

VIETNAMESE Journal of
Primateology

CHUYÊN ĐỀ LINH TRƯỞNG HỌC VIỆT NAM

ISSN 1859-1434



VOLUME 2 - ISSUE 3

APRIL 2015

Vietnamese Journal of Primatology

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Vietnamese Journal of Primatology (ISSN 1859-1434) is a peer-reviewed open access journal published yearly by the Endangered Primate Rescue Center. The subscription price outside Vietnam is \$40.00 including shipment (for one copy). The journal can be ordered from the Endangered Primate Rescue Center, Cuc Phuong National Park, Ninh Binh Province, Vietnam or by mail: <eprc.info@gmail.com>. All subscriptions will be sent by air. Payments should be made by transfer to: Indovina Bank, 88 Hai Ba Trung, Hanoi, SWIFT CODE: IABBVNX; Account: Frankfurt Zoological Society; Account no.: 2023828-001.



The **Vietnamese Journal of Primatology** is produced with support from German Primate Centre, Göttingen.

Cover: Francois langur (*Trachypithecus francoisi*). Photo: T. Nadler.

Reintroduction of the ‘Critically Endangered’ Delacour’s langur (*Trachypithecus delacouri*) into Van Long Nature Reserve, Ninh Binh Province, Vietnam

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Key words: Delacour’s langur, *Trachypithecus delacouri*, reintroduction, home range, path length, Van Long Nature Reserve

Summary

In November 2012 two captive bred ‘Critically Endangered’ Delacour’s langurs (*Trachypithecus delacouri*) were reintroduced into Van Long Nature Reserve, northern Vietnam. The objective of the study was to develop a suitable monitoring technique and evaluate the success of the release as well as to verify the suitability of the area for further reintroductions.

The langurs were equipped with light-weight GPS collars and tracked for seven months to research habitat use, home range characteristics and activity patterns. 1403 GPS locations were recorded for the male whereas only 390 locations were recorded for the female due to a malfunctioning tag. The home ranges were calculated using minimum convex polygon and kernel density estimation methods. Home range varied little between the two individuals with a home range size of 77 ha for the male and 68.5 ha for the female.

The male covered a total distance of 55 km in 208 days and his mean daily path length amounted to 254 m \pm 152 m. The female travelled significantly more and covered a total distance of 42 km in 53 days with a mean daily path length of 756 m \pm 404 m. Comparing monthly travel distances revealed the greatest path lengths in December and January for the male whereas path lengths of the female did not differ between months. Both individuals were diurnal with activity peaks in the morning and in the afternoon. Encounters between released individuals and wild groups or individuals of Delacour’s langurs could not be recorded. These events probably occurred as the home ranges of the released individuals overlapped with home ranges of residents.

The recorded data and observations suggest that the released individuals are capable of surviving in the wild without human assistance.

Tái thả loài linh trưởng cực kỳ nguy cấp, Voọc mông trắng (*Trachypithecus delacouri*) tại khu bảo tồn thiên nhiên Vân Long, Tỉnh Ninh Bình, Việt Nam

Tóm tắt

Tháng 11 năm 2012, hai cá thể Voọc mông trắng sinh sản trong nuôi nhốt đã được tái thả vào khu bảo tồn thiên nhiên Vân Long, phía bắc Việt Nam. Mục tiêu của nghiên cứu là phát triển kỹ thuật thích hợp nhằm giám sát động vật sau khi thả và đánh giá mức độ thành công của quá trình thả. Nghiên cứu

những khu vực phù hợp cho việc tái thả loài Voọc mông trắng trong tương lai. Hai cá thể được đeo vòng GPS loại nhẹ để theo dõi việc sử dụng sinh cảnh sống, vùng sống và mô hình hoạt động trong vòng bảy tháng. 1403 địa điểm đã được định vị nhờ công cụ GPS đối với cá thể đực. Chỉ có 390 địa điểm được ghi nhận ở cá thể cái do thiết bị GPS hỏng. Vùng sống của những cá thể này đã được tính toán sử dụng phương pháp Minimum convex polygon và Kernel density estimation. Kết quả cho thấy có sự sai khác không đáng kể giữa vùng sống của cá thể đực 77 ha và cá thể cái 68.5 ha. Cá thể đực đã di chuyển khoảng cách là 55 km trong 208 ngày. Trung bình mỗi ngày cá thể đực di chuyển $254 \text{ m} \pm 152 \text{ m}$. Cá thể cái di chuyển nhiều hơn với khoảng cách 42 km trong 53 ngày. Trung bình mỗi ngày di chuyển $756 \text{ m} \pm 404 \text{ m}$. Cá thể đực di chuyển với khoảng cách dài nhất trong tháng 12 và tháng 1. Trong khi đó khoảng cách di chuyển của cá thể cái là không khác nhau giữa các tháng. Cả hai cá thể đều hoạt động ban ngày và các hoạt động đạt đỉnh vào buổi sáng và buổi chiều. Sự gặp gỡ giữa những cá thể được thả với những cá thể sống ngoài tự nhiên không được ghi nhận trong suốt quá trình giám sát. Tuy nhiên những sự kiện này có thể đã xảy ra do có sự trùng lặp vùng sống của những cá thể được thả và những cá thể ngoài tự nhiên. Số liệu thu thập được từ GPS và quan sát trực tiếp cho phép gợi ý rằng những cá thể tái thả hoàn toàn đủ khả năng tự sống sót mà không cần sự hỗ trợ của con người.

Introduction

The Delacour's langur (*Trachypithecus delacouri*) is defined as 'Critically Endangered' (IUCN 2012) and is listed as one of "The 25 World's Most Endangered Primates" (Mittermeier et al., 2012) and thus facing an extremely high risk of extinction in the 21st century. The species is endemic to Vietnam and its occurrence is restricted to the limestone mountain ranges in the North of the country between 20°-21° N and 105°-106° E (Nadler, 2004; 2010). *T. delacouri* is considered one of the "limestone langurs" and is characterized by unique black and white body coloration. Amongst Vietnamese primates the Delacour's langur has been subject to the longest and most detailed studies, and more is known about this primate than any other Vietnamese langur (Nadler, 2010).

The species is threatened by hunting pressure, habitat destruction and habitat fragmentation (Nadler, 2012). Hunting with guns was prohibited in the early 1990s and in Van Long Nature Reserve no gun hunting has been reported in the last decade (Elser & Nguyen Hong Chung, 2013); nevertheless, hunting with guns is still common in the surrounding rural areas where offences are rarely punished. Other hunting techniques such as pitfall traps, snares or slingshots are widely used to catch birds and small mammals (Nadler, pers. comm.; own obs.). Limestone quarrying for cement production in the immediate vicinity of Van Long Nature Reserve is limiting the use of the habitat in the eastern part of the reserve (Nguyen Vinh Thanh & Le Vu Khoi 2006).

In 1993 Frankfurt Zoological Society (FZS) started the "Vietnam Primate Conservation Program" and soon afterwards confirmed the occurrence of the langur in Van Long, 85 km south of the capital Hanoi. The area was designated as a nature reserve in 2001. Since then, FZS has closely collaborated with the Management Board of the reserve, e.g. training staff, providing funds for salaries and equipment, building ranger stations, implementing conservation awareness measures in the surrounding communes, and the establishment of a village based patrolling system (Nadler, 2011). Due to these efforts the Delacour's langur has been recognized as a flagship species for the reserve, and due to strict protection its population increases steadily. In 2011 the population in the reserve comprised roughly 100 individuals (Nadler, 2010; Ebenau et al., 2011) and increased up to 110-120 individuals in 2013 (Nadler, pers. comm.) constituting about 50 % of the world's total

population (Mai Dinh Yen et al., 2010; Nadler & Brockman, 2014).

The western part of the reserve, consisting of rugged limestone karst mountain with dense rainforest, was chosen as the release site (Fig. 1). A small relic subpopulation of about 30 individuals in three to four groups occurs in this area, and therefore intraspecific competition is low (Ebenau et al., 2011; Nadler, pers. comm.).

The Biodiversity Action Plan for Vietnam (Government of the Socialist Republic of Vietnam & Global Environment Facility Project 2004) recommended captive breeding programs for Endangered Vietnamese primate species at the Endangered Primate Rescue Center (EPRC) and the reintroduction of individuals from the breeding program into suitable habitats in order to stabilize wild populations. Of all areas with Delacour's langurs' natural



Fig.1. Van Long Nature Reserve comprising four part, the eastern part with two limestone blocks, the central part and the largest western part.

occurrence, Van Long Nature Reserve was identified to provide the best opportunities for long-term survival of the langurs (Nadler, 2004; 2012; Workman, 2010). In August 2011 three captive born individuals were introduced in the reserve followed by the introduction of two individuals in November 2012.

An extended period of post-release monitoring, including fieldwork and research, is one of the most important elements of a reintroduction project. Following the IUCN Guidelines for Primate Reintroduction, monitoring should include behavioral, demographic and ecological studies and consider inter alia social changes, health, reproduction, mortality and habitat impact (Baker, 2002). In this respect, the our study intended to gather information about movement patterns, home ranges, path lengths, activity rhythms, social structures and potential threats.

Material and Methods

Radio tracking technology

Lightweight radio collars (e-obs GmbH, Germany) equipped with a Global Positioning System (GPS) element were used to track the langurs. The collars possessed no drop-off mechanism; instead, a biodegradable segment was integrated to ensure that the collar fell off after some time, but which is difficult to specify (Fig. 2). The tags featured a UHF transmitter, which allowed remote controlled download of the logged data. Therefore, animals do not have to be recaptured once released (e-obs GmbH, 2009). The technical equipment consisted of the base station with a Yagi

Antenna, two e-obs tags and a conventional radio receiver (Fig. 3). Each tag was programmed to record nine GPS-fixes per day, from 05:00 am until 09:00 pm. If the tag did not record a GPS position after 75 seconds due to a lacking satellite connection, the reading attempt was programmed to be skipped in order to save battery power.



Fig.2. Delacour's langur female "Johanna" with tag 2393.
Photo: Sarah Elser.



Fig.3. Biologist Nguyen Hong Chung downloading data with antenna and Base Station. Photo: Sarah Elser.

Preparations for release

The two langurs chosen for release, Johanna (f) and Jonathan (m), were captive born at the EPRC. They are part of the breeding program of the EPRC and have already twice procreated offspring as a pair. Due to their excellent condition and health, inconspicuous social behavior and previous breeding success they were considered suitable for release. A strict quarantine was implemented when preparing the langurs for release and several health checks were conducted by a qualified veterinarian to ensure the animals were fit for release and would pose no health risk to the wild population.

In order to minimize the stress for the langurs, it was decided to conduct a soft release. Therefore, a mobile cage was installed at the release site. The cage had a surface of 16 m² and consisted of 1.0 m x 2.5 m iron frames stringed with fine fishing net (Fig. 4). The langurs were anesthetized, put into separate transport boxes and transported to the release site two days before the release, so they had the possibility to become accustomed to their new environment and make sure they sufficiently recovered from the transport. The cages were finally opened at 09:30 am on 02/11/2012.



Fig.4. Delacour's langur male "Jonathan" and female "Johanna" sitting in the temporary cage at the release site. Photo: Sarah Elser.

Post-release monitoring

For four months the first author and biologist Nguyen Hong Chung tracked the animals almost every day. If necessary mountains were climbed to get better reception and receive a signal over larger distances. Occasionally it was possible to download GPS data directly from the roads around the reserve. Observations were attempted whenever strong signals suggested the animals were nearby and quick data download was possible.

Processing GPS data

The GPS data collected in this study are presented in geographical maps created by the open source Geographic Information System Quantum GIS (QGIS) 1.8.0 Lisboa. One-way ANOVA was applied to compare path lengths. The significance level of $\alpha = 0.05$ was chosen for all tests. If the assumptions for ANOVA were not fulfilled the data set was transformed by calculating the logarithm before conducting analyses.

Home ranges were calculated with the Minimum Convex Polygon method and the Kernel density estimation. Normal distribution of all parameters was conducted with the free software programming language R (Version 2.15.3).

Results and Discussion

Post-release monitoring

The tracking period amounted to 53 days for Johanna and 208 days for Jonathan. Unfortunately Johanna's tag malfunctioned for unknown reasons. It was working properly for four weeks, and then it suddenly failed to send any signal. After approximately four weeks, it started sending signals again and was working properly for six weeks. This suggests the power supply was interrupted. In general the tags had difficulties to record GPS locations due to the mountainous topography and the dense vegetation, which inhibited clear access to the satellites. Tag 2393 (Johanna) recorded 469 fixes, of which 79 fixes could not record a GPS position. This means the loss of fixes amounted to 17 % for Johanna. Tag 2392 (Jonathan) recorded 1877 fixes, of which 474 fixes could not record a GPS position, therefore the loss of fixes amounted to 26 % (Table 1).

Table 1. Overview of tracking time. Grey background indicates recording time.

ID	fixes	2012			2013				
		NOV	DEC	JAN	FEB	MAR	APR	MAY	
Johanna	390								
Jonathan	1403								

We were able to approach the released individuals eleven times within visual contact, also many weeks after the release.

The two individuals separated eight days after the release. Their movement patterns differed remarkably (Fig. 5; 6). Johanna's movements were characterized by short time spans where she covered very large distances in apparently random directions. Jonathan's movements were characterized by relatively steady moves during the entire study period.

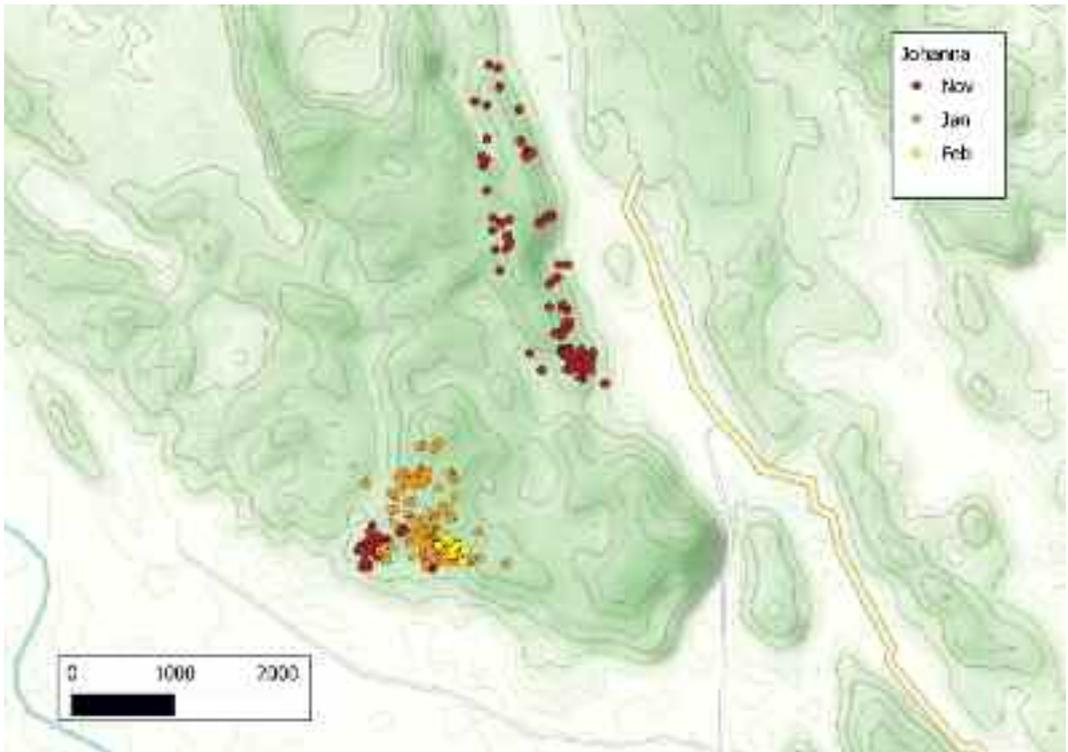


Fig.5. All recorded GPS-points for the Delacour's female "Johanna" (tag 2393) from 02/11/12-28/11/12 and 07/01/13-03/02/13 in color assorted by month in 2D.

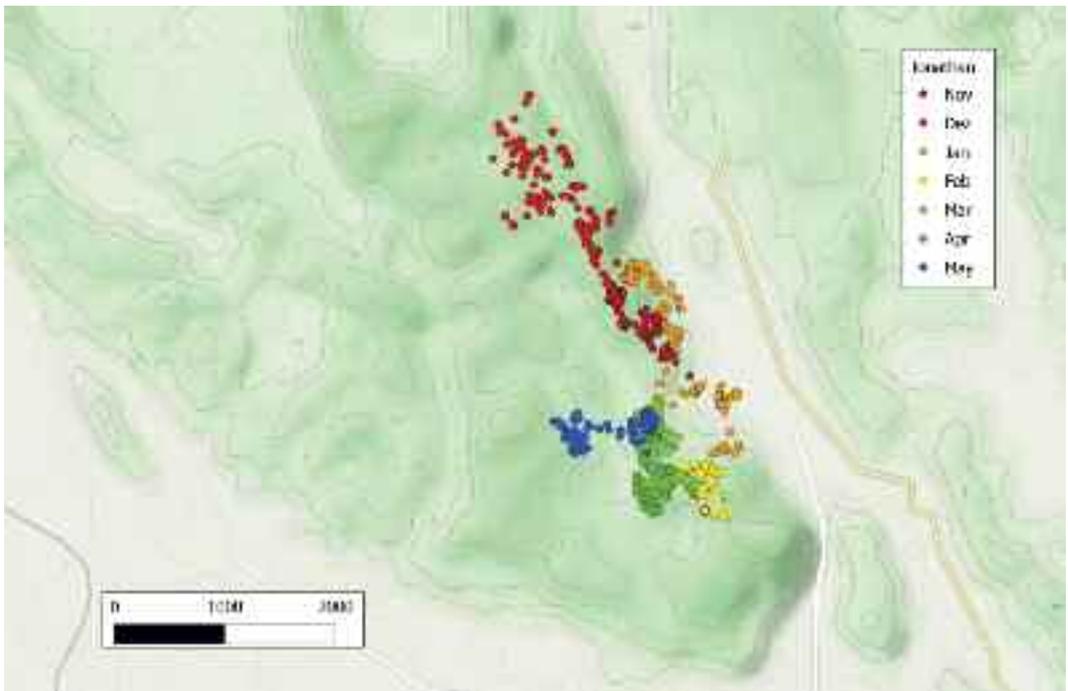


Fig.6. All recorded GPS-points for the Delacour's male "Jonathan" (tag 2392) from 02/11/12-29/05/13 in color assorted by month in 2D.

Baker (2002) predicted possible behavioral anomalies in released animal because of the previous association with humans. Jonathan was habituated to humans, which was particularly noticeable when observing him during the study period. Several times he did not retreat from the observers and it was possible to approach him within a few meters. Furthermore Jonathan stayed in the immediate proximity of human settlements for a few days in January; he even explored cultivated fields where he was reported by locals. This behavior is problematic. Nevertheless, Jonathan displayed normal social behavior; for example we observed him calling regularly over a long period early in the morning.

