. 1865	Euphorbiaceae	Green fruits
13.	*Ficus tikoua* Bureau, 1888	Moraceae	Ripe fruit
14.	*Aphananthe aspera* (Thunb.) Planch. in DC 1873	Ulmaceae	Young leaves
15.	*Knema squamulosa* De Wilde, 1979	Myristicaceae	Ripe fruits
16.	*Saurauia roxburghii* Wall. 1830	Actinidiaceae	Buds, green fruits
17.	*Sterculia lanceolata* Cav. 1788	Moraceae	Young leaves
18.	*Derris tonkinensis* Gagnep. 1907	Fabaceae	Young leaves
19.	*Spondias pinnata* (L.f.) Kurz, 1875	Anacardiaceae	Green and ripe fruits
20.	*Ficus depressa* Blume, 1822	Moraceae	Green and ripe fruits
21.	*Ficus annulata* Blume, 1825	Moraceae	Green and ripe fruits
22.	*Diospyros* sp.	Ebenaceae	Green and ripe fruits
23.	*Thunbergia grandiflora* (Roxb. ex Rottl.) Roxb. 1814	Acanthaceae	Leaves
24.	*Ficus racemosa* L. 1753	Moraceae	Young leaves
25.	*Nephelium chryseum* Blume, 1847	Sapindaceae	Young leaves
26.	*Cissampelos pareira* L. 1753	Menispermaceae	Young leaves
27.	*Gymnopetalum integrifolium* (Roxb.) Kurz, 1871	Cucurbitaceae	Young leaves
28.	*Aglaia gigantea* (Pierre) Pell.1911	Meliaceae	Young leaves

Table 2. Total monthly abundance indices (MAIp) of young leaves, flower and fruits used as food by northern white-cheeked gibbons (*Nomascus leucogenys*) at the Endangered Primate Rescue Center's semi-wild enclosure.

Month, Year	Young leaves	Flowers	Fruits
October, 2006	38.38	1.25	3.78
November, 2006	14.44	0.53	0.56
December, 2006	10.36	0.24	0.38
January, 2007	36.61	0	2.5
February, 2007	9.02	3.27	4.4
March, 2007	32.57	53.29	8.08
April, 2007	60.19	25.01	64.43
May, 2007	39.4	17.75	14.03
June, 2007	70.32	0.57	1.99
July, 2007	24.06	0.33	3.95
August, 2007	39.7	0.33	3.6
September, 2007	22.62	0.49	3.04
October, 2006	38.38	1.25	3.78
November, 2006	14.44	0.53	0.56
December, 2006	10.36	0.24	0.38

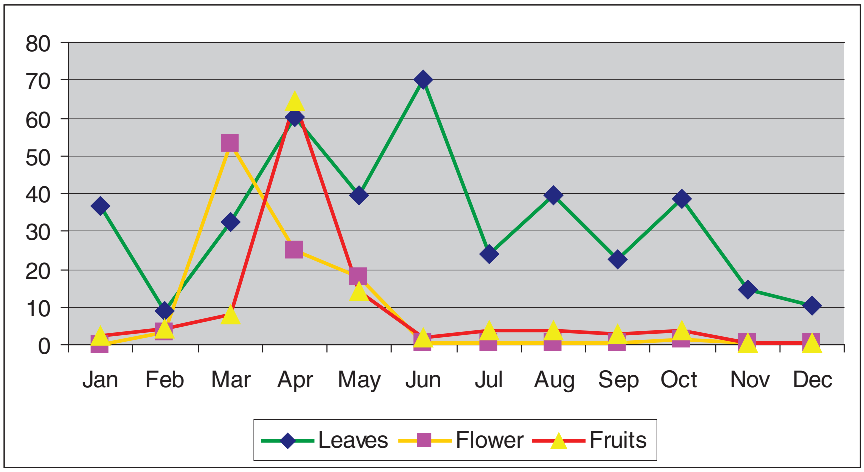


Fig. 5. Diagrams of total monthly abundance indices of plant parts as food of the northern white cheeked gibbons (*Nomascus leucogenys*).

Table 3. Ethogram of northern white-cheeked gibbons (*Nomascus leucogenys*) at the Endangered Primate Rescue Center's semi-wild enclosure.

Behavior types	Code	Description
1. Singing	**S**	Typical morning long loud vocalization of gibbons. In semi-wild condition, the gibbons usually emit singing at 5:20 to 8:00.
2. Feeding	**F**	It includes searching for food, taking food (leaves, fruits, insects, etc.) from environment and bringing it to its mouth, biting, chewing and swallowing food and drinking water.
3. Traveling	**T**	It includes brachiating, walking on feet, jumping,..
4. Watching	**W**	Gibbon is looking forward or around to detect something while sitting or standing on feet or hanging.
5. Grooming	**G**	It includes self-grooming, allo-grooming. In semi-wild enclosure, the gibbons often groom young douc langur and sometimes also barking deer. These grooming actions are also recorded.
6. Playing	**P**	Both plays between two gibbons and between gibbon with douc langur were recorded
7. Sitting & lying	**S & L**	Gibbon sits or lies without watching, almost doing nothing, eyes open. Gibbon mostly sits and lie for rest, however, sit may implicate other function which we are not sure.
8. Sleeping	**Sl**	Gibbon is lying on the substrate with close eyes and almost no movement of body.

tall secondary forest of 3 to 4 canopy levels. Most gibbon species are dominantly fruigivorous (Chivers, 1974; Whitten, 1984; Pham Nhat, 2002; Nguyen Xuan Nghia, 2006), therefore, fruit abundance plays a very important role for gibbon survival. Our study found very low density of fruit-bearing trees at the semi-wild enclosure and fruit availability was concentrated only in April and May. This indicates that the semi-wild enclosure could provide some fruit resource in April and May only, and almost none during other months of year, when the gibbons have to rely on their cage-fed fruits during months other than April and May.

Our behavior study shows that, in semi-wild condition, the gibbons have re-obtained some necessary behaviors for their natural arboreal life such as successful travel on trees, successful search for and taking food from plants, formulation of normal social behavior (grooming and playing with each other, etc.). However, the gibbons also showed some abnormal behaviors, for example where both gibbons often groomed and played with a young douc langur, sometimes, also with barking deer in the enclosure. Lisa groomed and played with a langur more than with Polly. Moreover, both gibbons often showed sexual behavior attempts towards the douc langur. This behavior occurs possibly because of lack of a gibbon male in the enclosure.

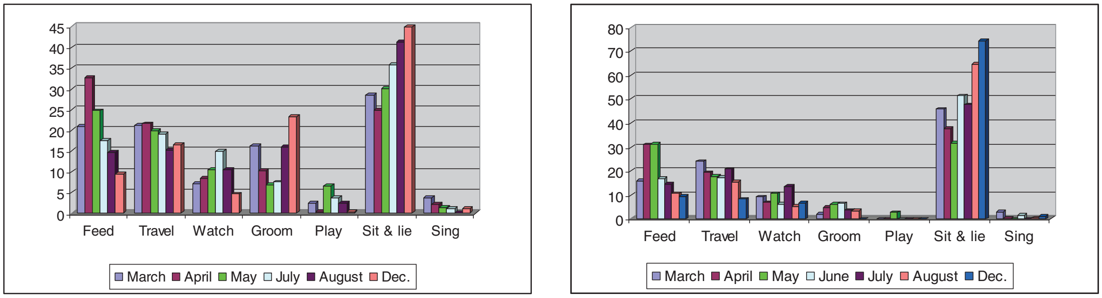
From our study findings we would suggest that, an adult male should be released to the semi-wild enclosure to eliminate abnormal sexual behavior in these females and to formulate normal social grouping. Due to a lack of necessary density of tall and fruit-bearing trees, this semi-wild enclosure should only used for the first step of gibbon release into semi-wild conditions, for their first practice on arboreal locomotion, natural foraging and social grouping. After that, the gibbons should be moved to other semi-wild conditions with better forest quality (primary forest or mature secondary forest of 3-4 levels.

ACKNOWLEDGEMENTS

This study was funded by the Endangered Primate Rescue Center a project of Frankfurt Zoological Society and Conservation International (CI). We would like to express our sincere thank to Ben Rawson, CI, Herbert H. Covert, University Colorado at Boulder; and Vu Ngoc Thanh, National University Hanoi for their valuable guidance in methodology and research designing for the study; to Truong Quang Bich director of Cuc Phuong National Park, Tilo Nadler, director of the Endangered Primate Rescue Center for their kind offering permits to work in the EPRC, to all staff members of the EPRC, and the Department of Vertebrate Zoology at the Institute of Ecology and Biological Resource, Hanoi, and many other colleagues and friends for their valuable support and assistance.

Table 4. Daily activity time budget (6:00 am to 5:00 pm) of northern white-cheeked gibbons (*Nomascus leucogenys*) at the Endangered Primate Rescue Center's semi-wild enclosure.

Month	Unit	Feed	Travel	Watch	Groom	Play	Sit & lie	Sing	Total
I. Gibbon Lisa									
March	Minutes	166	168	55	128	20	225	29	791
	%	**21.0**	**21.2**	**7.0**	**16.2**	**2.5**	**28.4**	**3.7**	**100.0**
April	Minutes	261	173	67	82	2	198	17	800
	%	**32.6**	**21.6**	**8.4**	**10.3**	**0.3**	**24.8**	**2.1**	**100.0**
May	Minutes	94	76	40	26	25	114	5	380
	%	**24.7**	**20.0**	**10.5**	**6.8**	**6.6**	**30.0**	**1.3**	**100.0**
July	Minutes	134	146	114	57	27	273	9	760
	%	**17.6**	**19.2**	**15.0**	**7.5**	**3.6**	**35.9**	**1.2**	**100.0**
August	Minutes	111	115	80	121	19	314		760
	%	**14.6**	**15.1**	**10.5**	**15.9**	**2.5**	**41.3**	**0.0**	**100.0**
Dec.	Minutes	64	112	31	158	2	306	7	680
	%	**9.4**	**16.5**	**4.6**	**23.2**	**0.3**	**45.0**	**1.0**	**100.0**
II. Gibbon Polly									
March	Minutes	68	103	40	9		197	13	430
	%	**15.8**	**24.0**	**9.3**	**2.1**	**0.0**	**45.8**	**3.0**	**100.0**
April	Minutes	248	155	56	39		301	1	800
	%	**31.0**	**19.4**	**7.0**	**4.9**	**0.0**	**37.6**	**0.1**	**100.0**
May	Minutes	112	64	38	22	10	114		360
	%	**31.1**	**17.8**	**10.6**	**6.1**	**2.8**	**31.7**	**0.0**	**100.0**
June	Minutes	126	129	46	47		380	12	740
	%	**17.0**	**17.4**	**6.2**	**6.4**	**0.0**	**51.4**	**1.6**	**100.0**
July	Minutes	110	158	103	27		362		760
	%	**14.5**	**20.8**	**13.6**	**3.6**	**0.0**	**47.6**	**0.0**	**100.0**
August	Minutes	81	118	40	26		491	4	760
	%	**10.7**	**15.5**	**5.3**	**3.4**	**0.0**	**64.6**	**0.5**	**100.0**
Dec.	Minutes	32	28	23			252	4	339
	%	**9.4**	**8.3**	**6.8**	**0.0**	**0.0**	**74.3**	**1.2**	**100.0**
Total (average daily budget)	Minutes	1607	1545	733	742	105	3527	101	8360
	%	**19.2**	**18.5**	**8.8**	**8.9**	**1.3**	**42.2**	**1.2**	**100.0**



(A. Gibbon Lisa) (B. Gibbon Polly)

Fig. 6. Daily activity time budget (from 6:00 am to 5:00 pm) of the northern white cheeked gibbons (*Nomascus leucogenys*) at the semi-wild enclosure.

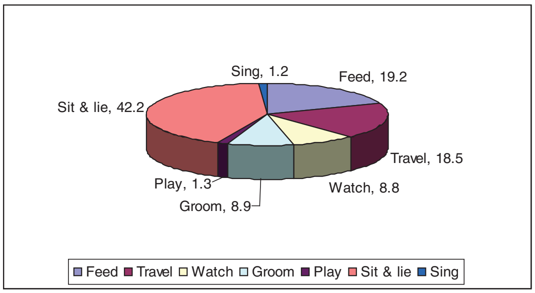


Fig. 7. Percentage of average daily activity budget of northern white-cheeked gibbons (*Nomascus leucogenys*).

MỘT SỐ ĐẶC ĐIỂM SINH THÁI DINH DƯỠNG CỦA VƯỢN ĐEN MÁ TRẮNG (*NOMASCUS LEUCOGENYS*) TRONG KHU BÁN HOANG DÃ, TRUNG TÂM CỨU HỘ LINH TRƯỞNG NGUY CẤP, VƯỜN QUỐC GIA CÚC PHƯƠNG, VIỆT NAM

TÓM TẮT

Nghiên cứu đặc điểm sinh thái dinh dưỡng của 2 cá thể vượn đen má trắng (*Nomascus leucogenys*) được tiến hành từ tháng 10/2006 đến tháng 9/2007 tại Trung tâm Cứu hộ Linh trưởng Nguy cấp (EPRC), Vườn Quốc gia Cúc Phương. Hai cá thể này đã được nuôi dưỡng trong điều kiện nuôi nhốt và được chuyển vào Khu bán hoang dã số 1 của EPRC để thích nghi trở lại với môi trường tự nhiên. Trong quá trình nghiên cứu, chúng tôi đã quan sát được động vật ăn lá non của 16 loài, hoa của 1 loài, quả của 12 loài và chồi của 2 loài cây. Theo dõi vật hậu học của 580 cây thuộc 81 loài bên trong Khu bán hoang dã cho thấy lá non tồn tại quanh năm, phong phú nhất từ tháng 3 đến tháng 7, hoa có chủ yếu từ tháng 3 đến tháng 5, còn quả cũng tập trung vào thời gian từ tháng 3 tới tháng 5. Do vượn chủ yếu ăn quả cây và xét về nguồn thức ăn tự nhiên, tháng 4 và tháng 5 là thời gian tốt nhất cho chúng trong Khu bán hoang dã này. Nghiên cứu quỹ thời gian hoạt động hàng ngày của 2 cá thể vượn ở đây cũng được tiến hành trong năm 2007 theo phương pháp quan sát lựa chọn cá thể. Trong tổng số 8360 phút quan sát, ghi nhận thấy chúng giành nhiều thời gian nhất cho dạng tập tính “ngồi và nằm” (42.2%), tiếp đến là “kiếm ăn” (19.2%), “di chuyển” (18.5%), “chuốt lông” (8.9%), “quan sát” (8.8%), “chơi” (1.3%) và “hót” (1.2%). So với các cá thể vượn được nuôi nhốt tại EPRC, thì vượn trong khu bán hoang dã đã giành thời gian cho dạng tập tính “ngồi và nằm” ít hơn và cho “kiếm ăn” nhiều hơn. Điều này có thể là do trong điều kiện bán hoang dã, vượn không chỉ giành thời gian ăn một số thức ăn được cung cấp sẵn mà còn phải tự tìm kiếm thức ăn từ các cây rừng trong Khu bán hoang dã. Nghiên cứu này cho thấy Khu bán hoang dã số 1 của EPRC, VQG Cúc Phương có thể cung cấp cho vượn một số điều kiện sinh cảnh tự nhiên cần thiết như nguồn thức ăn, nơi trú ẩn, giá đỡ để vận động và giúp cho vượn có thể tái thích nghi được phần nào với môi trường tự nhiên như tự kiếm thức ăn, di chuyển thành thạo trên cây kể cả đu mình. Tuy nhiên, nguồn thức ăn, sự phong phú thức ăn trong các mùa và không gian hoạt động hạn hẹp cũng làm hạn chế khả năng tái thích nghi của các cá thể vượn nuôi tại đây.

REFERENCES

Altmann, J. (1974): Observational study of behaviour: sampling methods. Behaviour 49, 227-267.

Chivers, D.L. (1974): The siamang in Malaya: a field study of a primate in tropical rainforest. Contributions to Primatology 4, 1-335.

Geissmann, T., Nguyen Xuan Dang, Lormee, N. & Momberg, F., (2000): Vietnam Primates Conservation Status Review 2000: Part 1. Gibbons. Fauna & Flora International-Vietnam Program, Hanoi.

Groves, C.P. (2001): Primate Taxonomy. Smithsonian Institution Press, Washington D.C. and London.

IUCN (2008): 2008 IUCN Red List of Threatened Species. <www.iucnredlist.org>.

Le Hien Hao (1973): White-cheeked Crested Gibbon. In: Le Hien Hao: Economic mammals of Northern Vietnam; pp. 195-247. Science and Technics, Hanoi (In Vietnamese).

Ministry of Science and Technology & Vietnam Academy of Sciences and Technology (2007): Red Data Book of Vietnam, Part 1. Animals. Publ. House Nat. Sci & Techn., Hanoi, (In Vietnamese).

Nadler, T., Vu Ngoc Thanh & Streicher, U. (2007): Conservation status of Vietnamese Primates. Vietnamese J. Primatol. 1(1), 7-26.

Nguyen Xuan Nghia (2006): Study of feeding and behaviour of captive white-cheeked gibbon, *Nomascus leucogenys* (Ogilby 1840) in Endangered Primate Rescue Centre, Cuc Phuong National Park. Thesis, Hanoi National University, (In Vietnamese, unpubl.).

Peterson, J.D. (2001): Primates behaviour, an exercise workbook. Waveland Press Inc., Long Grove, Illinois.

Pham Nhat (2002): Primates of Vietnam. Publ. House Agriculture, Hanoi. (In Vietnamese).

Silver S.C., Ostro, L.E.T., Yeager, C.P. & Horwich R. (1998): Feeding ecology of Black howler monkey (*Alouatta pigra*) in Northern Belize. Am. J. Primatol. 45, 263-279.

Southeast Asia Mammal Data Bank (2006): A tool for conservation and monitoring of Mammal diversity in Southeast Asia <www.ieaitaly.org/samd>.

Tallents, L. (2002): Behaviour of captive *Nomascus* Gibbons. EPRC Newsletter 7, 11-16.

White, L. & Edwards, A. (eds.) (2000): Conservation research in the African rain forests; a technical handbook. Wildlife Conservation Society, New York.

22

NON-HUMAN PRIMATES MASK SIGNS OF PAIN

ROLAND PLESKER AND VALENTIN MAYER

SUMMARY

A total of 54 cases of wounds/illnesses in non-human primates were recorded regarding a) individual data of the affected monkey, b) wound/illness-related behavior, c) wound/illness description and d) fictive human behavior with comparable wounds/illnesses. Putting into scores, the data were compared. It was found that the monkey behavior score was significantly lower than both the fictive human behavior score and the wound/illness score. This demonstrates that monkeys mask signs of pain. The results were first published in Laboratory Primate Newsletter 47(1), 1-3.

INTRODUCTION

It is widely known in biology, that wild animals have good reasons to mask signs of pain/illness in nature: First, they might be priority-targets for predators if they show signs of pain like abnormal behavior. Secondly, social living individuals might lose their social ranking position if they do not appear to be perfectly fit.

When kept in captivity, the question whether animals mask signs of pain is important for their health control. Since there are no generally accepted objective criteria for assessing directly the degree of pain that an animal is experiencing (Morton & Griffith, 1985), indirect criteria must be used. For example, changes from the species specific "normal" behavior can be used as an indication of pain (Smith *et al.*, 2006; Committee on Pain and Distress in Laboratory Animals, 1992).

For primates, it is known that it can be difficult to recognize pain in these species since they will often appear to show little reaction to pain (Wolfensohn & Honess, 2005). Also, experts know that conscious nonhuman primates frequently mask signs of pain (Fortman *et al.*, 2001; Committee on Pain and Distress in Laboratory Animals, 1992). However, it is difficult to prove this knowledge scientifically, since animals are unable to communicate in ways in which they can be readily understood by people (Hughes & Lang, 1983; Soma, 1987).

In this study, we try to compare primate behavior after detection of wounds/illnesses to fictive human behavior in a comparable situation. Moreover, we try to compare both behaviors to the "objective" severity of wounds/illnesses in order to receive scientific proof whether primates really mask signs of pain routinely (Laboratory Primate Newsletter 47(1), 1-3).

ANIMALS AND METHODS

Animals

The primate colony at the Paul-Ehrlich-Institut in Langen consists of 144 non-human primates (62 males, 82 females): 57 African green Monkeys (*Chlorocebus aethiops* = 40%), 41 rhesus macaques (*Macaca mulatta* = 28%), 21 pig-tailed macaques (*Macaca nemestrina* = 15%) and 25 long-tailed macaques (*Macaca fascicularis* = 17%). They are group-housed in an experimental indoor facility. The cages are made of steel with a size of 300cm x 125cm x 225cm, each.

Recording of behavior and wounds

When any signs of injuries/illnesses were detected in the monkey colony (blood in the cage, blood or wounds detected, strange behavior of individuals) experienced animal caretakers or veterinarians observed the particular monkey for a period of at least five minutes in order to detect and describe the actual behavior accurately. The observed behavioral changes were scored according to the following criteria:

0 = no detectable behavioral changes; 1 = slight behavioral changes; only influenced by local alterations; 2 = clear to obvious behavioral changes, locally influenced; 3 = general behavior involved.

Afterwards, the monkeys were anesthetised (general ketamine-xylazine-anesthesia) and the wounds/illnesses were described in detail by veterinarians. In the majority of cases, photos of the injuries were taken. The injuries/illnesses were independently scored according to the following criteria:

1 = only skin affected in a single wound (Fig. 1); 2 = muscles involved in a single wound or multiple wounds (Fig. 2); 3 = significant loss of tissue or general body condition affected (Fig. 3).

Fictive comparison to humans

For the comparison of the monkey behavior to fictive human behavior, an experienced medical doctor was consulted who had no access to the identified monkey scores. The sex of the fictively affected human was considered. Also, the age of the patient and the size of the wounds were translated to human dimensions. Photos of the monkey-wounds were used to obtain a better notion of the fictive wounds in humans. For the estimation of fictive human behavior, it was considered that the fictive patient could not speak to explain the pain. However, fictive groaning or other sounds in correlation with injuries/illnesses were considered. A five minute observation period of the fictive human behavior was imagined and the fictive behavioral changes were scored as described for the monkey behavior.

RESULTS

Monkeys

A total of 58 consecutive cases of injuries/illnesses in non-human primates were reported in a six month period. Among these, 54 cases were included into the study. Three cases were excluded from the study since a wound was detected on the distal part of the tail only; in one case the definite reason for illness-related behavioral changes could not exactly be determined. In 29 of these 54 cases rhesus macaques were involved (54%), in 16 African green monkeys (30%), in 5 pig-tailed macaques (9%) and in 4 cases long-tailed macaques (7%).

Among the 54 cases, 42 were wounds as a result of a fighting event within the group. Females (27 cases) were more often recipients of wounds than males (15). In 16 cases, more than one wound was detected in one individual. Furthermore, in 16 cases lower ranking individuals, in 16 cases middle ranking individuals and in 10 cases high ranking individuals were affected by wounds. In part, individuals were found with wounds more than once (7 individuals among the rhesus macaques with up to five counts; 2 individuals among the African green monkeys with up to seven counts).

Fictive comparison to humans

Table 1 demonstrates that the score for the monkey behavior turned out to be clearly lower than the fictive score for the corresponding human behavior (0.7 to 2.19 mean score). In none of the cases did a monkey score higher than the corresponding fictive human, whereas in 45 cases the monkey scored less than the corresponding fictive human (Table 1).

When the wound score is compared to the monkey behavior score, it becomes visible that the behavior score is significantly lower than the wound/illness score implies (1.81 to 0.7 mean score). In 44 of 54 cases the score was lower for the monkey behavior.

In contrast, when the fictive human behavior is compared to the wounds/illnesses, the differences in the scores are not as pronounced (1.81 to 2.19 mean score). In 50 % of the cases the fictive humans behave as our wound/illness score implies (27 of 54 cases). In 23 cases the fictive human behavior score was higher than our wound score implied (Fig. 4).

