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

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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 ± 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 ± 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 m ± 152 m. Cá thể cái di chuyển nhiều hơn với khoảng cách 42 km trong 53 ngày. Trung bình mỗi ngày di chuyển 756 m ± 404 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.).

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

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 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.

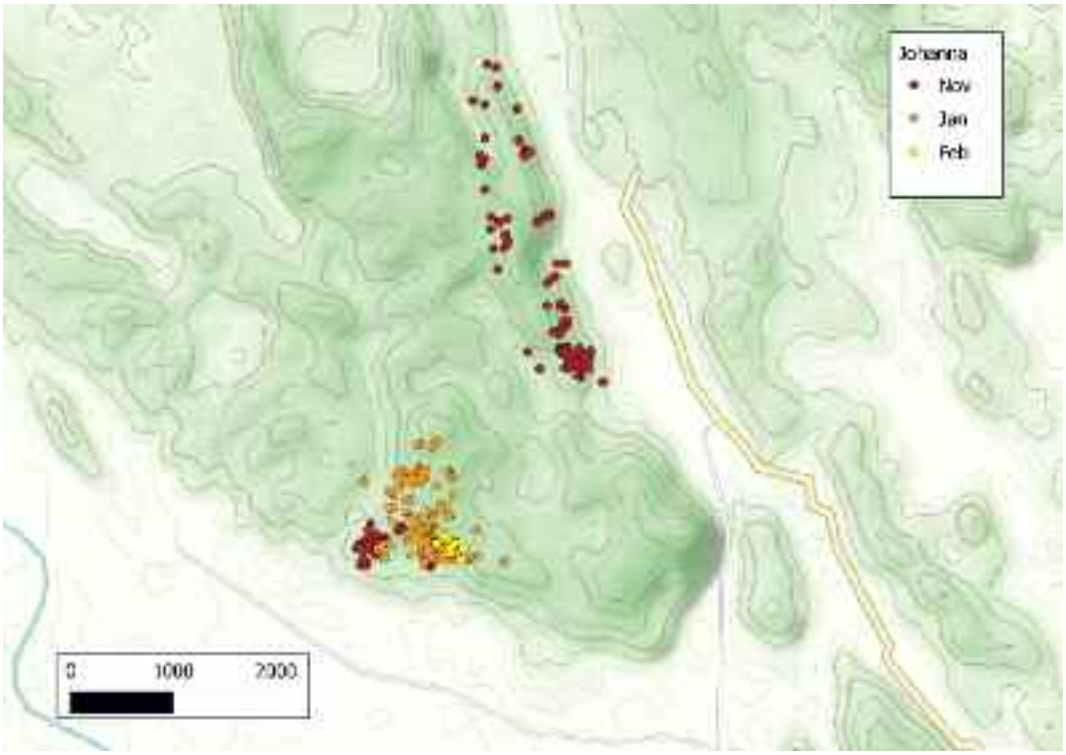

Fig.5. All recorded GPS-points for the Delacour's female "Johanna" (tag 2393) from 02/11/12-28/11/12 and 07/01/13-03/02/13 in color assorted by month in 2D.