Encounter with wild groups

Encounters between released and wild individuals, or between released individuals and individuals which had been released the year before, most likely occurred due to overlapping ranges (Fig. 7). It is likely that the released individuals found indications for the presence of conspecifics, especially in the northern and western parts of Van Long Nature Reserve. We suggest that Johanna's intense travelling activities were influenced by the presence of wild langur groups. There was also evidence that a previously released individual sojourned in the same area as Jonathan. Additionally, Jonathan's loud vocalizations in the early morning probably raised the attention of other Delacour's langurs. However we were unable to observe any contact and therefore cannot comment on interactions between released and wild individuals.

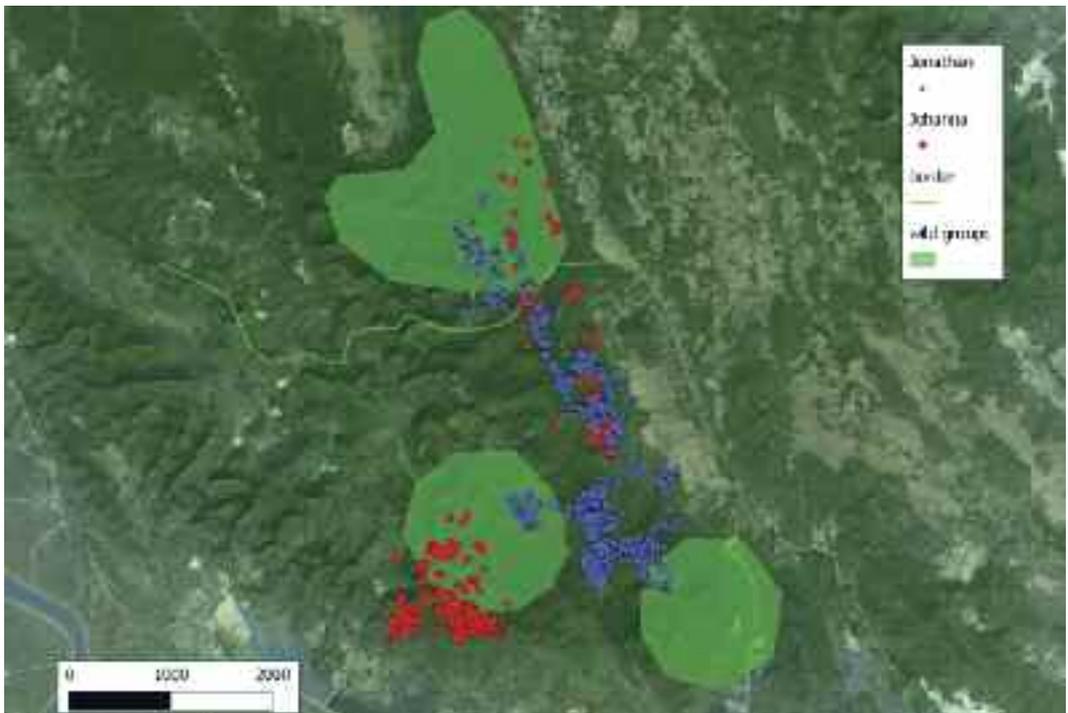


Fig.7. Tracking routes of Johanna and Johanna as well as home ranges of wild Delacour's langur groups in the western part of Van Long Nature Reserve.

Home range

Both individuals covered large distances during the first weeks after the release (up to 2665 m/day for Johanna and 1002 m/day for Jonathan) and did not settle in an identifiable home range initially. Evaluation of the GPS data over the following months however indicated the gradual formation of a home range for both individuals. Accordingly, it was decided to compute home ranges excluding the first month for Johanna and the first three months for Jonathan and consider these times as exploration periods. The data set thus decreased to 26 days for Johanna and 117 days for Jonathan.

Using the MCP calculations the home range size amounted to 60 ha for Johanna and 80 ha for Jonathan (Fig. 8).

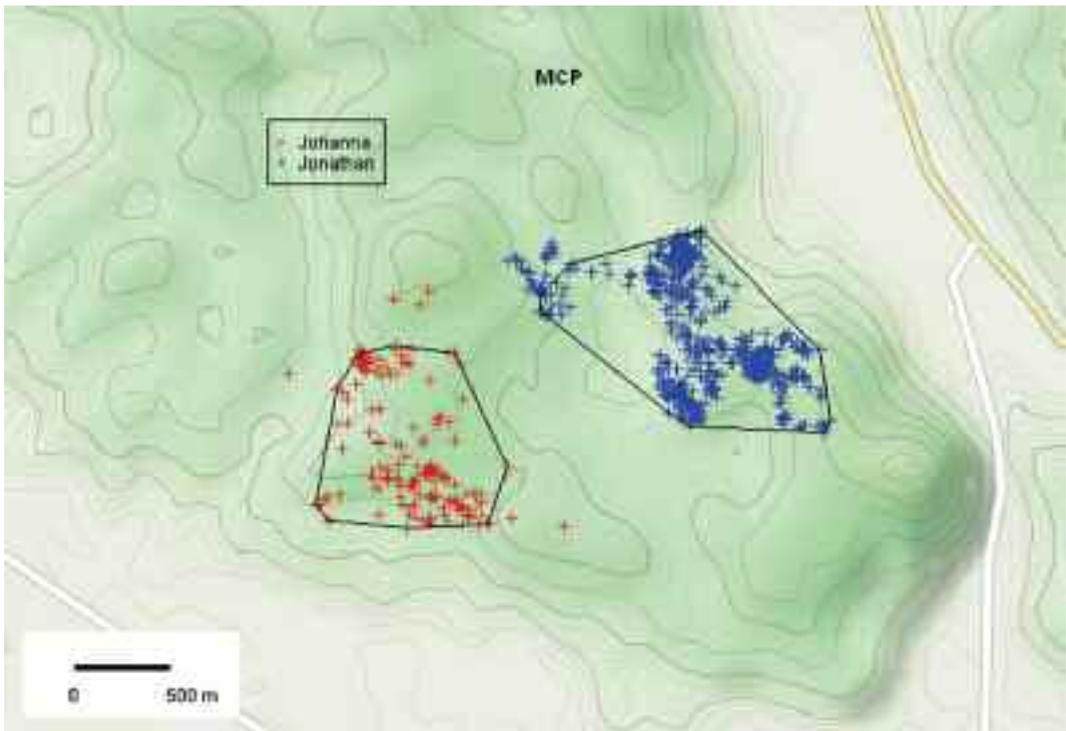


Fig.8. Home range size based on the Minimum Convex Polygon method (95 % of all locations) comprises for the female "Johanna" 60 ha (Jan.-Feb.) and for the male "Jonathan" 80 ha (Feb.-May).

Using the Kernel density calculations the home range size amounted to 77 ha for Johanna and 74 ha for Jonathan (Fig. 9). This method enables the user define a core zone (50 %) in addition to the 95 % line. The core zone of the home range amounted to 15 ha for Johanna and 17 ha for Jonathan.

For the largely arboreal *Trachypithecus* home range sizes vary from 2.5-100 ha (Oates & Davies, 1994; Geissmann, 2003) and Nguyen Vinh Thanh & Le Vu Khoi (2006) defined a home range of 36 ha for a group of *T. delacouri* in Van Long Nature Reserve.

However, home ranges of released individuals and wild individuals must be compared with caution. The individuals in this study were born in captivity and released into the wild; they did not

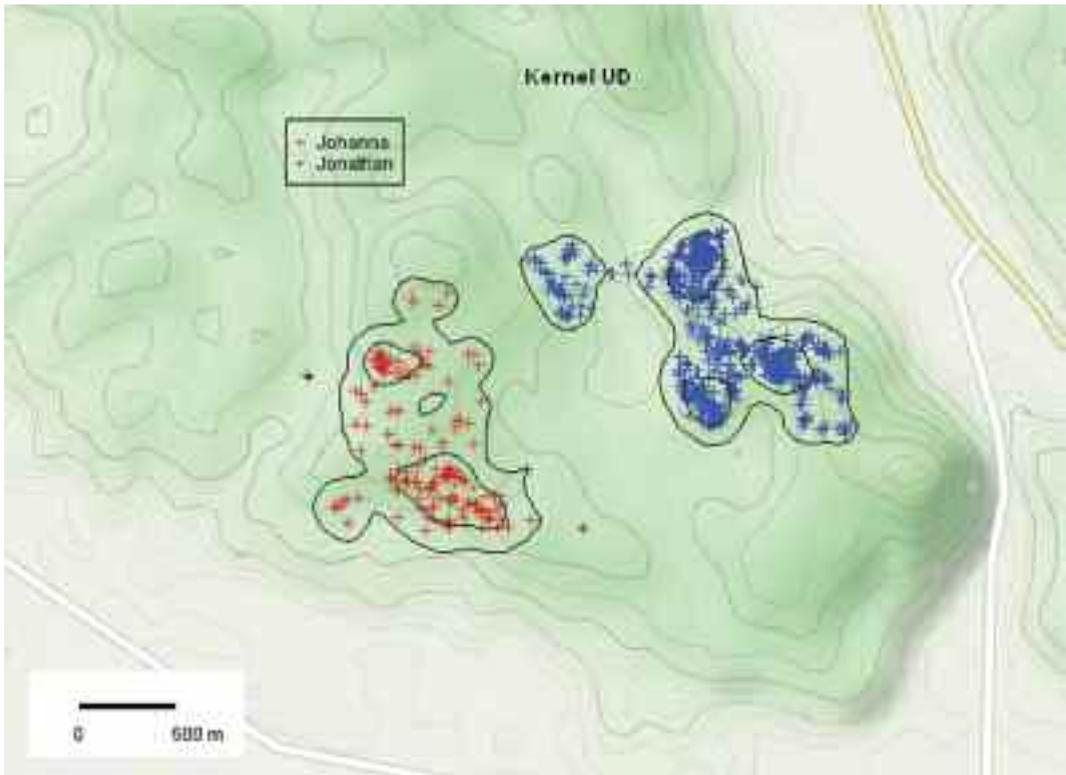


Fig.9. Home range size based on the Kernel density estimation with 50 % (inner lines) and 95 % (outer lines), smoothing factor $h = 60$, comprises for the female "Johanna" 77 ha (Jan.-Feb.) and for the male "Jonathan" 74 ha (Feb-May).

grow up in a wild population of VLNR with stable social structures and habitat knowledge. This might explain that the released individuals did not settle into a distinct home range during the tracking period, but ranged widely within the western area of the reserve and even beyond its borders. In this respect the term "home range" should rather be conceived as "ranging area" and comparisons with home ranges of wild Asian colobines should be considered in relative terms. The released individuals had to establish their status in the wild without the ecology and social context present in the wild conspecifics. Therefore they possibly initially explored the available habitat more extensively.

Home range was calculated with the MCP method in order to be able to compare with other studies, which mostly use MCP for their calculations. Unfortunately this method only allows drawing conclusions about the size of a home range but not about the utilization of the home range. Moreover, by simply connecting points, huge areas which are never used by the animal as well as unverified areas are included in the home range which can result in excessively great sizes (Boitani & Fuller, 2000; Girard, 2002). On the other hand, the Kernel density estimation holds the difficulty that few data points increase the home range (Girard et al., 2002). This becomes obvious for the data from Johanna. Nevertheless, the Kernel density estimation method should be considered preferable in order to achieve a high degree of information value (Girard et al., 2002).

Path length

In this study, the daily path length refers to the time of the day during which GPS data was

recorded; meaning 16 hours from 05:00 am until 09:00 pm. It must be taken into consideration that all travel distances are minimum travel distances, as the distance is calculated as the direct path between two points, which of course rarely reflects the actual path travelled. Altogether Johanna covered a total minimum distance of 42 km in 53 days. Johanna's mean daily path length amounted to $756 \text{ m} \pm 404 \text{ m}$. Jonathan covered a total distance of 55 km in 208 days. Jonathan's mean daily path length amounted to $254 \text{ m} \pm 152 \text{ m}$. Performing one-way ANOVA tests confirmed that Johanna travelled significantly more than Jonathan.

Whilst mean monthly path lengths for Johanna did not significantly differ between November and January (Fig. 10), Jonathan travelled unsteadily during the seven months of data collection and had the greatest mean monthly path lengths in December and January (Fig. 11).

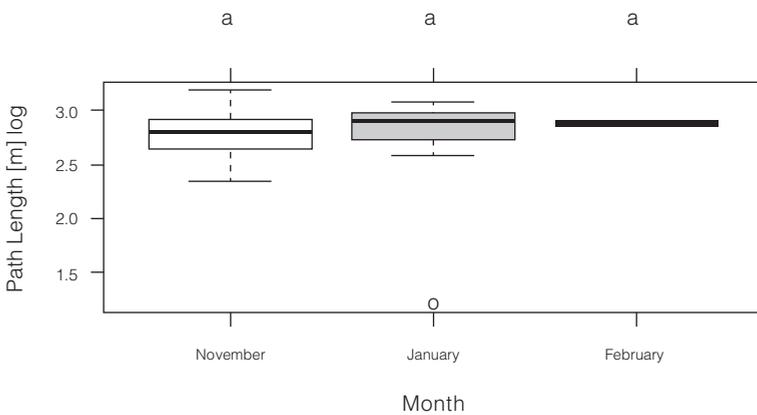


Fig.10. Johanna's mean monthly path length indicates no significant difference of path length between months. Groups with the same letter (a) don't have significantly different means.

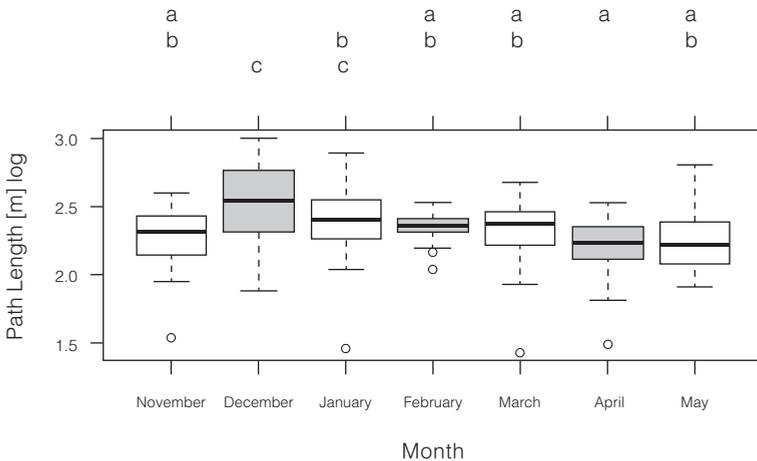


Fig.11. Jonathan's mean monthly path length indicate similarities of path lengths between months. Groups with the same letter (a, b, c) do not have significantly different means.

Colobines typically have daily travel distances of under 1 km (Campbell et al., 2004). Geissmann (2003) specifies this statement to a daily path length of 330-1000 m and Workman (2010) reported an average day path length of Delacour's langurs of 476 meters. The results of our study confirm path length descriptions of former studies.

Folivorous colobines usually spend a large amount of time resting, a strategy that minimizes energy expenditure and permits digestion of fibrous plant material (Oates & Davies, 2004). Workman (2010) also studied the foraging ecology of Delacour's langurs living on Dong Quyen Mountain in VLNR. She found out that Delacour's langurs spent 61.3 % of their day resting, 28.2 % feeding, 6.3 % socializing, and 4.2 % travelling, similar to other African and Asian Colobines, including other limestone langurs. Workman (2010) further concluded that Delacour's langurs are - along with *C. guereza* - some of the least active Colobines for which activity budget data are available. However, Delacour's langurs on Don Quyen Mountain in VLNR are very limited in available habitat, which could possibly affect their ranging budget. This was not the case for the released individuals.

Path length during different daytimes: activity rhythm

Comparing the path lengths at different times of day revealed that most travelling occurred during the morning and the afternoon for both individuals (Fig. 12, 13). Around midday, comparably less distance was covered. The shortest path lengths were found in the evening.

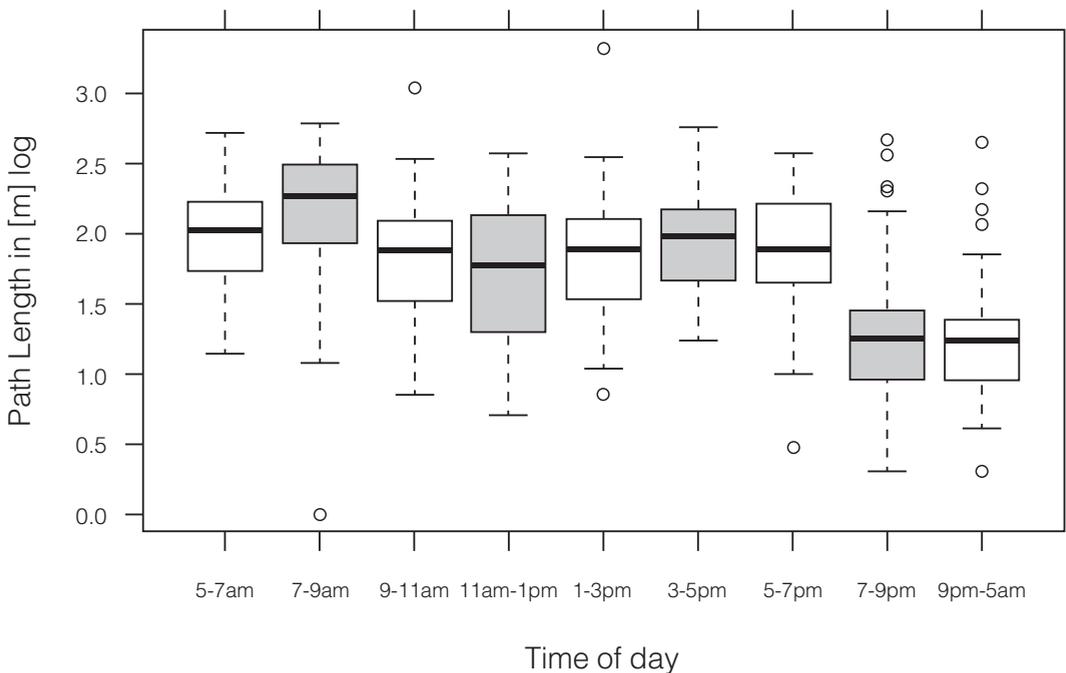


Fig.12. Johanna's mean path lengths during different daytimes. Groups with the same letter (a, b, c) do not have significantly different means.