DISCUSSION

When wild animals are kept in captivity, it is extremely important to care as well as possible for their health. The recognition of pain in captive individuals is one important element of the health surveillance and the judgement of their wellbeing. Since pain cannot be directly scored in wild animals like primates, the recognition of pain-related-behavior is the most important instrument available for the avoidance of this unpleasant feeling. Therefore, the knowledge that monkeys indeed

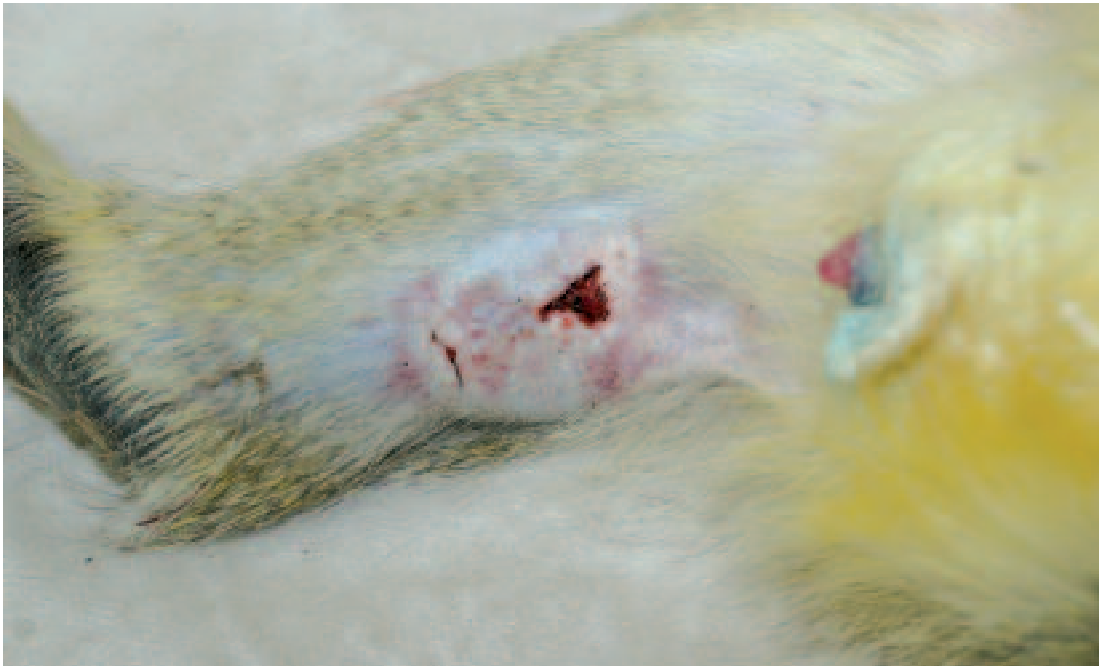


Fig. 1. Injury classified as wound score 3. *Photo: Roland Plesker.*

Fig. 2. Injury classified as wound score 2. *Photo: Roland Plesker.*

Fig. 3. Injury classified as wound score 3. *Photo: Roland Plesker.*

Table 1. Comparison of the scores for wounds/illnesses, monkey-behavior and the fictive behaviour of corresponding humans.

Case number	Score wound	Score behavior monkey	Fictive score behavior human
1	3	3	3
2	3	3	3
3	3	3	3
4	3	2	3
5	3	2	3
6	3	2	3
7	3	2	3
8	3	2	2
9	3	1	3
10	3	0	3
11	2	2	3
12	2	2	3
13	2	2	3
14	2	2	2
15	2	2	2
16	2	2	2
17	2	1	3
18	2	1	3
19	2	1	2
20	2	1	2
21	2	1	1
22	2	0	3
23	2	0	3
24	2	0	2
25	2	0	2
26	2	0	2
27	2	0	2
28	2	0	2
29	2	0	2
30	2	0	2
31	2	0	2
32	2	0	2
33	2	0	1
34	2	0	1
35	1	1	1
36	1	0	3
37	1	0	2
38	1	0	2
39	1	0	2
40	1	0	2
41	1	0	2
42	1	0	2
43	1	0	2
44	1	0	2
45	1	0	2
46	1	0	2
47	1	0	2
48	1	0	2
49	1	0	2
50	1	0	2
51	1	0	2
52	1	0	1
53	1	0	1
54	1	0	1
total	98	38	118
mean	1,81	0,7	2,19

mask pain- related-behavior is important information for anyone involved in the housing of primates.

The main problem in the evaluation of monkey pain behavior is the question of what can be used as reference. A comparison to human behavior seems to be advised mainly for four reasons:

1) Humans normally can explain their pain in words so that it is easier for other humans to understand their feelings. Therefore, extrapolation of pain behavior from given wounds/illnesses should be easier in humans than in any other species.
2) Medical doctors work with pain related injuries/illnesses every day. They should

Fig. 4. The fictive human behavior score is higher than the wound score implied. (behaviour score: 0; wound score: 2; fictive human behaviour score: 3)

Photo: Roland Plesker.

therefore be better qualified in anticipating sensations of pain in their patients without using linguistic descriptions than anyone else in any other species.

3) Human pain behavior nowadays should not be influenced by predators any more.
4) Except in certain gangs of youngsters, the social status within a group should not influence the pain behavior of humans in the same way as in monkeys.

Since one cannot inflict the same wounds/illnesses to humans in order to compare their behavior to monkey behavior, one has to imagine fictive human behavior on a given wound/illness based on experience. This wound/illness must be comparable to what was observed in a monkey before. Therefore, the data of the affected individual as well as the data of the wounds/illnesses must be translated into a human situation: Age, sex, size and severity of wounds/illnesses must be adapted and considered in order to avoid bias-induced interpretation of fictive human behavior.

The second problem in the evaluation of monkey pain behavior is the question of the standardization of both behavior and wounds/illnesses in order to avoid bias-induced miscalculation or misinterpretation. To avoid these problems,

1) A score system was set up prior to the calculation, and
2) The scoring itself was performed “blind”, e.g. without the prior knowledge of the other corresponding scores.
3) In addition, consecutive cases within the colony were used, no matter how well they fitted into the study, in order to avoid the possible reproaches that only well fitting cases were integrated into the study.

Nevertheless, serious potential causes of misinterpretation/miscalculation might include the following phenomena:

1) Marginal behavioral changes in the behavior of the monkeys might be overlooked, since observation of individuals in a group situation might sometimes be difficult.
2) When the monkey behavior was recorded the monkeys were aware of the fact that they were observed. This might lead to the masking of behavioral changes as long as the observer was present in the animal room.

Both points are accentuated by the result that many monkeys were recorded without any behavioral changes although wounds/illnesses were scored 2 or 3.

3) Medical doctors are normally confronted with patients that can articulate their sensations in words. In this study, however, the verbal expression of pain in words was excluded and simple imagination of fictive human behavior had to be judged based on photos of wounds or descriptions. Within this process, wide variation is principally possible and can not be excluded. It might be the case that the estimation of the human behavior score is severely influenced by individual experiences.

In conclusion, we would like to stress, that within this study only one case is available, where chronic pain might have occurred; all other cases were acute events.

Concerning additional monkey-related wound-information, it should be noted that:

Although in the colony only 28% of the monkeys were rhesus macaques, they scored for 54% of the cases. This is a reflection of both the relatively aggressive character of this species (de Waal, 1989) and the time span of case-collection in the spring with its rising hormone levels.

Regarding the results of this study (Table 1), one question might arise as to whether humans are simply too sensitive to injuries/illnesses in comparison to the wild living monkeys. To answer this question, we determined the wound score (an effort to standardize the severity of wounds/illnesses) in order to compare it to the human reaction: As can be seen, the difference between these two parameters was not very high. Therefore, in the comparison between humans-monkeys, humans are not too sensitive to wounds/illnesses but the monkey behavior revealed much less changes than the wounds implied. In other words: the monkeys mask signs of illness. In theory, there are good reasons for this coverage of pain:

1) Wild animals that show signs of pain will be the priority target for predators,
2) Individuals that show signs of pain risk their social position within the monkey groups and – together with this – their potential reproductive success.

In an experimental indoor primate facility the cage size in any case is limited, no matter whether the monkeys are group-housed or not. This eliminates to a larger extent the possibility of the primates to avoid contact in situations of tensions within a group. The possibility to escape from aggressors is also limited within a cage. This might be the reason for the relatively high numbers of wound within the reported cases.

The facts that almost two-thirds of the wounds were received by females cannot be explained by one simple reason: It might be due to the fact that males release their aggression more frequently towards females because they might not have to fear such intense fighting responses. It might also be due to stress in the group more often released to socially low ranking individuals, which are usually females. This is supported by the fact that low ranking females in part were presented with wounds more than once in this study. Fighting for ranking within the group might more often lead to biting between females than males since fighting between males (with their larger canines) might lead to more serious injuries in case it really happens.

For us it is no surprise that high ranking individuals are less often wounded than middle or low ranking group members: High ranking individuals might solve problems more often simply by their impressive and dominant appearance.

LINH TRƯỞNG CHE DẤU NHỮNG DẤU HIỆU CÓ BIỂU HIỆN CƠN ĐAU

TÓM TẮT

Tổng số 54 trường hợp các vết thương/ốm bệnh của linh trưởng được ghi nhận qua bốn dạng: a) dữ liệu riêng lẻ của từng trường hợp linh trưởng bị đau, b) hành vi ứng xử liên quan đến vết thương/ốm bệnh, c) mô tả vết thương/ốm bệnh và d) hành vi bắt chước con người với các vết thương/ốm bệnh tương tự. Sau khi đưa dữ liệu vào thang điểm và so sánh, chúng tôi đã đưa ra được số điểm dành cho hành vi biểu hiện đau đớn thấp hơn nhiều so với số điểm dành cho hành vi bắt chước con người và cho vết thương/ốm bệnh. Điều này chỉ ra rằng linh trưởng che dấu biểu hiện cơn đau. Các kết quả nghiên cứu này được xuất bản lần đầu tại Bản tin của Phòng thí nghiệm Linh trưởng số 47 (1), 1-3.

REFERENCES

Committee on Pain and Distress in Laboratory Animal, Institute of Laboratory Animal Resources, Commission on Life Sciences, National Research Council (1992): Recognition and Alleviation of Pain and Distress in Laboratory Animals; Chapter 4, p. 41. National Academy Press, Washington.

de Waal, F. (1989): Peacemaking among Primates. Harvard University Press, Cambridge.

Fortman, J., Hewett, T.A. & Bennett, B.T. (2001): The Laboratory Nonhuman Primate; chapter 4, p. 115. CRC Press, London, New York.

Hughes, H.C. & Lang, C.M. (1983): Control of pain in dogs and cats. In: Kitchell, R.L. & Erickson, H.H. (eds.): Animal Pain: Perception and Alleviation; pp. 207-216. American Physiological Society, Bethesda.

Morton, D.B. & Giffiths, P.H.M. (1985): Guidelines on the recognition of pain, distress and discomfort in experimental animals and an hypothesis for assessment. Veterinary Record 116, pp. 431-436.

Plesker, R. & Mayer, V. (2008): Nonhuman primates mask signs of pain. Laboratory Primate Newsletter 47 (1), 1-3.

Smith, J.J., Hadzic, V., Li, X., Liu, P., Day, T., Utter, A., Kim, B., Washington, I.M. & Basso, M.A. (2006): Objective measures of health and well-being in laboratory rhesus monkeys (*Macaca mulatta*). J. Medical Primatol. 35 (6), 388-396.

Soma, L.R. (1987): Assessment of pain in experimental animals. Laboratory Animal Science 37, 71-74.

Wolfensohn, S. & Honess, P. (2005): Handbook of Primate Husbandry and Welfare; chapter 5, p.60. Blackwell Publishing, Oxford.

Conservation

Chapter IV

23

STOPPING THE TRADE OF VIETNAM'S PRIMATES: EXPERIENCES AND CASES FROM ENV'S WILDLIFE CRIME UNIT

TRAN THU HANG

SUMMARY

Vietnam's primates are under serious threat due to heavy hunting pressure and an increasing demand for wildlife and wildlife products. In 2005 with response to the devastating effects of the wildlife trade, not only on primates but also on many endangered species in Vietnam the Vietnamese non-governmental organization (NGO) Education for Nature-Vietnam (ENV) established a Wildlife Crime Unit (WCU) and a toll-free hotline. This hotline facilitates public reporting of wildlife crimes and assists wildlife protection authorities in combating the illegal wildlife trade.

After nearly three years in operation, ENV's Wildlife Crime Hotline has recorded more than 1400 cases. Primate crime cases account for about 19% (about 267 cases).

Despite many successes, there are still significant obstacles to tackling the trade of primates in Vietnam. Some of the obstacles encountered by ENV's wildlife crime team in dealing with primate crime cases include: a lack of rescue center facilities for macaque species, the costs associated with placement, (including requests for compensation from residents) and weak enforcement with inadequate penalties that might otherwise deter future crimes.

INTRODUCTION

Vietnam's primates are under serious threat due to heavy hunting pressure and an increasing demand for wildlife and wildlife products. These threats, compounded by the fact that the majority of Vietnamese citizens are unaware of the wildlife protection laws and the legal status of primate species, is pushing Vietnam's primates closer to extinction.

In 2005, with response to the devastating effects of the wildlife trade, not only on primates but on many endangered species in Vietnam, the Vietnamese non-governmental organization (NGO) Education for Nature-Vietnam (ENV) established a Wildlife Crime Unit (WCU) and a toll-free hotline. This hotline facilitates public reporting of wildlife crimes and assists wildlife protection authorities in combating the illegal wildlife trade. The WCU works closely with authorities to respond to these crimes and has developed a national Wildlife Protection Volunteer Network to assist with the monitoring of wildlife consumer establishments. The aim of all WCU's activities is to bring an end to the wildlife trade in Vietnam.

RESULTS

After nearly three years in operation, ENV's Wildlife Crime Hotline has recorded more than 1400 cases. Primate crime cases account for about 19% (about 267 cases). In total there have been 929 cases involving live animals, which amounts to a total of nearly 16,000 individual live animals. Among these 267 primate cases which includes164 macaque cases, making up 61% of live animal cases; 26 gibbon cases making up 10% of live animal cases; 41 langur cases making up 16% of live animal cases; and 36 loris cases accounting for 13% of live animal cases (Fig. 1).

ENV's Wildlife Crime Database also indicates that crimes involving primate species include: possession (61%), transportation (20%), selling of live animals at markets, restaurants and shops (10%), hunting (4%), preservation in wine, and advertised on menus (5%) (Fig. 2 and 3). These figures highlight the demand for primates for pets or in private collections as a significant driver in the illegal trade of these taxa. Species of gibbons (northern white-cheeked, *Nomascus leucogenys*; southern white-cheeked, *N. siki* and yellow-cheeked gibbon, *N. gabriellae*)(Fig. 4), lorises (pygmy loris, *Nycticebus pygmaeus*; northern

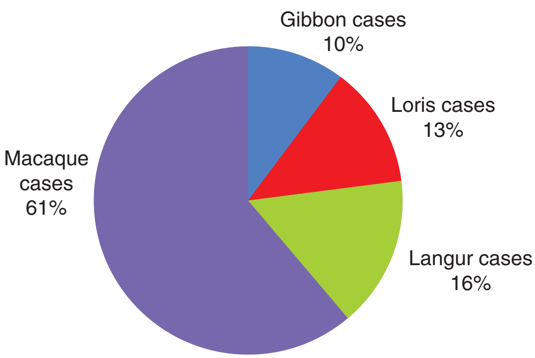


Fig. 1. Primate taxa involved in primate trade from ENV's Wildlife Crime Database.

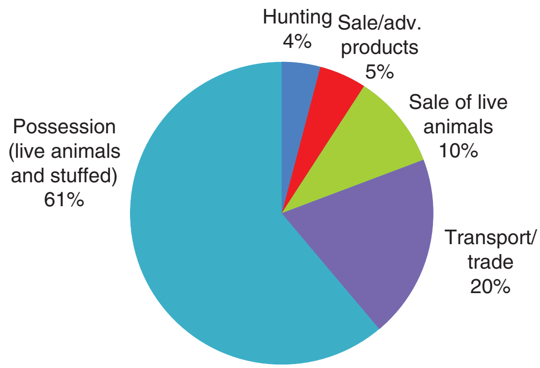


Fig. 2. Type of crime involving primate species.

Fig. 3. Juvenile Delacour's langur (*Trachypithecus delacouri*), listed as "Critically Endangered" species in brandy as "traditional tonic".

Photo: Tilo Nadler.

slow loris, *N. bengalensis*) and douc langurs (red, black and grey-shanked douc langur *Pygathix nemaeus*, *P. nigripes*, *P. cinerea*) (Fig. 5 and 6) are most often found in possession cases, and macaques (long-tailed, *Macaca fascicularis*; pig-tailed *M. leonina*; stump-tailed, *M. arctoides* and rhesus macaques, *M.*

Fig. 4. Confiscated baby yellow-cheeked gibbon (*Nomascus gabriellae*), an "Endangered" species.
Photo: Tilo Nadler.

Fig. 5. Confiscated grey-shanked douc langur (*Pygathrix cinerea*) a "Critically Endangered" species.
Photo: Elke Schwierz.

Fig. 6. Black-shanked douc langurs (*Pygathrix nigripes*), listed as "Endangered" species as ornaments in a restaurant in Hanoi.
Photo: Elke Schwierz.

mulatta) are common in both the possession and transportation cases.

Over the past three years, ENV's Wildlife Crime Hotline has recorded a number of successful cases involving public participation in helping to end the wildlife trade of primates. In most of these successful cases, the animals were transferred to rescue centers.

However, despite many successes, there are still significant obstacles to tackling the trade of primates in Vietnam. Some of the obstacles encountered by ENV's wildlife crime team in dealing with primate crime cases include: a lack of rescue center facilities for macaque species; the costs associated with placement (including requests for compensation from residents) and weak enforcement with inadequate penalties that might otherwise deter future crimes (Fig. 7 and 8).

Fig. 7. Poached black-shanked douc langurs (*Pygathrix nigripes*), listed as "Endangered" species.

Photo: Vo Van Tao.

Fig. 8. In 2009 a criminal court sentenced the two hunters of the black-shanked douc langurs (in Fig. 7) to a high amount of punishment that entailed 24 and 30 months of jail time. This is still a very rare exception but shows the increasing awareness about the value of the threatened and endangered wildlife.

Photo: Tilo Nadler.

CHỐNG BUÔN BÁN CÁC LOÀI LINH TRƯỞNG TẠI VIỆT NAM: KINH NGHIỆM VÀ CÁC VỤ VI PHẠM, GHI NHẬN TỪ NHÓM CHỐNG TỘI PHẠM THIÊN NHIÊN CỦA TỔ CHỨC ENV

TÓM TẮT

Các loài linh trưởng tại Việt Nam đang bị de dọa hết sức nghiêm trọng do nạn săn bắt diễn ra trầm trọng và do nhu cầu về động thực vật hoang dã cũng như các sản phẩm của chúng ngày càng tăng cao. Trước tác động nguy hại từ nạn buôn bán động thực vật hoang dã, không chỉ đối với linh trưởng mà còn nhiều loài động thực vật khác cũng đang nguy cấp tại Việt Nam. Vào năm 2005, tổ chức phi chính phủ Việt Nam ENV (Giáo dục bảo tồn thiên nhiên Việt Nam) đã thành lập nên Nhóm chống tội phạm thiên nhiên và một đường dây nóng miễn phí. Đường dây này là nơi giúp cộng đồng báo lại những trường hợp vi phạm của tội phạm thiên nhiên, đồng thời giúp các cơ quan chính quyền về bảo tồn thiên nhiên trong công tác đấu tranh chống lại nạn buôn bán động thực vật hoang dã bất hợp pháp. Sau gần 3 năm đi vào hoạt động, Đường dây nóng tội phạm thiên nhiên của EVN đã ghi nhận được hơn 1,400 trường hợp. Các vụ tội phạm thiên nhiên về linh trưởng chiếm khoảng 19% (với khoảng 271 vụ).

Mặc dù đạt được nhiều thành công, nạn buôn bán linh trưởng tại Việt Nam vẫn còn gặp nhiều vấn đề nan giải cần được giải quyết. Một số vấn đề mà Nhóm chống tội phạm thiên nhiên ENV gặp phải như sau: thiếu các trung tâm cứu hộ cho các loài khỉ, thiếu kinh phí cho công tác tịch thu bắt giữ, chuyển giao cứu hộ (bao gồm cả một số yêu cầu cần thiết để thả lại tự nhiên), thực thi pháp luật còn yếu kém và các hình phạt, nghiêm cấm vẫn chưa đầy đủ để có thể ngăn chặn những vi phạm trong tương lai.

24

PROTECTION OF THE CAT BA LANGUR (*TRACHYPITHECUS* [*POLIOCEPHALUS*] *POLIOCEPHALUS*) THROUGH THE 'CAT BA LANGUR CONSERVATION PROJECT'

DANIELA SCHRUDDE, PIETER LEVELINK, AND MARTINA RAFFEL

SUMMARY

The Cat Ba langur (*Trachypithecus* [*poliocephalus*] *poliocephalus*) is a leaf-eating monkey endemic to Cat Ba Island, North Vietnam. Due to poaching, habitat fragmentation, and disturbance through an increasing number of immigrants and increased tourism, the Cat Ba langur is classified by IUCN as 'Critically Endangered'. Only 60 to 70 individuals are left in the wild. Despite the alarmingly low numbers, there is still hope for the Cat Ba langur. Since the Cat Ba Langur Conservation Project (CBLCP) started in 2000, the number of individuals has continuously increased. Besides the establishment of a strictly protected area, a community based protection network was also initiated on Cat Ba Island. Almost 200 people are involved on a daily basis in the protection of the Cat Ba langur and its habitat. Among other activities the CBLCP is involved in several programs with local and foreign partners. Additionally, through presentations in local schools, the next generations will be made more aware of the species plight and conservation measures being put in place to conserve it. Together with the local authorities in Hai Phong and UNESCO, the University of Queensland currently undertakes a program to find solutions for sustainable tourism on Cat Ba Island. All these measures are aimed towards giving Cat Ba Island the chance to survive as an outstanding natural site, which is a precondition for the Cat Ba langur to persist.

INTRODUCTION

Cat Ba Island

Cat Ba Island, in Ha Long Bay, is the heart of the "Cat Ba Archipelago" Biosphere Reserve, which was recognized by the UNESCO in 2004. This biggest island out of 366 in the Archipelago, it is located 50 km east of Hai Phong City. The island is made of steep karst, the surface of which is mainly covered by primary and secondary limestone forest or shrub vegetation (Fig. 1). In 1986 Cat Ba National Park was established and in 2006 the boundaries of the national park were expanded so that now the national park covers more than 50% of Cat Ba Island. The park has a total size of 16196 ha. Including the small offshore islands the park has a

Fig. 1. The scenic landscape on Cat Ba Island.
Photo: Marco Mehner.

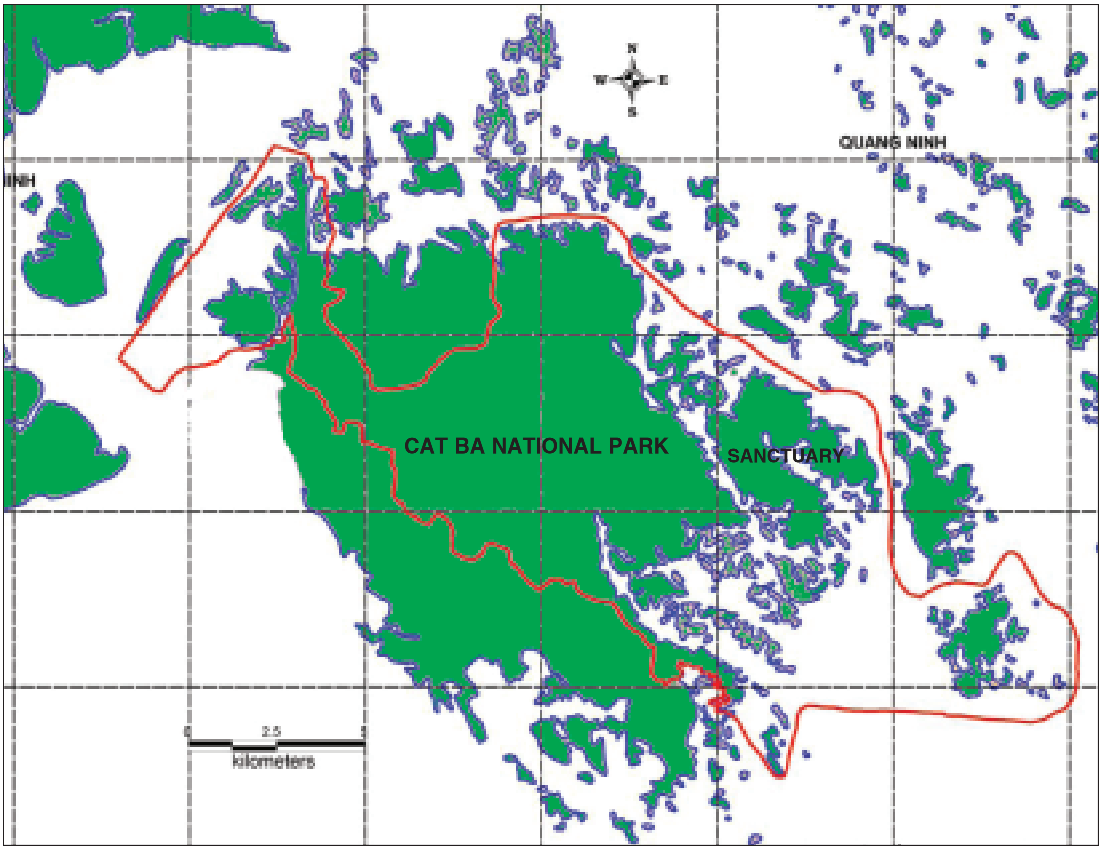


Fig. 2. Cat Ba Island, the border of Cat Ba National Park, and the langur sanctuary.

land surface area of 10931 ha. An additional 5265 ha of inshore waters also belong to the national park. Therefore, Cat Ba National Park is one of only a few national parks in Vietnam that encompasses a terrestrial and a marine component. 14 Ranger stations with a total of 56 rangers are in charge of protection of the park (Fig. 2).

Cat Ba Archipelago is famous for its abundant biodiversity. In the National Biodiversity Action Plan (Government of SR Vietnam and the Global Environment Facility, Project Vie/91/G31, 1994), Cat Ba National Park is listed under the highest category regarding the value for biodiversity conservation. Currently 27 terrestrial animals, 72 terrestrial plants and 16 marine species are listed as rare in the Red Data Book of Vietnam (Ministry of Science and Technology & Vietnam Academy of Sciences and Technology, 2007)).