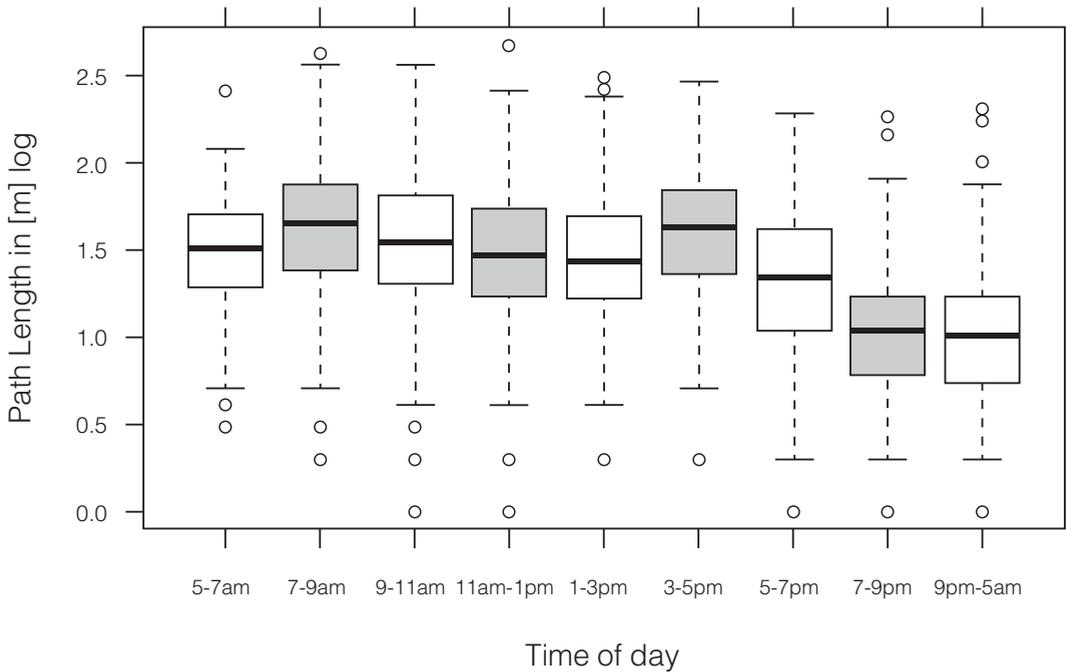


Fig.13. Jonathan's mean path lengths during different daytimes. Groups with the same letter (a, b, c, d) do not have significantly different means.

Delacour's langur show peaks of activity in the early morning and late afternoon and have a resting period at midday. Partly due to their high degree of folivory, Colobines as a group are among the least active of primates. In this respect, the activity rhythms found in our study corresponded with expected behaviors.

Conclusion

Primates are assumed to have a potentially diminished capacity to survive after reintroduction (Baker, 2002). However monitoring the two released individuals over 7 months after release suggest that they were capable of surviving in the wild without human support. Observations at short distance in January and March confirmed that both individuals were in good health and overcame the harsh winter unscathed. Though the animals had no previous knowledge of their new environment, their preliminary home ranges and path lengths did not particularly diverge from those found in other studies of Colobines.

The results of the present study allow the recommendation of future reintroductions into VLNR. Although this study did not bring evidence for an interaction of the released individuals with wild individuals, hope remains that beneficial interactions will happen in the future. If the released individuals integrate into the wild population at VLNR this will be a significant contribution to the genetic variability of this isolated population. This also allows confiscated and captive born individuals to live a life in their natural environment far from human interference and contribute to

the survival of the species. Further studies on natural ecology, behavior and habitat requirements of Delacour's langurs in the wild are needed.

Acknowledgements

Huge thanks go to the local authorities of Ninh Binh Province for permission to conduct the field studies. Furthermore, special thanks go to the Management Board of Van Long Nature Reserve including all the guards for their kindness and close cooperation. Many thanks go to Tilo Nadler for the great support during the study and to the reviewers of the paper for comments and corrections.

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Experiences using VHF and VHF/GPS-GSM radio-transmitters on released southern yellow-cheeked gibbons (*Nomascus gabriellae*) in South Vietnam

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Key words: Gibbons, *Nomascus gabriellae*, post-release monitoring, VHF/GPS-GSM radio-transmitter, Vietnam

Summary

Vietnam is home to six gibbon species, which are all either “Endangered” or “Critically Endangered” (IUCN, 2010). Suitable techniques to rehabilitate, release and monitor gibbons successfully have to be developed now, if we want to have them available to save the most “Critically Endangered” species, and prevent that more common species ever reach the “Endangered” state.

From 2010 to 2013 eight adult “Endangered” southern yellow-cheeked gibbons (*Nomascus gabriellae*) were rehabilitated and fitted with VHF or VHF/GPS-GSM radio-transmitters attached to Biothane collars, and released into secondary rain forest in South Vietnam. The aim was to assess the suitability of various collars for gibbons and determine the fix success rate (FSR) on arboreal primates in this type of habitat. We collected valuable data on methods to monitor reintroduced gibbons in cases where human presence needs to be limited. Including the radio-transmitters the collars weighed between 47 g (VHF) and 230 g (VHF/GPS-GSM) and were fitted on gibbons weighing between 5 kg and 6.5 kg; thus collar weight ranged from 0.7 to 3.8 % of the gibbons’ body weight. For the first six collars we created weak links, while the last two collars had a drop-off buckle with a programmed timer. Battery life for all collars was estimated at a minimum of 5-6 months, but was considerably longer in practice. Collars remained in place for up to 13 months and whilst no collars caused damage to the skin, hair loss was observed with the GPS collars. The VHF collars had antennas up to 20 cm long, which were the only part the gibbons tried to manipulate, usually during the first hours after fitting, after which they were ignored. Gibbons wearing the GPS collars were not observed singing, otherwise there were no behavioural changes observed. VHF transmission reached up to a maximum of 700 m. FSR of the GPS collars was 60 % or more. Our data shows that collaring gibbons with GPS collars is a suitable method to monitor released gibbons in secondary rain forest and allows collecting valuable data after release.

Ứng dụng tín hiệu radio trong việc giám sát Vượn sau tái thả (*Nomascus gabriellae*)

Tóm tắt

Sáu loài vượn ở Việt Nam đều trong tình trạng nguy cấp và cực kỳ nguy cấp. Những kỹ thuật cứu hộ, tái thả về tự nhiên và giám sát sau khi thả đối với các loài vượn cần phải được phát triển nhằm bảo tồn các loài vượn này. Các kỹ thuật trên cũng góp phần ngăn chặn sự suy thoái chủng quần ở những loài thông thường. Từ năm 2010 đến 2013 tám cá thể trưởng thành của loài vượn má vàng phía Nam (*Nomascus gabriellae*) đã được tái thả và được đeo vòng cổ Biothane gắn chip điện tử VHF và VHF/GPS-GSM trước khi thả vào môi trường rừng mưa nhiệt đới thứ sinh ở miền Nam Việt Nam. Mục tiêu của nghiên cứu này là đánh giá sự phù hợp của các loại vòng cổ điện tử khác nhau đối với giám sát vượn; mặt khác xác định mức độ thích nghi đối với môi trường sống sau khi tái thả. Chúng tôi đã thu thập những dữ liệu dựa trên phương pháp giám sát các loài vượn được tái thả trong môi trường hạn chế sự xuất hiện của con người. Những vòng đeo nặng từ 47 gam đối với loại VHF và 230 gam đối với loại VHF/GPS-GSM. Với trọng lượng cơ thể vượn từ 5 kg đến 6.5 kg, mỗi vòng đeo cổ nặng từ 0.7 đến 3.8%. 6 vòng đeo đầu chúng tôi tạo kết nối lỏng lẻo, trong khi đó 2 vòng đeo sau có khóa mở tự động theo bộ phận đếm thời gian. Năng lượng pin của các vòng đeo được ước lượng tối thiểu là 5-6 tháng, trong thực tế pin kéo dài hơn. Vòng đeo cổ vẫn còn sau 13 tháng mà không gây tổn hại về da. Tuy nhiên, đối với vòng đeo có GPS thì có hiện tượng rụng lông. Vòng đeo VHF có ăng ten dài 20 cm, đây là phần động vật cổ loại bỏ vài giờ sau khi đeo vào. Tuy nhiên, động vật không để ý đến nó nữa sau một thời gian. Không có cá thể vượn nào thể hiện sự thay đổi tập tính, ngoại trừ tập tính hót không được quan sát đối với những cá thể đeo vòng cổ có GPS. Với vòng cổ VHF, khoảng cách truyền tín hiệu lên đến 700 m. Tỷ lệ thành công đối với vòng đeo cổ GPS là khoảng 60% hoặc hơn. Số liệu của chúng tôi chứng tỏ rằng việc đeo vòng cổ GPS cho các cá thể vượn là hoàn toàn phù hợp nhằm theo dõi các cá thể sau khi tái thả trong điều kiện rừng mưa thứ sinh.

Introduction

Gibbons (Hylobatidae) are strictly arboreal, frugivorous, brachiating primates (Chivers, 1984; MacKinnon & MacKinnon, 1987), living in socially flexible family groups (Sommer & Reichard, 2000; Fan et al., 2010; Kenyon et al., 2011), occupying territories from 20 to 100 ha (Chivers et al., 1984; Fan et al., 2006; Brockelman et al., 1988; Kenyon, 2007). A suggested 19 species of gibbons within four genera (Brandon-Jones et al., 2004; Mootnick & Groves 2005; Geissmann 2007; Van Ngoc Thinh et al., 2010) are distributed throughout South East Asia. Vietnam is home to six of these species of which three are classified as “Critically Endangered” (IUCN, 2014).

Gibbon populations throughout South East Asia have been greatly reduced through habitat loss and habitat degradation, which in Vietnam occurred mostly during the war and the post-war economic recovery (Westing 1971; Geissmann et al., 2000; Rawson et al., 2011). Today land-use has somewhat stabilised (Rawson et al., 2011). Hunting pressure on gibbon populations in the North of the country is intense; populations have been decimated by hunting for meat, medicinal purposes and a rise in demand for gibbons as pets (Wildlife Conservation Society, 2009). Conservation efforts have been focussed on these northern species; thus the most southern species of gibbon in Vietnam, the yellow-cheeked gibbon (*Nomascus gabriellae*) has to date received little attention. However populations of this species have declined by an estimated 20% over the last two generations, and are now considered “Endangered”, with less than an estimated

2500 mature individuals remaining (Rawson et al., 2011).

The Dao Tien Endangered Primate Species Centre (DTEPSC), founded in 2008 in Cat Tien National Park, Dong Nai Province, South Vietnam, specializes in conservation of *N. gabriellae* working directly with the Forest Protection Department, through rescue, rehabilitation, and release of gibbons, alongside conservation education. Rehabilitation involves the care for displaced, sick, orphaned or injured animals confiscated from the wildlife trade or illegal captivity and assisting the animals in re-gaining the condition and skills required to survive in the wild (Molony et al., 2006). Conservation benefits of reintroduction include education of the community about the fate of the animals, promotion of conservation values and increasing the number of individuals of this species in the wild with the possibility of the species fulfilling their ecological role. For reintroduction to be successful a range of methods need to be developed and tested, ideally before the numbers of a species are critically low and the loss of any further individuals – whether in a rescue facility or the wild – threatens the genetic viability of that species. Post-release tracking is essential to understand the fate of released individuals, to assess the impact on resident fauna and flora at the release site and the potential for human–wildlife conflict (Trayford & Farmer, 2012).

In the past post-release monitoring of primates has either not been carried out (Butynski et al., 2011; Robins et al., 2013) or has been inadequate, lacking simple details such as the number of surviving animals (Bennett, 1992; Cheyne, 2009; Cheyne et al., 2012). The use of radio-transmitters has transformed this area of primate conservation (Britt et al., 2004; Gursky, 2003; Guy et al., 2012; Hulme et al., Kenyon et al., 2014; Moore, 2012; 2013; Streicher & Nadler, 2003; Streicher, 2004; Tutin et al., 2001;) maintaining contact with the animals after release enabled researchers to determine their ranging patterns and in particular their survival (Britt et al., 2004; Robins et al., 2013). However radio-tracking possibilities depend on habitat structure and data can only be gathered during the actual tracking time and often the location of the animal can only be given approximately.

Thanks to the recent improvements in microelectronics and battery technology, automated tracking using a satellite global position system (GPS) are now available for small and medium-sized primates (Markham & Altmann, 2008; Recio et al., 2011). This allows the collection of animal locations at higher rates and shorter intervals, in remote and poorly accessible areas and optimizes researcher efforts (Hulme et al., 2013). GPS positional data are considered to be of greater accuracy than the locations obtained via triangulation of VHF radio signals.

The use of GPS collars on primates in open savannah environments has been highly successful, displaying impressive reliability, high spatial accuracy, and low impact on the study animal (Markham & Altman, 2008), but experiences in dense forest habitats are still scarce. Forest canopy interferes with the satellite signals, often preventing reception of enough signals to calculate a position, especially in small GPS units, where some functions have been sacrificed to achieve low weight (Sprague et al., 2004).

The two key measures used to quantify the probability of obtaining a position are: 1. fix success rate (FSR) as the proportion of successful fixes of all attempted fixes and 2. location error, so called position dilution of precision (PDOP), which describes the precision, with which multiple satellites in view of a receiver combine according to the relative position of the satellites to the receiver; when visible navigation satellites are close together in the sky, the geometry is weak and the DOP value is high; when they are far apart, the geometry is strong and the DOP value is low.

In forest habitats GPS fix failure is very common. Sprague et al. (2004) found a FSR of only 9.8%

for Japanese macaques in closed canopy forest.

Transmitter attachment methods for primates include collars, backpacks, ankle bracelets, and subcutaneous implants, with collars being the most frequently used attachment type (82%) (Trayford & Farmer, 2012). Due to the species' anatomy and ecology, collaring holds an element of risk and is considered not suitable for all primates, the classic examples being the orang-utan with a large throat sac and male howler monkeys with a large hyoid bone (Hansen et al., 2000). Problems can also occur with skin infections (Muller & Schildger, 1994; Moore 2012) including infestation with screwworm (*Cochliomyia hominivorax*) that can develop under the collar (Hansen et al., 2000) and can potentially be fatal. Collared primates had also been found to be socially compromised (De Ruiter, 1992; Teichroeb et al., 2005), which was assumed to be linked to the extra weight (Juarez et al., 2011; Gursky 1998). Furthermore it proves difficult to keep the collars in place long enough (Hansen et al., 2000; Kenyon et al., 2014). The suitability of collars therefore needs to be evaluated for each species individually.

In this study we tested two hypotheses: 1. Collars are a suitable method to fix radio transmitters on gibbons and 2. GPS technology is suitable to monitor arboreal medium sized primates in secondary rain forest.

Study Site

The Dao Tien Endangered Primate Species Centre was established in 2008 by the Endangered Asian Species Trust (EAST) in collaboration with Cat Tien National Park and the Ministry of Agriculture and Rural Development (Kenyon et al., 2012). The centre receives confiscated endangered primates from South Vietnam for rehabilitation and, if possible, reintroduction to the wild. The centre is located on Dao Tien island in the Dong Nai River. The island measures 56h and is part of Cat Tien National Park, which itself is part of the Dong Nai Biosphere Reserve. The Biosphere Reserve is located 120-150 km north of Ho Chi Minh City on the southern edge of the Annamite mountain range (11°20'50" N to 11°50'20" N and 107°09'05" E to 107°35'20" E) and comprises one of the few areas of lowland rain forest remaining in Vietnam with a total size of 970,000 ha. The climate of this area is classified as tropical monsoon, with a dry season from November to December and a raining season from March to April (rainfall exceeding 300 mm/month). Average annual temperatures are 26.2°C with little fluctuation, with maximum temperatures reaching 35°C and minimum temperatures of 18°C. All gibbons of this study were rehabilitated at the centre and returned to forest sites within the Dong Nai Biosphere Reserve.

Release Site 1

The first release site was located on Dao Tien Island and comprised highly disturbed habitat consisting of a mix of bamboo, and semi-deciduous forest. No wild gibbons lived on the island, although wild gibbons could be heard from the main forest of the national park from across the river.

Release Site 2

Within the Dong Nai Biosphere Reserve lies Vinh Cuu Nature Reserve. The release site was located in the southern part of this nature reserve, which comprises a former logging concession which at the time of the study consisted of young regeneration forest. No wild gibbon populations remained here, although macaques (*Macaca* spp.) and black-shanked douc langurs (*Pygathrix nigripes*) are present. The northern part of the nature reserve (an estimated 3 km north of the

release site), contains a small wild population of gibbons but not within hearing distance.

Release Site 3

The third site was located in the eastern section of Cat Tien National Park in mature semi-deciduous secondary forest, in an empty section of forest next to the river edge. North of the release site two wild groups of gibbons were confirmed within hearing distance (2 km).

Methods

Prior to release all gibbons received two health checks under anaesthesia, which included blood biochemistry, TB test, dental profile and assessment of general condition. Animals spent a period of time in a cage at the Dao Tien Endangered Primate Species Centre for behavioural assessment and socialisation with conspecifics, followed by time in a semi-forested enclosure (Table 1). When both health checks and behavioural assessment indicated that the animal was fit for release, the animal was collared under anaesthesia. The collar was fitted with just two fingers space between collar and the animal's neck. After collaring the gibbons recovered in small transfer cages, followed by a minimum of two days in a release cage (2 m x 2 m x 2 m) in the forest at the actual release site. During that time the gibbons were closely monitored for reaction to the collars. Once released, gibbons were monitored until the collar was removed or dropped off, the longest monitoring period being 13 months.

Table 1. Collared yellow-cheeked gibbon's background and collar deployment histories.

Year	Individual name	Sex	Est age (years)	Date Collared	Type	Neck circumference (cm)	Drop off schedule	Battery life (days)	Collar removal date
2010	Lee Lee	♂	22	16-03-2010	VHF	20	Weak link-gardening twine	09-10-2010 battery expired	12-02-2011 removed by veterinarian
	Merry	♀	16	16-03-2010	VHF	23	Weak link-gardening twine	09-10-2010 Battery expired	11-02-2011 removed by veterinarian
2011	Da	♂	12	06-05- 2011	VHF	n/a	Weak link-gardening twine	09-12-2010 Battery expired	04-08-2011 removed by veterinarian
	Ellie	♀	6	18-03-2011	VHF	18.5	Weak link-gardening twine	n/a Early removal	24-04-2011- removed by primate care staff
	Lee Lee	♂	23	05- 08-2011	VHF/GPS-GSM	20	Yes- Sailing twine	n/a Early removal	10-09-2011- found dead
	Da	♂	12	04-08-2011	VHF/GPS-GSM	22	Yes-Sailing twine	05-06-2012 Battery expired	04-08-2012- removed by veterinarian
2013	Misu	♀	6	13-06-2013	VHF	21	Programmed drop off 52 weeks	20-05-2014	Timed drop off 05-2014
	Limhuyen	♂	5	13-06-2013	VHF	23	Programmed drop off 52 weeks	n/a Early removal	early veterinary removal

Collar specification

Three types of collar were tested (Table 2). The first type were VHF collars (A), the second type were VHF/GPS-GSM collars (B), and the third type was a VHF collar with a programmed time drop-off buckle (C) (Fig. 1)

Table 2. Collar specifications of the three collar types deployed on yellow-cheeked gibbons between 2010 and 2013.

Collar type	Brand	Collar weight (g)	Collar material	Collar width (mm)	Dimensions of battery and GPS elements	pulse length (ms), rate (ppm, pulse per minute)	Antenna length- detail-thickness	Battery type	Expected battery life
VHF	Biotrack	50g	Biothane	13mm	37mm length x 25mm depth x 15mm width	20ms, 45ppm	15/ 20 cm long 2 mm thickness	2 x 10-28 (3V) (in Series)	5 months
VHF/GPS/GSM	Lotek	230g	Biothane	32mm	Battery – 85mm width x 3.5mm height x 3.6mm depth GPS – 78mm width x 25mm height x 47mm width	20ms, 40ppm	Internal antenna	2 x AA for GPS/GSM, 1 x 1/2AA for VHF	Dependent on programmed schedule
VHF timed drop off	Biotrack	176g	Biothane	32mm	Battery - roughly 37mm length x 25mm depth x 15mm width Drop-off – 32mm length x 30mm width x 22mm height	20ms, 45ppm	20 cm long 2 mm thickness	2 x 10-28 (in Series)	6 months for VHF, 52 week drop off



Fig.1. Collar types tested (A) VHF (B) VHF/GPS-GSM and (C) VHF with programmed drop off buckle.