Cat Ba Langur

The most notable endemic animal on Cat Ba Island is the Cat Ba langur or golden-headed langur (*Trachypithecus* [*poliocephalus*] *poliocephalus*) (Fig. 3). Due to its restricted range and small population size, it is listed in the ICUN Red List of Threatened Species (IUCN, 2008) and the Vietnam Red Data Book as 'Critically Endangered' and since 2000 as one of 'The World's 25 most Endangered Primates' (Mittermeier *et al*., 2007). The Cat Ba langur is protected according to Vietnamese law, listed in Decree 32/2006/ND-CP list IB, banning all exploitation and commercial use. Nadler & Ha Thang Long (2000) estimated that at least 2400-2700 individuals lived on Cat Ba Island around 1960. After a three-month survey in 1999 Nadler & Ha Thang Long (2000) found a maximum of 135 individuals remaining. Only 10 months later the alarming

Fig. 3. Cat Ba langur female with baby and male (*Trachypithecus* [*p.*] *poliocephalus*).
Photo: Jörg Adler.

evidence that only 53 individuals were left on Cat Ba (Stenke *et al.*, 2008). Thanks to extensive protection measures currently 60-70 individuals are left in the wild. Divided into 11 groups, the langurs occur in seven separated areas on Cat Ba Island with all reproductive social units located in the South of the island. Through the extension of the national park in 2006, all areas where langurs occur are now inside the park boundaries. The average group size in the regularly monitored groups is 6.1. Cat Ba langurs have a low reproduction rate (Stenke, 2004). Since July 2008, 8 new births and 2 deaths, both as a result of natural causes, have been reported.

As a member of the leaf-eating monkeys, the species belongs to the subfamily Colobinae, which include the langurs and snub-nosed monkeys of Asia and the colobus monkeys of Africa. Based on molecular studies of colobine monkeys, the Cat Ba langur is closely related to the white-headed langur (*Trachypithecus* [*poliocephalus*] *leucocephalus*) in southern China (Fig. 4) and the Francois' Langur (*Trachypithecus francoisi*) in southern China and northern Vietnam (*Roos et al.*, 2007) (Fig. 5).

The fur of the Cat Ba langur is dark brown while head, neck and shoulder are bright golden to yellowish-white. A grey band goes from the thighs to the back above the root of the tail. Babies are golden-orange, the fur starts to change colour from about the fourth month on (CBLCP, pers. observ.). In contrast to males, females have white hairs and visible white skin in their pubic area. The average head-body length in adults is 53 cm and length of the tail 85 cm (Nadler & Ha Thang Long, 2000). Weight is estimated to vary between 9 and 11 kg.

Threats

The status of the langur is critical for several reasons. The main reason for the historical decline of the Cat Ba langur population was poaching. In former times the hunting of the langurs was motivated as a kind of leisure time activity, whereas mainly macaques were hunted for their meat and to produce monkey balm. Also langurs were regularly trapped by chance. Nadler & Ha Thang Long (2000) discovered a shocking number of 500 to 800 individuals were killed between 1970 and 1986. The

Fig. 4. White-headed langur group (*Trachypithecus* [*poliocephalus*] *leucocephalus*).

Photo: Tilo Nadler.

Fig. 5. Francois' langur with juvenile (*Trachypithecus francoisi*).

Photo: Tilo Nadler.

more the number of langurs decreased the more attractive the langurs became for poachers, because it became a rare commodity. Although the poaching of Cat Ba Langurs is under control now, the possibility of poaching continues to be an important threat to the species. Because of the observant and protective attitude of the dominant male in a langur group; initiating movement and sitting on bare cliffs or rocks inspecting the surroundings; males are more easily hunted. The last reported poaching case on langurs on Cat Ba Island since the start of the CBLCP was a male in 2001.

Because of the enormous hunting pressure in the past, the population has become severely fragmented into small subpopulations. Currently the North of Cat Ba Island no longer has reproductive social units. Another threat is a serious fragmentation of the langur habitat. The human population and the number of tourists visiting Cat Ba Island are increasing rapidly and continuously. Besides the negative impact upon the habitat of the langur through unsustainable use of resources and environmental pollution, the langur groups are trapped between new roads, settlements and agricultural areas. Individuals can no longer transfer between groups and therefore partner choice for reproduction is seriously limited. Together with the low number of individuals this creates a high risk of inbreeding, with its well-known negative effects, in the very near future. Strict conservation measures are thus necessary to save the Cat Ba langur from extinction.

Cat Ba Langur Conservation Project (CBLCP)

After the rapid decline of the Cat Ba langur population had been observed by Nadler & Ha Thang Long (2000), the Zoological Society for the Conservation of Species and Populations (ZGAP) together with Münster Zoo, both located in Germany, decided to start a project in order to save the Cat Ba langur. They established the CBLCP under the management of Roswitha Stenke in November 2000. Together with Vietnamese counterparts, the Ministry of Agriculture and Rural Development, replaced by the Provincial Department of Agriculture and Rural Development in 2005, and Cat Ba National Park, an emergency program for rigorous protection of the Cat Ba Langur was designed. In 2008 the main responsibility for the coordination of the CBLCP was transferred from ZGAP to Münster Zoo. At the same time a new project manager started and in the beginning of 2009 an additional position for a deputy manager was established. At present the management board on site in Vietnam is filled by a veterinarian and a zoologist. The CBLCP is dedicated to design, organize and support several protection measures on Cat Ba Island with the main aim to conserve the Cat Ba langur and to contribute to the conservation of Cat Ba's overall biodiversity.

PROTECTION MEASURES

Establishment of a Sanctuary

One of the first achievements of the cooperation between the Cat Ba National Park and the CBLCP, in 2001, was the establishment of a strictly protected area inside the national park which contains approximately 35% of the remaining langur population. Recent observations revealed that there are more male langurs than expected in this area, occurring in two reproductive groups with an additional solitary male. In the past this area with a length of 8 km and a width of 3.5 km carried a much higher number of langurs. This indicates that the current number of animals is far below carrying capacity, making this area ideal for the recovery of the species. This peninsula inside the national park is protected through natural barriers like steep cliffs and only a very small land bridge as a connection to the main island. Four ranger stations are charged to prevent human presence on the land. Several local people are contract holders with the duty to protect the entrance of fjords close to the sanctuary. In return, they are the only floating house owners legally allowed to stay inside the National Park. To mark the whole area several buoys and signs were set, informing about the status of the sanctuary.

Organization of a Protection Network

The general protection in the national park is supported by the CBLCP through providing equipment for the daily work, including the radio system of the park, boats, and the maintenance of a floating ranger station and education material. Capacity building of national park staff through the organization of regular training courses for rangers and the management board of the park plays an important part in the success of long-term conservation measures. Recently a violation database has been designed to standardize the documentation of violations and to simplify the information exchange between park rangers, district rangers and the CBLCP. Beside the cooperation with the national park, several groups of local people are part of a community based langur protection program, organized and supported by the CBLCP.

In three communes several local people are in charge of monitoring and protecting single langur groups occurring in their areas. These so called 'langur guards' are also responsible to educate people in their communes and to exchange the collected data with the CBLCP regularly. To protect the forest close to langur groups, forest protection groups (BVR) in two communes are responsible to clean the forests from traps and to assess the human impact in these areas. Because the communes of the BVRs are actively involved in wildlife trade, the members of these groups are also essential as informants in the fight against wildlife trade. Additionally, particularly sensitive areas and rare animal and plant species are under strengthened control through seasonal increase in the frequency of patrols in cooperation with national park rangers.

Although all langur groups occur inside the national park, Cat Ba Island in its entirety should be considered as part of the langur habitat that needs to be conserved for the future. Under the supervision of district rangers with the CBLCP as a supporter, six forest protection clubs (FPC) were initiated to protect the forests outside the national park. Apart from that the FPCs are also responsible to fight against forest fires, to organize loudspeaker education in their communes and to visit households of well-known violators to educate them on their crimes and the impact it has on the environment. A special task of the FPC in Cat Ba Town is the fight against wildlife trade. Cat Ba Island and especially Cat Ba Town are hotspots for illegal trade of wild animals. Since 2008 an instruction of the People's Committee in Hai Phong outlaws every kind of wildlife trade. Still, law enforcement represents a great challenge, amongst other things through existing connections between traders and influential persons. In total approximately 200 local people are daily involved in the various protection programs of the CBLCP.

Additional cooperation on Cat Ba Island

So far all protection and education programs were aimed at adult inhabitants of Cat Ba Island. With the support of the Biosphere Reserve and the People's Committee of Cat Hai, the CBLCP has been asked to educate teachers on Cat Ba Island in conservation measures. Additional regular presentations for school children are planned in the near future with the aim to get younger generations interested in their forests and its protection.

Through an increasing number of immigrants and the pressure of tourism, Cat Ba Island is facing the challenge to deal with these impacts in a sustainable way. The CBLCP is involved in a program of the University of Queensland which, together with UNESCO and Vietnamese authorities, they started in order to assess the fundamental problems of unsustainable development on Cat Ba Island, focused on tourism and conservation work. The design of a theoretical model should help to analyse the main problems with the aim to find and finally implement solution strategies.

Translocation

In the north of Cat Ba Island there are no reproductive social units, and at least two groups contain only females. Because of the low number of individuals and suitable habitat remaining on Cat Ba Island, a plan was designed as part of a longterm strategy to involve these females in reproduction. Three females, isolated on a small offshore island, were chosen as the first group to be translocated to the sanctuary. In the past one male and two females became isolated on the offshore island because of the destruction of the mangrove forest which was once a connection between the main island and the smaller islands. In 2001 one female baby was born. Only several months later the male of the group was shot by a poacher. The three females are well-known and regularly monitored by several langur guards. Collected data suggest that all three females are still of reproductive age. So far a sleeping cave was chosen as the catch site and a catching net has been designed, first steps towards habituation took place successfully and several potential release sites have been identified. Together with the support of Vietnamese authorities and the IUCN, the preparations for translocation are ongoing.

CONCLUSIONS

For a long time the Cat Ba langur has been considered a ‘flagship species’ on Cat Ba Island. This has positively influenced governmental decisions and guaranteed greater conservation efforts and raised awareness of the species on all levels. Nevertheless more education and strengthened implementation of conservation measures must take place. The protection of the Cat Ba langur goes hand in hand with the protection of its habitat. The poaching of langurs was brought under control, but the exploitation of the forests on Cat Ba Island is still ongoing. Because all langur groups exist inside the national park, the CBLCP is focused on reinforcing the cooperation with the park to identify conservation priorities for the whole area. More long term protection strategies must be developed by all stakeholders involved on Cat Ba Island. A recent step is the implementation of the ranger guidelines which include more strategic and controlled patrolling and improved communication. Also the CBLCP needs to make great efforts to raise the awareness of Cat Ba’s inhabitants that their langur and their Island is unique and something to take pride in and preserve. With that awareness, the enormous biodiversity in this area has a chance to persist.

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BẢO TỒN VOỌC CÁT BÀ (*TRACHYPITHECUS* [*POLIOCEPHALUS*] *POLIOCEPHALUS*) THÔNG QUA "DỰ ÁN BẢO TỒN VOỌC CÁT BÀ"

TÓM TẮT

Voọc Cát Bà (*Trachypithecus* [*poliocephalus*] *poliocephalus*) là một đại diện cho loài khỉ ăn lá đặc hữu của đảo Cát Bà, nằm ở phía Bắc Việt Nam. Do nạn săn bắt, sự chia cắt sinh cảnh và các tác động gây ra bởi áp lực gia tăng số lượng người nhập cư và phát triển du lịch. Voọc Cát Bà đã bị đe doạ đến mức "Cực kỳ Nguy cấp" theo Sách Đỏ IUCN. Chỉ còn khoảng 60 đến 70 cá thể sống sót trong tự nhiên. Mặc dù được báo động với số lượng còn lại rất ít nhưng vẫn còn hy vọng để bảo tồn loài voọc Cát Bà. Kể từ khi Dự án Bảo tồn voọc Cát Bà (CBLCP) đi vào hoạt động năm 2000, số lượng cá thể loài được ghi nhận là tăng lên. Ngoài việc thiết lập khu bảo vệ nghiêm ngặt, Dự án còn triển khai mạng lưới bảo tồn dựa vào cộng đồng trên đảo Cát Bà. Hàng ngày, có gần 200 người cùng tham gia vào bảo vệ voọc Cát Bà và môi trường sống của chúng. Ngoài ra, Dự án Bảo tồn voọc Cát Bà còn tổ chức nhiều chương trình hoạt động khác cùng với đối tác địa phương và cộng đồng quốc tế. Thông qua các bài giảng tại các trường học, những thế hệ tương lai sẽ có cơ hội nâng cao nhận thức về các biện pháp bảo tồn. Cùng với chính quyền địa phương xã, huyện, thành phố Hải Phòng và UNESCO, Trường Đại học Queensland hiện đang thực hiện một Chương trình nhằm tìm kiếm giải pháp cho du lịch bền vững ở trên đảo Cát Bà. Tất cả các biện pháp này đều nhằm mục đích mang lại cơ hội cho Cát Bà, một vùng thiên nhiên độc đáo, nổi bật - điều kiện tiên quyết cho sự tồn tại của voọc Cát Bà.

REFERENCES

Government of Vietnam & Global Environment Facility Project VIE/91/G31 (1994). National Biodiversity Action Plan for Vietnam. Hanoi.

IUCN (2008): 2008 IUCN Red List of Threatened Species. <www.iucnredlist.org>.

Ministry of Science and Technology & Vietnam Academy of Sciences and Technology (2007): Red Data Book of Vietnam, Part 1. Animals. Publ. House Nat. Sci & Techn.,Hanoi, (In Vietnamese).

Mittermeier, R., Ratsimbazafy, J., Rylands, A.B., Williamson, L., Oates, J.F., Mbora, D., Ganzhorn, J.U., Rodríguez-Luna, E., Palacios E., Heymann, E.W., Cecília, M., Kierulff, M., Yongcheng, M., Supriatna, J., Roos, C., Walker, S. & Aguiar, J.M. (2007): Primates in Peril: The World's Most Endangered Primates, 2006-2008. Primate Conservation 22, 1-40

Nadler, T. & Ha Thang Long (2000): The Cat Ba Langur: Past, Present and Future. The Definitive Report on *Trachypithecus poliocephalus*, the World´s Rarest Primate. Frankfurt Zoological Society, Hanoi.

Roos, C., Vu Ngoc Thanh, Walter, L. & Nadler, T. (2007): Molecular systematics of Indochinese primates. Vietnamese J. Primatol. 1 (1), 41-53.

Stenke, R. & Chu Xuan Canh (2004): The Golden-headed Langur (*Trachypithecus poliocephalus poliocephalus*) on Cat Ba Island – Status, Threats factors and recovery options. In: Nadler, T., Streicher, U. & Ha Thang Long (eds.) Conservation of Primates in Vietnam; pp. 72-77. Frankfurt Zoological Society, Hanoi.

Stenke, R., Raffel, M. & Wirth, R. (2008): Conserving the Cat Ba langur, one of the World´s rarest primates. WAZA Magazine 9, 14-17.

25

THE PRIMATE REINTRODUCTION PROGRAM IN PHONG NHA-KE BANG NATIONAL PARK, CENTRAL VIETNAM

MARTINA VOGT AND BERNHARD FORSTER

SUMMARY

In 2005, as part of the Vietnam Primate Conservation Programme of the Frankfurt Zoological Society (FZS), FZS in cooperation with Cologne Zoo initiated a primate reintroduction program in the Phong Nha – Ke Bang (PNKB) National Park in Central Vietnam. In the long run, the project strives to enforce and link currently isolated populations of two endangered primate species, the Hatinh langur (*Trachypithecus hatinhensis*) and red-shanked douc langur (*Pygathrix nemaeus*). PNKB National Park comprises about 125,000ha and is one of the last remaining areas of retreat for both species. The animals for reintroduction come from the Endangered Primate Rescue Center in Cuc Phuong National Park. As a first step, a semi-wild enclosure was built and in September 2007 two groups of Hatinh langurs, comprising four individuals each, all equipped with radio transmitters, were brought to the site. A continuous long-term monitoring program was started for general supervision and protection of the langurs, as well as to collect data on their behavioural ecology. As the long-term aim of the program is the final release of the primates into their natural habitat, forest protection is another essential component of our work. In cooperation with the Forest Protection Department, a ranger program was initiated to set up special protected areas in PNKB National Park. To define these areas as well as to obtain actual data on the population size and distribution of the wild populations, primate surveys are carried out. Moreover, awareness campaigns for locals and tourists are arranged.

INTRODUCTION

In 2005, as part of the Vietnam Primate Conservation Programme of the Frankfurt Zoological Society (FZS), FZS in cooperation with Cologne Zoo (CZ) initiated a Primate Reintroduction Program in Phong Nha-Ke Bang (PNKB) National Park, Central Vietnam (Nadler & Streicher, 2003; Vogt *et al*., 2006; Vogt & Forster, 2008). In the long run, the project strives to enforce and link currently isolated populations of two endangered primate species, the Hatinh langur (*Trachypithecus hatinhensis*) (Fig. 1) and red-shanked douc langur (*Pygathrix nemaeus*) (Fig. 2). Hatinh langurs and red-shanked douc langurs are endemic to Truong Son (Annamite Mountains) in Central Vietnam and Lao PDR. Although red-shanked douc langurs have been recently confirmed from Cambodia (Rawson & Roos, 2008). Both species are mainly threatened by poaching, and high hunting pressures especially in the past led to a severe decline of their natural populations (Nadler *et al*., 2003). The distribution of Hatinh langurs is restricted to Vietnam's Quang Binh and Quang Tri Provinces (BirdLife International Vietnam Programme 2005; Nadler *et al*., 2003). Besides the recently declared Bac Huong Hoa Nature Reserve in Quang Tri, the PNKB NP in Quang Binh is the only protected area within the distribution range of Hatinh langurs in Vietnam

Fig. 1. Hatinh langur group (*Trachypithecus hatinhensis*) at Phong Nha-Ke Bang National Park.
Photo: Bernhard Forster.

Fig. 2. Red-shanked Douc Langur (*Pygathrix nemaeus*).
Photo: Tilo Nadler.

(Nguyen Manh Ha, 2006; Timmins *et al*., 1999) (Fig. 3). The distribution of red-shanked douc langurs ranges from about 18º40'N latitude in Lao PDR and 19º30'N in Vietnam southwards to about 14º33'N. In Vietnam the occurrence of this species has been confirmed in seven areas, but there are currently no estimates of the total remaining population size (Nadler *et al*., 2003).

PNKB National Park (17º22'-17º44'N; 106º42'-106º23'E), located along the border to Lao PDR in Quang Binh Province and comprising about 125,000 ha, is an important key area for the conservation of both species. Animals for reintroduction come from the Endangered Primate Rescue Center (EPRC) in Cuc Phuong, northern Vietnam. Founded in 1993 by the Zoological Society for the Conservation of Species and Populations (ZGAP) and the IUCN/SSC Primate Specialist Group, it is the operational basis for the Vietnam Primate Conservation Programme of Frankfurt Zoological Society. Since its establishment in 1993, the EPRC has received, among other species, numerous confiscated Hatinh and douc langurs. The animals have been successfully composed into breeding groups, and today both species already bred in the second generation.

The Primate Reintroduction Program comprises two main steps. First of all, small groups of Hatinh langurs and later on red-shanked douc langurs should be transferred to a semi-wild area in PNKB National Park, where they are maintained, protected and observed for an appropriate period of time. Second, after a sufficient preparation phase, the animals will be finally released into specified areas of the national park.

THE SEMI-WILD ENCLOSURE

Semi-wild areas have turned out to be a suitable tool to prepare animals for a potential reintroduction, as they allow the animals to adjust to wild food sources, natural climbing substrates, selection of suitable resting sites and predator avoidance, while at the same time containing them in a certain area and protecting them from hunting and other human disturbance (Nadler & Streicher, 2003). In addition, these facilities offer favourable conditions for research and monitoring. Therefore, as the initial step of the program, a semi-wild enclosure was built at the border of PNKB. A single forested limestone hill of 20 ha, containing different vegetation types as well as some small streams, rocks and limestone cliffs was selected as an appropriate area and

Fig. 3. The extensive karst forest of Phong Nha – Ke Bang National Park.

Photo: Martina Vogt.

surrounded by an electrical fence (Fig. 4 and 5). Due to several challenges such as the rough terrain, impassable parts and some devastating typhoons during the rainy season, construction was a demanding undertaking, but was finally completed in summer 2007. The facility comprises a cage inside the enclosure for temporary housing of the langurs after their arrival in PNKB. Moreover a field station was set up at the site and permanently manned by at least two staff for protection, monitoring and maintenance.

TANSFER AND MONITORING OF LANGURS

In early September 2007, the first primates were transferred to the semi-wild enclosure (Fig. 6). Two groups of Hatinh langurs, comprising four individuals each, all equipped with radio transmitters were brought to the site. Each group contained one male and three females. At that time a long-term, continuous monitoring program was started for general supervision and protection of the langurs, as well as to collect data on their behavioural ecology.

During the first months, spatial use and movement patterns as well as the social structure were the focus of our observations. The langurs settled-in well and rapidly explored the whole enclosure. Original group composition was not maintained, but the langurs finally merged into one group. While during the first weeks, observation conditions were limited as animals were hiding under dense liana covers, later on the langurs gradually exposed themselves in more open areas, allowing extended data sampling periods (Vogt *et al*., 2008). Supported by students and volunteers, we subsequently focused on the langurs feeding ecology. Preliminary data show that the Hatinh langurs spend 30% of their time with feeding, 25% observing, 23% with resting, 14% moving and 8% with social behaviour. During the day there are two feeding peaks, one in the morning between 7:00 and 8:00 am, another in the late afternoon between 4:00 and 5:30 pm. The langurs mainly feed on trees (66%) and lianas (33%), feeding almost exclusively on leaves (98.7%) and rarely fruits (1.3%). Further data are currently being collected and results will be analysed and prepared for publication.

Continuous observations for more than one year now show that the first transfer was successful and the langurs adapted quite well to the conditions in PNKB National Park. Therefore further relocations shall take place in the near future.

Fig. 4. The 20 ha semi-wild enclosure, an isolated limestone block surrounded with elektric fence.

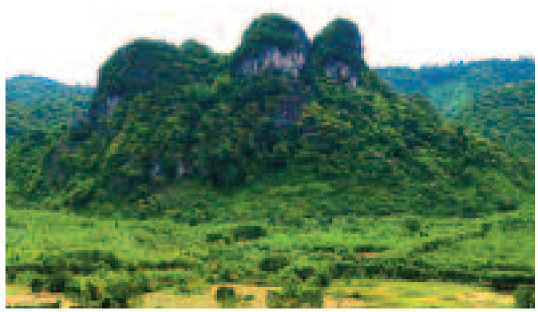

Fig. 5. The semi-wild enclosure at the border of Phong Nha – Ke Bang National Park.

Photo: Judith Riedel.

Fig. 6. First transfer of captive bred Hatinh langurs from the Endangered Primate Rescue Center into the semi-wild enclosure.

Photo: Jens Gerlach.

Fig. 7. Local people use the strictly prohibited electric fishing also inside the national park.
Photo: Martina Vogt.

FOREST PROTECTION

With regard to the final release in the future, forest protection is another important component of the project. To prepare and develop so called Forest Protection Leagues, which should be established later on for the protection of the final release sites in the national park, we closely cooperate with the Forest Protection Unit (FPU) and the ranger stations of the national park. One of the main threats to the biodiversity of the PNKB National Park is the still ongoing human impact, such as illegal logging and hunting (Fig. 7). Despite the considerable number of about 250 rangers and forest guards, who are working in eight ranger stations situated at the "main gates" to the park, the protection of the forest is not being realized successfully. Poor living conditions in the ranger stations, poor salaries, corruption, low motivation, young and inexperienced forest protection staff, lack of equipment and training as well as fear of arresting loggers and hunters are some of the main reasons for that problem.

Hence in 2006 CZ in cooperation with FZS started a Forest Protection Program (FPP), which currently includes four out of eight ranger stations. The basic concept of this program is regular patrols of defined areas, recognizing essential criteria such as human impact, main routes of hunters and loggers, suitability as release sites etc. Besides general control the patrol team has to destroy traps and camps, collect and burn all rubbish, confiscate hunted forest products and expel unauthorized persons from the national park. Each Station has to patrol several routes (length between 2 and 10 km) and all patrol activities have to be recorded by GPS. The patrol teams alternately conduct one- or multi-day patrols. Monthly meetings, patrol record sheets, participation of project staff in patrols and, most importantly, GPS-based patrols allow for efficient supervision and contribute to an effective implementation of the FPP. As the four ranger posts are located adjacent to each other, the patrolled regions overlap and in total cover an area of approximately 220 km², which corresponds to 18% of the whole national park area.

In return the project supports the ranger stations by providing patrol and field equipment, detailed maps of patrol areas and allowances and help to improve the living conditions in the rather poorly equipped stations. Moreover training and capacity building is offered on topics most needed such as law enforcement, species identification, and application of GPS etc. In addition, exchange programs with FPUs of other National Parks in Vietnam were initiated by FZS and CZ. The objective of this program is to enhance the knowledge about other national parks, encourage information transfer between the participating FPUs, presenting patrol concepts and protection challenges in the respective national parks.

SURVEYS IN PHONG NHA-KE BANG NATIONAL PARK

In order to identify potential release sites, as well as to assess the current population size and distribution of both langur species in PNKB National Park, primate surveys have to be conducted in different areas of the park. In the past there have been several surveys to determine the biodiversity of the PNKB NP including studies focused on primates (Dinh Hai Duong, 2005; Le Khac Quyet *et al*., 2002; Le Xuan Canh *et al*., 1997; Nguyen Quang Vinh, 2002; Timmins *et al*., 1999). Results of these investigations showed that the density of most primate species seems to be relatively low, but these data did not provide estimates of population sizes. To protect endangered species and to observe important population dynamics such as numbers and structure in time, data collected by standardized census methods are necessary.