Collar A. This was a TW3 VHF transmitter (Biotrack.co.uk) fitted on a biothane collar (13 mm in width) weighing 50 g in total (< 1% of body weight). The biothane collars are flexible and tough, but do not degrade over time. They were secured with a bolt on the side of the tag. The dimensions of the battery and VHF transmitter were 37 mm x 25 mm x 15 mm, with a 2 mm thick, silicon coated antenna either 15 cm or 20 cm long. The batteries had a predicted life expectancy of 5 months. A weak link consisting of gardening twine was added in-situ, giving an unpredictable drop-off. The VHF radio transmitted continuous signals enabling radio-tracking at any time, with a pulse rate of 20 ms, 45 ppm.

Collar B. This was a small Wildcell collar (LOTEK: <http://www.lotek.com/small-wildcell.pdf>) with VHF/GPS-GSM technology weighing 230 g (3.8 % of body weight) with stitched, 32 mm wide belt. The dimensions of the battery were 85 mm x 3.5 mm x 3.6 mm, and the dimension of the GPS unit 78 mm x 25 mm x 47 mm. The VHF antenna was internal. The GPS/GSM unit was powered by 2 x AA and the VHF unit was powered by 1 x 1 / 2 AA for VHF. Battery life expectancy depends on GPS and VHF beacon schedule. We limited VHF-signal transmission to the time from 05 h - 09 h daily, at a pulse rate of 20 ms, 45 ppm. The GPS/GSM unit collar was programmed to record 4 GPS fixes/day at 04 h/09 h/14 h/19 h, providing locations for morning sleeping site, morning feeding site, afternoon sleeping site and evening sleeping site. In order to save battery the collar was programmed to skip a reading attempt if no position was recorded in 180 sec. Data including date, time, longitude, latitude, number of satellites, and the HDOP were recorded in a built-in store on board memory. In addition the collar had a GSM download set once daily. All pre-programmed schedules could be altered when necessary via GSM upload. An artificial weak link of sailing twine was created in-situ, giving an unpredictable drop-off.

Collar C. This was a TW3 VHF transmitter with a Lotek drop-off mechanism (Biotrack.co.uk) fitted on a collar with the width of 32 mm, weighing 176 g, thus less than 2.9 % of body weight. The dimensions of the battery were 37 mm x 25 mm x 15 mm, and the drop off unit 32 mm x 30 mm x 22 mm, with a 2 mm thick, 20 cm long antenna. The radio transmitted a continuous signal powered by 2 x 10 mm – 28 mm batteries with an expected 6 months lifespan and 52 weeks drop off (thus guaranteed after battery exhausted). Two collars of this type were deployed in 2012 on adult southern yellow-cheeked gibbons, one male and one female. The gibbons were transferred to a release cage for two days and then released into release site 3.

All transmitters were used with either SIKA radio tracking receiver (Biotrack.co.uk) or Telonics receiver (telonics.com), with Yagi flexible antennas.

RESULTS

Collar Type A

Transmitter operation and signal quality

All VHF collars operated well and no collar failure occurred. Signals were received at a maximum distance of 700 m. There was no significant difference in signal quality between the collars with a long, versus the collars with a short antenna.

Drop-off mechanisms

Collars remained in place for up to 13 months and all collars were removed after recapture of the animals. The artificial weak link of gardening twine built into these collars did not break during the study period and, after collar retrieval closer examination of the weak link showed no deterioration.

Effects on the animals

The collars caused no damage to hair or skin. The gibbons tried to manipulate the antenna initially, but after one day ignored the collar entirely. Conspecifics were not observed touching the collars. Gibbons wearing collars were observed to travel, forage and sing normally.

Collar Type B

Transmitter operation and signal quality

VHF transmission in these collars reached up to 700 m. The daily GSM download was only possible three times during the two collar deployment periods, based on the incomplete phone network coverage in the area. On collar retrievals, GPS locations were downloaded from the collars, FSR for collar (1) was 123/149 (83%) and for collar (2) it was 483/732 (67%). Successful average acquisition time was 2.07 ± 0.0005 min. The accuracy of the collar readings (PDOP) were highly accurate in 47.5% of fixes, acceptable in 41.4 % of cases and poorly accurate in 11.3 % of cases (based on British Columbia Ministry of Environment, Lands and Parks, 2001).

Drop-off mechanism

The collars were in place for up to 12 months, at which time the animals were recaptured and the collars removed. The weak link (gardening twine) showed no deterioration at the time of collar removal.

Effects on the animals

On both gibbons hair loss was noticed at the site of the transmitter unit. Weight loss was observed on collared and non-collared individuals. Gibbons were observed to travel and forage normally, but at no time was either of the pairs observed to sing a morning duet and the only vocalization recorded were alarm and contact calls.

Collar Type C

Transmitter operation and signal quality

No collar failed and all transmitters operated well during the study. Signal transmission reached 600 m through the dense secondary forest.

Drop-off mechanism

One collar was removed when the gibbon had to be recaptured and returned to the centre, while the other collar remained on the animal for the entire scheduled period with successful drop-off at the programmed time.

Effects on the animal

The skin of the gibbon, from which the collar was manually removed, showed no damage. In both animals we observed travelling, foraging and singing (Fig. 2). According to visual observations social pressure from neighbouring groups limited the travel of one individual. The second individual suddenly became very ill, no conclusive evidence was found of the cause; it was possibly linked to stress through the pressure from neighbouring groups. Both individuals were recaptured and returned to Dao Tien Endangered Primate Species Centre.



Fig.2. Collared yellow-cheeked gibbon with collar type (C) VHF collar with timed drop off buckle fitted. Photo: Marina Kenyon.

Discussion

Reintroduction is the most challenging aspect of wildlife rehabilitation, with a series of potentially stressful challenges (Teixeira et al., 2007) it should scientifically approached and conducted over several years (Robins et al., 2013).

Candidates to trial the collars were selected based on their suitability for release into forest. Individuals chosen for collar testing were all adults, to ensure no increase in neck circumference. Animals chosen for collaring also were not to have dependent infants.

The main reason to choose collars over other methods of fixing the transmitters was the gibbons' way of locomotion. Gibbons brachiate and movements are usually led by the arms and gibbons most of time have the body in an upright position. Considering this the risk of the collar getting caught on a branch (snagging) during movement appears low. However to test the risk of 'snagging' and how the gibbons adjust to collars, collars were first trialled on animals in a 20 ha semi-wild enclosure at the Dao Tien Endangered Primate Species Centre. Here the gibbons could travel naturally but we had the possibility to easily recapture the animals if problems arose. To test the general suitability of collars other studies have for example fitted apes with dummy collars prior to release (Hulme et al., 2013).

It is not possible to entirely compare the behavioural reactions to the collars as the different collar types were used at different sites. So site specific influences like the proximity to or absence of neighbouring groups can not be distinguished from influences of the collar.

Two VHF collar types had external antennas and the collared gibbons manipulated the antennas for the first few hours, sometimes spinning the entire collar around their neck for 360 degrees, but this stopped after the first day. After this the collars were ignored by the collared individual and the conspecifics. With all three types of collars (type A, B & C) the gibbons exhibited normal, species specific behaviours (foraging, mating, and brachiating) for the duration of the collar attachment. Animals collared with VHF collars (type A, C) were observed to sing normal morning duets. Animals collared with GPS collars (type B) were not observed to sing, but alarm calls were recorded.

Although the GPS collars can't be excluded as a factor to prevent duet calls, we believe the local environment played a major factor, for example the lack of neighbouring singing gibbons. In both other collaring deployment situations, where the collared gibbons sang, neighbouring gibbons were present to trigger singing. However our observations are too scarce to determine if and how the different types of collars influenced the singing behaviour. Song recordings and comparison of sonogram structure pre and post collaring could also be used to determine changes.

The VHF transmission on all collars worked without problems. The transmission distance in the forest was with 700 m much lower than the up to 7000 m given by the producing companies, but this distance allowed a localization of the gibbons. VHF collars have been used successfully in many studies in similar rainforest habitats (Kenyon et al., 2014; Moore, 2012; Starr, 2011; Streicher & Nadler, 2003), but failures have also been reported (Britt et al., 2004). GPS collars have been found to fail more often (Blackie, 2010; Ren et al.; 2008), but in our study the GPS function worked well and a high number of GPS fixes was collected. However we were not able to determine the effectiveness of GSM download, as we had changed the release site from the time of ordering the collars to the time of the actual release and the SIM card used in the GSM unit used a network that had very poor coverage in the new release area. However as all GPS points were saved in the collar we were able to retrieve this data later after the collars were collected.

Battery life for the VHF collars reached the expected longevity and beyond; the change of release site however did impact battery life of the GPS collars. The poor network coverage for the network of the built-in SIM card resulted in many failed attempts of the transmitter to send signals via the network as programmed and every failed dialling attempt used up battery power, which shortened the operating time of the transmitter severely. The transmitter will try up to three times to send the data via SMS and each attempt has a small impact on battery life. After a failure the information is saved as unsent. Though we were aware of this problem the bad network coverage made it impossible to contact the collars via the network to change the download schedule and reduce the frequency, at which the transmitter attempted to send data and thus save battery power. Other projects in Vietnam in similar habitats have been using GPS collars with a mobile ground station option, where data is sent to the ground station via UHF when within 500 m. Though this option has been suggested to be more successful than the GSM technology it also had numerous problems (Elser pers. com.; Nadler pers. com.). But as a certain amount of monitoring on the ground is necessary after release to observe the condition of the animals, GSM technology does not give a major advantage over a mobile ground station option.

The data acquisition rate of the GPS collars was good. FSR for collar (1) was 83% (123/149), for collar (2) it was 67 % (483/732). Both values are slightly lower than the daily acquisition rate obtained for radio-collared Yunnan snub-nosed monkeys in high altitude temperate forests, which were 82.2 % (Ren et al., 2008). They are also lower than the acquisition rates obtained for savannah baboons (*Papio cynocephalus*), which could be up to 99.3 % in a variety of habitat types including tree groves, open savannah and shrub land (Markham & Altmann, 2008). However our acquisition rates were much higher than those obtained for Japanese macaques (*Macaca fuscata*) in closed canopy forests, which were only 9.8 % (Sprague et al., 2004). Acquisition rates from GPS collared elephants in rain forests in central Africa clearly illustrate the influence of the habitat on the data acquisition rate, which varied from 80 % in scrub with relatively open canopy structure and 9.8% in closed canopy forest (Blake et al., 2001). Also micro-habitat selection contributes to data loss (Fradkin et al., 2007); in the case of the arboreal gibbons the selection of sleeping sites high in the

canopy may be a reason for the relatively high fix success in a habitat, where obtaining GPS data otherwise is difficult.

However the time it took for a successful fix in this study was relatively long with an average of 127 seconds (32 – 192 seconds) which was close to the programmed cut-off point at 180 seconds. The time transmitters required to successfully obtain a location fix in GPS collars on olive baboons (*Papio anubis*) in savannah habitats averaged less than one minute (50.9 seconds) (Markham & Altmann, 2004), which also illustrates the influence of habitat structure. The accuracy of the GPS collar readings (PDOP) was highly accurate in 47.5 %, (<4) of the cases, acceptable in 41.4% (4-8) and poorly accurate in 11.3% (>8) of the cases. As expected PDOP is lower than in studied on primates in open savannah, where it could be highly accurate in more than 84% of the cases (Markham & Altmann, 2004). Habitat variability between studies is a major factor in acquisition rate success and accuracy, which ultimately influence battery life and length of possible post-release monitoring.

The assessment of the success or failure of a reintroduction is heavily influenced by the duration of post-release monitoring; the longer the animal is monitored, the truer the picture of reintroduction success or failure and the reasons behind them (Robins et al., 2013; Hansen et al., 2000). Thus management of battery life and possibilities for extending it within weight and size limitations are major considerations influencing the development of this field of conservation. Some present strategies involve recapture of individuals on average every 12 months and fitting new batteries (Hulme et al., 2013; Nekaris, pers.com.). In this study all gibbons were easily recaptured by provisioning in a capture cage, enabling successful collar removal. It would have been possible at this time to fit new batteries, but maintaining the use of a recapture cage must be balanced with the risk of rehabilitated primates maintaining familiarity with humans.

A combination of indirect observation through automated data collection and direct observations is the key. In this study monitoring through direct observation helped recognizing behavioural and health issues, which caused us in several cases to intervene. Relying solely on indirect observation through automated data collection, would not have allowed recognizing the problems and their causes and responding quickly enough to maintain animal welfare. However the GPS data collected provided a greater insight into establishment of home-ranges as it showed that the animals covered areas significantly larger than those recorded by direct observations, a finding frequently found in GPS data collection (Goldsmith, 2000; Hulme, et al., 2013).

In conclusion, the arboreal forest-dwelling yellow-cheeked gibbons appear good candidates for collaring using transmitters with VHF or dual VHF/GPS function. GPS collars are an important tool in long-term post-release monitoring and provide valuable insights into the relationship between rehabilitation procedures and the success of a reintroduction.

Acknowledgements

This project would not have been possible without the dedicated work from the staff from the Dao Tien Endangered Primate Species Centre, Cat Tien National Park and Dong Nai Biosphere Reserve, with special thanks to the Forestry Protection Department of Vietnam for continued support and protection. With particular thanks to the rangers Binh and Kangh working tirelessly to maintain full post-release monitoring with support from Carla, Raphael, Sun, John, Lopi, Stephanie and Lee. Special thanks also goes to John Lewis for veterinary consultation and George Henderson for telemetry technical support, and to reviewers of the paper.

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Non-conceptive sexual behavior and its function in an unusually composed group of Francois langurs (*Trachypithecus francoisi*) in Guangxi, China

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Key words: Non-conceptive sexual behavior, unusual social group, Francois langur, *Trachypithecus francoisi*.

Summary

Heterosexual and homosexual behaviors were observed in a group of Francois langurs (*Trachypithecus francoisi*) at Fusui Nature Reserve, Guangxi, China, from September 2005 to August 2006. The group was unusual in its composition and consisted of one subadult male (SM), one adult female (AF), one subadult female (SF) and a three year old female (JF). Three adults including the resident adult male and the other two offspring had disappeared in early 2005 due to unknown reasons. The observations indicated that AF actively initiated most of the mounting and most of the grooming after mounting. Only SF and SM were involved in mounting events with AF. There are at least four hypotheses to interpret the functions of the nonconceptive sexual behavior of primates; in a group comprising adults of both sexes training is considered the least important function of non-conceptive mountings. Our observations suggest that after the break of the group, the training function of non-conceptive mountings initiated by the only remaining adult individual (AF) might have been increased as a response to the unusual situation.

Những hành vi giới tính không kèm theo giao phối và chức năng của nó đối với quần thể loài Voọc đen má trắng (*Trachypithecus francoisi*) ở Guangxi, Trung Quốc

Tóm tắt

Những hành vi giới tính khác giới và đồng giới đã được quan sát ở một đàn Voọc đen má trắng từ tháng 9 năm 2005 đến tháng 8 năm 2006 tại khu bảo tồn thiên nhiên Fusui, Guangxi, Trung Quốc. Đàn bao gồm một cá thể đực bán trưởng thành, một cá thể cái trưởng thành, một cá thể cái bán trưởng thành và một cá thể cái khoảng 3 tuổi. Trước đó cá thể đực trưởng thành và 2 con non đã mất tích khoảng thời gian đầu năm 2005. Kết quả quan sát cho thấy cá thể cái trưởng thành thường xuyên khởi xướng các hành vi giới tính như chải lông và vuốt ve (không giao phối) với cá thể đực bán trưởng thành và cá thể cái bán trưởng thành. Bốn giả thuyết để giải thích chức năng của các hành vi giới tính không kèm theo giao phối trong quần thể các loài linh trưởng bao gồm: thể hiện sự thống trị, thể hiện sự ham muốn giới tính và khởi động việc giao phối, thể hiện sự trấn tĩnh sau các xung đột bầy

đàn, và thể hiện việc truyền dạy các hành vi giới tính cho thế hệ sau. Với những số liệu thu thập trong nghiên cứu cho thấy hành vi giới tính không kèm giao phối ở đàn có chức năng như một cách truyền dạy các hành vi giới tính cho những cá thể chưa trưởng thành. Đồng thời cũng là hệ quả của việc mất đi của cá thể đực trưởng thành.

Introduction

Sexual behavior between adult and immature individuals is found in many nonhuman primates (e.g. *Gorilla gorilla beringei*, Watts, 1990; *Macaca mulatta*, Perry & Manson, 1995; *Papio cynocephalus*, Rasmussen, 1983; *Pan paniscus* and *Cebus capucinus*, Manson et al., 1997).

Most colobine monkeys live in one-male groups in which the resident male only tolerates smaller or younger males, often his own offspring (Jolly, 1985, Liu et al., 2013). The adult male monopolizes all the fertile females and keeps the females away from other adult males like their grown sons or intruders. This monopolization can be interpreted as an effort of the adult male to maximize breeding success (Cords, 1987). If the male of a group is replaced, the breeding success of the new male will be maximized through the behavior of infanticide (Cheney et al., 1987). All studies on sexual behavior to date are conducted on groups with the typical species-specific composition (Bartlett, 2001; Chapais & Mignault, 1991; Dewsbury, 1972; Edwards & Todd, 1991; Fox, 2001; Kapsalis & Johnson, 1999; Ren et al., 2002a; 2002b; Tyler, 1984; Vasey, 1996; Vasey & Gauthier, 2000; Vasey, 2004a; 2004b). But what happens in respect to sexual behavior if the group has not adult male? Does any sexual behavior occur at all? And if it does, who initiates it? And what is its purpose and meaning?

The group of Francois langurs inhabiting Zuowei village, Fusui County, Guangxi, China (Fig. 1) is such an extreme case.