Thus, for PNKB National Park we investigated for the first time the populations of diurnal primates based on line transect and distance sampling (Buckland *et al*., 2001). After conducting basic pre-surveys in 2006, we started the main research in 2007. In cooperation with Zoologisches Forschungsmuseum Alexander Koenig / University of Bonn, a five-months-study was conducted, focused on Hatinh langurs and red-shanked douc langurs. The data provided by this research allows a rough preliminary estimate of approximately 1500-2500 Hatinh langurs and 1000-2000 red-shanked douc langurs in PNKB National Park (Haus *et al*., 2009). However, as this has been only the first primate survey in PNKB based on standardized census methods, further data collection is necessary to consolidate population density estimates. Especially the proposed national park extension area has to be included in future research.

The surveys also help to asses the degree of a population fragmentation, i.e. if and to what extent subpopulations are separated from each other. These gaps could be potential release sites, provided that they offer a suitable habitat for the respective species. Further selection criteria include the carrying capacity of the habitat (i.e. number, composition and size of langur groups in close vicinity etc.), accessibility and, with regard to post-release monitoring general topography and observation conditions. So far, several suitable areas have been identified, but the final decision is still to be made.

EDUCATION AND AWARENESS

Last but not least, education and awareness programs, especially for locals and tourists, are to be carried out as well. These activities have just started and so far mainly focus on the production and distribution of information materials, promotional items and souvenirs. Education lessons and information events were held for schools in the PNKB region, during which all children received caps and raincoats from the project (Fig. 8). As public relations lead to increasing numbers of interested visitors to the semi-wild area, in the future the site shall not only be used for further research on langurs, but also for small scale tourist programs, such as an education trail and observation spots around the hill.

Fig. 8. Education and awareness campaign in a local primary school.

Photo: Martina Vogt.

OUTLOOK

The Primate Reintroduction Program is a long-term project and there are still many things to be put into action. Awareness and education projects for locals, tourists and surrounding areas have to be continued. The surveys in the national park will go on, finally leading to the selection of some suitable release sites. A special Forest Protection League will be trained and assigned for the protection of these reintroduction areas. Post-release monitoring with radio tracking will not only help ensure the protection of the released animals, but also allow the collection of important eco-ethological data.

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CHƯƠNG TRÌNH TÁI HÒA NHẬP LINH TRƯỞNG TẠI VƯỜN QUỐC GIA PHONG NHA-KẺ BÀNG, MIỀN TRUNG VIỆT NAM

TÓM TẮT

Vào năm 2005, trong khuôn khổ Chương trình Bảo tồn Linh trưởng Việt Nam của Hội Động vật học Frankfurt (FZS), FZS đã hợp tác với Vườn thú Cologne triển khai "Chương trình Tái hòa nhập Linh trưởng tại Vườn Quốc gia Phong Nha-Kẻ Bàng (VQG PN-KB) ở miền Trung Việt Nam. Chủ trương hoạt động lâu dài, mục tiêu của dự án nhằm tăng cường thực thi pháp luật và liên kết các quần thể của hai loài linh trưởng nguy cấp tại đây mà chúng đang sống biệt lập với nhau, đó là loài voọc Hà Tĩnh (*Trachypithecus hatinhensis*) và voọc chà vá chân đỏ (*Pygathrix nemaeus*). Vườn Quốc gia Phong Nha-Kẻ Bàng có diện tích 125,000 ha và là một trong những khu vực sinh sống cuối cùng của cả hai loài linh trưởng này. Động vật của chương trình được sinh sản trong điều kiện nuôi nhốt ở Trung tâm Cứu hộ Linh trưởng Nguy cấp (EPRC), Vườn Quốc gia Cúc Phương. Giai đoạn đầu tiên đã tiến hành xây dựng một khu nuôi bán hoang dã với diện tích 20 ha. Đến năm 2007, hai đàn voọc Hà Tĩnh, mỗi đàn gồm 4 cá thể được gắn máy phát tín hiệu và được đưa vào khu nuôi bán hoang dã này. Tiếp theo là hoạt động giám sát dài hạn diễn ra liên tục nhằm mục đích theo dõi và bảo vệ quần thể loài voọc này cũng như thu thập các thông tin về các tập tính sinh thái của chúng. Với mục đích dài hạn của Chương trình là tái hòa nhập động vật trở về với môi trường sống tự nhiên vốn có của chúng, do vậy công tác bảo vệ rừng cũng là một hoạt động tất yếu của dự án. Hợp tác với Chi cục kiểm lâm, dự án đã xây dựng một chương trình tuần rừng cho kiểm lâm để xây dựng một số khu bảo vệ nghiêm ngặt trong VQG PN-KB. Nhằm đánh giá được các khu vực này, công tác thu thập dữ liệu thực tế về kích cỡ quần thể và sự phân bố loài đã được tiến hành khảo sát. Thêm vào đó, các chiến dịch nâng cao nhận thức bảo tồn cho người dân địa phương và du khách cũng được thực hiện.

REFERENCES

BirdLife International-Vietnam Programme (2005): The rare Hatinh langur discovered in Quang Tri province for the first time. News Release. <www.birdlifeindochina.org>. Downloaded January 24, 2008.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L., & Thomas, L. (2001): Introduction to distance sampling. Estimating abundance of biological populations. Oxford University Press, New York.

Dinh Hai Duong (2005): Survey results of primate species in the Phong Nha–Ke Bang National Park and adjacent areas. Report to the administration of the Phong Nha–Ke Bang National Park. (In Vietnamese; unpublished).

Haus, T., Vogt, M., Forster, B., Vu Ngoc Thanh & Ziegler, T. (2009): Distribution and Population Densities of Diurnal Primates in the Karst Forests of Phong Nha – Ke Bang National Park, Quang Binh Province, Central Vietnam. Int. J. Primatol. 30, 301-312.

IUCN (2008): 2008 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded April 05, 2009.

Le Khac Quyet, Dinh Hai Duong, Bui Ngoc Thanh, & Le Van Long (2002): Results of Surveys on Primates in Vuc Tro and Hung Dang Areas, Phong Nha–Ke Bang National Park, Quang Binh Province, Vietnam, 09/2002. Report to Fauna & Flora International - Vietnam Programme, Hanoi. (In Vietnamese; unpubl.).

Le Xuan Canh, Truong Van La, Dang Thi Dap, Ho Thu Cuc, Ngo Anh Dao, Nguyen Ngoc Chinh & Nguyen Quoc Dung (1997): A Report on Field Surveys on Biodiversity in Phong Nha–Ke Bang Forest (Quang Binh Province) Central Vietnam. WWF and UNDP, Hanoi.

Nadler, T., Momberg, F., Nguyen Xuan Dang & Lormee, N. (2003): Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys. Fauna & Flora International-Vietnam Program and Frankfurt Zoological Society, Hanoi.

Nadler, T. & Streicher, U. (2003): Re-introduction possibilities for endangered langurs in Vietnam. Re-introduction News 23, 35-37.

Nguyen Manh Ha (2006): Some observations on the Hatinh langur, *Trachypithecus laotum hatinhensis* (Dao, 1970), in north central Vietnam. Primate Conservation 21, 149–154.

Nguyen Quang Vinh (2002): Report on primate monitoring in the third conduct. Areas: Cop Bo Binh and Hung Lau. Phong Nha–Ke Bang National Park, WWF LINC Project. (In

Vietnamese; unpubl.).
Rawson, B. & Roos, C. (2008): A new primate species for Cambodia: *Pygathrix nemaeus*. Cambodian J. of Natural History 1(1), 7-11.
Timmins, R.J., Do Tuoc, Trinh Viet Cuong & Hendrichsen, D.K. (1999): A preliminary assessment of the conservation importance and conservation priorities of the Phong Nha-Ke Bang proposed National Park, Quang Binh Province, Vietnam. Fauna & Flora International-Indochina Programme, Hanoi.
Vogt M., Forster B., Pagel, T. & Ziegler, T. (2006): Neues vom Naturschutzprojekt des Kölner Zoos in Vietnam. Zeitschrift des Kölner Zoo 49 (1), 35-49.
Vogt, M. & Forster, B. (2008): The Primate Reintroduction Program in Central Vietnam. WAZA Magazine 9, 18-21.
Vogt, M., Forster, B. & Riedel, J. (2008): Radio tracking of Hatinh langurs (*Trachypithecus laotum hatinhensis*) at a semi-wild enclosure in Phong Nha – Ke Bang National Park, Central Vietnam. Vietnamese J. of Primatol. 1 (2), 3-12.

26

THE USE AND ABUSE OF GIBBON SURVEY TECHNIQUES: SHORTCOMINGS OF AUDITORY SURVEY TECHNIQUES

BENJAMIN M. RAWSON

SUMMARY

Gibbon (Family Hylobatidae) populations are under heavy threat across their range. Having accurate population estimates for species and populations is important for determining threat level and for prioritising populations for conservation interventions, however, methods used for surveying gibbons have a large number of pitfalls and assumptions that often lead to erroneous results. Here I outline some of the most common errors made by gibbon surveyors and discuss the inherent shortcomings of using auditory survey methods, especially in relation to density and population estimate calculation.

INTRODUCTION

Of the 16 species of gibbons recognized under the IUCN Red List of Threatened Species, all are considered threatened with extinction with four considered “Critically Endangered”, eleven “Endangered” and only one listed as “Vulnerable”. The fact that gibbons are one of the most threatened families of primate means that there is a great need and desire to determine and monitor their status in order that conservation interventions can be conducted in the most effective fashion. This need for population surveys has been mirrored in an increase in funding in recent years for gibbon conservation work, most significantly through USFWS Great Ape Conservation Fund, resulting in an increase in survey work on gibbon populations throughout their range.

While exploration has been made into the use of occupancy methods as laid down by MacKenzie *et al*. (2006) (see Hallam & Johnson, this volume) and with large survey effort and healthy gibbon populations, distance sampling can be effective (Pollard *et al*., 2007; Rawson *et al*., 2009), most population surveys use a point count approach taking advantage of gibbons’ loud vocalizations.

The seminal paper concerning this approach to surveying gibbon populations is Brockelman & Ali (1987). In this paper they outline the auditory technique that is still used in the vast majority of gibbon surveys today in one form or another (e.g. Duckworth *et al*., 1995; Nijman & Menken, 2001; O'Brien *et al*., 2004; Whittaker, 2005; Traeholt *et al*., 2006; Ruppell, 2008; Rawson *et al*., 2009). This approach takes advantage of the ecology of gibbons, specifically that they make loud, sex specific vocalizations that can be heard from several kilometers away, and that gibbons form stable family groups that are strongly territorial.

The auditory survey technique uses point counts, with surveyors typically located in areas of high elevation such as mountain tops and ridges where gibbons can be heard more easily. When gibbons are heard to vocalize from these points (commonly called listening posts), the observer notes the time, compass bearing and approximate distance to the group. Brockelman & Ali (1987) outline two basic approaches for conducting auditory surveys at listening posts. The first involves simply using standalone listening posts, a single point, while the second involves having two or more listening posts in close proximity in order that there is overlap in listening radius between posts which allows for triangulation of calling groups (see Brockelman & Ali, 1987; Fig. 4a and 4b respectively, p. 43).

The number of gibbon groups within the survey area is determined by mapping the locations of heard vocalizations. The fact that gibbons sing usually during a delimited time in the morning and do not move outside of their territories means that vocalizations mapped in different areas can generally be attributed to different groups. Groups do not, however, make these loud vocalizations every day, meaning that there will be animals within the survey area that are not detected. To help counter this, survey teams often remain at the same listening post for several days in order to survey a larger proportion of the population through cumulative addition of mapped groups over days.

While this approach is generally appropriate for finding the location of groups for very rare species (e.g. Johnson *et al*., 2005; Le Trong Dat & Le Huu Oanh, 2007; Geissmann, 2007; Luu Tuong Bach & Rawson, 2009), there are considerable issues when these techniques are used to determine population densities or used as sample units for extrapolation to population numbers across non-surveyed areas. Below I describe the inherent assumptions in the techniques and their shortcomings.

METHODS

Non-random Locations of Listening Posts

An overarching shortcoming of almost all gibbon surveys attempting to determine density and population estimates using auditory techniques is that listening posts are generally not located using a random sampling design. This approach is generally taken for one or more of two reasons.

First, surveyors take advantage of the prevailing topography, situating listening posts in areas of high elevation, in order to maximize the distance that one can hear calling gibbons (see O'Brien *et al*., 2004; Rawson *et al*., 2009 for two rare exceptions). Because of issues with sound transmission into valleys and gullies, high elevation areas are selected as it allows surveyors to effectively survey greater areas with the same survey effort. However, calculating densities from posts that are non-randomly placed on hilltops violates assumptions of random sampling designs and are not susceptible to evaluation using theorems of probability theory (e.g. Krebs, 1999). This data can not therefore be used in site wide density calculations or extrapolations of population estimates.

The second reason posts are often placed non-randomly is that gibbon populations are often fragmented and heavily suppressed, meaning that survey effort is wasted in randomly assigning survey locations across a landscape where populations are patchy. In these instances, surveyors will generally look at a range of information sources such as species appropriate habitat, past records and interview surveys with locals who regularly visit the forest, in order to determine the most important areas to survey and exactly where to place their listening posts.

While this is an appropriate approach for finding remaining populations of rare species, it is not an appropriate approach for determining density estimates for anything other than the area which has been surveyed, i.e. they can not be extrapolated to the population as a whole. For example, it has been suggested that gibbon density in Pu Mat National Park is lower than that in several other areas in Vietnam and Laos (Ruppell, 2008), however density estimates from this and all comparative studies come from non-randomized survey protocols with small sample sizes, and as such comparisons are not warranted. The real danger in these assertions is that they may provide misinformation about the relative health of populations and their relative conservation value, meaning that sites may be prioritized for conservation interventions based on erroneous assumptions about the relative densities of gibbons in these areas.

Neither can these estimates educate us about anything other than the maximum possible density the species may be capable of attaining. For example, density estimates derived in this way have been used to hypothesize that more northern populations of *Nomascus* gibbons may occur at lower densities (Geissmann *et al*., 2007), however all density estimates quoted that I could obtain came from non-randomized surveys and/or were conducted in areas with heavily impacted gibbon populations and therefore are not useful in deriving theories about ecological correlates of density.

Errors in Distance Estimates

Calculating the area surveyed from a listening post, and thus the density of gibbons at that location, remains one of the most problematic issues in conducting auditory surveys for gibbons. Two approaches are generally used for calculating the area surveyed, and can equally be applied to stand alone or overlapping post survey designs, although areas of overlap need to be counted only once in the latter instance:

a) The estimated maximum distance that gibbons can be heard vocalizing (*r*), which is then used as a radius to calculate the area of a circle around the post which has been surveyed (using the formula Πr^2) or;
b) As in (a) above, however the dimensions of the calculated circle are then clipped based on the observers assessment of any topographical conditions which prohibit hearing in some areas within the surveyed area (e.g. on the opposite side of high mountains).

Both of these approaches, however, have an inherent problem; estimating *r*, maximum listening distance, is prone to very large inter- and even intra-observer error. In fact, inexperienced observers can differ in estimated distance by half an order of magnitude from one another (Rawson *et al*., 2007). Additional factors such as changes in ambient noise level during different parts of the day, local topography and even the effect that air temperature has on sound transmission means that distance estimates will always be suspect. Even if there is a relatively small difference between estimated *r* relative to *r*'s actual value (assuming such a constant exists) the effects this has on density estimates are large, as area increases non-linearly with increased *r*. For example, the difference in using an estimated *r* of 1.0 km radius and one of 1.5 km (a difference which is very difficult to differentiate in the field), gives a calculated density of more than double.

Many studies do not acknowledge this issue at all, or at least do not explicitly discuss how area was calculated, and as such density estimates should be interpreted with considerable caution. Some studies approach this problem by providing several density estimates for different possible listening distances (e.g. Duckworth *et al*., 1995; Nijman & Menken, 2001; Rawson *et al*., 2009), which while responsible, limits the usefulness of the estimate and widens the range for population estimates. For example, Duckworth *et al*. (1995) provided several estimates for *r* from a survey conducted in Xe Pian NBCA, Laos, which resulted in a population estimate of 400-6720 groups; a range so large as to make any population monitoring, or comparison between sites for conservation prioritization totally impossible..

Some studies try to avoid this problem by attempting to quantify *r* using various approaches. For example, one method that has been attempted is to locate calling groups and calculate the distance between the observers initial listening location and the group to ascertain how well estimates and actual rs match up (Whittaker, 2005; Rawson *et al*., 2009). However, it is difficult to get a sufficient sample size and only gibbons close to the observer will generally be located with certainty, whereas it is the most distant groups which this approach needs to be applied to.

Brockelman & Ali (1987) suggested a way of avoiding the issue of determining survey area by setting a predetermined survey radius, e.g. 1 km, and having several listening posts in close association allowing for triangulations. In this approach, only vocalizations which are triangulated within the predetermined listening radius are counted, theoretically resulting in an accurate determination of survey area. Conversely, gibbon vocalizations which are heard from only one post and those that are triangulated but occur outside of the predetermined survey distance are discarded from the analyzed data set.

There are, however, still several issues with this approach. First, it demands that a large percentage of data is discarded. Based on the relationship between the radius and area of a circle, for each halving of the surveyed listening radius, an additional 75% of potential gibbon records will be unavailable for inclusion in analysis. Additionally, many records will come from only one post, and these can not be used in analysis. Second, it means that additional survey effort relative to survey coverage is required, as a large amount of overlap between posts will be desirable to increase the number of groups heard by more than one post. Thirdly, it does not take into account bearing error which, when triangulated, creates an error polygon (Heezen & Tester, 1967; Springer, 1979; Saltz & Alkon, 1985) rather than a clear cross between triangulated observations. This would be expected to create edge effects towards the periphery of the predetermined listening radius, as records may be incorrectly included inside the survey area or outside of it as the actual location of the gibbon group is not known exactly (see below for more discussion of bearing error). These issues mean that in reality most studies do not use this approach, at least in its entirety.

The post-hoc clipping of the surveyed area to counter the fact that some calling groups within r can not be heard due to local topography is a largely subjective practice. While some studies have done this (O'Brien *et al*., 2004; Phoonjampa & Brockelman, 2008; Rawson *et al*., 2009), there are no guidelines based on studies of sound transmission in uneven terrain (if such a thing is possible given the vast variability surveyors are likely to encounter) and there has not even been any assessment as to whether different individuals clip different areas off the map (inter-observer error). Therefore there is no evidence to date, one way or another, of the efficacy of this approach in accurately determining surveyed area.

Detection Probability is <1.0

Another issue that needs to be addressed to increase the accuracy of auditory survey techniques for gibbons is that the detection probability within the survey area is <1.0. That is, not all gibbons that call within the designated survey area will be heard, *even if they do sing*. There may be many reasons for this, including topography impacting sound transmission, high or changing ambient noise levels (birds, insects, rivers etc), inexperience or lack of attention of observers etc. That not all groups calling will be heard means that density will probably always be underestimated using these methods.

While not explicitly stated, it appears that Brockelman & Ali (1987) attempted to tackle this problem, suggesting that using a predetermined listening radius coupled with triangulations can be used to increase the detection probability closer to 1.0. That is, as groups further away are less likely to be detected, resulting in an underestimation of density, only groups that are close by, and therefore likely to be heard, should be included in analysis.

While a good approach to a difficult problem and one that has been used in some studies (e.g. O'Brien *et al*., 2004; Whittaker, 2005), this necessitates using a small maximum listening radius relative to the maximum distance gibbons can be heard, and still provides no assurance that detection probability of calling groups = 1.0. Additionally, as maximum listening radius is reduced with concurrent increases in detection probability, the amount of data that has to be discarded increases as gibbon vocalizations heard from outside the predetermined radius cannot be included in analysis. This has the same implications of requiring considerable increases in survey effort relative to gain decent survey coverage as discussed above under Errors in Distance Estimates

Cumulative Mapping of Gibbon Groups

Gibbon groups do not vocalize every day. The implication of this is that there will be animals within the survey area that are not detected because they did not sing. To help counter this, survey teams often remain at the same listening post for several days in order to survey a larger proportion of the population through cumulative addition of mapped groups over days. Because gibbons are territorial, the assumption is that gibbons will not move great distances between days and therefore groups that are mapped in different areas can be considered different groups, while groups that map closely together over several days can be considered the same group, and therefore double counting over the survey period is avoided.

By using acoustic and directional cues an experienced surveyor should theoretically be able to differentiate groups across days (Brockelman & Ali, 1987). Often however survey groups are comprised of a mixture of experienced gibbon researchers, students, forest protection authorities, local community members etc, with considerably variable experience and ability. Therefore, it is common that final cumulative mapping is done after the completion of the surveys based on the raw data. The process is highly subjective, with the researcher using best guesses as to which vocal events represent different groups.

A commonly quoted rule of thumb for cumulative mapping is "song locations that map more than 500 m apart (the approximate diameter of a territory) may be assumed to be in the territories of separate groups," (Brockelman & Srikosamatara, 1993; p. 95). Assuming a circular territory with a diameter of 500m gives a total territory size of under 20 ha. Therefore, this assumption only holds true for species in areas where territories might be this small. For example, in crested gibbons (Genus *Nomascus*), territory sizes appear to be considerably larger (see Geissmann *et al*., 2000; p. 35). For a territory of 100 ha for example, the diameter of a circular territory would be over 1100 m, meaning that this rule of thumb should not be applied without considerable caution.

Added to this is the issue of bearing error. There is likely to be considerable intra- and inter-observer error in bearing estimates made to calling groups. Small errors in bearing become significant when gibbon groups are quite distant, meaning that the same group can be double counted over multiple days purely because locations map far enough apart. For example, a ±5° bearing error at 1.5 km, equates to a distance of 520 m between points. Therefore, bearing error may have a considerable impact on cumulative counts, especially if using a 500 m rule of thumb.

Ultimately, cumulative mapping of groups is a highly subjective process, however despite these problems, in areas of low density it is likely that this is an effective approach. In these instances, as no more than a few groups will be heard from any one post, direction cues and times of calling are appropriate ways to discriminate groups. In areas of medium to high density, however it can become highly problematic.

Application of Correction Factors

An additional issue to be considered is that not all gibbon groups will sing on any one day or even during a prolonged study period. To counter this, some studies also attempt to determine calling frequency in order that a correction factor can be applied to account for non-detection of groups that have not called during the survey period (e.g. O'Brien *et al*., 2004; Rawson *et al*., 2009). Issues concerning correction factors to account for non-calling gibbons are not addressed here (see Brockelman & Srikosamatara, 1993; for a discussion), however additional work remains to be done to outline how these are best calculated, how calling frequencies vary between groups and species, to what extent it is density dependent, and how it is linked to environmental variables such as weather and fruit production (Rawson, 2004).

CONCLUSION

In conclusion, auditory survey methods using a point count approach are the most often utilized method for determining gibbon densities and population sizes, however there are significant problems with the approach. These issues include a conflict between randomized survey designs and the "best practice" data collection approach of situating posts in high elevation areas, considerable difficulty in determining the area surveyed, detection probability of calling groups being <1.0, no information about the accuracy of compass bearings, the subjective nature of cumulative counts, and difficulty in determining correction factors for groups that don't sing. When these issues are coupled with large differences in skill sets between observers, often small sample sizes, and general piecemeal approach to using the method it results in problematic density and population estimates which can be utilized incorrectly for setting conservation priorities. A more rigorous and transparent approach to gibbon surveys will mitigate many of these issues, however additional models should be developed in order to remove these significant biases.

VIỆC SỬ DỤNG VÀ LẠM DỤNG CÁC KỸ THUẬT ĐIỀU TRA VƯỢN

TÓM TẮT

Vượn (Họ Hylobatidae) đang phải chịu nhiều mối nguy cơ lớn đối với vùng sống của chúng. Để có được những ước tính số lượng chính xác cho loài và các quần thể là điều rất quan trọng nhắm xác định được mức độ nguy cơ đe dọa và sự can thiệp của các hoạt động bảo tồn đối với các quần thể được ưu tiên. Mặc dù có rất nhiều phương pháp khác nhau đã được sử dụng, nhiều khó khăn không lường trước trong công tác điều tra các loài vượn và cũng có rất nhiều giả định thường làm sai lệch các kết quả. Bài luận này của tôi nhằm chỉ ra một số thiếu xót phổ biến của các nhà điều tra vượn thường mắc phải và thảo luận mở về việc sớm ra đời các phương pháp điều tra qua thính giác, đặc biệt liên quan đến mật độ và ước tính số lượng quần thể các loài vượn.

REFERENCES

Brockelman, W.Y. & Ali, R. (1987): Methods of Surveying and Sampling Forest Primate Populations. In: Marsh, C.W. & Mittermeier, R.A. (eds.): Primate Conservation in the Tropical Rainforest; pp. 23-62. Alan R. Liss, Inc, New York,

Brockelman, W.Y. & Srikosamatara, S. (1993): Estimation of Density of Gibbon Groups by Use of Loud Songs. Am. J. Primatol. 29, 93-108.

Duckworth, J.W., Timmins, R., Anderson, G.Q.A., Thewlis, R.M., Nemeth, E., Evans, T.D., Dvorak, M. & Cozza, K.E.A. (1995): Notes on the Status and Conservation of the Gibbon *Hylobates* (*Nomascus*) *gabriellae* in Laos. Tropical Biodiversity 3(1), 15-27.

Geissmann, T. (2007): First Field Data on the Laotian Black Crested Gibbon (*Nomascus concolor lu*) of the Nam Kan Area of Laos. Gibbon Journal 3, 56-65.

Geissmann, T., Nguyen Xuan Dang, Lormee, N. & Momberg, F. (2000): Vietnam Primate Conservation Status Review 2000 Part 1: Gibbons. Fauna & Flora International, Hanoi.

Geissmann, T., Trinh Dinh Hoang, La Quang Trung & Tallents, L. (2007): A Brief Survey for Crested Gibbons in Bach Ma National Park, Central Vietnam. Gibbon Journal 3, 43-49.

Heezen, K.L. & Tester, J.R. (1967): Evaluation of Radio-tracking by Triangualtion with Special Reference to Deer Movements. J. of Wildlife Mangement 31(1), 124-141.

Johnson, A., Singh, S., Duangdala, M. & Hedemark, M. (2005): The Western Black Crested Gibbon *Nomascus concolor* in Laos: New Records and Conservation Status. Oryx 39(3), 311-317.

Krebs, C. J. (1999): Ecological Methodology. Benjamin/Cummings, Menlo Park.

Le Trong Dat & Le Huu Oanh (2007): Report of Full Census of Vietnam's Largest Known Population of Western Black Crested Gibbon *Nomascus concolor*: Mu Cang Chai Species/Habitat Conservation Area (Yen Bai Province) and Adjacent Forests in Muong La District (Son La Province). Fauna & Flora International, Hanoi.(Unpubl.).

Luu Tuong Bach & Rawson, B. (2009): An Assessment of Northern White-cheeked Crested Gibbon (*Nomascus leucogenys*) Population Status in Pu Huong Nature Reserve, Nghe An Province, Vietnam. Conservation International, Hanoi. (Unpubl.).

MacKenzie, D.I., Nichols, J.D., Royle, A.J., Pollock, K.H., Bailey, L.L. & Hines, J.E. (2006): Occupancy Estimation and Modeling: Inferring Patterns and Dynamics of Species Occurrence. Elsevier Inc, California.

Nijman, V.H. & Menken, S.B.J. (2001): Density and Biomass Estimates of Gibbons (*Hylobates muelleri*) In: Nijman, V.H. (ed.): Bornean Rainforest: A Comparison of Techniques. Forest (and) Primates: Conservation and Ecology of the Endemic Primates of Java and Borneo; pp. 13-31. Academisch proefschrift, geboren te Oudorp.

O'Brien, T.G., Kinnaird, M.F., Nurcahyo, A., Iqbal, M. & Rusmanto, M. (2004): Abundance and Distribution of Sympatric Gibbons in a Threatened Sumatran Rain Forest. Int. J. Primatol. 25(2), 267-284.

Phoonjampa, R. & Brockelman, W.Y. (2008): Survey of Pileated Gibbon *Hylobates pileatus* in Thailand: Populations Threatened by Hunting and Habitat Degredation. Oryx 42(4), 600-606.

Pollard, E., Clements, T., Nut Meng Hor, Sok Ko & Rawson, B. (2007): Status and Conservation of Globally Threatened Primates in the Seima Biodiversity Conservation Area, Cambodia. Wildlife Conservation Society, Phnom Penh. (Unpubl.).

Rawson, B.M. (2004): Vocalisation Patterns in the Yellow-cheeked Crested Gibbon (*Nomascus gabriellae*). In: Nadler, T., Streicher, U. & Ha Thang Long (eds.): Conservation of Primates in Vietnam; pp. 130-136. Frankfurt Zoological Society, Hanoi,

Rawson, B.M., Clements, T.J. & Nut Meng Hor (2009): Status and Conservation of Yellow-cheeked Crested Gibbons in Seima Biodiversity Conservation Area, Mondulkiri Province, Cambodia. In: Lappan, S. & Whitaker, D.M. (eds.): The Gibbons: New Perspectives on Small Ape Socioecology and Population Biology; pp. 387-408. Springer, New York,

Rawson, B.M., Paov Somanak & Namyi, H. (2007): Report on Community Ranger Gibbon Monitoring Training Course in the CCPF. Conservation International, Phnom Penh. (Unpubl.).

Ruppell, J. (2008): The Gibbons of Pu Mat National Park in Vietnam. Gibbon Journal 4, 39-45.

Saltz, D. & Alkon, P.U. (1985): A Simple Computer-Aided Method for Estimating Radio-location Error. J. Wildlife Management 49(3), 664-668.

Springer, J.T. (1979): Some Sources of Bias and Sampling Error in Radio Triangulation. J. Wildlife Mangement 43(4), 926-935.

Traeholt, C., Roth Bunthoen, Rawson, B.M., Mon Samuth, Chea Virak & Sok Vuthin (2006): Status Review of Pileated Gibbon, *Hylobates pileatus* and Yellow-cheeked Crested Gibbon, *Nomascus gabriellae*, in Cambodia. Fauna & Flora International - Indochina Programme, Phnom Penh. (Unpubl.).

Whittaker, D.J. (2005): New Population Estimates for the Endemic Kloss's Gibbon *Hylobates klossii* on the Mentawai Islands, Indonesia. Oryx 39(4).

27

CONSERVATION OF THE WESTERN BLACK GIBBON (*NOMASCUS CONCOLOR*) IN MU CANG CHAI SPECIES AND HABITAT CONSERVATION AREA

HOANG VAN LAM, NGUYEN THI THANH NGA, AND PAUL INSUA-CAO

SUMMARY

The western black gibbon (*Nomascus concolor*) is one of four "Critically Endangered" crested gibbon species of the *Nomascus* genus. Of the crested gibbons, it has the most northerly distribution from western and central Yunnan Province in China down to the Hoang Lien Mountains between the Red and Black Rivers in North-west Vietnam and Bokeo Province in North-west Laos.

N. concolor was believed to be extinct in Vietnam, until in 1999 it was rediscovered by Fauna & Flora International (FFI) in a forest spanning Mu Cang Chai District, Yen Bai Province and Muong La District, Son La Province.

Since than FFI began working with local authorities to protect the population in Mu Cang Chai. FFI broadened its goal to piloting a community-based approach to conservation in the landscape, with *N. concolor* as one of its flagship species.

In the springs of 2006, 2007 and 2008, censuses of *N. concolor* were conducted by FFI across the whole forest area. In 2008 fewer groups were recorded in Muong La, as a result of what seemed to be increased human pressure on the forest. In Mu Cang Chai, the number of groups remained constant compared to 2006. Altogether 17 groups were recorded in 2008, indicating a possible decline of more than 50% since 2001.

FFI's work at Mu Cang Chai has led to the development of an innovative approach to community involvement in protected area management, which can serve as an example for Vietnam. Nevertheless, since the focus of FFI's work was turned towards local livelihoods, in the belief that poverty alleviation would directly support conservation, there has been a clear decline in the gibbon population.

INTRODUCTION

The western black gibbon (*Nomascus concolor*) is one of four "Critically Endangered" crested gibbon species of the Nomascus genus. Of the crested gibbons, it has the most northerly distribution from western and central Yunnan Province in China down to the Hoang Lien Mountains between the Red and Black Rivers in North-west Vietnam and Bokeo Province in North-west Laos. There may once have been overlap between its range and that of the northern white-cheeked gibbon (Nomascus leucogenys). The populations of both species are fragmented and there is currently no evidence of sympatry.

N. concolor was believed to be extinct in Vietnam, until in 1999 it was rediscovered by Fauna & Flora International (FFI) in a forest spanning Mu Cang Chai District, Yen Bai Province and Muong La District, Son La Province. This is considered to be the largest and only viable population of this species in Vietnam. Another smaller and more fragmented population was discovered in Van Ban District of Lao Cai Province. These are the only locations where this species is known to occur in Vietnam.

MATERIAL AND METHODS

After rediscovery in 1999 FFI began working with local authorities to protect the population in Mu Cang Chai. Given the suite of important biodiversity values in the Hoang Lien Mountains, FFI broadened its goal to piloting a community-based approach to conservation in the landscape, with *N. concolor* as one of its flagship species (Fig. 1). The goal was to develop a win-win scenario by which benefits to conservation also improved local livelihoods. In order to achieve this goal, village level forest regulations were established and a new model for Vietnam of collaborative management developed for the newly-established Mu Cang Chai Species and Habitat Conservation Area. At the same time, direct interventions were implemented to improve local livelihoods. A community-based patrol group was established to patrol the forest, monitor wildlife, conduct awareness raising and support law enforcement. The patrol group is supervised directly by the protected area. Also a Forest Protection Council has been established as an advisory body of community representatives to the protected area.

Fig. 1. Adult male and juvenile western black gibbons (*Nomascus concolor*).

Photo: Fan Pengfei.

In the springs of 2006, 2007 and 2008, censuses of *N.concolor* were conducted by FFI across the whole forest area on each occasion and following the same survey method (Le Trong Dat & Luong Van Hao, 2008). Comparing results between 2001 and 2006, the population appears to have declined. However in 2000 and 2001, several smaller surveys were conducted at different times and may have led to an overestimate of the gibbon population due to double counting groups. The census in 2007 shows the population stabilising, but in 2008 less groups were recorded in Muong La, as a result of what seemed to be increased human pressure on the forest there, especially from logging. In Mu Cang Chai, the number of groups remained constant compared to 2006. Altogether 17 groups were recorded in 2008, indicating a possible decline of more than 50% since 2001. Table 1 summarises the results of censuses and surveys between 2000/1 and 2008 (Le Trong Dat & Luong Van Hao, 2008).

RESULTS

FFI's work at Mu Cang Chai has led to the development of an innovative approach to community involvement in protected area management, which can serve as an example for Vietnam. Nevertheless, since the focus of FFI's work was turned towards local livelihoods, in the belief that poverty alleviation would directly support conservation, there has been a clear decline in the gibbon population. To date there has been no conclusive analysis as to how much the approach has reduced threats to the gibbon population. It may be that without any intervention the decline may have been much greater. Current activities of FFI are now focussed on continuing to strengthen the role of the Forest Protection Council with *N. concolor* very much back at the focus of conservation objectives.

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Table 1: Results of western black gibbon (*Nomascus concolor*) census in Mu Cang Chai Species/Habitat Conservation Area (Yen Bai Province) and adjacent forests in Muong La District (Son La Province) from 2000 to 2008 (Le Trong Dat & Luong Van Hao, 2008).

Year	Mu Cang Chai		Muong La		Total for the area	
	Minimum no. of groups	Minimum no. of individuals	Minimum no. of groups	Minimum no. of individuals	Minimum no. of groups	Minimum no. of individuals
2000/1	23	-	16	-	39	91
2006	11	28	14	40	25	68
2007	12	29	14	43	26	72
2008	11	40	6	17	17	57

funds the regional Co-management Learning Network. We would also like to thank Le Trong Dat for his commitment and support to the gibbon censuses, to the Forest Protection Departments and People's Committees of Yen Bai, Son La and Mu Cang Chai for their support and to the members of the community-based monitoring groups at Mu Cang Chai for their perseverance.

BẢO TỒN VƯỢN ĐEN TUYỀN (*NOMASCUS CONCOLOR*) Ở KHU BẢO TỒN LOÀI VÀ SINH CẢNH MÙ CANG CHẢI

TÓM TẮT

Loài vượn đen tuyền (*Nomascus concolor*) là một trong bốn loài vượn Nguy cấp thuộc giống *Nomascus*. Trong số các loài vượn có mào này, vượn đen tuyền hầu hết phân bố từ phía tây và trung bắc tỉnh Vân Nam Trung Quốc xuống đến dãy Hoàng Liên giữa sông Hồng và sông Đà ở phía tây bắc Việt Nam và tỉnh Bokeo ở tây bắc nước Lào. *N. concolor* từng được xem là bị tuyệt chủng tại Việt Nam, mãi cho đến năm 1999 mới được FFI (Tổ chức Động Thực vật Quốc tế) tái phát hiện ở cánh rừng thuộc huyện Mù Cang Chải, tỉnh Yên Bái và huyện Mường La, tỉnh Sơn La.

Kể từ đó FFI hợp tác cùng làm việc với chính quyền địa phương hướng đến bảo tồn quẩn thể loài này tại huyện Mù Cang Chải. FFI đã mở rộng mục tiêu hướng đến thí điểm một phương pháp bảo tồn cảnh quan dựa vào cộng đồng, trong đó loài *N. concolor* được xem là một trong các loài biểu trưng. Vào mùa xuân năm 2006, 2007 và năm 2008, các đợt nghiên cứu về quần thể loài *N. concolor* được FFI tiến hành thực hiện trên toàn bộ khu rừng. Vào năm 2008, một vài đàn được ghi nhận tại Mường La vì chính sự tác động ngày càng gia tăng của con người lên cánh rừng đã làm giảm nhanh số đàn vượn. Tại Mù Cang Chải, số đàn ghi nhận được giữ nguyên so với năm 2006. Tổng cộng có 17 đàn được ghi nhận vào năm 2008, và kết quả cho thấy số bày đàn bị giảm đi hơn 50% kể từ năm 2001.

Hoạt động của FFI tại Mù Cang Chải đã đem lại hướng phát triển phương pháp tiếp cận đầy sáng tạo có sự tham gia của cộng đồng địa phương trong quản lý khu bảo tồn. Đây có thể xem là một ví dụ điển hình tại Việt Nam. Tuy nhiên kể từ khi FFI hướng đến hoạt động sinh kế cho người dân địa phương với niềm tin rằng xóa đói giảm nghèo có thể trực tiếp hỗ trợ cho công tác bảo tồn thì số lượng loài vượn lại bị giảm đi rõ rệt.

REFERENCES

Le Trong Dat & Luong Van Hao (2008): Census of the Vietnam's largest known population of western black crested gibbon *Nomascus concolor*: Mu Cang Chai Species/Habitat Conservation Area (Yen Bai Province) and adjacent forests in Muong La District (Son La Province). Fauna & Flora Internnational – Vietnam Country Programme, Hanoi. (Unpubl.).

IUCN. (2008): IUCN Red-list of Threatened Species. http://www.iucnredlist.org.

HOW TRANSBOUNDARY COOPERATION AND FIELD-BASED CONSERVATION HAVE LED TO IMPROVED HOPE FOR SURVIVAL OF THE EASTERN BLACK GIBBON (*NOMASCUS NASUTUS*) ON THE VIETNAM – CHINA BORDER

PAUL INSUA-CAO, YAN LU, NGUYEN THE CUONG, AND NONG VAN TAO

SUMMARY

In 2002, the Critically Endangered eastern black gibbon (*Nomascus nasutus*) (also known as cao vit gibbon) was rediscovered by a team from Fauna & Flora International (FFI), in about a 1600 ha block of limestone mountains in Trung Khanh District, Cao Bang Province on the border with China. At that time, 26–28 individuals were recorded in five groups and FFI initiated a project to protect this population, focusing mainly on community forest patrols, interventions to reduce firewood extraction and establishing a protected area in 2007. In 2006 the FFI China Programme also began conservation measures in the adjacent border area, having seen there was viable habitat for the gibbons. Towards the end of 2006 a survey there recorded three more gibbon groups and led to the announcement that the species had been rediscovered in China.

In September 2007, a transboundary census of the gibbon population was conducted over the entire area of viable habitat; the most comprehensive survey effort to date. Survey teams were assigned to listening posts on the summits of the mountain tops before dawn to record gibbon vocalisations. Visual observations were used to determine the numbers and structure of gibbon family groups where possible. Both the Vietnam and China survey teams followed the same approach, with both sides beginning close to the border on 8 September.

By comparing data from both surveys, the team concluded that 18 different groups were recorded, totalling about 110 individuals. Three groups appear to move across the border, and this has been confirmed by field research conducted since the beginning of 2008 in China. The revised population estimate was much higher than expected, and the results of the census are a milestone indicator of the success of conservation efforts so far.

INTRODUCTION

Until recently the eastern black gibbon (*Nomascus nasutus*) was considered to be a subspecies of the Hainan gibbon (*Nomascus hainanus*) (Brandon-Jones *et al*., 2004; Geissmann *et al*., 2000). The historical distribution of both taxa extends from southern Yunnan Province in China, east of the Red River in Vietnam and on Hainan Island in China (Geissmann *et al*., 2000). Together they are recognized as one of the world's 25 most endangered primates (Mittermeier *et al*., 2007). There is growing consensus that the two taxa should be recognized as separate species based upon differences in vocalisations and fur colouration (Geissmann, 2007). The Hainan gibbon is only found on Hainan Island with a population of less than 20 individuals and now rightly deserves the unfortunate epithet "the world's rarest ape". The eastern black gibbon is listed as "Critically Endangered" on the "IUCN Red list of Threatened Species" (Bleisch & Geissmann, 2008).

The eastern black crested gibbon was believed to be extirpated in Guangxi Province, southern China since the 1950s (Tan, 1985) and in Vietnam it was also feared extinct with the last reliable record for its

Fig. 1. Male eastern black gibbon during the 2007 census. *Photo: Zhao Chao / FFI.*

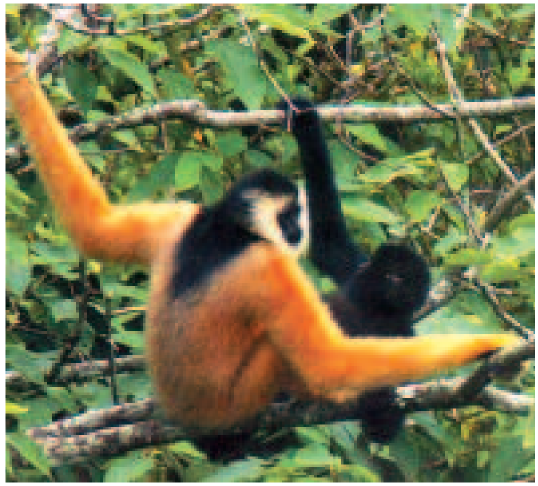

Fig. 2. Female eastern black gibbon with juvenile. *Photo: Zhao Chao / FFI.*

occurrence coming from the 1960s (Geissmann *et al*., 2002). In January 2002, a small remnant population was re-discovered by a survey team of Fauna & Flora International (FFI) in Trung Khanh District of Cao Bang Province, Vietnam, on the Chinese border (La Quang Trung & Trinh Dinh Hoang, 2002). In a follow-up survey soon after, Geissmann et al. (2002) confirmed at least five groups comprising 26 to 28 individuals at that location. This discovery led to FFI and Cao Bang Provincial Forest Protection Department to take immediate measures to protect the forest where the gibbon was discovered. Further surveys were conducted in 2004 and 2005 establishing that there were at least 8 groups of 37 individuals (Trinh Dinh Hoang, 2004; La Quang Trung, 2005; Vu Ngoc Thanh *et al*., 2005) (Fig.1, 2 and 3).

In early 2006, staff from the FFI Vietnam and China Programmes visited the neighbouring forest in Jingxi County with support from the county forestry bureau and assessed that the forest was sufficiently intact to provide an important contiguous extension of the gibbon's habitat from Vietnam, even though no gibbons were actually recorded at the time. Later that year, in September, Kadoorie Farm & Botanic Garden and Jingxi Forestry Bureau conducted a survey there and recorded three groups of 19 individuals, establishing the rediscovery of the species in China (Chan Bosco Pui Lok *et al*., 2008).

In September 2007, synchronized survey teams coordinated by FFI Vietnam and China Programmes conducted a survey of the entire known gibbon habitat and recorded an estimated 18 groups of 110

Fig. 3. Female eastern black gibbon with baby; January 2009.

Photo: Zhao Chao / FFI.

individuals (Le Trong Dat *et al*., 2008). A more detailed description of the survey and results are described below.

BIO-GEOGRAPHICAL DESCRIPTION OF THE LOCATION

The border area of Cao Bang Province in Vietnam and Guangxi Province in China is dominated by tower and cone limestone karst formations. However, much of the forest in this area has been severely degraded by uncontrolled logging and agricultural encroachment, particularly in the 1980-1990s. The forest block where the eastern black gibbon was discovered covers about 5,000 ha and straddles the international border between Phong Nam, Ngoc Khe and Ngoc Con Communes in Trung Khanh, Vietnam and Bangliang and Daxin villages in Jingxi County, China. For clarity this forest block is henceforth referred to as the Trung Khanh – Bangliang forest.

The forest block is characterized by a typical karst limestone landscape consisting of densely packed sharp-peaked mountains with very steep (30-90o) slopes and ridges with vertical cliffs interspersed with lowland valleys and depressions known as nungs. The elevation of the forest ranges from approx. 400-900 m asl. The entire karst forest area extends from the North-west in China to the South-east in Vietnam with coordinates from 22º57'N to 22º52' N and 106º28'E to 106º33'E. This block of karst limestone mountains is also the catchment area for and is bounded by two branches of what is called the Quay Son River in Vietnam where the branches meet at the southern end. In China the two branches of the river are called Ge Bao River in the west and Luo Xi River in the East.

The natural forest cover at the core of the forest block is characterised by secondary sub-tropical broadleaf forests with occasional patches of bamboo forest and some conifers on the mountain peaks. Humans have heavily impacted the edges of the forest block. The habitat there is characterized more by shrubs and even grasslands in some areas. Maize is cultivated in some valley bottoms (Vu Anh Tai & Nguyen Huu Tu, 2007). Despite the high levels of habitat degradation, the forest still maintains important floral biodiversity values. The scattered conifers represent last remnants of limestone coniferous forests, which is a unique kind of vegetation in Southeast Asia and orchid floral diversity is still rich, although many species are rare and difficult to find (Averyanov *et al*., 2004).

A surprisingly high diversity of large mammals has been recorded in this forest block, most notably Francois' langur (*Trachypithecus francoisi*), Assamese macaque (*Macaca assamensis*), rhesus macaque (*Macaca mulatta*), stump-tailed macaque (*Macaca arctoides*), Asian black bear (*Selenactros thibetanus*), giant flying squirrel (*Petaurista petaurista*), southern serow (*Naemorhedus sumatraensis*), lesser mouse deer (*Tragulus javanicus*) and even reports of leopard (*Panthera pardus*) (Vu Ngoc Thanh *et al*., 2005; Chan Bosco Pui Lok *et al*., 2007). Other notable records of fauna include the first record of the Chinese leopard gecko (*Goniurosaurus luii*) (Vu Ngoc Thanh *et al*., 2006) and a new species of snake of the genus Protobothrops to science (Orlov, in press.).

GIBBON CONSERVATION ISSUES

From the outset, hunting has not been a major threat to the eastern black gibbon. It had been hunted opportunistically in the past. There have been occasional reports of hunting activity in the area, sometimes targeting birds or bears. On the China side Francois' langurs have been targeted to produce what is referred to as "black ape wine". This has led to the loss of some Francois' langur groups in the recent past and could pose a threat to the gibbon.

The major issues related to conservation of the eastern black gibbon have been recognized from early on as the limited available habitat and its continuing degradation. Fuel wood collection is the major cause of forest degradation. There is a low level of timber collection for local use, particularly extracting young hardwood tree species for constructing waterwheels for irrigation in local Vietnamese villages. At the beginning of project activities, on both the Vietnam and China side charcoal production in the forest was a common occurrence and an important driver for habitat degradation. Free livestock grazing by buffalos, cows and goats prevents forest regeneration and some areas inside the outer edges of the forest block are kept to grassland as a result. There are areas of cultivated land inside the forest block, which local families have been using for decades, typically for maize and on the valley bottoms. This does not appear to be expanding significantly, if at all, partly due to the nature of the terrain preventing significant cultivation on valley slopes and also the marginal economic benefit related to other more profitable activities, particularly in China.

ADRESSING GIBBON CONSERVATION ISSUES

Forest protection through patrols

Since 2004 in Vietnam, FFI has been supporting a community patrol group of six individuals, comprised mainly of local villagers, and also with representation from the local border army. This group was initially managed by the Trung Khanh District Forest Protection Department and now by the 'Cao Vit Gibbon Conservation Area'. A similar patrol group of four individuals has been established on the China side since early 2007. They are managed by staff of nearby Diding Nature Reserve, which has been assigned to manage the Bangliang forest by Jingxi County Forestry Bureau.

Improved enforcement and establishing protected areas

In both Vietnam and China, local authorities responded positively to news of the discovery of the eastern black gibbon and the need to take measure to protect it, in particular by immediately issuing regulations to specifically protect this forest and supporting FFI's work to raise awareness among local communities. The respective government forest protection agencies on both sides of the border have dedicated more human resources and attention to the area and to address some of the more immediate issues, in particular charcoal production and possible threats from hunting.

In April 2007, the 'Cao Vit Gibbon Conservation Area' was established on the Vietnam side of the border covering an area of just over 1,657 ha up to the international border, of which about 900 ha is good forest habitat for the gibbons. Protected area gazettement followed participatory resource use planning in 29 local villages covering (what was then) two communes[1] and biodiversity surveys led by FFI. The protected area has four members of staff.

In 2007, Guangxi Provincial Forestry Bureau initiated steps to establish a contiguous protected area for the Bangliang forest. This has been mainly a government-led process with support from FFI to strengthen participation of local communities in protected area planning. The approach was intended to serve as a model for establishing protected areas elsewhere in Guangxi Province. It is expected that a protected area of between 4,000 and 5,000 ha will be established in 2009.