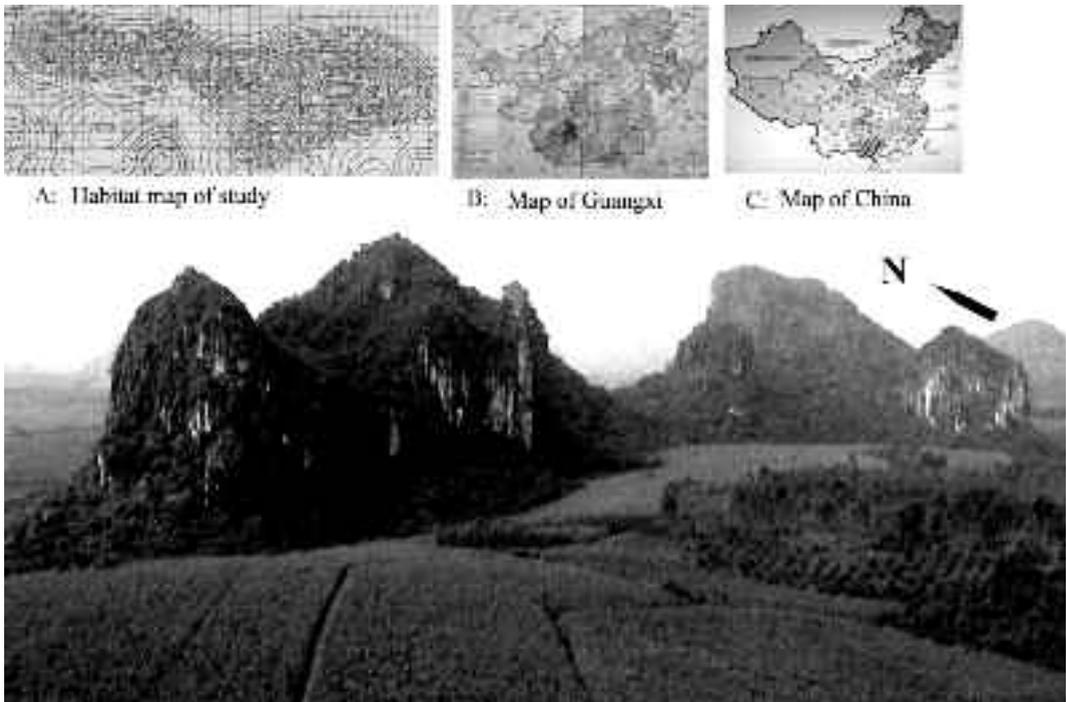


Fig.1. The home range of the Francois langur group, which is isolated by farmland.

Francois langurs are endemic to limestone hill habitats (Nadler, 2006), have special patterns of habitat use and locomotion adaptive to this environment (Zhou et al., 2013) and live typically in one-male/multi-females groups. The species is found in Northern Vietnam and Southern China (Zhang et al., 1992; Canh, 1996; 1997) with an estimated population of approximately 2000 individuals (Zhang & Bleisch, 2006). During the past 30 years, the population suffered a great decline from illegal hunting, human interference, habitat loss and habitat fragmentation. In Guangxi Province, China, the Francois langur population has decreased from 4,000–5,000 in the 1980s (Wu, 1983; Wu et al., 1987) to 2,000–2,500 in the mid 1990s (Liu & Wei, 1995). The species continued to decline dramatically and at present only about 300 individuals in 14 isolated populations survive, which represents a 90% decrease in population size since the early 1980s and an 85% decrease since the mid 1990s (Li et al., 2007). A population study in Fusui County provided evidence that the dramatic decline of this langur population is mainly a result of heavy hunting and conversion of their habitat to agricultural farmland (Hu et al., 2004).

This has led to a complete isolation of our study group at Zuowei village. The closest group is 5 km away, being separated from the study group by agricultural land and several villages (Hu et al., 2004; Huang et al., 2006; Li et al., 2007). Since 2001 we studied foraging ecology, ranging behavior and habitat utilization of this group and continuously recorded the group composition. That the group structure suddenly changed to a very unusual composition provided us with an excellent opportunity to study its sexual behaviors, answer the preceding questions and analyze the function of sexual behavior.

Methods

Study Site and Group

The study group inhabits a 42 km² karst area in Fusui Nature Reserve, Fusui County, Guangxi, China (22°36'22"-22°41'51"N, 107°23'-107°41'E) (Zhou et al., 2007). They live entirely on the isolated hills, which are about 100 m high and full of rocky cliffs (Fig. 1). Monkeys prefer to utilize the cliffs, as they provide safety against humans and in the past also against other terrestrial predators (Guangxi Forestry Bureau, 1993; Jiang, 1996; Zhou et al., 2007). The flat land surrounding the karst hills is completely cultivated and planted with *Manihot esculenta*, *Arachis hypogaea*, *Calamus thysanolepis*, *Eucalyptus citriodora* and other crops (Fig. 1). Due to firewood collection by the local villagers, the remaining habitat on the hills lacks large trees (DBH >20cm, Huang et al., 2006). The dominant trees found within the habitat are *Litsea glutinosa*, *Cleistanthus saichikii*, *Albizzia kalacora*, *Sterculia lanceolata*, *Syndilcis montana* and *Pinus massoniana*. The latter species is artificially planted on the lower foothills and their surroundings. The site has a typical north tropical monsoon climate, characterized by an average annual temperature of 21.5°C, an average humidity of 78% and a total precipitation of 1151 mm (Huang, 2002).

At the beginning of 2001 the study group had been observed with four individuals (one adult male and three adult females), the birth of three infants increased the group size to seven by the end of 2002. In 2004 two more infants were born bringing up the group size to nine. Five members of the group disappeared in May 2005 and were never seen since. Four individuals remained in the group - one subadult male (SM) about three years old, one adult female (AF), one subadult female (SF) of similar age as the subadult male, and one juvenile female (JF) about two years old. Most of the observed groups of *T. francoisi* consisted of one male/multi-female groups and this group composition was highly unusual. Without a breeding male no more infants have been born since

2005. Observations in 2010 found there were still four individuals in the group, which confirmed that no infant was born since 2005.

All the research reported here complied with protocols approved by the appropriate wildlife conservation committee of China and adhered to the legal requirements of China.

Data Collection and Analysis

Earlier studies found that this langur group leaves its sleeping cave in the early morning about 6:30am during the raining season and 7:30am in the dry season (Huang et al., 2006). So we started observation around this time and continued until the group returned to the same or another cave to sleep in the evening (Huang et al., 2006). We followed the group when they moved on the farmlands around the isolated hills (Fig. 1). We recorded data on sexual behavior for 10-15 days every month from September 2005 to August 2006. Since we were able to recognize all of the individuals in the group, we chose focal animal sampling (Altmann, 1974) and behavior sampling (Martin & Bateson, 2001). The group was observed from a distance of 30-100 m with binoculars. Mounting behavior was recorded whenever it occurred. The data recorded included the name of the mounter, mountee, and the duration of mounting, time and date as well.

Three mounting patterns were identified during the observation, which are defined as follows:

Pattern A:

Mounter stood with the hind feet on the ground and had its hands on the mountee's hip, while rubbing against the mountee. (cf. *Macaca mulatta*; Akers & Conaway, 1979; *M. fuscata* Wolfe, 1984).

Pattern B:

Mounter applied four limbs on the back of the mountee. (cf. *Macaca mulatta* Akers & Conaway, 1979).

Pattern C:

Two individuals quadrupedally stood on the ground, hip to hip in line, and rubbed each other.

We used the Chi-square tests to test the differences between various variables. All statistical analyses were performed using the SPSS statistical package. Results of the statistical tests were considered significant at the conventional $p \leq 0.05$ (2 tailed).

Results

The total observation time was 2189 hours; 994 hours in 2005 and 1195 hours in 2006. Forty-nine mounting behaviors were recorded in the observation period. The mounting process lasted 4.1 seconds (4.1 ± 2.45 , $n=49$) ranging from 2 seconds to 15 seconds. The three mounting patterns were recorded with the following frequency: 34 times we observed pattern A, 9 times pattern B and 6 times pattern C ($\chi^2=28.939$, $df.=2$, $P<0.001$).

The frequency of mounting behaviors in different hours of the day showed a significant variation ($\chi^2=22.958$, $df=12$, $P=0.028$). A significant peak in mounting behavior was found between 8:00am and 10:00am. There was a minor mounting peak at 5:00 pm and a lower frequency of mounting behavior was observed during the long siesta time at noon (Fig. 2).

Mounting behavior also occurred significantly more frequently in February and in July ($\chi^2=46.000$, $df=11$, $P<0.001$) (Fig 3).

Mounting behavior could either be heterosexual or homosexual. Heterosexual mounting

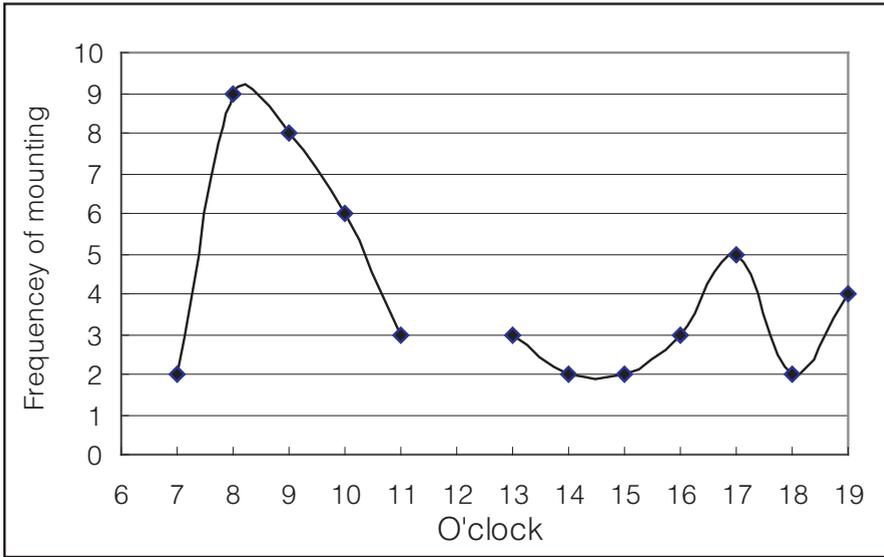


Fig.2. Frequency of mounting behavior of the study group occurred at different times.

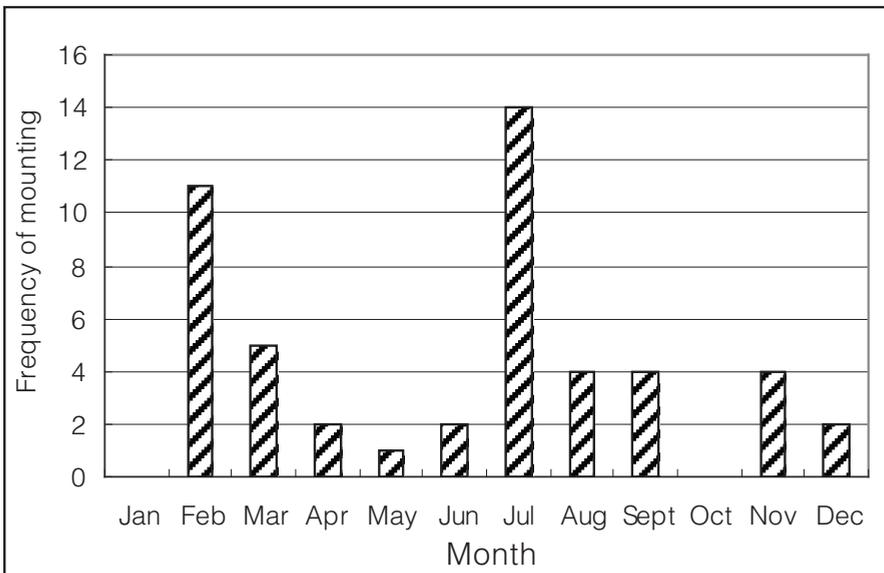


Fig.3. Frequency of mounting behavior of the study group occurred at different months.

accounted for 24.5% of total mounting records. In the heterosexual mounting events, the SM only acted as the mounter (Table 1), and he mounted AF 10 times and SF 2 times. SM was never seen to mount JF. AF often sexually solicited SM first with head shaking and sexual prostration, or grooming the latter. AF often groomed SM after the mounting event. Homosexual mounting contributed to 75.6% out of the 49 mounting events recorded. Between AF and SF, the AF could either be the mounter or the mountee (Table 1), but was the mountee significantly more often than mounter (91.1% to 8.9%). SF and JF were the mounters significantly more than mountee ($\chi^2=22.224$, $df=1$, $P<0.001$).

Table 1. Frequency of mounting behavior between different dyads in the study group.

Mounter \ Mountee	AF	SF	SM	JF	Total
AF		28	10	3	41
SF	4		2	1	7
SM	0	0		0	0
JF	0	1	0		1
Total	4	29	12	4	49

Grooming behavior often followed the mounting event (32 out of 49 times). Hereby the mountee initiated most of the grooming bouts. For AF, she engaged in mounting 41 times as mountee and 4 times as mounter and she initiated grooming 25 times (78.1%) after being mounted.

JF often sat close to AF during the day, and they often hugged, while SM and SF kept alone during the daily activities.

Discussion

This langur group has been studied for more than six years for its activity and time budget (Huang et al., 2006), diet and feeding strategy (Huang et al., 2008), habitat utilization (Huang et al., 2007) and behavior of cave entering and leaving (Huang et al., 2004). The disappearance of one adult male, two adult females and two other unidentified individuals lead to an unusual group composition and there was no offspring till 2010. However, non-conceptive heterosexual and homosexual mounting behaviors between the adult female and subadult group members were still observed.

Francois langur groups in captivity kept as one-adult male and multi-adult female groups often display mounting behavior. Reports indicate that mounting behavior occurs mostly in the morning and afternoon in February and from July to September (Hu, 2003), similar to the peaks in mounting events we found in our unusual group in the wild. This suggests that the timing of sexual activity (mounting) and seasonal preference are similar both in captivity and wild.

The result of heterosexual copulation is often successful reproduction and the function of the mounting is clear (Hashimoto & Furuichi, 1996).

Homosexual mountings between individuals of the same sex were reported both in captivity and in the wild and may serve different purposes in different primates or in different situations (Akers & Conaway, 1979; Chapais & Mignault 1991; Srivastava et al. 1991; Edwards & Todd, 1991; Kapsalis & Johnson, 1999; Ren et al., 2002a; Vasey, 2004a).

Firstly, homosexual mounting behavior is often interpreted as showing the dominance of the higher ranking mounter over the lower ranking mountee (Srivastava et al., 1991; Akers & Conaway, 1991; Vasey, 2004a). Because mount-giving behavior was linked to the male, while the mount-receiving behavior was linked to the female, the mounter was assumed to play the masculine role and the mountee the feminine role (Srivastava et al., 1991).

Secondly, mounting behavior is related to physical satisfaction. Both mounter and mountee can acquire physical sexual satisfaction through the genital contact (Akers & Conaway, 1991).

Thirdly, homosexual mounting behavior may play an important role in the copulation pattern by raising the interest of the male in the female by mimicking the male copulation act of a potential rival (Parker & Pearson, 1976).

Edwards & Todd (1991) suggested a forth meaning of the mounting behavior in white-handed gibbons (*Hylobates lar*). They concluded the sexual behavior had the function to reassure the mountee after a chase. In *Macaca nigra* the mountee was mounted and comforted after a conflict by the aggressor (Dixon, 1972). Mounting behavior in other primate species, such as baboons (*Papio anubis*), golden snub-nosed monkeys (*Rhinopithecus roxellana*) and chimpanzees (*Pan troglodytes*) serves the same function and is also interpreted as a way of reducing social tension (Ren et al., 2002a; Edwards & Todd, 1991).

Additionally it was also reported that mounting serves a training function for immature individuals in some primates and that adult individuals often invited immature individuals to mount (Edwards & Todd, 1991; Van Lawick-Goodall, 1968).

In this group, there were fecund heterosexual males, and there might have been homosexual mountings already before the group broke apart in 2005. Indeed both the heterosexual and the homosexual mountings in this group might have the same functions as in a normal social group.

But it is also possible that the function of the mountings changed after the group break. After the break AF was the only adult individual and our observations show that she solicited other individuals and initiated most of the mounting behaviors as mountee and received less mounting from other individuals through typical mounting invitations, such as head shaking, presentation of the hindquarters and tail lowering, similar to other primates (Sommer & Rajpurohit, 1989; Srivastava et al., 1991). As a result, she played the main role in both the heterosexual and the homosexual mountings. For her positive behavior, we may suggested she played function of mature female as before to solicit SM to mount her for physical sexual satisfaction and to train SM. She also often solicited SF to mount, which could imply she may act as parent to train SF. She rarely invited JF to mount, possibly because JF was still too young.

SF was mostly involved in mounting behaviors as a mounter especially with AF (Table 1). The mounting behavior between AF and SF does not indicate a demonstration of dominance and subordination, because SF apparently is not a high ranking group member. It does also not serve for reassurance because we rarely observed any conflict between AF and SF. The most likely function of this mounting was training.

SM was the only male and immature. He only was involved in mounting behaviors as mounter, mainly with AF (Table1). Mounting between him and AF does probably not indicate a demonstration of dominance either, as observations of captive Francois langurs have shown that subadults never rank higher than adult individuals (Wang et al., 2006). So in this group mounting served mostly for training and reproduction.

Grooming behavior often occurs before and after mounting encounters in Hanuman langurs (Srivastava et al., 1991). In a one-male Hanuman langur group, the adult male (mounter) often initiated the grooming, while the adult female (mountee) received the grooming and this has been considered to possibly serve as a form of reward (Srivastava et al., 1991; Vasey, 2004a; 2004b). Grooming often occurred also in the study group after mounting similar to observations made in other primates; however as the mountee AF interestingly also was the animal initiating the grooming and not the animal receiving the grooming. So in this case AF was the one giving the reward not the one receiving it. We suggest interpreting the function of the behaviors displayed by AF mostly as training.

In captivity, adult females of Francois langurs were reported to initiate most of the heterosexual mountings (19 out of 24), while the adult male initiated the rest and lower ranking females initiated most the homosexual mountings (28 out of 38) (Wang, 2009). Studies also demonstrated that a high

ranking individual in captivity played as groomer after mounting more than that of reverse (Zhou et al., 2006), which was similar to other primates and different from this unusual group.

Akers & Conaway (1979) argued that captivity could exaggerate behaviors which might be less frequent in wild populations, but it would not change the basic function of mounting. It seemed in the present study that after the group break the dominant AF was unusual likely to solicit others for mounting and grooming, which might imply she was training other individuals in mounting behavior.

In conclusion, the unusually composed group continued to display sexual behaviors after the loss of the adult male. The only adult individual (AF) was positively initiating sexual activity. We suggest that the training function of AF in mounting was exaggerated after the group break.

Acknowledgments

This study was sponsored by the National Nature Science Foundation of China (30560023-31360093, 31372145); the monitoring of the conservation of langur project by the National Forestry Administration of China. We thank Naiguang Huang, Director of Fusui Nature Reserve and his colleague for helping us to carry out this study and Baoping Ren for providing valuable suggestions for completing this manuscript. We thank Wesley Skidmore for his kind offer to improve the English grammar. We especially thank reviewers for their valuable evaluations and suggestions.

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Effect of orally applied ivermectin on gastrointestinal nematodes in douc langurs (*Pygathrix* spp.)

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Key words: Gastrointestinal parasites, ivermectin, douc langurs, *Pygathrix cinerea*, *Pygathrix nemaeus*

Summary

The aim of the study was to test the orally administered effectiveness of the anthelmintic drug Ivomec® (Merial) with the active ingredient ivermectin against gastrointestinal nematodes. The effectiveness was tested in seventeen grey-shanked douc langurs (*Pygathrix cinerea*) and seven red-shanked douc langurs (*Pygathrix nemaeus*) at the Endangered Primate Rescue Center in Cuc Phuong National Park, Ninh Binh Province, Vietnam. The number of eggs in the faeces of each douc langur was counted three times every second day, and then the drug was given orally at a dosage of 0.2 mg/kg. Ten to sixteen days after drug administration the eggs were counted again three times every second day. The number of eggs was determined using a modified McMaster method. Applied at a dosage of 0.2 mg ivermectin per kg body weight Ivomec® did not significantly reduce the number of eggs of gastrointestinal nematodes in faeces of douc langurs.