Addressing fuel wood collection

Since 2004, FFI has been introducing technologies to local communities in Vietnam to reduce their dependence on fuel wood, particularly from the gibbons' forest. Twenty-one domestic biogas plants were constructed and between 2005 and 2008, subsidies were provided for constructing 522 improved cooking stoves. Fuel wood plantations have been established with limited success so far, using a native species that is adapted to limestone. The success has been limited by damage from free livestock grazing.

Guangxi Province is one of the leading provinces in China for providing biogas plants to rural households, and they are already used among communities around the Bangliang forest.

Further support to local communities

Since 2007, in Ngoc Khe[1] and Ngoc Con Communes in Vietnam, FFI has been working closely with the five villages adjacent to the protected area using village development planning to provide the framework for a more integrated approach to conservation, particularly to improve management of livestock grazing

TRANSBOUNDARY SURVEY OF THE CAO VIT GIBBON

Method

In early 2007, staff from FFI's Vietnam and China Programmes began planning a transboundary census across the entire known range of the eastern black gibbon in the Trung Khanh – Bangliang forest in order to establish a good estimate of the population of the eastern black gibbon. It was important that the same methodology was followed and timing of the survey synchronised in order to be able to compare data from both sides of the border and in particular identify groups that were recorded from both Vietnam and China.

The census began on 8 September 2007 with both survey teams establishing camps close to the international border. In Vietnam the survey lasted eleven days, including one day to move camp, and in China, with a smaller area to cover, the survey lasted seven days. The field team was comprised of 39 active participants, 17 in China and 22 in Vietnam (Le Trong Dat *et al*., 2008). All attended a two-day training course, although many had already participated in previous gibbon surveys in the same area and were familiar with the gibbon calls.

The auditory survey technique following Brockelman & Ali (1987) and direct observation were employed to record gibbons. Fixed listening posts were established using a combination of knowledge from previous surveys and in relation to topography.

[1] Since 2008, Ngoc Khe Commune has been divided into Ngoc Khe and Ngoc Con Communes.

Listening posts were located on ridges, from which several valleys could be surveyed at the same time. Six listening posts were used in China and 18 in Vietnam. All were sufficiently spaced to ensure that all suitable habitat was covered. Listening posts were monitored on five successive days from 06:00 to 11:00, the time period when eastern black gibbons call most actively (Geissmann *et al*., 2002; Chan Bosco Pui Lok *et al*., 2008). Occasionally it was necessary to continue surveys until 17:00 in order to cover the whole activity period of the gibbons. For each gibbon song bout, the surveyors recorded starting time, ending time, direction and estimated distance from observer, call type and the number of individuals producing male-type calls and great-calls. Call types included duet song bouts, male solo song bouts, female solo song bouts, isolated great-calls, and alarm calls. Different song bouts or isolated great-calls were separated by an arbitrarily defined interval of at least five minutes. Any other characters of the song bouts that could be used to distinguish different groups were also recorded.

To supplement the information derived from the calls, survey team also tried to identify the number of individual gibbons within each group to define group composition by direct sightings. In this way, surveyors noted starting and ending time of the sighting, age and sex of all animals seen, direction and distance of the gibbons from the surveyors.

Results

The field survey by the Vietnam team recorded a total of 17 groups of gibbon with 94 to 96 individuals. Sixteen groups with around 60 individuals were recorded by songs; and 15 groups with 87 to 89 individuals were recorded by direct observations. The China team recorded 32 individuals in five groups. Data from both surveys were compared side by side by representatives from Vietnam and China and lead to the conclusion that altogether 18 different groups were recorded, numbering about 110 individuals (Le Trong Dat *et al*., 2008). Three groups appear to move across the border, as has been noted during field research conducted since the beginning of 2008 in China. The satellite image in Fig. 4 shows the approximate locations of all recorded gibbon groups.

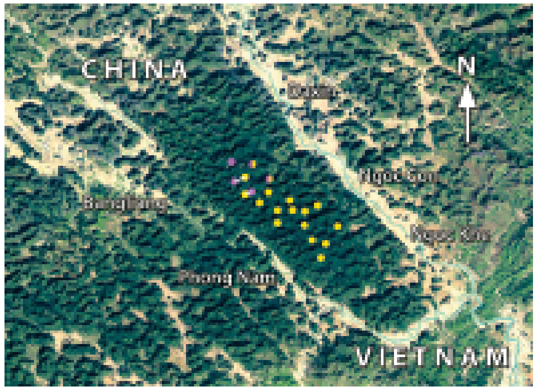

Fig. 4. Satellite image of the Trung Khanh – Bangliang forest showing records of gibbon groups following the 2007 census. Yellow circles: gibbon groups recorded by the Vietnam survey team; pink circles: gibbon groups recorded by the China survey team; yellow-pink circles: gibbon groups recorded by both survey teams; linked circles: gibbon groups recorded by both survey teams that are understood to be the same.

DISCUSSION

Results of the census

The census results more than doubled previous estimates of the eastern black gibbon population in this forest area. It is not appropriate to directly compare the results of this census to previous surveys to accurately assess trends in population size. The increased estimate for population size could partly be attributed to greater man-effort and coverage of the forest area. There are nevertheless clear indications that since the beginning of conservation interventions, the eastern black gibbon population is starting to make a recovery. The census recorded gibbon groups for the first time in the southern end of the forest in Vietnam where they have not been recorded before. A small survey conducted in Vietnam in March 2007 as a training exercise recorded seven or eight groups in the core area of the gibbon's habitat, which already indicated a higher population density than previously estimated (Trinh Dinh Hoang, 2007), and is in agreement with the results of this census.

Since early in 2008, three of the groups have been closely monitored as part of a research programme from the China side and their group sizes and social behaviour now carefully documented. Home ranges of gibbon groups are currently estimated to be about 150ha (Fan Pengfei, pers. comm.). This leads to some doubt that the figure for the total number of groups can be as high as it was estimated in the survey, perhaps due to double counting, and that it might be slightly lower.

The census recorded gibbon groups across most of the range of forest, which has sufficient quality for gibbons and the results raise the issue of limited available habitat to a higher priority. Detailed observations of the gibbon groups and forest quality in China have led to a preliminary assessment that there may be sufficient habitat for just one or two more groups under current forest conditions and given known home ranges (Fan Pengfei, pers. comm.).

Results of conservation efforts so far

With strong support from local authorities, some important threats to the gibbon and wildlife of the forest have been curtailed. There have been very few records of hunting activities, and where it has been recorded, there was no direct threat to the gibbons, but to other wildlife such as birds, macaques and bears. There is currently no charcoal production occurring in the forest, as this has been significantly reduced due to strong enforcement in Jingxi County targeted against local markets directly, as well as through forest patrols.

Fuel wood collection still occurs, although to a lesser extent. It is assumed that the introduction of improved cooking stoves in Vietnam has had an impact, as surveys among users indicate a reduction in fuel wood use of about 50 percent (Pham Thanh Thuy, 2007). In addition, the new protected area has improved enforcement, especially through closer management of the community patrol group by the protected area staff. In particular there is strong cooperation between authorities on both sides of the border to deal with trade in fuel wood from Vietnam to China. In some locations in Vietnam the forest has clearly begun recovering since conservation interventions began.

FFI has been well-placed in Vietnam and China to coordinate conservation interventions on both sides of the border. This has been a necessary extension of a conservation project that began in Vietnam. The transboundary census in 2007 was a starting point for close collaboration between the two country programmes of FFI. During 2008 that collaboration was further developed and has brought authorities from Vietnam and China closer together in addressing their objectives for the area. Two study tours were organised by FFI for protected area and government forest protection staff from both sides of the border to visit each others respective areas. This has led to a keen interest in developing further transboundary cooperation.

CONCLUSIONS

The eastern black gibbon population in the Trung Khanh – Bangliang forest block appears to be recovering well, based upon the census results and subsequent observations. The main constraint to gibbon population growth now appears to be limited habitat availability for the establishment of many more groups.

Direct human threats to the gibbon and its habitat appear to have reduced as a result of both improved enforcement and, in Vietnam, from investments in supporting local communities to reduce their impacts on the forest.

Important steps have been taken so far to coordinate efforts between Vietnam and China and it is hoped that it will lead to strong transboundary cooperation between the two adjacent protected areas. In particular another forest block to the west could provide an important extension of the gibbon's habitat in the long-term future. However, while most of that block lies on the Vietnam side of the border, the area on the China side is planned to be incorporated into the new protected area and will provide the most feasible location for establishing a linking forest corridor.

ACKNWOLEDGEMENTS

The authors would like to thank DEFRA Flagship Species Fund for funding the survey in Vietnam and National Geographic and US Fish and Wildlife Service for funding the survey in China. Support from Le Trong Dat, Fan Pengfei and Ben Rawson was invaluable for leading the survey and ensuring the scientific rigour of the census.

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Finally the results so far would not have been possible without our partnership with the respective government forestry agencies of Cao Bang Province and Guangxi Province, institutional support from local authorities of Trung Khanh District and Jingxi County, technical support from People, Resources and Conservation Foundation, perseverance of the community patrol groups and participation of local communities.

HỢP TÁC XUYÊN BIÊN GIỚI VÀ CÁC HOẠT ĐỘNG BẢO TỒN CƠ BẢN LIỆU CÓ ĐEM LẠI HY VỌNG CỨU LẤY LOÀI VƯỢN CAO VÍT (*NOMASCUS NASUTUS*) TRÊN TUYẾN BIÊN GIỚI VIỆT NAM – TRUNG QUỐC

TÓM TẮT

Năm 2002, loài vượn đen đông bắc được xếp loại đang bị đe doạ nghiêm trọng (*Nomascus nasutus*) (còn được biết đến với tên gọi vượn Cao Vít) được FFI tại Việt Nam tái phát hiện tại một khu vực núi đá vôi có diện tích 1600 ha thuộc huyện Trùng Khánh, tỉnh Cao Bằng nơi có chung đường biên giới với Trung Quốc. Tại thời điểm đó, có 26-28 cá thể thuộc 5 đàn đã được phát hiện và FFI đã bắt đầu triển khai một dự án bảo vệ quần thể này. Nội dung chủ yếu tập trung vào công tác tuần tra rừng dựa vào cộng đồng, giảm thiểu sự khai thác củi đốt ở đây cũng như thành lập khu bảo tồn vào năm 2007. Năm 2006, chương trình FFI tại Trung Quốc cũng bắt đầu các biện pháp bảo tồn tại khu vực biên giới liền kề, nơi được xem là sinh cảnh của vượn. Đến cuối năm 2006, có thêm 3 đàn vượn nữa đã được phát hiện trong khu vực này, nhờ đó mà loài này cũng được công bố là được tái phát hiện ở Trung Quốc. Vào tháng 9 năm 2007, một cuộc điều tra số lượng được thực hiện xuyên biên giới trên toàn bộ khu vực sinh cảnh sống của chúng, cho đến thời điểm này đây là cuộc điều tra toàn diện nhất về loài này đã được tiến hành. Các địa điểm nghe và quan sát đã được thiết lập trên các đỉnh núi để ghi âm tiếng hót cũng như xác định số lượng, cấu trúc của các đàn vượn trước lúc bình minh. Phương pháp này đã được áp dụng bởi cả 2 nhóm nghiên cứu của Việt Nam và Trung Quốc, 2 bên gặp nhau tại biên giới vào ngày 8 tháng 10. Bằng cách so sánh số liệu giữa 2 bên, nhóm nghiên cứu kết luận rằng, có 18 đàn vượn khác nhau đã được ghi nhận, với khoảng 110 cá thể. Có 3 đàn xuất hiện qua lại ở cả 2 bên biên giới và điều này đã được xác nhận bởi một nghiên cứu thực địa khác được tiến hành vào đầu năm 2008 tại Trung Quốc. Số lượng của quần thể ước tính đã lớn hơn nhiều so với mong đợi và các kết quả của cuộc điều tra là một mốc quan trọng cho những thành công của các nỗ lực bảo tồn cho tới nay.

REFERENCES

Averyanov, L.V., Phan Ke Loc, Nguyen Tien Hiep, Pham Van The & Nguyen Tien Vinh (2004): Preliminary survey of orchids and gymnosperms in Trung Khanh District, Cao Bang Province, northern Vietnam. Fauna & Flora International and American Orchid Society. (Unpubl.).

Bleisch, B. & Geissmann, T. (2008): *Nomascus nasutus*. In: IUCN 2008. 2008 IUCN Red List of Threatened Species. <www.iucnredlist.org>, downloaded on 05 May 2009.

Brandon-Jones, D., Eudey, A.A., Geissmann, T., Groves, C.P., Melnick, D.J., Morales, J.C., Shekelle, M. & Stewart, C.-B. (2004): Asian Primate Classification. Int. J. Primatol. 1 (1), 97-164.

Brockelman, W.Y. & Ali, R. (1987): Methods of surveying and sampling forest primate populations. In: Marsh, C.W. & Mittermeier, R.A. (eds.) Primate conservation in the tropical rain forest, pp. 23-62. Alan R. Liss, Inc. New York.

Chan Bosco Pui Lok, Tan Xue-feng & Tan Wu-jing (2008): Rediscovery of the critically endangered eastern black crested gibbon *Nomascus nasutus* (Hylobatidae) in China, with preliminary notes on population size, ecology and conservation status. Asian Primate Journal 1(1), 17-25.

Geissmann, T. (2007): Status reassessment of the gibbons: Results of the Asian Primate Red List Workshop 2006. Gibbon Journal 3, 5-15. Gibbon Conservation Alliance, Zürich.

Geissmann T., La Quang Trung, Trinh Dinh Hoang, Dang Ngoc Can, Pham Duc Tien & Vu Dinh Thong (2002): Report on an overall survey of cao vit gibbon population *Nomascus* sp. cf. *nasutus* in Trung Khanh District, Cao Bang Province (second overall survey). FFI Asia Pacific Programme. Fauna & Flora International-Indochina Programme, Hanoi. (Unpubl.).

Geissmann, T., Nguyen Xuan Dang., Lormee, N. & Momberg, F. (2000): Vietnam Primate Conservation Status Review 2000. Part 1: Gibbons. Fauna & Flora International-Indochina Programme, Hanoi.

La Quang Trung (2005): Integrated report on capacity assessment of the community patrol group in training on using equipment for and recommendation of an annual work plan for monitoring the Eastern Black-crested Gibbon

(*Nomascus nasutus nasutus*) population. Fauna & Flora International-Vietnam Programme, Hanoi. (Unpubl.).

La Quang Trung & Trinh Dinh Hoang (2002): Report on survey of Eastern Black Crested Gibbon (*Nomascus* sp. cf. *nasutus*) in Trung Khanh District, Cao Bang Province, January, 2002. Fauna & Flora International-Indochina Programme, Hanoi. (Unpubl.).

Le Trong Dat, Fan Pengfei, Yan Lu, Le Huu Oanh, Nguyen The Cuong & Josh Kempinski (2008): Census report for the global cao vit gibbon (*Nomascus nasutus*) population. Report to Fauna & Flora International-Vietnam and China Programme. (Unpubl.)

Mittermeier, R.A., Ratsimbazafy, J., Rylands, A.B., Williamson, L., Oates, J.F., Mbora, D., Ganzhorn, J.U., Rodríguez-Luna, E., Palacios, E., Heymann, E.W., Cecília, M., Kierulff, M., Long Yongcheng, Supriatna, J., Roos, C., Walker, S., & Aguiar, J.M. (2007): Primates in Peril: The World's 25 Most Endangered Primates 2006-2008. Primate Conservation 22, 1 – 40.

Pham Thanh Thuy (2007): Survey of stakeholders' attitudes on improved stove programme of the Cao Vit Gibbon Conservation Project. Fauna & Flora International-Vietnam Programme, Hanoi. (Unpubl.).

Tan, B. (1985): The status of primates in China. Primate Conservation 5, 63-81.

Trinh Dinh Hoang (2004): Gibbon monitoring survey and training in Trung Khanh, Cao Bang Province. Fauna & Flora International-Vietnam Programme, Hanoi. (Unpubl.).

Trinh Dinh Hoang (2007): Training in developing a reporting format and a census plan for the Cao Vit Gibbon Conservation Project. Fauna & Flora International-Vietnam Programme, Hanoi. (Unpubl.).

Vu Ngoc Thanh, Nguyen Xuan Dang, Nguyen Manh Ha, Luu Tuong Bach & Nguyen Thi Hien (2005): Survey and Assessment of the Cao Vit Gibbon Population, Phong Nam – Ngoc Khe Proposed Species/Habitat Conservation Area, Trung Khanh District, Cao Bang Province. Fauna & Flora International-Vietnam Programme, Hanoi. (Unpubl.).

Vu Ngoc Thanh, Nguyen Quang Truong, Grismer L.L. & Ziegler, T. (2006): First record of the Chinese Leopard Gecko, *Goniurosaurus luii* (Reptilia: Eublepharidae) from Vietnam. Current Herpetology 25(2), 93-95.

Vu Anh Tai & Nguyen Huu Tu (2007): Flora and Vegetation of Cao Vit Gibbon Conservation Area at Trung Khanh, Cao Bang Province. Fauna & Flora International-Vietnam Programme, Hanoi. (Unpubl.).

29

GIBBONS AS LANDSCAPE SPECIES: STRATEGIC PLANNING FOR PRIMATE CONSERVATION IN LAO PDR.

CHRIS HALLAM AND ARLYNE JOHNSON

SUMMARY

Bolikhamxay Province in Lao PDR (hereafter Laos) contains the largest block of high quality dry evergreen forest remaining in Indochina in the 1570 km^2 Nam Kading National Protected Area (NKNPA). The Integrated Ecosystem and Wildlife Management Project (IEWMP) used the Wildlife Conservation Society's 'Landscape Species Approach' to bring together government, communities and NGO stakeholders to select seven landscape species for the province, which included the northern white-cheeked gibbon (*Nomascus leucogenys*). Government staff worked with the IEWMP to create maps identifying areas of management priority for the gibbons, which took into account the most suitable habitat and the location and relative importance of human-caused threats. The resulting maps were used to build a conceptual model, which identified a population target for the species as well as management interventions for reducing direct and indirect threats to the species to reach the target.

A monitoring program using line transects was implemented in the NKNPA to measure gibbon population change over time to assess the effectiveness of management interventions and to adapt actions accordingly. This paper presents baseline results of the modeling, management interventions and line transect monitoring for gibbons in the Nam Kading National Protected Area.

INTRODUCTION

Planning for conservation requires the consideration of the complex interplay between different social, ecological, and biological factors, and trying to prioritize inevitably limited resources to obtain the greatest conservation benefit. At times this must also be done with limited information and must take into account the heterogeneous and changing nature of large landscapes. The 'Landscape Species Approach' is a strategic planning process that guides wildlife management within large landscapes of human influence. The approach engages multiple stakeholders and uses GIS, modeling, monitoring, and evaluation of "landscape species" to measure success (Sanderson *et al.*, 2002). This paper outlines the application and results of this approach in the landscape of Bolikhamxay Province in central Laos and reports on the monitoring baseline for one "landscape species" - the northern white-cheeked gibbon (*Nomascus leucogenys*).

MATERIAL AND METHODS

Study Area

The Nam Kading landscape (Fig. 1) is part of the larger Northern Annamites eco-region (Wikramanayake & Dinerstein, 2002), which is renowned for the recent discovery of several unique endemic species of global conservation significance (Duckworth *et al.*, 1999). The Nam Kading landscape boundaries are the same as those of the 'Tiger Conservation Landscape' (Wildlife Conservation Society *et al.*, 2006), which contains five national

Fig. 1. The Nam Kading Landscape.

protected areas as well as three provincial protected areas. The landscape also covers six provinces, Luang Prabang, Bolikhamxay, Khammouane, Vientiane Capital, Vientiane Province and Xieng Khuang. The focus of this paper is on the Nam Kading NPA (NKNPA) in Bolikhamxay Province.

The NKNPA is 169,000 ha entirely within Bolikhamxay Province. It is a mix of upper and lower mixed deciduous forest with a primary forest cover of 85% (Forest Inventory and Planning Division, 2001). There are 24 villages within 5 km in the NKNPA and 3 enclave villages which have a total population of around 13,802 people (National Statistics Centre, 2005). This is lower than other protected areas in Laos. The area is very rugged which has afforded it better protection from habitat loss and illegal hunting than other protected areas in Laos.

In 2005, the Wildlife Conservation Society (WCS) along with the Provincial Agriculture and Forestry office of Bolikhamxay (PAFO) received funding from the Global Environment Facility (GEF) and the MacArthur Foundation to implement the Integrated Ecosystem and Wildlife Management Project (IEWMP), a five year project to build national capacity to effectively manage the globally significant biodiversity of Bolikhamxay Province.

Methods

During the first year of implementation, the IEWMP used a conceptual model approach to set a conservation goal and broadly assess threats (Wilkie, 2004). The process involved the following steps: a) Developing a vision state for the NKNPA, b) design a conservation objective (e.g. Margolius & Salafsky, 1998) c) state the direct threats d) state the indirect threats. The indirect threats were identified as factors contributing to the direct threats, e) design interventions (management activities) to reduce the threats. From this point the project employed the living landscape process to plan conservation within the larger landscape. The steps taken by the IEWMP are:

Step 1: Landscape species selection
Step 2: Spatial modeling of habitat and threats and production of conservation landscapes
Step 3: Designing approaches and measures of success

Step 4: Implement actions and measure effectiveness

Step 5: Review progress and revise approach.

These form an adaptive management framework outlined in Fig. 2. The methods and results from implementing each step in the NKNPA were as follows:

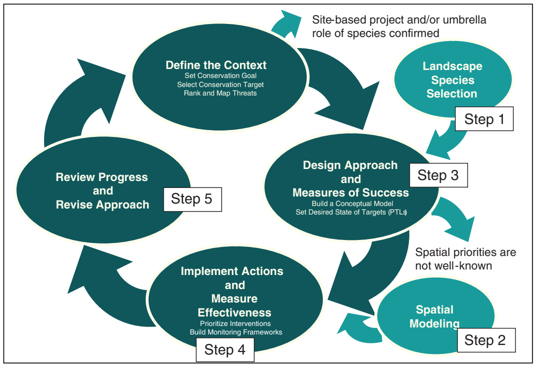

Fig. 2. The 'Living Landscapes' process.

Step 1: Landscape species selection

Landscape species (LS) have five characteristics:

- they range over large areas
- use a variety of habitat types
- are especially vulnerable to threats in the landscape (such as over harvest or habitat loss)
- are socio-economically important
- have a strong ecological function in the natural ecosystem (e.g. seed disperser, top predator) (Coppolillo & Gomez, 2004).

Candidate species presented must have at least one of the five criteria. Based on the above criteria a set of 21 candidate species was made (Table 1). This list was sent to eleven taxa experts in preparation for selecting 'Landscape Species' for the Nam Kading landscape. Each expert was asked to contribute information on the characteristics of each species as related to the five criteria outlined above.

Following this process a three day workshop was held in March 2006. The workshop was attended by district and provincial government agencies, village headmen and WCS staff with the aim of assessing the candidate species list. These stakeholders were consulted on the selection of the species, the assessed threats and susceptibility to threats, species utilized habitats and management zones where the species occurred. During the workshop the IEWMP used 'Landscape Species Selection' software Version 2.1. (Wilkie, 2004; Strindberg, 2006). Further details about how this process was carried out can be found in the 'Landscape Species Selection Report for the NKNPA' (Strindberg, 2006).

Table 1. Initial list of candidate species for selection as 'Living Landscape' species.

1	Great hornbill	*Buceros bicornis*
2	Wreathed hornbill	*Rhyticeros undulatus*
3	Lesser fish eagle	*Ichthyophaga humilis*
4	River lapwing	*Vanellus duvaucelii*
5	Big-headed turtle	*Platysternon megacephalum*
6	Water monitor	*Varanus salvator*
7	Oriental small-clawed otter	*Aonyx cinerea*
8	Eurasian otter	*Lutra lutra*
9	Stump-tailed macaque	*Macaca arctoides*
10	Francois' langur	*Trachypithecus francoisi*
11	Northern white-cheeked gibbon	*Nomascus leucogenys*
12	Bear	*Ursus* sp.
13	Clouded leopard	*Neofelis nebulosa*
14	Tiger	*Panthera tigris*
15	Asian elephant	*Elephas maximus*
16	Sambar	*Cervus unicolor*
17	Gaur	*Bos gaurus*
18	Wild boar	*Sus scrofa*
19	Serow	*Naemorhedus sumatraensis*
20	Pakhe	*Bagarius bagarius*
21	Pakheung	*Hemibagrus wyckoides*

Results

The process resulted in a final list of six 'Landscape Species': Asian elephant (*Elephas maximus*), tiger (*Panthera tigris*), southern serow (*Naemorhedus sumatraensis*), Eurasian wild pig (*Sus scrofa*), northern white-cheeked gibbon (*Nomascus leucogenys*), and great hornbill (*Buceros bicornis*) (Strindberg, 2006).

Step 2: Spatial modeling of habitat and threats

Methods

Following the first meeting, modeling for each of the species was conducted.

It was intended to:

- show where the important human-caused threats are occurring and how strongly they impact the species (called 'Threats Landscapes'), and
- use the Biological and Threats Landscapes to create 'Conservation Landscapes' (Didier, 2006). The Conservation Landscapes for Bolikhamxay Province identify the areas of the landscape that are a management priority for the species (Bryja, 2006, Rasaphone & Johnson, 2007).

As little was known on northern white-cheeked gibbons in the wild, a literature review of closely related species was completed to assess likely important spatial and lifecycle requirements. This was used to guide modeling and selection of GIS proxies.