Hiệu quả của thuốc ivermectin thông qua đường uống đối với giun tròn sống trong hệ tiêu hóa của các loài Voọc chà vá (*Pygathrix* spp.)

Tóm tắt

Mục tiêu của nghiên cứu này là nhằm kiểm tra hiệu quả của thuốc trị giun Ivomec® (Merial) với thành phần chính là ivermectin trong điều trị nhiễm giun tròn ở đường tiêu hóa. Đối tượng được kiểm tra là 17 cá thể chà vá chân xám (*Pygathrix cinerea*) và 7 cá thể chà vá chân nâu (*Pygathrix nemaeus*) tại trung tâm cứu hộ linh trưởng nguy cấp, vườn quốc gia Cúc Phương, Ninh Bình, Việt Nam. Số lượng trứng được xác định bằng phương pháp McMaster có hiệu chỉnh. Số lượng trứng giun trong phân của mỗi cá thể chà vá được đếm 3 lần mỗi ngày và thuốc được cho uống với liều lượng 0.2 mg/kg. 10 đến 16 ngày sau khi cho uống thuốc, trứng giun lại được đếm 3 lần mỗi ngày để so sánh. Kết quả cho thấy, với liều lượng 0.2 mg ivermectin cho một kg trọng lượng cơ thể, thuốc không có hiệu quả trong việc giảm số lượng trứng giun trong phân của các loài chà vá.

Introduction

Gastrointestinal parasites pose a severe threat to wild animals in captivity. Due to the close

phylogenetic relationship to humans infectious diseases in non-human primates have a great zoonotic potential and deserve special attention. Furthermore keeping primates in captivity facilitates the transfer of infectious agents among individuals. Compared to the life of free-roaming animals captive primates live in closer proximity and often at a higher density. And host density and the abundance of strongyloid nematodes are known to correlate significantly (Arneberg et al., 1998).

These risks make regular parasitological examinations a necessity for any primate holding facility. The present study was conducted at the Endangered Primate Rescue Center (EPRC) in Cuc Phuong National Park, Ninh Binh Province, Vietnam. Important aims of the EPRC are captive breeding and the reintroduction of endangered primates. To achieve these aims, animals must be in a very good condition and regular health checks are essential (Cunningham, 1996).

The work at the EPRC focusses on two genera of the cercopithecoid subfamily Colobinae: these are the langurs which belong to the genus *Trachypithecus* and the douc langurs within the genus *Pygathrix*. The genus *Pygathrix* comprises three species which all are endemic to Indochina. The red-shanked douc langur (*P. nemaeus*) occurs in Laos and central Vietnam, the grey-shanked douc langur (*P. cinerea*) occurs in the Central Highlands of Vietnam and the black-shanked douc langur (*P. nigripes*) occurs in southern Vietnam and eastern Cambodia. All species are threatened with *P. nemaeus* and *P. nigripes* assessed by IUCN (IUCN, 2014) as “Endangered” and *P. cinerea* as “Critically Endangered”. The latter species is also listed among the “The World's 25 Most Endangered Primates” (Schwitzer et al., 2014). The EPRC is the only institution keeping *P. cinerea* thus the stock is of enormous conservation value.

Anthelmintic treatment in non-human primates should be as gentle as possible. As some of the primates at the EPRC are intended for reintroduction, habituation and handling is kept at a necessary minimum. Regular drug administration by injection poses a challenge as animals are kept in groups and immobilization of each individual would be necessary to ensure proper drug application and dosage. Thus oral treatment is the most feasible option. In the past animals were usually dewormed twice per injection during the initial quarantine after arrival and after that deworming was continued roughly annually by oral administration. Animals born at the center however were not subjected to any initial treatment. During the years the primates at the EPRC were irregularly dewormed with 0.2 mg per kg bodyweight ivermectin (injectable solution IVOMEC-S®, ivermectin 10 mg/ml, Merial, United Kingdom).

Colobines have a multi-chambered stomach, comparable to the digestive system of a ruminant. The stomach consists of three compartments in *Trachypithecus* langurs and of four compartments in douc langurs (Caton, 1998; Chivers, 1994). Bacteria in the first sections split cellulose, lignin and other substances, which are otherwise indigestible for vertebrates. Afterwards shorter carbohydrates can be resorbed in the more distal parts of the gastrointestinal system. An in-vitro study on the effectiveness of moxidectin and ivermectin in ruminal and abomasal content of sheep showed that ivermectin binds > 90 % to the solid ingesta of the fore-stomach (Lifschitz et al., 2005). Due to their special digestive system it is questionable whether orally administered ivermectin is effective in members of the subfamily Colobinae and to date no study on the effect of oral ivermectin in langurs is available. The aim of the study was to test the orally administered effectiveness of ivermectin (Ivomec®, Merial) against gastrointestinal nematodes in langurs. We hypothesized that orally applied ivermectin in the dose of 0.2 mg/kg is not effective against nematodes.

Materials and Methods

Currently 15 species of primates are living at the EPRC. The langurs are housed in groups or solitary in outdoor enclosures under ambient weather conditions. The size of the larger cages is 10 m x 5,5 m x 3,5 m and the smaller cages measure 10 m x 5 m x 3,5 m. The larger cages have concrete floors whereas the smaller ones have natural soil. All enclosures are made of wire-mesh fence and the interior fitting consists of bamboo poles. The floors of the cages are cleaned two times per day, in the morning thoroughly with water and brush and in the afternoon faeces are collected and the cages are swept dry.

In preparation of the study faeces of all groups of primates at the EPRC were examined for gastrointestinal parasites. Pooled samples were collected two hours after the first cage cleaning in the morning, so the samples were not older than two hours. The samples were directly examined, using four different examination methods: direct smear, flotation, sedimentation and Baermann-Wetzel method. Detection of protozoa was not possible as no immersion oil was available. The preliminary control showed that the parasite load in the primates was high except in a few adult males that were kept solitary.

Eggs were identified according to their shape, color and content (Schnieder, 2006, Eckert et al., 2005). Measurement of the eggs was not possible. For the microscope at the EPRC (LABOVAL 4, Carl Zeiss Jena, Germany) an appropriate micrometer was not available.

For the study we selected 24 clinically healthy douc langurs, of which seven were red-shanked douc langurs and 17 were grey-shanked douc langurs (Table 1). The group size in which the

Table 1. Demographic data of the individuals.

Name	Number	Sex	Species	Date of Birth	Source
Butz	6-09	M	<i>P. nemeaeus</i>	1997	Confiscated
Detlef	6-75	M	<i>P. nemeaeus</i>	2.5.2012	Born EPRC
Orsa	6-60	M	<i>P. nemeaeus</i>	2007	Confiscated
Julius	6-16	M	<i>P. nemeaeus</i>	1995	Confiscated
Laura	6-55	F	<i>P. nemeaeus</i>	2.2.2008	Born EPRC
Borsti	6-21	F	<i>P. nemeaeus</i>	12.30.1998	Born EPRC
Halbfuss	6-46	F	<i>P. nemeaeus</i>	~2002	Confiscated
Sung	7-25	M	<i>P. cinerea</i>	~2000	Confiscated
Mr. Ham	7-67	M	<i>P. cinerea</i>	5.14.2013	Born EPRC
Gordon	7-09	M	<i>P. cinerea</i>	~1996	Confiscated
Gin	7-46	M	<i>P. cinerea</i>	~2005	Confiscated
Cactus	7-55	M	<i>P. cinerea</i>	5.6.2010	Born EPRC
Falk	7-39	M	<i>P. cinerea</i>	~2003	Confiscated
Bummi	7-49	M	<i>P. cinerea</i>	2009	Confiscated
Seba	7-65	M	<i>P. cinerea</i>	2008	Confiscated
Ben	7-40	M	<i>P. cinerea</i>	10.10.2007	Born EPRC
Eric	7-52	M	<i>P. cinerea</i>	~2003	Confiscated
Cac Mac	7-16	M	<i>P. cinerea</i>	unknown	Confiscated
Eco	7-14	M	<i>P. cinerea</i>	1998	Confiscated
Sung	7-25	M	<i>P. cinerea</i>	2000	Confiscated
Pip	7-48	F	<i>P. cinerea</i>	March 2009	Born EPRC
Naomi	7-24	F	<i>P. cinerea</i>	1.15.2004	Born EPRC
Phu Cat	7-34	F	<i>P. cinerea</i>	unknown	Confiscated
Lychee	7-56	F	<i>P. cinerea</i>	4.17.2011	Born EPRC
Lucy	7-28	F	<i>P. cinerea</i>	6.6.2005	Born EPRC

animals lived varied between two and four members. 23 of the douc langurs live in family groups or in bachelor groups with other douc langurs. One male shared the cage with two Hatinh langurs (*Trachypithecus hatinhensis*). The youngest individual was one year and two months old, the oldest one 20 years. 16 douc langurs were male, eight were female.

Sample collection

Sample collection for the study was carried out between June 10th and 28th June 2014. The faeces were collected from each animal three times every second day. The groups were observed until every animal defecated and a sample had been collected. Once three samples had been examined from every animal, all were treated orally with 0,2 mg/kg ivermectin on the 13 June. Twelve individuals were treated orally with the injection solution from Ivomec-S® for pigs (ivermectin 10 mg/ml). The other twelve were treated with the Ivomec-P® horse paste (ivermectin 18,7 mg/g). Both pharmaceutical products were imported from Germany. The drugs were administered in a piece of sweet potato (*Ipomoea batatas*). All animals in a cage were dewormed, also those animals that were not part of the study.

On day 10 to day 16 after drug administration faeces were collected again (23rd to 28th June 2014), three times from each animal every second day.

A total of 143 samples were analyzed. The samples were either analyzed the same day or the following day. If they were analyzed the following day, they were stored in the fridge over night at temperatures of about 10°C. The number of eggs was measured using a modified McMaster method. Therefore two grams of the sample were mixed with 60 ml of a saturated saline solution. After ten minutes the counting chamber was filled and the eggs counted. The eggs were always counted by the same person.

Statistical analysis

The data were analyzed using the statistics program RProject® (The R Foundation for Statistical Computing, Austria). A paired t-test was carried out. A p-level of 0.05 was considered significant.

Results

73 % of the samples were found positive for gastrointestinal nematodes, 8 % were positive for large gastrointestinal strongylids, 24 % were positive for nematodes of the genus *Trichuris* and 49 % for *Strongyloides* spp.

100 % of the animals were positive before administration of ivermectin and 100 % of the animals were positive after the administration. There was no significant decrease between number of eggs before and after drug administration ($t = -2,3405$, $p = 0,0283$). We were not able to show a pharmacological effect of ivermectin in the animals of our study when orally applied at a dosage of 0.2mg/kg, irrespective of the formulation of the drug (Table 2).

Discussion

Since the establishment of the center in 1993 the primates at the EPRC were more or less regularly dewormed with Ivomec-S® (10 mg ivermectin/ml) at a dosage of 0.2 mg/kg and sometimes with fenbendazole (Panacur®, MSD, United States). From 1998 to 2006 regularly controls by a veterinarian were performed. Nevertheless reinfection with gastrointestinal parasites

Table 2. Mean egg counts before and after administration of ivermectin of each douc langur.

Name	Number	Mean Egg Count I - III (EpG)	Mean Egg Count IV - VI (EpG)
Butz	6-09	2933	4567
Laura	6-55	1333	1700
Borsti	6-21	1233	1067
Halbfuss	6-46	767	533
Detlef	6-75	3067	4667
Julius	6-16	2867	2400
Orsa	6-60	667	1033
Cactus	7-55	1600	1167
Phu Cat	7-34	267	33
Gordon	7-09	333	433
Ben	7-40	1033	500
Eric	7-52	200	467
Bummi	7-49	967	833
Seba	7-65	1167	2800
Cac Mac	7-16	67	933
Eco	7-14	333	1000
Falk	7-39	600	5767
Lychee	7-56	633	1433
Gin	7-46	1367	1533
Pip	7-48	800	567
Sung	7-25	800	900
Naomi	7-24	267	1867
Lucy	7-28	1000	600
Mr. Ham	7-67	4667	10000

can be expected: the animals climb down to the ground for drinking, eating or playing or touch bamboo furnishings contaminated with faeces. Doucs also show coprophagia occasionally (Nadler, pers. obs.). Frequent contact with infectious parasite stages is thus probable.

However this study showed that at least in douc langurs the treatment with ivermectin in a dosage of 0.2 mg/kg is ineffective.

Though Ivomec S is a formulation made for injection its off-label use is common in many areas of veterinary medicine. Ivermectin at this dosage is successfully orally used in animals with a simple digestion system (eg. bears) or in hindgut fermenters (eg. horses).

After years of irregular deworming with a low dose of ivermectin a resistance of nematodes against ivermectin should be taken into consideration. Resistances against ivermectin are known for various parasite species (Geary, 2005).

Proper storage of drugs in remote tropical areas is a problem. The injectable solution was stored in a dark container several months in a room which was cooled down for some hours per day, but might in other times reach outside temperatures in particular during the almost regular power cuts. The paste for oral treatment in horses was stored in the same room for one week. Both formulations were imported from Germany and inappropriate storage during transport could have occurred.

Eggs of parasites survive a long time under the hot and humid climate conditions. Despite its limited technical possibilities the study showed that the parasite pressure on the primates is high with the exception in the males which are kept alone. It is important to note that none of the animals in our study showed any symptoms of a parasite mediated disease. Nonetheless to protect the

health of the extremely valuable stock and to minimize the zoonotic potential some of the parasites hold, an effective and practicable treatment of helminthes in douc langurs should be investigated. Furthermore the effect of oral ivermectin at higher dosages and in other colobines should be researched.

Acknowledgements

The authors would like to thank Truong Quang Bich, Director of Cuc Phuong National Park for the possibility to undertake this study. This research would not have been possible without the help of the staff at the Endangered Primate Rescue Center and the support of Leipzig Zoo, Germany.

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Eastern black gibbon (*Nomascus nasutus*) at the Parc zoologique de Clères, France

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Key words: Eastern black gibbon, *Nomascus nasutus*, Parc zoologiques de Clères

Summary

In 1926 three young female gibbons arrived from Vietnam at the Parc zoologique de Clères, France. The exact origin of the gibbons is not known. One of the gibbons was kept until its death in 1946. The head coloration of this gibbon supports the systematic identification as eastern black gibbon (*Nomascus nasutus*). There is only one animal of this species known to have been kept in captivity, at Tierpark Berlin, Germany. This individual, also a female, arrived at the Tierpark in 1962 from northern Vietnam.

Vượn đen Đông bắc (*Nomascus nasutus*) tại vườn thú Clères, Pháp

Tóm tắt

Ba cá thể vượn cái từ Việt Nam được đưa đến vườn thú Clères, Pháp vào năm 1962. Nguồn gốc xuất xứ của những cá thể vượn này không được xác định rõ. Một cá thể được nuôi nhốt tại vườn thú và chết năm 1946. Màu sắc trên đầu của cá thể vượn này phù hợp với đặc điểm hình thái ngoài của loài Vượn đen Đông bắc (*Nomascus nasutus*). Chỉ có một cá thể cùng loài được nuôi nhốt ở một vườn thú châu Âu khác là vườn thú Berlin, Đức. Cá thể vượn cái này được đưa đến vườn thú Berlin năm 1962 từ miền Bắc, Việt Nam. Cá thể này đã chết sau nhiều năm nuôi nhốt.

In 1926 three young female gibbons arrived at the Parc zoologique de Clères as a present to Jean Delacour from the Governor of Cochinchine (now southern Vietnam). These gibbons were the first ones in Clères.

The Governor was interested in animal keeping and received individuals from all over Indochina. The origin of the gibbons has never been verified but Delacour mentioned: "Belonging to the Tonkinese race".

One of the three gibbons was moved to an island in the lake of the Duke of Westminster, at Heaton Hall, near Chester and finally to London Zoo. A second animal was gifted from Delacour to one of his friends.

The third gibbon with the name "Orfeuille" (Fig. 1) was kept in Clères. Delacour pointed out: "Her face was really beautiful, with a prominent nose; she had a long, thick, pale coat, a black cap and a black patch between the shoulders" (Delacour 1966). The gibbon survived the bombing and destruction of Clères and died in 1946.



Fig.1. Jean Delacour at the Parc zoologique de Clères, France, with the female eastern black gibbon “Orfeuille” (*Nomascus nasutus*). Photo: Collection Jean Delacour [Delacour J (1966): The Living Air].



Fig.2. Female eastern black gibbon (*Nomascus nasutus*). Photo: Zhao Chao.

Delacour noted: “In 1945, when things quietened down, “Orfeuille” alone was there (speaking about Clères), but she died soon after, probably old age, and when I returned to Clères the following year not a single gibbon remained”.

All female gibbons of the seven currently recognized species belonging to the genus *Nomascus* (Mittermeier et al., 2013; Roos et al., 2013) show very similar head coloration, except the females of the eastern black gibbon. Only these females have long white hairs around the face, like a frame (Mootnick, 2006) (Fig. 2). The gibbon “Orfeuille” shows this typical feature and is most likely an eastern black gibbon.

The only known individual of this species in captivity was the gibbon “Patz” at Tierpark Berlin, Germany (Fischer, 1980) (Fig. 3). It was also a female and originated from the Hon Gai area, in northeastern Vietnam. The gibbon arrived in November 1962 at the Tierpark Berlin (Fischer 1966).



Fig.3. The female eastern black gibbon “Patz” (*Nomascus nasutus*) at Tierpark Berlin, Germany. Photo: Wilfried Fischer.

The species had in historical times quite a large distribution area in northern Vietnam and southern China (Rawson et al., 2011), but is limited now to the very small Cao Vit Gibbon Conservation Area, Trung Khanh District, Cao Bang Province, close to the Chinese border (Rawson et al., 2011), and on the Chinese side of the border in the adjacent Bangliang Nature Reserve (Fan

Pengfei et al., 2007). The total population of this species is estimated to be around 120 individuals (Nguyen The Cuong 2013; Nguyen The Cuong et al. 2014).

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Necropsy findings in slender Lorises (*Loris lydekkerianus*)

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Key words:

Summary

Little has been published about necropsy findings in slender lorises. Necropsy findings of 28 adult slender lorises and 4 additional newborns are presented in this report. Since two species of lorises occurring in Vietnam, pygmy loris (*Nycticebus pygmaeus*) and northern slow loris (*Nycticebus bengalensis*) are closely related to slender lorises the given necropsy data might also be of interest for these two Vietnamese species.