GIS proxies were chosen and modeled based on inputs in Table 2 to produce biological landscapes, based on information collected during the first stakeholder meeting. A second stakeholder meeting was held in November 2006, eight months after the first, to allow stakeholders to assess the habitat and threat modeling (Bryja, 2006). Below are the biological, threats and conservation landscapes for the northern white-cheeked gibbon as generated in the modeling.

Results

Biological landscape for the northern white-cheeked gibbon (Fig. 3).

The biological landscape was defined by gibbon preference for a habitat with a high density of tree cover, a minimum core area (as discussed below) and an elevation below 2000 m asl. The GIS proxies used included vegetation type and elevation models. For vegetation, a score of 1-100 was given to represent suitability based on the literature review (Table 2).

Since gibbons have very limited dispersal capabilities and do not cross open spaces that are wider than 10 m, major roads and rivers were treated as barriers to their movement. It was assumed that gibbons could cross smaller rivers and unpaved roads as long as there was a high density of tree cover. For the minimum core area, we considered a minimum viable number of groups/families to be six

Table 2. GIS proxies for gibbon 'Landscapes' (Bryja, 2006).

Land cover	gibbon
Urban	0
Agriculture	0
Regeneration forest	50
Secondary forest	30
Forest plantation	0
Savannah	0
Scrub	0
Grassland	0
Mixed broad-leaved	80
Coniferous forest	0
Lower dry evergreen	
low density	90
high density	100
Upper dry evergreen	
low density	90
high density	100
Lower mixed deciduous	
low density	70
high density	80
Upper mixed deciduous	
low density	70
high density	80
Dry dipterocarp	0
Bamboo	0
Riparian	100
Swamp	0
Water	0
Rock	0

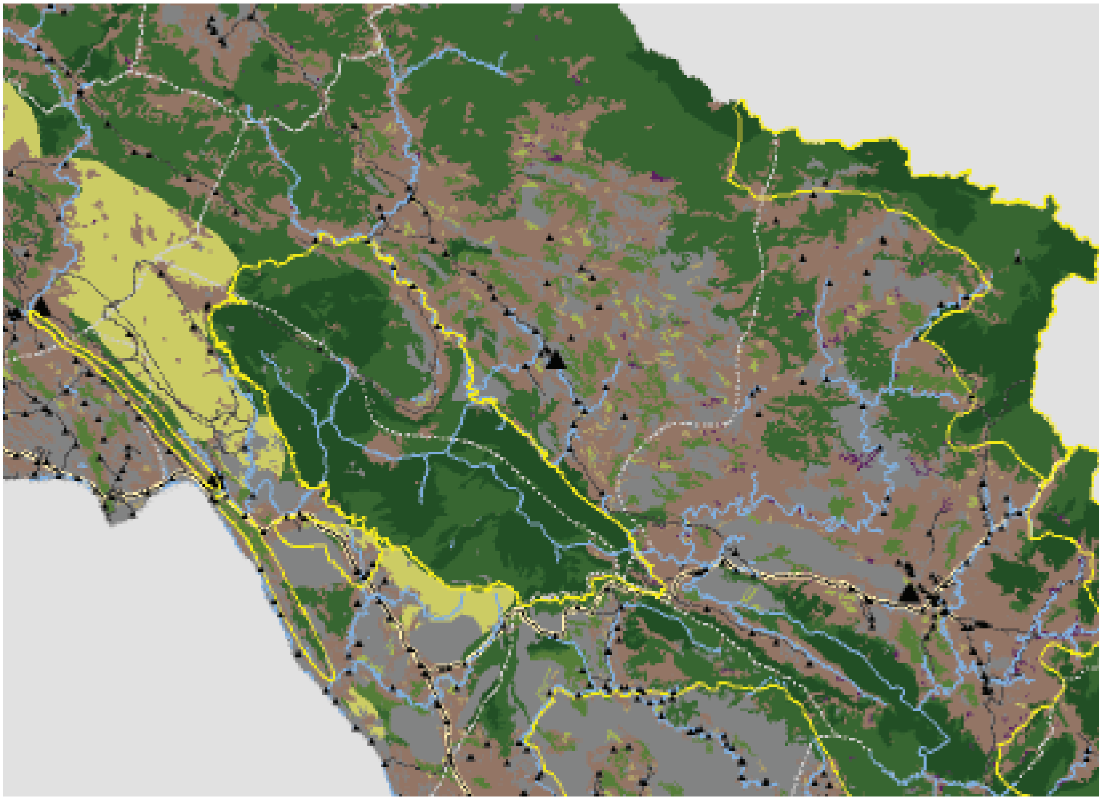

Fig. 3. Biological landscape for northern white cheeked gibbons *(Nomascus leucogenys)*(darker green represents higher quality habitat) (Bryja, 2006).

groups for a patch of habitat (without distinction of quality) to be considered suitable. Core area needed per group was estimated to be 30 ha, hence a patch of minimum size 6 x 30 ha = 180 ha is needed for a viable population.

'Threat Landscape' for the northern white-cheeked gibbons

Hunting (Fig. 4)

To assess hunting pressure, access to the area and population pressure were modeled. A model buffering travel routes (rivers and roads) and a costs surface were developed. A cost surface represents the difficulty of movement over the landscape and takes into account terrain and access routes. The effects of population pressure were modeled by adapting existing programs used in WCS Congo to the Southeast Asian situation (AML Arc Info) (Bryja, 2006).

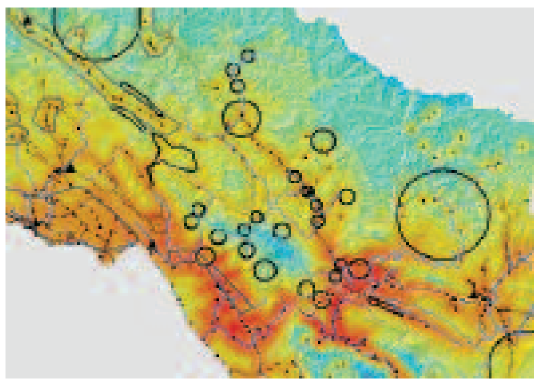

Fig. 4. Combined travel cost and population modeling to assess hunting threat within the landscape for northern white-cheeked gibbons (*Nomascus leucogenys*) (red areas represent high hunting pressure, circles represent known areas of trade and/or hunting) (Bryja, 2006).

Logging (Fig. 5)

Logging was identified as one of the most important threats to gibbons. To create the layer that represents the risk of logging, we used information about the presence of plantation forests and logging activities provided by government officials. We also modified the layer by identifying additional areas, which might be under a higher risk of logging activities within the province. We based our assumption about the logging threat on the forest type, slope and proximity to roads.

'Conservation Landscape' for the northern white-cheeked gibbon (Fig. 6)

The threat and the biological landscapes were then merged to form the conservation landscape. The conservation landscape provided a visual representation of both the threats and habitat for each of the LS in the landscape and can be used to prioritize actions within the landscape.

Step 3: Design approaches and measures of success

3.1 Build a conceptual model
Methods

A single general root-cause-analysis diagram, termed a conceptual model (Wilkie, 2004), for the NKNPA was developed by the IEWMP with district staff in November 2005 (Vannalath & Hedemark, 2005). Following landscape species selection and production of 'Conservation Landscapes', detailed conceptual models for each of the six LS that represent the Nam Kading landscape (Johnson & Vannalath, 2006) were made. The team that was assembled to develop the conceptual models included district government officers from all districts surrounding the NKNPA, the NKNPA Manager and Deputy Manager, IEWMP site staff and volunteers, and WCS staff working with the IEWMP project.

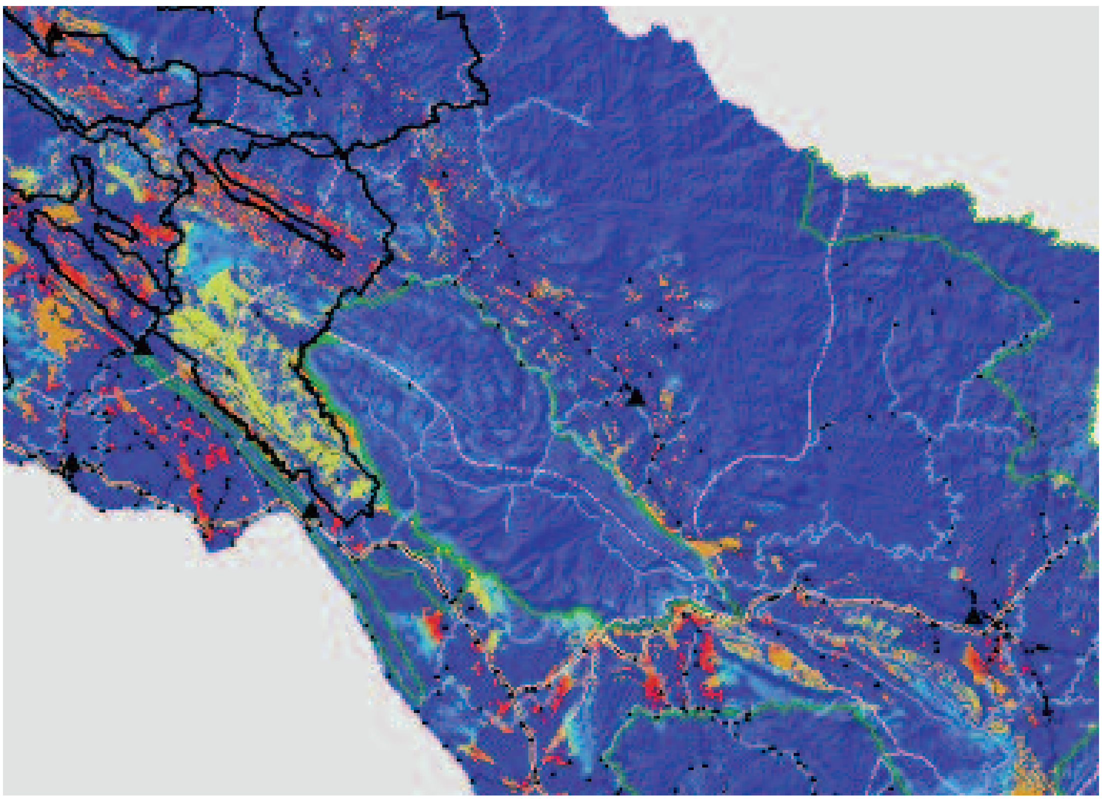

Fig. 5. The map represents the risk of logging. The areas marked with black graphics show the area of plantation forest where selective logging is happening.

The methods used to develop the conceptual models were:

- Review the 'Conservation Landscape' and the basic biology of the species.
- Based on the 'Conservation Landscape' and the biology of the species, state the conservation objective. Participants aimed to construct SMART objectives that were S: Specific, M: Measurable, A: Achievable, R: Realistic, and T: Time-bound (Margolius & Salafsky, 1998).
- State the direct threats. We used data that resulted from the Landscape Species selection and habitat modeling activities as above (Bryja, 2006; Strindberg, 2006) to define the direct threats.
- State the indirect threats. The indirect threats were identified as factors contributing to the direct threats. To keep the exercise focused on ways to reduce the most direct threats, we specifically defined the indirect threats as - who was carrying out the actions that were leading to the direct threat, how and for what reason.
- Design interventions (management activities) to reduce the threats.

Results

After reviewing the gibbon 'Conservation Landscape' (Fig. 6), we concluded that most of the NPA still provides high quality evergreen forest habitat for gibbon, but that the majority of the area is threatened by hunting (red and orange areas overlaid with blue circles that indicate high levels of hunting). Habitat loss as a result of logging is also a threat along the western boundary of the NPA. The conservation landscape shows that only the very core of the NPA now provides high quality habitat where the level of threat is low (green area).

In our review of gibbon biology, we discussed gibbon reproduction, dispersal, and population viability. In general, gibbons live in pairs and have one offspring approximately every two years (Leighton, 1987). The juvenile stays with the parents for approximately eight years before it must disperse to find its own territory in which to survive. Gibbons

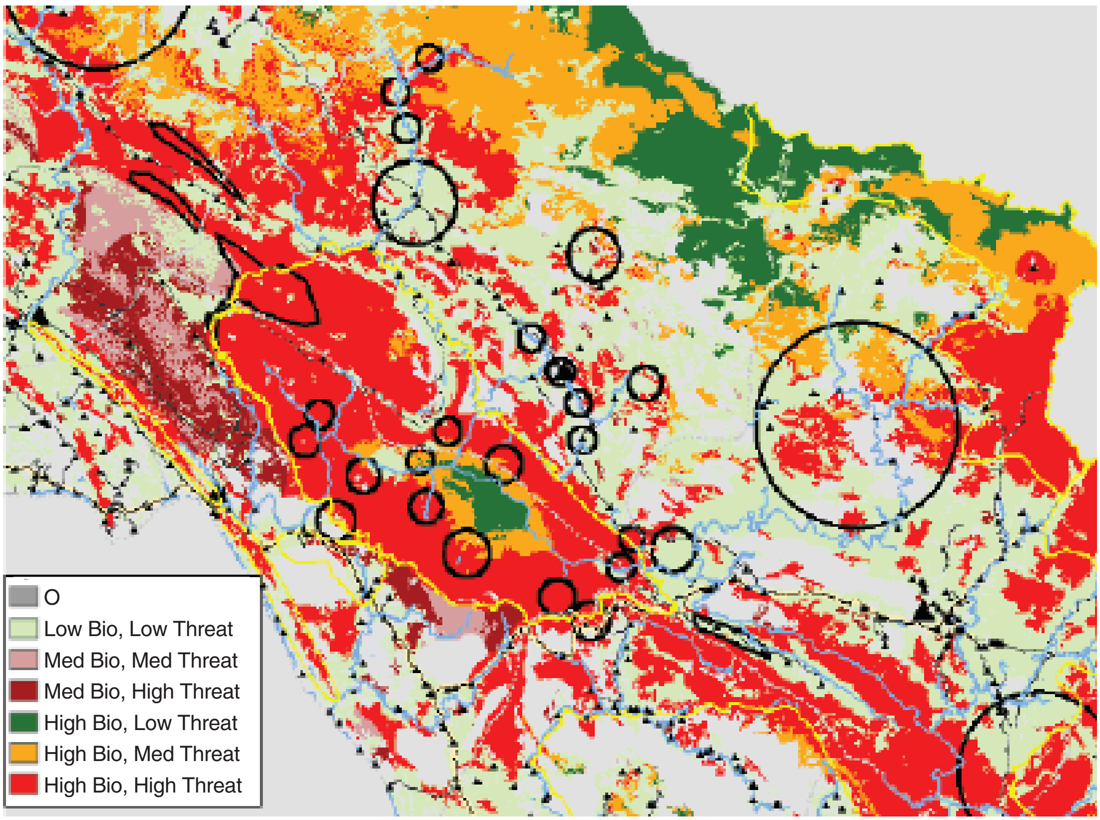

Fig. 6. Conservation landscape for northern white-cheeked gibbons (*Nomascus leucogenys*).

are unlikely to cross forest gaps that are greater than 10-20 m and are unable to cross large rivers.

Based on the literature, we estimated that the evergreen forest in Nam Kading could possibly contain three family groups/km^2 with an average group size of four individuals (Leighton, 1987; Geissmann *et al.*, 2000). For long-term population viability, references indicated that 125 groups is a minimum and the ideal population size would be at least 1250 groups (Bleisch & Jiang, 2000). To achieve the latter would require 416 km^2 of ideal habitat. Based on our 'Conservation Landscape', we estimated that 80-90% of the NKD (total area of 1690 km^2) may be suitable for gibbons. Theoretically, it would be possible to harbor up to 4500 groups, or around 18,000 individuals, in the NPA in the absence of all threats.

Based on the above review of gibbon biology the workshop participants settled on the following objective:

"A 10% increase in population of northern white-cheeked gibbons will be achieved within five years of the baseline survey within the NKD NPA."

Following the review of the 'Conservation Landscape' and gibbon biology, the participants discussed what could be done where, and by when, to expand gibbon populations in the NPA and together developed a conceptual model outlining the conservation goal, direct and indirect threats and conservation interventions. The interventions are outlined in the conceptual model for white-cheeked gibbons (Fig. 7).

3.2 Develop a monitoring strategy to measure success

Methods

Prior to beginning the project no quantitative surveys of any wildlife within the NKNPA had been done. In order to inform and design a robust and effective monitoring strategy we conducted an encounter rate survey for the LS in early 2007 (Vanderhelm & Johnson, 2007). Teams conducted surveys in eight locations around the park (Fig. 8). In each of the survey zones teams looked for signs of each of the six LS species. Signs included prints, vocalizations, and sightings. Teams walked at a rate of around 1 km per hour from sunrise to 12 pm every day recording signs of target species. For each sign a GPS point was taken. Track logs from the GPS provided rough estimates of the distance traveled and thus encounter rates for detecting each of the species was calculated (Vanderhelm & Johnson, 2007).

From 233 km of transects walked, gibbon encounters (vocalizations or sightings) were around

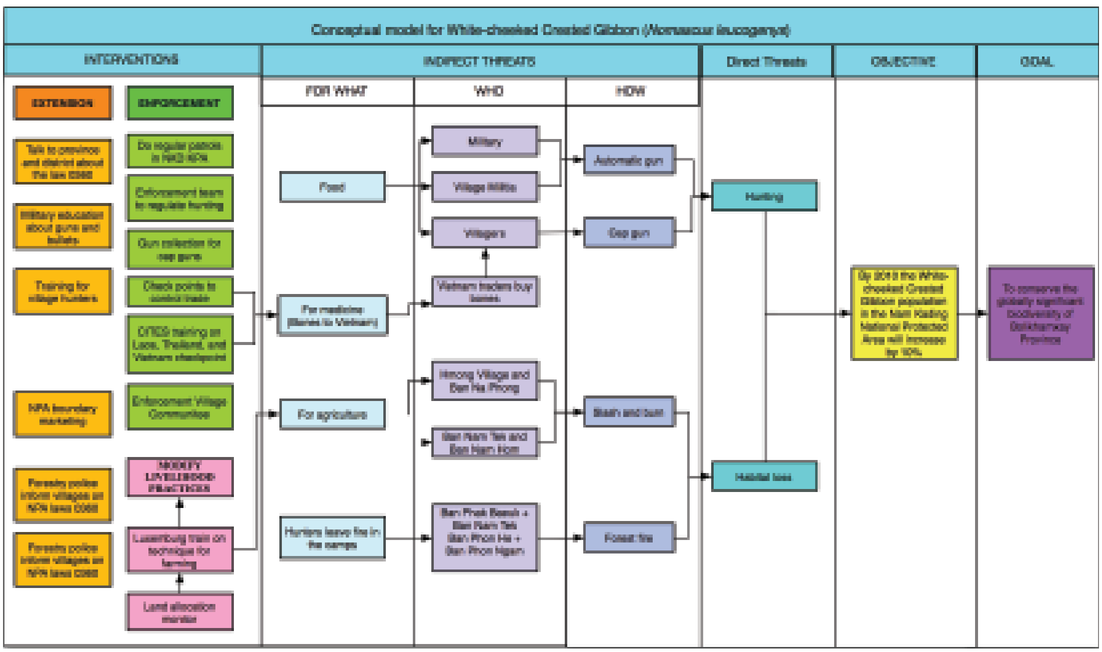

Fig. 7. Conceptual model of the northern white-cheeked gibbon (*Nomascus leucogenys*) for the Nam Kading National Protected Area (Johnson *et al.*, 2006).

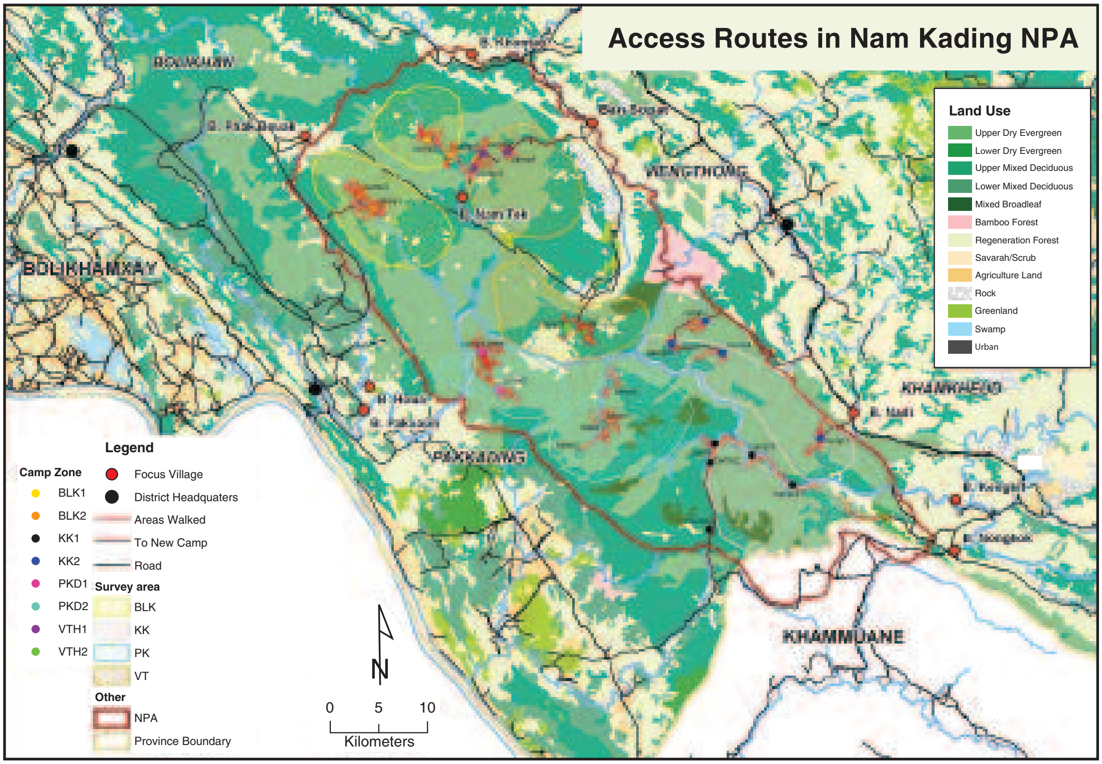

Fig. 8. Encounter rate survey zones (Vanderhelm & Johnson, 2007).

7 per 100 km (Vanderhelm & Johnson, 2007). For this and other species these encounter rates are extremely low. The information from this report went into the formation of a monitoring strategy to monitor change in LS populations over time.

A monitoring strategy was designed that took into account the limited resources and technical capacity available (e.g. Danielsen & Balete, 2000) and ensured that the monitoring could be correctly carried out and continued by the IEWMP in the long-term. We also considered that the strategy must be able to collect sufficient and appropriate data to detect relevant changes in the LS (Danielsen & Jensen, 2005).

Results

Line transect methods were chosen to monitor gibbon populations in the NKNPA. These methods, although not optimal for gibbons, were chosen to capture other LS during each survey. By conducting a simple power analysis following Gerrodette (1987), we determined a total transect length of ~260 km was required in order to be sure of detecting any change in populations over time. As encounter rates were so low we decided to use patch occupancy as a state variable to estimate the status of the LS populations in the NKNPA following MacKenzie & Nichols (2002). We defined 5 survey zones covering around 25% of the NKNPA. A total of 204 transects were planned with a total length of 260 km. As each transect is traversed 4 times the total effort is ~1040 km. Transects were placed 1 km apart and are up to 2 km long (Fig. 9). Transects were walked repeatedly on four consecutive mornings between sunrise and midday and signs of LS species were collected.

Step 4: Implement actions and measure effectiveness

4.1 Implement conservation actions

Methods

Conservation actions were developed following those outlined in the conceptual models. The actions described in Fig. 7 fall broadly into 3 work units:

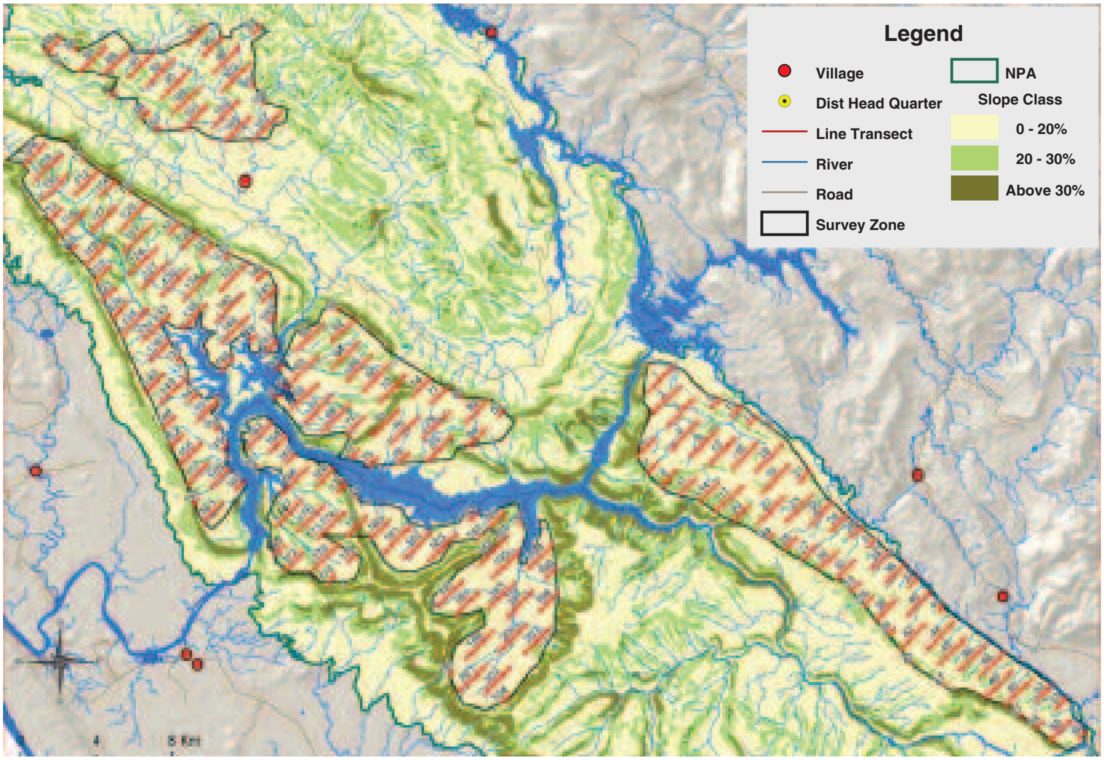

Fig. 9. Sampling design for transects for the Nam Kading National Protected Area (Strindberg & Johnson, 2007).

awareness raising, law enforcement and village development activities. Over the past 4 years activities have been guided by the conceptual models built for each species. Teams were formed, trained and activities implemented on the ground. Each work unit used an adaptive management framework (Margolius & Salafsky, 1998) to review and improve activities.

Results

The awareness raising team has developed key conservation messages based on the conceptual model (Fig. 7) and up until November 2008 has implemented these in three of the four districts surrounding the NKNPA. The activities implemented involved: teacher training, village visits, military camp visits, short radio spots, posters, plays, competitions, market visits and bus station visits. Each activity was assessed against objectives using a pre and post test design. Activities are described by Vannalath & Hedemark (2006).

Enforcement work started in earnest in March 2007 with the completion of an enforcement strategy for the NKNPA (Hallam & Lynam, 2007). The enforcement strategy used the conservation landscapes and additional local knowledge from districts to design strategies to protect the populations of LS within the NKNPA, prevent trade along major trade routes and stop the sale of LS in local markets. From 2007 to 2008, 36 staff members were involved in active implementation of these key activities in and around the NKNPA.

Village development work has been done in order to encourage positive conservation behavior. The IEWMP works in eight target villages with a total population of 3500 people. This is around 25% of the total population within 5 km of the NPA. An initial ‘Participatory Rural Appraisal’ (PRA) (Chambers, 1994) was done. From this interventions and activities were designed with the objective of alleviating poverty while encouraging positive conservation behavior. Examples of activities included: non-timber forest product (NTFP) management planning and market links, formation of fish conservation and frog conservation zones, forming village patrolling teams, and village revolving funds linked to positive conservation behavior.

In addition to these broad activities the IEWMP also established and officially recognized boundary for the NKNPA and a total protected zone (TPZ) within the NKNPA. Villages were intimately involved in deciding on and negotiating the location of both the boundary posts and the TPZ sign locations. In each village area abutting the NKNPA concrete boundary posts were erected and TPZ signs established attached. This was followed up by raising awareness on the benefits of the TPZ. This action has clarified village land areas and allows easier enforcement of NKNPA rules.

4.2 Measure effectiveness

Methods

The monitoring strategy was implemented in line with the steps described in Step 3.

While walking line transects, data were collected on presence or absence of gibbons, using sounds or sightings. In addition, standard distance sampling measurements were made during sighting only. Each transect was traversed four times to increase the detection probability for occupancy surveying. Transect results were exported from the Excel database and analyzed using PRESENCE software (Hines, 2006). We ran several models to assess best fit (a lower AIC represents a better model fit) and concluded that the ‘Single Season Heterogeneity Model’ was the most suitable (Royle & Nichols, 2003).

We then ran this model to obtain occupancy results in the survey area. We also calculated the coefficient of variation (CV) for the occupancy estimate to assess the reliability of the estimates. This is the estimate of standard error (SE) of the occupancy divided by occupancy estimate. For species such as gibbons that have a high amount of spatial heterogeneity in the estimate, low CV’s can be difficult to achieve. Thus for gibbons in this survey we decided that a CV of 30% or lower was acceptable.

Results

In total only 405 km of the anticipated 1040 km were surveyed. This was due to the incredibly rugged nature of the NKNPA and an early onset of the wet season in May 2008. At this point we have established the first quantitative baseline of wildlife populations within the NKNPA.

In total 105 of 204 transects representing 405 km of transect were completed. The results represent only 37% of the planned 1040 km survey effort. Twenty-eight gibbon detections were recorded along the 405 km of line transects walked. This included 25 independent detections of gibbon vocalizations and three sightings of gibbons (gibbons were also detected outside transects). These results were used in occupancy analysis provided they were within 500 m (the patch size) of the transect and between sunrise and 12 pm as stated in the protocol (Table 3).

Gibbons were detected (sightings and vocalizations) on 18% of transects walked (n=105; naïve estimate of occupancy in Table 4). Based on these detections, the estimated occupancy for gibbons is 30% (SE=8 CV=28%). Individual detection probability (20%) was relatively good, and the SE relatively low (6) with an acceptable CV of 30%. This means that the occupancy estimate of 30% is a fair representation of the true occupancy.

Step 5: Review progress and revise approach

The overwhelming advantage of the ‘Living Landscape’ process is that it has provided a planning strategy firmly based on biological knowledge that provides a clear vision of both where and when to implement conservation actions. It has ensured efficiency in conservation actions where resources are scarce. It has also promoted management participation in a tangible product through several stakeholder workshops. The ‘Conservation Landscapes’ are a key tool that are used regularly in planning and are easily explained to non expert audiences.

The ‘Living Landscapes’ process has also contributed practical tools for long term planning, and these have been incorporated into the first management plan for the NKNPA. Various difficulties

Table 3. Table of detections of northern white-cheeked gibbons (*Nomascus leucogenys*) (sightings or vocalizations) in Nam Kading National Protected Area, 2008-2009.

Record type	on transect			off transect			Grand Total
	seen	heard	Total	seen	heard	Total	
Number of gibbon	3	25	28	0	8	8	36

Table 4. Occupancy table for northern white-cheeked gibbons (*Nomascus leucogenys*) in Nam Kading National Protected Area.

Species	A Naïve	B λ (Std. error)	C r (Std. error)	D Psi (Std. error)	E N	CI
Gibbon	18	36(12)	20(6)	30(8)	47.6	15.8 - 77.6

A Naïve estimate of occupancy; does not incorporate detection probability (p)
B Abundance index of gibbon cluster per transect
C Individual detection probability of gibbon
D Estimated probability of transect occupied by gibbons
E Abundance index of gibbon clusters

were encountered during the process. At times, the process, development of methods, and key terms has proved confusing. This is especially the case when trying to translate the concepts and technical words into local language. In addition the time taken was much longer than initially expected. The process of selecting species and landscape modeling along with development of the monitoring strategy took approximately 18 months. The total cost of the process was around US$40,000. However once established the process can easily be updated within the adaptive management cycle (Fig. 2)

The monitoring results for gibbons support the 'Conservation Landscape' developed as part of the 'Living Landscape' process. Populations of gibbons within the NKNPA are low based on interpretation of the occupancy results but there is potential for recovery with reduction in threat and in consideration of good habitat already within the NKNPA. Repeat surveys will discover if the interventions are having the required effect. However, the monitoring protocol also proved over-ambitious for the time and topography of the NKNPA resulting in incomplete survey effort. As the management of the NKNPA matures the living landscape process will continue to provide a solid basis for continuing management.

CÁC LOÀI VƯỢN ĐƯỢC XEM NHƯ LÀ LOÀI CẢNH QUAN: CHIẾN LƯỢC HOẠCH ĐỊNH CHO CÔNG TÁC BẢO TỒN LINH TRƯỞNG Ở CHDCND LÀO

TÓM TẮT

Tỉnh Bolikhamxay của nước CHDCND Lào chiếm diện tích lớn nhất của những cánh rừng thường xanh có độ khô ráo cao còn lại ở Đông Dương có tổng diện tích 1.570km^2 của Khu Bảo tồn Quốc gia Nam Kading. Dự án quản lý hệ động thực vật thiên nhiên lồng ghép với hệ sinh thái (IEWMP) sử dụng phương pháp tiếp cận các loài cảnh quan của Quỹ Bảo tồn Động Thực vật hoang dã đã tiến hành cùng hợp tác với các cơ quan Chính phủ, các tổ chức cộng đồng và các tổ chức phi chính phủ liên quan để chọn ra bảy loài cảnh quan cho tỉnh, trong đó có loài vượn đen má trắng (*Nomascus leucogenys*). Cán bộ nhà nước làm việc với dự án IEWMP để lập ra những bản đồ xác định các vùng quản lý ưu tiên cho loài vượn, trong đó bao gồm sinh cảnh, địa điểm phù hợp nhất cũng như tác động từ các mối đe dọa do con người gây ra cho loài. Những bản đồ được sử dụng để xây dựng một mô hình mang tính khái niệm xác định mục tiêu cho mật độ quần thể loài cũng như các can thiệp lên công tác quản lý làm giảm các mối đe dọa trực tiếp hay gián tiếp đến loài để đạt được mục tiêu đề ra. Một chương trình giám sát sử dụng phương pháp giám sát tuyến được tiến hành thực hiện trong Khu bảo tồn Quốc gia Nam Kading (NKNPA) nhằm đo đếm mật độ quần thể vượn thay đổi qua thời gian và đánh giá tính hiệu quả các can thiệp lên công tác quản lý, đồng thời làm quen với các hoạt động một cách phù hợp. Tài liệu này giới thiệu các kết quả cơ bản về cách thức lập mô hình, các can thiệp quản lý và giám sát tuyến cho loài vượn tại Khu bảo tồn Quốc gia Nam Kading.

REFERENCES

Bleisch, W. & Jiang, X.L. (2000): Action plan for conservation of gibbons of the Wuliang mountains, Kunming, China., Sino-Dutch Forest Conservation and Community Development Project, Kunming.

Bryja, G. (2006): Building Conservation Landscapes for the Bolikhamxay province (with focus on the Nam Kading NPA).Wildlife Conservation Society, Vientiane (Report).

Coppolillo, P. & Gomez, H. (2004): Selection criteria for suites of landscape species as a basis for site-based conservation. Biological Conservation 115(3), 419-430.

Chambers, R. (1994): Participatory Rural Appraisal (PRA): Analysis of Experience. World Development 22(9), 1253-1268.

Danielsen, F. & Balete, D.S. (2000): A simple system for monitoring biodiversity in protected areas of a developing country. 9(12), 1671-1705.

Danielsen, F. & Jensen, A.E. (2005): Does monitoring matter? A quantitative assessment of management decisions from locally-based monitoring of protected areas. Biodiversity and Conservation 14(11), 2633-2652.

Didier, K. (2006): Living Landscapes Program—Building Biological and Threats Landscapes. Technical Manual No 6. Living Landscapes Program, Wildlife Conservation Society, New York.

Duckworth, J.W., Salter, R.E. & Khounboline, K. (compilers) (1999): Wildlife in Lao PDR: 1999 Status Report; pp. 275. IUCN-The World Conservation Union / Wildlife Conservation Society / Centre for Protected Areas and Watershed Management. Samsaen Printing, Bangkok.

Forest inventory and Planning Division (2001): Landcover of Lao PDR. Department of Forestry, Vientiane.

Geissmann, T., Nguyeen Xuan Dang, Lormee, N. & Momberg, F. (2000): Vietnam Primate Conservation Review 2000. Part 1: Gibbons. Fauna & Flora International – Indochina Programme, Hanoi.

Gerrodette, T. (1987): A power analysis for detecting trends. Ecology 68, 1364–1372

Hallam, C. & Lynam, A.J. (2007): Guidelines for a Wildlife Protection Strategy for the Nam Kading NPA: Summary of workshop findings 1 – 2 April, 2007. Vientiane Lao PDR, Provincial Agriculture and Forestry Office, Bolikhamxay and WCS Lao PDR Program. (Unpubl.).

Hines, J.E. (2006): Presence 2 - Software to estimate patch occupancy and related parameters. Laural, MD, USA, USGS-PWRC.

IEWMP (2006): Report on Living landscapes species selection. March 2006, WCS/PAFO Bolikhamxay Province.

Johnson, A. & Vannalath, S. (2006): Using conservation landscapes to build conceptual models for the Nam Kading National Protected Area Landscape. Vientiane. (Unpubl.).

Leighton, D.R. (1987): Gibbons: territoriality and monogamy. In: Smuts, B.B., Cheney, D.L., Seyfarth, R.M., Wrangham,R.W. & Struhsaker, T.T (eds.): Primate Societies; pp. 135–145. University of Chicago, Chicago.

Mackenzie, D.I. & Nichols, J.D. (2002): Estimating site occupancy when detection probabilities are less than one. Ecology 83, 2248-2255.

Margolius, R. & Salafsky, N. (1998): Measures of Success. Centre for Resource Economics, Washington DC.

National Statistics Centre (2005): Population and housing census year 2005. Vientiane.

Rasphone, A., & Johnson, A. (2007): Technical Report on Building Species Conservation Landscape for Central Laos (Mainly around Nam Kading National Protected Area, Bolikhamxai). Vientiane. Wildlife Conservation Society. (Unpubl.).

Royle, J.A. & Nichols, J.D. (2003): Estimating Abundance from Repeated Presence-Absence Data or Point Counts. Ecology 83(3), 777-790.

Sanderson, E.W. & Redford, K.H. (2002): A conceptual model for conservation planning based on landscape species requirements. Landscape and Urban Planning 58, 41-56.

Strindberg, S. (2006): Landscape Species Selection for the Nam Kading Landscape. Lao PDR. Vientiane. Wildlife Conservation Society. (Unpubl.).

Strindberg, S. & Johnson, A. (2007): Recommendations for Monitoring Landscape Species in the Nam Kading National Protected Area. Vientiane, Lao PDR. Wildlife Conservation Society and the Integrated Ecosystem and Wildlife Management Project (IEWMP). (Unpubl.).

Vannalath, S. & Hedemark, M. (2005): Conceptual model for the Nam Kading NPA, Vientiane Lao PDR. Bolikhamxay Provincial Agriculture and Forestry Office and Wildlife Conservation Society. (Unpubl.).

Vanderhelm, F. & Johnson, A. (2007): Baseline investigation into the status of wildlife in the Nam

Kading National Protected Area. Bolikhamxay Provincial Agricultural and Forestry Office and Wildlife Conservation Society. (Unpubl.).

Wildlife Conservation Society, Worldwide Fund for Nature & Smithsonian Institution (2006): Tiger conservation landscape: classification and prioritization.

Wilkie, D.S. (2004): Technical Manual No.2: Conceptual Models. Living Landscapes Technical Manuals. Living Landscapes Program. Wildlife Conservation Society, New York.

Wikramanayake, E. & Dinerstein, E. (2002): Terrestrial ecoregions of the Indo-Pacific: A Conservation Assessment. Island Press, Washington DC.

30

DAO TIEN ENDANGERED PRIMATE SPECIES CENTRE, CAT TIEN NATIONAL PARK, VIETNAM

MARINA KENYON, LUONG VAN HIEN, ALISON CRONIN, KURTIS PEI, TRAN VAN THANH

SUMMARY

Dao Tien Endangered Primate Species Centre is located on a 56 ha island at the entrance of Cat Tien National Park. Officially opening on July 12th, 2008, the centre was established in collaboration with Cat Tien National Park, Monkey World - Ape Rescue Centre, UK, Pingtung Rescue Centre, Taiwan, and the Forestry Protection Department of Vietnam. The centre specializes in the rehabilitation, reintroduction and research on endangered primates of southern Vietnam. Species include the yellow-cheeked gibbon (*Nomascus gabriellae*), black-shanked douc langur (*Pygathrix nigripes*), silvered langur (*Trachypithecus margarita*), and the pygmy loris (*Nycticebus pygmaeus*). The Dao Tien Endangered Primate Species Centre project is supported by EAST (Endangered Asian Species Trust) founded in 2007 by Monkey World - Ape Rescue Centre, UK.

The program offers many benefits from helping to facilitate the placement of confiscated primates and enabling the government to enforce laws on illegal hunting / trade, thus increasing protection on remaining wild populations. Secondly the program helps improve captive welfare standards. Lastly, it also helps to develop primate release protocols which lead to the re-establishment of endangered primates back into regenerating lowland forested areas.

INTRODUCTION

Cat Tien National Park (CTNP) is located in South Vietnam, 150 km NNE of Ho Chi Minh City on the southern edge of the Annamite mountain region. In 2002 CTNP was declared a Biosphere Reserve and more recently it has become a candidate for World Heritage Site as well as for Ramsar Convention, comprising, due to its composition of a mosaic of regenerating forest types with rich biodiversity. The collaboration between Monkey World - Ape Rescue Centre, UK and CTNP began in 2001.

Monkey World - Ape Rescue Centre, UK, opened in 1987, as one of the world's first primate rescue centres. Their mission, at the time was to provide a home for confiscated chimpanzees that had been stolen from the wild and were being used as beach photographers' props in the tourist industry of southern Europe.

Monkey World has developed strong associations in Southeast Asia, especially thanks to collaboration with the Pingtung Rescue Centre for Endangered Wild Animals for more than a decade. The Taiwanese centre was set up in 1993 by the Taiwanese authorities at the Pingtung University of Science and Technology, to provide accommodation for wild animals that had been smuggled into the country illegally. The centre's faculty has a strong background in wildlife research as well as veterinary medicine.

Over ten years the two centres have worked well together in confiscating both gibbons and orangutans. Several of these gibbons had originated in the forests of southern Vietnam and illegally smuggled into Taiwan. In 2001 the trade of Vietnamese primates was found to reach as far as the UK, with a young female yellow-cheeked gibbon confiscated in Cambridge, UK. Due to the discovery of the international trading problem of southern Vietnamese primates, an *in-situ* project in South Vietnam was developed.

THE DAO TIEN ENDANGERED PRIMATE SPECIES CENTRE

Planning

While the Dao Tien Centre and associated facilities took only nine months to build, seven years had passed since the planning began with Vietnamese authorities in 2001. First, it was imperative and the correct sight be chosen for the centre. The centre had to be located within the geographical range of the endangered primates it would specialize in as well as not cause any negative impact on the limited remaining lowland forest in Vietnam. This was achieved by selecting a small island next to continuous forest which would serve as a perfect training ground. After environmental assessments by Pingtung University, no detrimental affects from establishing the centre in its location were found (Fig. 1). All parties agreed that only endangered species of primates belonging to this region would be brought to the centre and that the Vietnamese Forestry Protection Department would work with Dao Tien and CTNP to confiscate any endangered primates that were discovered or reported (Fig. 2).

Fig. 2. Yellow-cheeked gibbon (*Nomascus gabriellae*) during rehabilitation.

Photo: Marina Kenyon.

Fig. 1. Map of Dao Tien.

Rehabilitation

Initial construction involved 10 'phase 1' cages (Fig. 3) for the larger primates (gibbons, douc langurs and langurs). The cages function as quarantine units, located at least 10 meters from another cage, one large play area with soil floor and 2 small bedrooms with concrete floors, enabling high-quality hygiene standards during quarantine. On arrival newly confiscated individuals are de-wormed and given thorough health checks by the veterinary support team from Pingtung Rescue Centre. During the health checks blood is taken for disease screening, blood cell count and biochemistry. Individuals are also tested for TB and given tetanus vaccinations. Hair is taken for DNA analysis and general body condition and teeth are checked. If teeth need attention they will be treated immediately or re-scheduled for a later date (Fig. 4).

For the smaller loris' a small rehabilitation unit with four cages provides final care before release (Fig. 5). Most loris' arrive from Cu Chi Wildlife Rescue Centre, where health checks are done prior to transfer to Dao Tien.

Individuals unfit for release will be transferred to a non-release centre in Vietnam, as only healthy animals can be kept on Dao Tien. Individuals who pass disease screening but are unfit for release (due to extensive snare damage on limbs etc.) who could still be valuable in captive breeding programs could potentially be transferred into the captive breeding programs as agreed by the Vietnamese Government.

Successful healthy candidates start social rehabilitation. Most illegally kept primates are kept in social isolation so they have limited social skills, thus it is crucial to give them social interaction with conspecifics prior to release. They will not necessarily be released together, but this phase will provide a valuable social education, so when individuals come across gibbons in the wild, social repertoire and skills are present.

For gibbons social groupings created consist of (a) a male and female pair, which may take several combinations of individuals before social compatibility is obvious, or (b) young infants placed into nursery groups with similar aged individuals, or with a surrogate mother. It is becoming clear, from individuals at Dao Tien and Monkey World that artificially constructed families are only stable for a limited period. For example adult female gibbons will oust adopted daughters often 2-3 years earlier than would naturally occur with a biological daughter. This is one reason this phase is seen as gaining social skills and not necessarily forming social groups suitable for release.

Fig. 3. Cage for quarantine: 'Phase 1' cage.
Photo: Marina Kenyon.

Fig. 4. Health check by veterinarian from Pingtung Rescue Centre, Taiwan.
Photo: Marina Kenyon.

Fig. 5. Loris' rehabilitation cages.
Photo: Marina Kenyon.

Once individuals appear socially sound; reach a suitable age, are physically fit, have a good weight and pass a second round of health checks, they are moved on to 'phase 2'. Two 'phase 2' areas are being developed on Dao Tien a large 20 ha area, and a small 1.5 ha area (Fig. 1). The forested semi-free areas allow gibbons to be totally arboreal, as they naturally would do in the wild as well as learn to stay quiet or move away silently if humans are seen.

In both semi-free areas a small cage is present where the gibbons will be conditioned to return for food, importantly enabling re-capture prior to final release. The first pair of gibbons in the large semi-free area will be fitted with radio collars, made by Biotrack, UK. This will allow easier monitoring of enclosure use, including behavior as well as seeing how the gibbons cope to being collared. Professor Kurtis Pei from Pingtung University has run a radio tracking workshop which trained primate care staff, CTNP technical staff and forest rangers.

With the first releases a comparison of success with paired or solitary releases will be made. Paired release can take considerably longer in captivity to ensure a good pair bond, yet with a high risk of separation on release. While a solitary young adult release reflects a more normal wild situation, as sub adults in the wild when 6-7 year old gibbons are ousted from the family group to travel on their own to find a mate and territory. This could lead to shorter rehabilitation periods in captivity.

The first 'final releases' will occur in CTNP, where density monitoring of present gibbon populations has already been done, running alongside with a highly trained primate monitoring team experienced in monitoring wild gibbons, led by Thanh Vo Binh, Forest Protection Department of CTNP. Gibbons will be monitored by radio or GPS tracking to obtain valuable post-release data. Future releases once successful protocols have been established are planned in neighboring areas where gibbons are presently extinct or at very low densities. Individuals from the pet trade potentially will be founders of new wild populations, a valuable conservation resource.

The aim is for all four-primate species to be monitored, post-release, in order to gain valuable data on survival and behavior. This will help to provide the Government with data for the development of Vietnamese release protocols for South Vietnamese primates. EAST will provide scholarships for Vietnamese students to undertake this vital post-release monitoring.

TRUNG TÂM CÁC LOÀI LINH TRƯỞNG NGUY CẤP Ở ĐẢO TIÊN VƯỜN QUỐC GIA CÁT TIÊN, VIỆT NAM

TÓM TẮT

Trung tâm Các loài Linh trưởng Nguy cấp ở Đảo Tiên được thành lập vào ngày 12 tháng 7 năm 2008, nằm trên một hòn đảo với diện tích 56 hecta ngay lối vào của Vườn Quốc gia Cát Tiên. Với sự hợp tác giữa Vườn Quốc gia Cát Tiên, Trung tâm Cứu hộ Linh trưởng của Vương Quốc Anh, Trung tâm Cứu hộ Động vật hoang dã Nguy cấp Pingting của Đài Loan và Cục Kiểm lâm Việt Nam. Đây là một Trung tâm chuyên cứu hộ, phục hồi, thả lại tự nhiên và nghiên cứu các loài linh trưởng nguy cấp ở miền Nam Việt Nam. Các loài linh trưởng bao gồm vượn má vàng (*Nomascus gabriellae*), chà vá chân đen (*Pygathrix nigripes*), voọc bạc (*Trachypithecus margarita*), và cu li nhỏ (*Nycticebus pygmaeus*). Dự án Trung tâm Các loài Linh trưởng Nguy cấp Đảo Tiên được hỗ trợ bởi Tổ chức Niềm tin Các loài Nguy cấp Đông Nam Á (EAST), được thành lập năm 2007 thuộc Trung tâm cứu hộ linh trưởng của Vương Quốc Anh. Phúc lợi của chương trình nhằm khuyến khích các cơ quan chức năng tích cực trong việc tịch thu bắt giữ động vật hoang dã từ các vụ săn bắt, buôn bán và nuôi giữ bất hợp pháp và chuyển giao cứu hộ, thúc đẩy việc thực thi pháp luật bảo vệ động vật hoang dã qua công tác tăng cường bảo vệ rừng và duy trì các quần thể linh trưởng hoang dã. Bước thứ hai là nhằm nâng cao chất lượng chăm sóc linh trưởng sau khi bắt giữ. Bước cuối cùng là xây dựng kế hoạch và cẩm nang cho việc tái thả lại linh trưởng nguy cấp sau khi cứu hộ trở lại những vùng rừng tái sinh núi thấp nơi mật độ quần thể linh trưởng còn rất ít và hiện nay đã bị tuyệt chủng tại khu vực này.