A total of 32 slender lorises mainly from one colony at Bochum University were investigated post mortem. Five pathological changes in slender lorises which appear to be found more often and to be more important than others: Polycystic nephropathy, Tooth alterations, Gallstones, Cataracts and Trichobezoar. Other findings were a hint of diabetes mellitus, intensive iron storage in the liver of one loris, ovarian cysts, and some probably mostly age related alterations

Những phát hiện trong giải phẫu tử thi ở loài Culi slender (*Loris lydekkerianus*)

Tóm tắt

Hiện nay vẫn còn rất ít những tài liệu xuất bản về giải phẫu tử thi đối với loài Culi slender. Nghiên cứu này công bố những phát hiện về giải phẫu tử thi của 28 cá thể trưởng thành, 4 cá thể con non của loài Culi slender. Ở Việt Nam, hai loài Culi nhỏ (*Nycticebus pygmaeus*) và Culi lớn (*Nycticebus bengalensis*) có quan hệ gần gũi với loài Culi slender, do vậy những hiểu biết về giải phẫu tử thi của loài Culi slender sẽ rất có ý nghĩa. Tổng cộng có 32 cá thể từ một quần thể ở Đại học Bochum đã được nghiên cứu. Có 5 sự thay đổi bệnh lý quan trọng và thường xảy ra ở loài Culi slender đó là: viêm thận, thay răng, sỏi mật, mất nước, và búi lông dạ dày. Ngoài ra, những phát hiện khác như tiểu đường, nhiễm kim loại nặng trong gan, buồng trứng cũng được tìm thấy ở một số cá thể.

Introduction

Little has been published about necropsy findings in slender lorises. Most reports include few slender lorises in a large group of prosimians (Boraski, 1981; Griner, 1983; Benirschke et al., 1985). Therefore necropsy findings of 28 adult slender lorises and 4 additional newborns are presented in this report.

Post mortem results, diseases and treatment recorded at the colony at Bochum University and cooperating zoos as well as additional literature data are also published in the internet database for

conservation of lorises and pottos (<http://www..loris-conservation.org/database>).

Since two species of lorises occurring in Vietnam, pygmy loris (*Nycticebus pygmaeus*) and northern slow loris (*Nycticebus bengalensis*) are closely related to slender lorises the given necropsy data might also be of interest for these two Vietnamese species. Additional data on the health of *Nycticebus pygmaeus* and *Nycticebus bengalensis* are also available in the database.

Material and Methods

Animals

A total of 32 slender lorises mainly from one colony at Bochum University were investigated post mortem. The results of 4 newborn slender lorises babies (2 males, 2 females), one juvenile female of six month and 25 adults (9 males, 16 females) between 5 and 16 years of age of *Loris lydekkerianus nordicus* were reported. In addition, the results of a 9 years old female and a 16 years old male probably of *Loris. tardigradus* were also included.

Housing and clinical colony history

The animals were kept alone or in family groups of up to eight animals. The cages, made of wood and wire mesh, measured 2.5 to 40 m³ and were densely equipped with natural branches. Frequent cleaning of the branches was avoided. Instead, new cages were offered after several months. The breeding facility was rather quiet, and taming of the animals had reduced environmental stress. In order to decrease the susceptibility of the lorises to psychic stress, some unfamiliar stimuli were provided, for instance access to unfamiliar cages or passages, invitation of human visitors or a radio automatically switched on at intervals. The day length was kept constantly at 13 hours (neon light). Temperature was about 24°C with a relative humidity of 60-70%.

Nutrition included milk formula with some milk-protein and egg yolk, calcium and vitamins added, live insects (locusts, crickets, mealworms), marmoset pellets and pieces of fruits and vegetable. Fennel tea or water was regularly offered, but drinking is regarded as unusual in this species. The daily quantity of food was usually kept constant with meagre food supply one day per week.

Necropsy and histopathology

At necropsy, the animals were fresh, frozen or fixed in 4% formaldehyde solution. The degree of post-mortem conservation was in a large range between fresh and putrefied/autolytic. In one case the body of an animal was available without head and neck. Photographs of the organs of interest were taken. Afterwards the organs were fixed in a 4% formaldehyde solution for at least 24 hours. Tissue samples were paraffin embedded, 8 µm slides were prepared and a haematoxylin-eosin-stain was performed according to standard methods. In one euthanized animal an immunohistology was performed for insulin and glucagon using antibodies against the human hormones.

Results

Kidneys

At necropsy, in one new-born and 21 adults different degrees of juvenile/adult polycystic nephropathy were observed (see also Plesker & Schulze, 2006). Whereas in the affected new-born

only histological changes were detected in the form of some slightly dilatated distal tubuli, in 21 adults already macroscopically a wavy, nodular surface of the kidneys was observed. Mostly miliary, in some cases up to 4 mm large, unilocular fluid filled cysts were detected on the surface as well as on the cortex part of the sections (Fig. 1). Histologically extensive tubular dilatation varying from very mild to extreme was seen. Significant sclerosis and fibrosis in combination with moderately severe infiltrates of lymphocytes and histiocytes were seen in the tissue between the cysts with the consequence that only few areas of functional active parenchyma remained. The remaining glomeruli revealed - in part - a spectrum from mild proliferation of the mesangial matrix/cells and local proliferation of the parietal endothelial cells to totally obliterating fibrosis or homogenic sclerosis of the glomerulum.



Fig.1. Multiple cysts in the cortex of the kidney of a slender loris (*Loris lydekkerianus*) affected by polycystic nephropathy (section of the kidney). Photo: Roland Plesker.

In eight of these lorises emaciation was confirmed, in 7 of these individuals a clear uremia was noted at necropsy. One individual displayed clear anemia.

Spleen

In histology, in 11 adult individuals only very few follicles were detectable in the spleen. This was interpreted as a sign of immunosuppression. In addition, in one case of a 9 years old female moderate extramedullary hemopoiesis was observed in the red pulpe of the spleen.

Teeth

In seven individuals, alterations affecting the teeth were seen such as dental calculus or

loosening/loss of single teeth (Fig. 2). In one of these cases, a severe periodontal disease was seen without abscess formation. In four additional of these cases, teeth alterations were combined with purulent/gangrenous inflammation in the surrounding maxillar or mandibular tissues (Plesker & Schulze, 2013).

Gallbladder and liver

In 5 adults (4 females, 1 male) the gallbladder was completely filled with either one or multiple gallstones. All of them were made of 100% cholesterol as determined by infrared spectroscopy (see also Plesker et al., 2012). In two of these lorises a slight icterus was diagnosed macroscopically. In a more than 15 years old male two moderately large areas with adenoid proliferation of the gall vessels in combination with moderate lymphatic infiltration of the liver were detected. In a 9 year old female multiple regenerative nodes were seen in the liver, in part with fibrosis. Histologically both local fibrosis and proliferation of the bile ducts was present.

In one case of a 13 year old female, histologically intensive iron storage in the liver (hemochromatosis) was proven by using a Berlin-blue-staining.

Eyes

In three adult individuals, cataracts were detected (Fig. 3).

Ovaries

Large unilocular fluid filled cysts of both ovaries, up to 7 mm in diameter, were noticed in a 9 years old female. This animal was reported to show male behaviour in the cage.

Gut (Bezoar)

One animal died of an occluding trichobezoar in the beginning of the jejunum.

Additional pathological alterations include

Myocardial infarcts (female, 12 years), arteriosclerosis (male, 15 years), demineralisation of bones (female, 6 month) as well as serial broken ribs of one thorax side (female, 11 years). seminoma (male, 15 years) and testical atrophy (male, 16 years).



Fig.2. Hole after surgical treatment of a teeth-related abscess in the throat of a slender loris (*Loris lydekkerianus*) (arrow). Yellow colour due to disinfection. Photo: Roland Plesker.



Fig.3. Bilateral cataract in a young-adult slender loris (*Loris lydekkerianus*). Photo: Roland Plesker.

Discussion

First of all, we would like to stress five pathological changes in slender lorises which appear to be found more often and to be more important than others:

Polycystic nephropathy

The occurrence of such a large number of individuals with polycystic nephropathy in one colony is unusual, since usually only single cases of polycystic nephropathy in primates are reported in literature. This implies, that a systemic factor in the colony, e.g. the specific nutrition, might be responsible/contributes to the occurrence of the disease.

In humans, at least some forms of polycystic nephropathy are known to be genetically fixed and there are strains of rats and mice available with a genetic fixation of the disease.

In addition, the alterations are inducible with insecticides or corticosteroids in rats. Third, the occurrence of “chronic nephrosis with nephritis” associated with extensive tubular dilatations in *Microcebus murinus* was correlated to stress-induced increased corticoadrenal activity (PERRET, 1982). The permanent stress was thought to be induced by housing conditions in captivity since the degree of kidney alterations in *Microcebus murinus* could be correlated to the period of time the animals were kept in captivity. In our cases in *Lorises*, there was no behavioural evidence that the animals that had been affected had suffered from more severe stress than others. However, the loss of follicles (immunosuppression) in the spleen as seen histologically in 11 individuals might be an indication for chronic stress at least in these individuals.

Tooth alterations

are fairly common in the Bochum colony of *Lorises* (Plesker & Schulze, 2013). We have seen dental calculus formation as well as loose teeth or loss of teeth. As a consequence, in some cases, abscess formation/gangrenous inflammation was correlated to these former teeth alterations (see also Eisenberg et al., 2012). We believe that feeding *Lorises* with locusts may contribute significantly to teeth problems since sharp spikes on the hind legs of migratory and other locusts (used as food insects) may cause regular injuries in periodontal tissues. These wounds may serve as “point of tissue invasion” for pathogenic bacteria. Species of bacteria isolated from the oral cavity or tooth roots of lorises with symptoms of gingival infection or tooth root abscess included *Prevotella melaninogenica*, *Eikenella corrodens*, *Pseudomonas aeruginosa*, *Acinetobacter baumannii* and *Proteus mirabilis*. All of them are ubiquitous, but may cause problems in humans or farm animals, however, the significance of these bacteria for lorises has to be further investigated. The same is the case for *Trueperella pyogenes* (Eisenberg et al., 2012).

Gallstones

are known to occur rarely in baboons (*Papio* sp.), orangutan (*Pongo*), *Callithrix kuhlii*, *Leontopithecus* sp. and in owl monkeys (*Aotes trivirgatus*) (Chalifoux & Anver, 1993). In owl monkeys, the gallstones are of cholesterol origin. The reason for this is unclear. In slender lorises no preference for one sex could be confirmed. However, the occurrence of these stones are known to be quite painful in humans and this is an excellent explanation for a behaviour seen in some individuals of slender lorises that is described as “having abdominal pain”. Another possible consequence of gallstones - icterus - was seen in two of our four cases.

Cataracts

are not only limited to slender lorises but have also been observed in two pygmy lorises at the EPRC in Cuc Phuong National Park, Vietnam (Fig. 4).

Trichobezoar

Although in our cases there is only one individual that died from a trichobezoar, in the history of this colony as well as in other necropsy reports from *slender lorises* sometimes the occurrence of trichobezoars is described. The occurrence is due to a special behaviour in prosimians: these animals clean their hairs with their lower incisors and canines. These teeth are arranged in the form of a comb that is cleaned with an additional sublingual tongue made of fibrous material. The removed loose hairs are swallowed, which is the reason for the normal occurrence of masses of hairs in the faeces.



Fig.4. Cataract in a pygmy loris (*Nycticebus pygmaeus*) at the Endangered Primate Rescue Center, Vietnam. Photo: Tilo Nadler.

Other findings

There were some hints for diabetes mellitus both in the colony history and at necropsy (like potentially necrotic ends of fingers and toes (2 individuals) in combination with slight cataract (one 11 years old female). Normally, diabetes mellitus can be identified clinically by glucose determination in the urine; only on one occasion blood glucose level has also been tested in the colony of Bochum University (using blood received via blood-sucking tropical bug, *Gromphadorhina portentosa*). However, the results of urine testing and of the blood testing must be interpreted very carefully (if the urine is not obtained under very clean conditions the testing mostly is false positive and blood results might have been changed by the passage within the bugs). The degree of post mortem conservation in most individuals made it impossible to make a diagnosis of the pancreas isles in a hematoxylin-eosin stained slide. In two cases in which the pancreas was fresh, slight oedematous disintegration and enlargement of the isles was noticed in routine histology. In immunohistology - using antibodies against human insulin and glucagon - the detected amount of insulin was very high and the amount of glucagon was reduced in comparison to the human reference. Since no slender loris reference was available for comparison the significance of this finding remains unclear. However this illness must be taken into consideration at least when there is an enlarged volume of urine observed in single individuals. Changes of the skin and loss of hair on the limbs, occasionally observed in lorises with severe wasting disease and also described as a usual symptom before death in captive slender lorises by Osman Hill (1937), might indicate diabetes or be a sign of malnutrition (possibly fatty acid deficiency).

We demonstrated intensive iron storage in the liver of one loris. However, this was the only individual that was tested. We are convinced that more affected individuals would have been

detected if they would have been tested. Intensive iron storage in the liver had been described in several prosimian species.

The occurrence of ovarian cysts is more frequent in certain mammal species than in others. In our material for example we see ovarian cysts mostly in guinea-pigs. A conclusion from the one case we observed in slender lorises is - of course - not possible. However for us it was interesting to find the ovarian cysts in an individual that revealed male behaviour when observed clinically. Biochemically this is due to testosterone's that produced normally in the ovary as an intermediate product and that is released in large amounts in the case of ovarian cysts.

Artherosclerosis and myocardial infarcts, osteoporosis, loss of teeth and dental stones, regenerative nodes of the liver and fibrosis of the gall vessels, reduction of follicles in the white pulpe of the spleen, residues of former traumata and even seminomas, all together are alterations that are more often seen in elder individuals and are well known in a variety of species. Therefore these alterations are regarded as more age related than slender lorises specific.

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Endangered Primate Rescue Center, Vietnam – Report 2013/2014

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Key words: Primates, Vietnam, Endangered Primate Rescue Center

Summary

End of 2013 the EPRC kept in total 174 primates in 15 species, seven of them currently in no other facility in the world. This includes 174 langurs, 18 gibbons and 19 lorises. During the year 27 individuals were confiscated and arrived at the center, 21 were born, and 14 died.

End of 2014 the total number of primates was nearly stable, and included 129 langurs, 18 gibbons and 26 lorises. In cooperation with the Forest Protection Authorities 23 individuals were confiscated and arrived the center, 20 individuals were born and 42 died. A number of confiscated individuals arrived at the center in a critical stage of health and subsequently died.

With the increasing number of animals at the EPRC, the staff of animal keepers increased from 21 in 2013 to 26 in 2014.

The EPRC has already a long tradition to support research and scientific work. More than 20 Masters and PhD studies have been completed at the EPRC or via EPRC-led field projects. Also in 2013 and 2014 research activities continued with an analysis of primates in the illegal wildlife trade, a study about the effect of parasitological treatment on the primates and the continuation of monitoring for Delacour's langur populations in several areas.

Activities for the reintroduction of primates continued. The monitoring of released Delacour's langurs in Van Long Nature Reserve continued and a second reintroduction was carried out in 2013. In preparation of a reintroduction project for Hatinh langurs, the EPRC carried out field surveys in several potential areas for reintroduction. Suitable conditions were found in Ke Go Nature Reserve and an agreement for the reintroduction of Hatinh langurs into Ke Go Nature Reserve was discussed and signed between the Management Board of the reserve and EPRC.

In September 2014 the EPRC started a reintroduction project for pygmy lorises in Cuc Phuong National Park.

On 8th to 11th October 2013 the third international primate conference "Conservation of Primates in Indochina" was organized from the EPRC in Cuc Phuong National Park. About 80 conservationists and primatologists from 12 countries attended the conference.

The year 2014 brought special "primate events" for Vietnam: in August the 25th Congress of the International Primatological Society was held in Hanoi, and in connection with this a Pre-Congress Training Program for students at the Endangered Primate Rescue Center, Cuc Phuong National Park.

Trung tâm cứu hộ thú linh trưởng nguy cấp, Việt Nam – Báo cáo năm 2013/2014

Tóm tắt

Về số lượng động vật, tính đến cuối năm 2013, Trung tâm nuôi giữ 174 cá thể của 15 loài linh trưởng khác nhau, trong số đó có 7 loài không nơi nào trên thế giới nuôi nhốt. Có tổng cộng 147 cá thể Voọc, 18 cá thể Vượn, và 19 cá thể Culi. Trong vòng 1 năm, có 27 cá thể được cứu hộ và đưa về trung tâm, 21 cá thể mới được sinh và 14 cá thể chết.

Cuối năm 2014 số cá thể vẫn tương đối ổn định. Tổng cộng có 129 cá thể Voọc, 18 cá thể Vượn, và 26 cá thể Culi. Trong năm trung tâm đã phối hợp với lực lượng kiểm lâm trung tâm cứu hộ 23 cá thể, có 20 cá thể mới được sinh và 42 cá thể chết. Số lượng cá thể mới đến trung tâm năm 2014 có tình trạng sức khỏe kém và thường bị chết.

Tại trung tâm cứu hộ thú linh trưởng nguy cấp, số lượng nhân viên chăm sóc động vật tăng từ 21 năm 2013 lên 26 năm 2014 do số lượng động vật tăng. Trung tâm thường xuyên hỗ trợ các nhà nghiên cứu, nhà khoa học đến làm việc tại đây. Hơn 20 thạc sỹ, nghiên cứu sinh đã hoàn thành nghiên cứu tại trung tâm hoặc tham gia các dự án do trung tâm khởi xướng. Những nghiên cứu trong năm 2013 và 2014 bao gồm: phân tích tình trạng buôn bán các loài linh trưởng hoang dã trái phép; hiệu quả của việc điều trị ký sinh trùng ở linh trưởng; giám sát quần thể Voọc mông trắng ở một số địa điểm.

Hoạt động tái hòa nhập các loài linh trưởng được tiếp tục với dự án giám sát sau khi thả loài Voọc mông trắng ở khu bảo tồn thiên nhiên Vân Long. Đàn thứ hai được thả vào năm 2013. Nghiên cứu khả thi việc tái thả Voọc Hà Tĩnh ở khu bảo tồn thiên nhiên Kê Gỗ đã được tiến hành. Bản ghi nhớ hợp tác giữa trung tâm và ban quản lý khu bảo tồn thiên nhiên Kê Gỗ được ký kết. Tháng 9 năm 2014, trung tâm tiến hành dự án tái thả loài Culi nhỏ ở Vườn quốc gia Cúc Phương.

Hội thảo “Bảo tồn thú linh trưởng ở Đông Dương” được tổ chức tại Vườn quốc gia Cúc Phương từ ngày 8 đến 11 tháng 10 năm 2013 quy tụ gần 80 đại biểu là các nhà bảo tồn và linh trưởng học. Hội thảo quốc tế về linh trưởng học lần thứ 25 được tổ chức tại Hà Nội vào tháng 8 năm 2014. Trong đó, khóa tập huấn trước hội thảo cho sinh viên được tổ chức tại trung tâm cứu hộ linh trưởng nguy cấp, Vườn quốc gia Cúc Phương.

Introduction

The year 2014 brought special “primate events” for Vietnam: in August the 25th Congress of the International Primatological Society was held in Hanoi, and in connection with this a Pre-Congress Training Program for students at the Endangered Primate Rescue Center, Cuc Phuong National Park. Many Primatologists from around the country and the region were involved in preparation of material and presentations for the IPS Congress. In addition during this time we continued the preparation and final publication of the volume *Primates of Vietnam*. All this led to a delay to the preparation of the 2014 issue of the *Vietnamese Journal of Primatology*, and this report will now cover the years 2013 and 2014.

With Leipzig Zoo, Germany as the new project partner for the EPRC since the beginning of 2014, the work has continued without any break, delay or restrictions. A new five-year project 2014 to 2018 was approved by the Ministry of Agriculture and Rural Development and signed with the national park (Fig. 1). The support to confiscate highly endangered primate species and the

possibility of a proper placement of such species is an important activity to motivate the Forest Protection Departments and rangers in the fight to combat poaching and illegal wildlife trade. Poaching and illegal wildlife trade is increasing with the economic development of the country, and the lack of law enforcement drives several species close to the brink of extinction. Conservation activities, including the work of rescue centers is urgent.



Fig.1. Signing of the project agreement between Cuc Phuong National Park (Director Truong Quang Bich) and Leipzig Zoo (Representative of Leipzig Zoo and Director of the EPRC Tilo Nadler). Photo: Luong Van Hien.

Animals at the EPRC

End of 2013 the EPRC kept in total 174 primates in 15 species, seven of them currently in no other facility in the world. This includes 174 langurs, 18 gibbons and 19 lorises. During the year 27 individuals were confiscated and arrived the center, 21 were born, and 14 died.

End of 2014 the total number of primates was nearly stabile, and included 129 langurs, 18 gibbons and 26 lorises. In cooperation with the Forest Protection Authorities 23 individuals were confiscated and arrived the center, 20 individuals were born and 42 died. A number of confiscated individuals arrived the center in a critical stage of health and subsequently died.

Staff at the EPRC

With the increasing number of animals at the EPRC, the staff of animal keepers increased also from 21 in 2013 to 26 in 2014. After several changes of short term workers, the staff stabilized in 2014 and a number of young workers could be recruited from the surrounding villages close to the national park.

Maria Bischoff, a professional and trained animal keeper from Leipzig Zoo continued her work

from July 2012 to January 2013 and was replaced by Sebastian Schorr, also an employee at Leipzig Zoo who worked seven months at the EPRC. The provision of these staff is based on the agreement with Leipzig Zoo.

Liam Shephard, a trained and experienced animal keeper from Howletts Zoo, London worked from the end February 2013 to October 2013. Howletts Zoo has a long tradition in keeping sensitive leaf-eating langurs and Liam's experience was also an advantage for the EPRC.

In November 2013 Elke Schwierz continued her work at the EPRC and plans to stay until April 2015. Elke is an employee at Leipzig Zoo and has worked now, for varying periods of time, a total of seven years at the EPRC. Her engagement and knowledge about the organization, her management of the day to day work and her Vietnamese language skills contributes greatly to the success of the project.

Dirk Engbersen a former trainee from Zoo Leipzig, supported - with high engagement - the work at the EPRC for one month, from June to July 2014

Research

The EPRC has a long tradition to support research and scientific work. More than 20 Masters and PhD studies have been completed at the EPRC or via EPRC-led field projects. These studies contributed immensely to the understanding of status, behaviour, distribution, systematics and also captive care of highly endangered and especially endemic Vietnamese primates.

The work on the Primate Data Base, a program to collect all relevant information about Vietnamese primate species is solely organized with volunteers and continued in September to December by Tilly Blake, student at Plymouth University, UK.

An analysis of primates in the illegal wildlife trade, based on the Wildlife Data Base compiled by the organization Education for Nature Vietnam (ENV) was conducted from January to March 2014 by Jasmin Beyle, student at the University Koblenz-Landau, Germany.

A study about the effect of parasitological treatment on the primates kept at the EPRC was carried out from April to July 2014 by Constanze Hartmann, veterinarian student at the University Wien.

Surveys for Delacour's langur in Cuc Phuong National Park were carried out in January and June 2014 by Le Trong Dat, biologist at Cuc Phuong National Park and Do Dang Khoa forestry engineer at the EPRC.

During 2014 surveys were also conducted for isolated populations for this species in the Kim Bang area, Ha Nam Province, Bim Son area, Thanh Hoa Province, and Hoa Lu Nature Reserve, Ninh Binh Province by Le Van Dung. Le Van Dung started his career as an animal keeper at the EPRC and was supported to earn his master degree at the Institute of Ecology and Biological Resources, Hanoi. These surveys are part of the long-term monitoring program for the Delacour's langur.

Reintroduction projects

A second reintroduction of captive bred Delacour's langur into Van Long Nature Reserve was organized in November 2012. The monitoring of the two released animals, a male and a female was conducted by Sarah Elser, Master student at the University Koblenz-Landau, Germany (until May 2013) and the Vietnamese biologist Nguyen Hong Chung (until June 2013). The animals were equipped with GPS-radio collars and the daily tracking of the animals ended with the lifespan of the

batteries in June 2013.

In September 2014 the EPRC started a reintroduction project for pygmy lorises in Cuc Phuong National Park. In total five lorises were equipped with VHF-radio collars and released to the national park, close to the compound of the EPRC (Fig. 2, 3). The lorises are tracked every night.



Fig.2. Pygmy loris (*Nycticebus pygmaeus*) move out from the cage at the reintroduction site. Photo: Tilo Nadler.



Fig.3. Released pygmy loris (*Nycticebus pygmaeus*) with radio collar feed on a grasshopper. Photo: Tilo Nadler.

The radio-tracking was managed from September 2014 to December 2014 by Joerdis Scheidegger, a graduate student from Jacobs University, Bremen, Germany and supported by the animal keepers from EPRC, which also continued the tracking after Joerdis' departure.

In preparation of a reintroduction project for Hatinh langurs, the EPRC carried out field surveys in several potential areas for reintroduction - Ke Nuoc Trong proposed Nature Reserve, Hoang Hoa Nature Reserve and Ke Go Nature Reserve. We assessed the conditions of the habitat, evaluated human impact to the area, and the capability of the reserves management. Suitable conditions were found in Ke Go Nature Reserve and three surveys were carried out (December 2013, August 2014, October/November 2014) in cooperation with the Vietnamese NGO Green Viet, Danang and Frankfurt Zoological Society. An agreement for the reintroduction of Hatinh langurs into Ke Go Nature Reserve was discussed and signed between the Management Board of the reserve and EPRC (Fig. 4). To introduce the project to the stakeholders in November 2014 a meeting was organized in cooperation with Ke Go Nature Reserve and the provincial Forest Protection Department in Hatinh City. About 90 participants attended the meeting, including leaders and representatives from the surrounding communes, commune police, representatives from youth union, women's, and farmer union (Fig. 5, 6).



Fig.4. An agreement for the reintroduction of Hatinh langurs into Ke Go Nature Reserve was discussed and signed between the Management Board of the reserve and EPRC. Photo: Tran Huu Vy.

(Fig. 5, 6).



Fig.5. The Director of Ke Ge Nature Reserve introduce in a meeting in Hatinh City the reintroduction project for Hatinh langurs into Ke Go Nature Reserve to the stakeholders. Photo: Tilo Nadler.



Fig.6. About 90 participants attended the meeting and agreed to support the reintroduction project. Photo: Tilo Nadler.

Protection activities in Van Long Nature Reserve

With the nomination of the Van Long area as a nature reserve in 2001, an area which carries the only viable population of the critically endangered Delacour's langur, Frankfurt Zoological Society and EPRC supported the protection of the reserve with the establishment of a community based protection unit. The project included training of the community guards, payment for wages, equipment and courses. After twelve years FZS withdrew from the project and requested the province administration to continue this protection project, which serves as an example for community supported protection projects in Vietnam. But the province was unable to provide the funds. Based on a proposal from EPRC, the EAZA IUCN/SSC Southeast Asia Conservation Fund provided generously a grant to continue the protection activities in 2014.

Capacity building, conferences and education program

In September 2013 five animal keepers from EPRC attended a one-week "Shape of Enrichment Workshop" held at Hanoi Zoo.

In August 2014 a one-week "Shape of Enrichment Workshop" was organized at Saigon Zoo and again five animal keepers attended.

An annual primate training course, already in its tenth year, was held at Danang University. In October 2013 the course was attended by 30 students, and in September 2014, the course focusing on field survey and techniques was attended by 22 students, including Do Dang Khoa from the EPRC (Fig.7)



Fig.7. Participants on the Primate Training Course at Danang University in September 2014.



From 8th to 12th July 2013 the Conference “Zoos and Aquariums Committing to Conservation” (ZACC) took place in Des Moines, Iowa, USA. Tilo Nadler and Nguyen Thi Thu Hien attended the conference on their own costs.

The 5th Conference of the East and South-East Asian Wild Animal Rescue Network (WARN) took place from 26th to 30th November 2013 in Kota Kinabalu, Sabah, Malaysia. Tilo Nadler and Nguyen Thi Thu Hien attended the conference (Fig. 8, 9, 10).



Fig.8,9. The Sabah Wildlife Rescue Units impressive presentations of their activities at the conference venue during the 5th WARN Conference in Kota Kinabalu. Photo: Tilo Nadler.



Fig.10. On a break during the presentations wildlife protection issues are discussed from participants on the WARN Conference. (left to right: Professor Kurtis Pei, Chair of WARN and Director of the Pingtung Rescue Center, Taiwan, Matt Hunt, Representative of Free the Bears, Datuk Seri Panglima Masidi Manjun Minister of Tourism, Culture and Environment in Sabah, and Tilo Nadler, Director of the Endangered Primate Rescue Center. Photo: Nguyen Thi Thu Hien.

The 6th WARN Conference was organized 24th to 27th 2014 at the Kadoorie Farm in Hong Kong. Eighty participants from 18 countries attended the conference and 25 presentations were on the program. A new board of the now internationally registered organisation was elected (Fig. 11). Tilo Nadler, Nguyen Thi Thu Hien and Elke Schwierz represented the EPRC. We were



Fig.11. The newly elected board members of the recently international registered organization "Wild Animal Rescue Network" (WARN). From left: Geert Drieman, Dutch lawyer, Tan Kit Sun, Kadoorie Farm Hong Kong, Kurtis Jai-Chyi Pei, Pingtung Rescue Center for Endangered Wild Animals, Taiwan and Chair of WARN, Tilo Nadler, Endangered Primate Rescue Center, Vietnam, Edwin Wiek, Wildlife Friends Foundation, Thailand, Annemarie Wegenaar, Animal Asia Foundation and Kati Löffler, International Fund for Animal Welfare.

impressed at the Kadoorie Farm by the breeding program for the three-striped box turtle, also known as the golden coin turtle (*Cuora trifasciata*). This species is in high demand for captive breeding and the illegal wildlife trade, primarily for use in traditional medicine. A wild caught male of the species can reach a price up to 50,000\$US. This has brought the species in Vietnam to the brink of extinction and it is questionable whether a viable population still exists (Fig. 12). Included in the program was the visit of Mai Po Nature Reserve, an excellent birding area. The number of bird species is impressive, including rarities like the endangered black-faced spoonbill (*Platalea minor*) (Fig. 13).



Fig.12. A three-striped box turtle (*Cuora trifasciata*) at the breeding station in Kadoorie Farm Hong Kong. The species is the most expensive reptile used in the traditional medicine. The price can be up to 50,000\$US for one individual. Photo: Tilo Nadler.



Fig.13. A group of the endangered black-faced spoonbills (*Platalea minor*) in front of the skyline Hong Kong. Photo: Tilo Nadler.

Following an invitation of the European Environment Foundation Tilo Nadler and Nguyen Thi Thu Hien attended the 2nd International Convention of Environmental Laureates, 10th to 13th April 2014 in Freiburg, Germany.

In Cooperation with Cuc Phuong National Park, and sponsored by the organization "Four Paws International" EPRC organized an education and awareness program for wildlife protection and conservation. During August to December 2014, 119 lectures were provided in four schools of two communes, and about 500 children attended the lectures (Fig. 14).



Fig.14. In an education program organized by Cuc Phuong National Park and the EPRC and financed by Four Paws International, 119 lectures about nature conservation were given in four schools around Cuc Phuong National Park and about 500 children attended the lectures. Photo: Tilo Nadler.



Fig.15. Dr. Tran The Lien, Director of the Department for Conservation at the Ministry of Agriculture and Rural Development holds the opening speech for the 3rd International Conference "Conservation of Primates in Indochina" in Cuc Phuong National Park. Photo: Tilo Nadler.

Primate events

3rd International Conference "Conservation of Primates in Indochina"

On 8th to 11th October 2013 the third international primate conference "Conservation of Primates in Indochina" was organized from the EPRC in Cuc Phuong National Park. About 80 conservationists and primatologists from 12 countries attended the conference. During three days 33 presentations related to a number of fields in primate research were given to the audience. The visits to the EPRC with its unique primate collection, and to Van Long Nature Reserve with excellent observations of Delacour's langur groups in the wild, were special highlights of the conference (Fig. 15, 16).



Fig.16. Participants of the 3rd International Conference "Conservation of Primates in Indochina". Photo: Tilo Nadler.

25th Congress of the International Primatological Society

The Congress held from 11th to 16th August in Hanoi has been a highlight for primatologists working in Vietnam. About 900 Participants attended the congress (Fig. 17). To commemorate the

occasion Vietnam Post issued a special stamp set which was released during the opening of the congress (Fig. 18). The production of the stamp set was initiated by the EPRC (Fig. 19, 20, 21, 22, 23, 24). A high number of congress participants visited the Endangered Primate Rescue Center in special organized tours or also in self organized trips (Fig. 25).



Fig.17. Opening ceremony of the 25th Congress of the International Primatological Society, 11th to 16th August 2014, Hanoi. Vice Minister Ha Cong Tuan of the Ministry of Agriculture and Rural Development holds an opening speech. Photo: Tilo Nadler.



Fig.18. The President of the International Primatological Society Professor Matsuzawa presents a postal stamp set on the occasion of the 25th Congress. Vietnam postal stamp set. The production of the stamps was initiated by the EPRC and the design of the stamps follows photos of the primates. Photo: Tilo Nadler.



Fig.19. Eastern black gibbon (*Nomascus nasutus*), female as pattern for the stamp block. Photo: Zhao Chao.

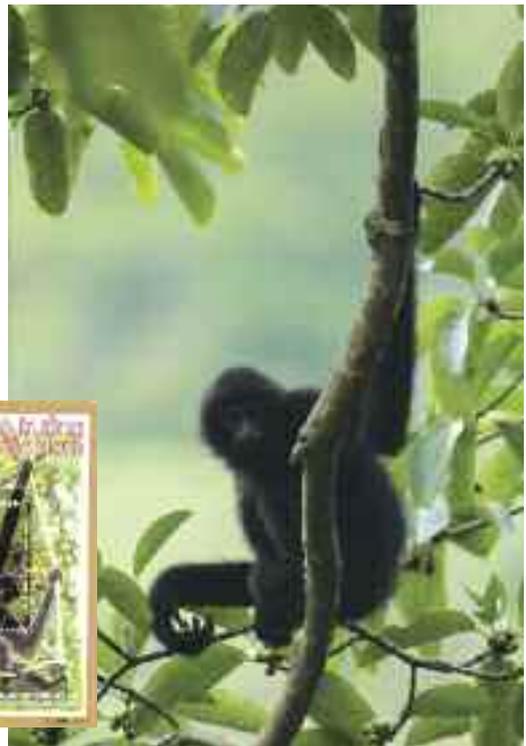


Fig.20. Eastern black gibbon (*Nomascus nasutus*), male as pattern for the stamp block. Photo: Zhao Chao.



Fig.21. Tonkin snub-nosed monkey (*Rhinopithecus avunculus*), male as pattern for the 3000 VND stamp. Photo: Nguyen Van Truong.



Fig.22. Cat Ba langur (*Trachypithecus poliocephalus*), female as pattern for the 5500 VND stamp. Photo: Tilo Nadler.



Fig.23. Grey-shanked douc langur (*Pygathrix cinerea*) as pattern for the 8500 VND stamp. Photo: Tilo Nadler.



Fig.24. Delacour's langur (*Trachypithecus delacour*) as pattern for the 12500 VND stamp. Photo: Tilo Nadler.



Fig.25. Dr. Russel A. Mittermeier, President of Conservation International and Chair of the IUCN/SSC Primate Specialist Group and Tilo Nadler, Director of the EPRC "in a meeting" with a black langur, currently the sole individual in captivity. Photo: Elke Schwierz.

Pre-Congress Training Program

In connection with the Congress of the International Primatological Society the IPS has developed a tradition of hosting a Pre-Congress Training Program that provides for an exclusive and small number of young primatologists the chance to receive training and mentoring on selected topics. The training program, 6th to 11th August 2014 was hosted by the Endangered Primate Rescue Center and Cuc Phuong National Park under Janette Wallis as Chair and Tilo Nadler as Vice Chair. Twelve participants from 11 countries attended the program with presentations on various topics, group discussions and practical work at the EPRC.

Television and radio reports, PR-activities, and publications

In 2013 Vietnamese TV-channels broadcast four reports about the EPRC's work and primate conservation in Vietnam, and five reports were broadcast in 2014.

In 2013 two radio reports were produced by VOV (Voice of Vietnam) about the critical situation for wildlife in Vietnam and in particular for the endangered and endemic primate species.

In April 2014 Joel Sartore, photographer from National Geographic visited the EPRC, together with Peter Riger (Houston Zoo) to take photos of individuals from all primate species at the EPRC for documentation and fund raising (Fig. 26). These photos are taken with a special artistic technique (Fig. 27; 28)



Fig.26. Joel Sartore photographer of the National Geographic Society at the EPRC to shoot special artistic photos of primates. Photo: Tilo Nadler.



Fig.28. Red-shanked douc langurs (*Pygathrix nemaeus*). Photo: Joel Sartore.



Fig.27. Southern white-cheeked gibbon, female (*Nomascus siki*).
Photo: Joel Sartore.

To coincide with the 25th Congress of the International Primatological Society the EPRC produced a Primate Field Guide of Vietnamese primates (Fig. 29), and a comprehensive book about Vietnamese primates, including history of primate discoveries and research, important primate habitats, primate use in traditional medicine, primate conservation, description, systematics, biology, distribution and status. A chapter includes the original descriptions of all Vietnamese primate taxa (Fig. 30).

Acknowledgements

We would like to thank all organisations and institutions persons, volunteers and visitors who supported our work during the years with generous grants, donations, and also working time. And it's not possible to mention all individuals.

Besides notable financial contributions from our leading project partner, Zoo Leipzig, Germany we received in 2013 additional considerable financial support from Ford Company Vietnam, German Primate Center, International Primate Protection League (IPPL), International Primatological Society, Zoological Society of Philadelphia, and in 2014 from European Association of Zoos and Aquaria (EAZA), Four Paws International, Houston Zoo, International Primate Protection League (IPPL), Ocean Park Hong Kong, and Frankfurt Zoological Society.

We are very grateful for all support which contributes to the protection and conservation of some of the world's rarest primates.



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INSTRUCTIONS FOR CONTRIBUTORS

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Tilo Nadler	Christian Roos
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Endangered Primate Rescue Center	German Primate Center
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The first page of the manuscript should include the complete title of the paper, the authors' names, an abstract and key words. The complete postal addresses, e-mails and affiliated institutions of the authors must be given at the bottom of the title page.

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Research articles and short communications must be organized into the following sections: Introduction, Materials and Methods, Results, Discussion, Conclusions, Acknowledgements and References. Acknowledgements may include funding sources such as agency and grant numbers, and the names of those who contributed.

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Papers published in periodicals

Dao Van Tien (1989): On the trends of the evolutionary radiation on the Tonkin Leaf monkey (*Presbytis francoisi*) (Primates: Cercopithecidae). *J. of Human Evolution* 4, 501-507.

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