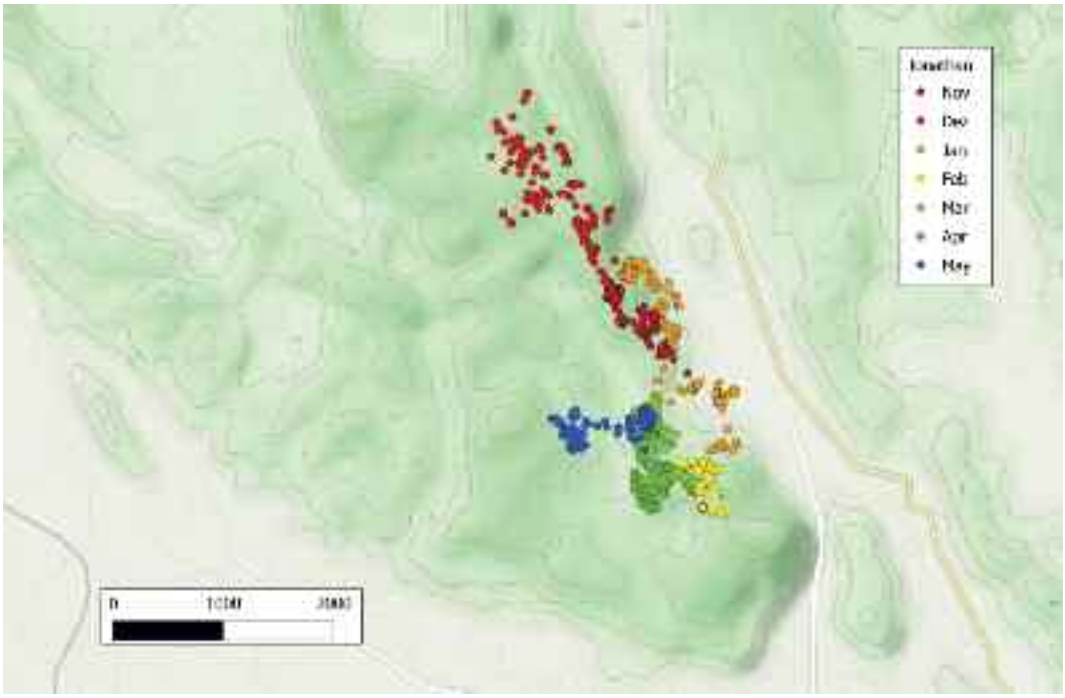

Fig.6. All recorded GPS-points for the Delacour's male "Jonathan" (tag 2392) from 02/11/12-29/05/13 in color assorted by month in 2D.

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.

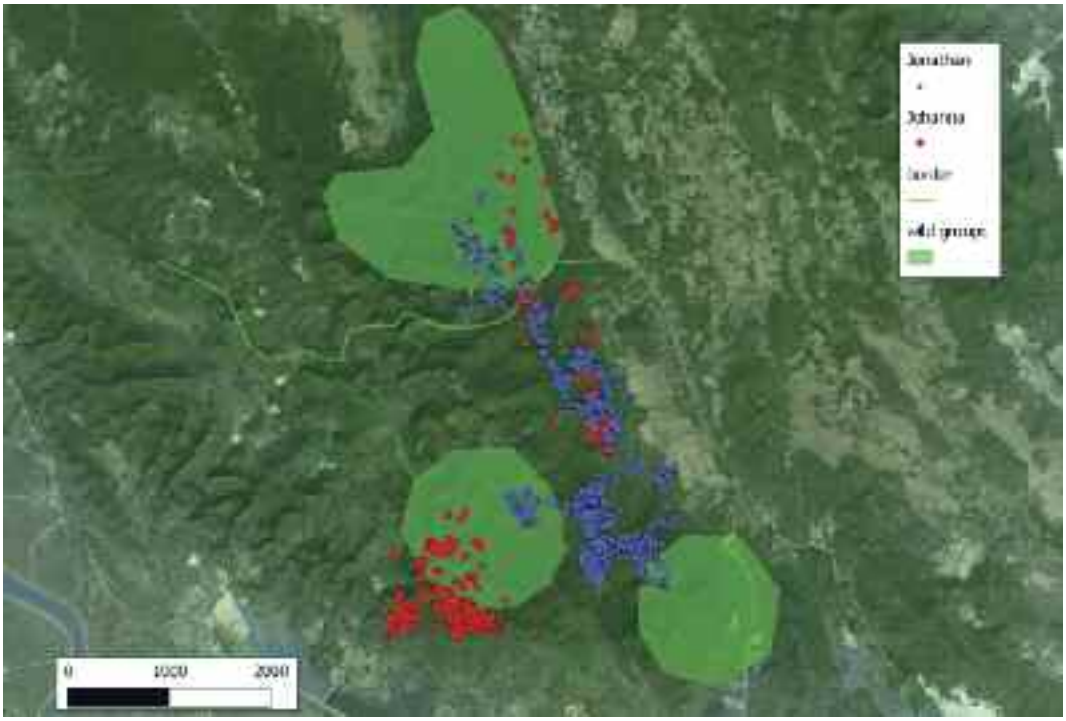

Fig.7. Tracking routes of Johanna and Johanna as well as home ranges of wild Delacour's langur groups in the western part of Van Long Nature Reserve.

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).

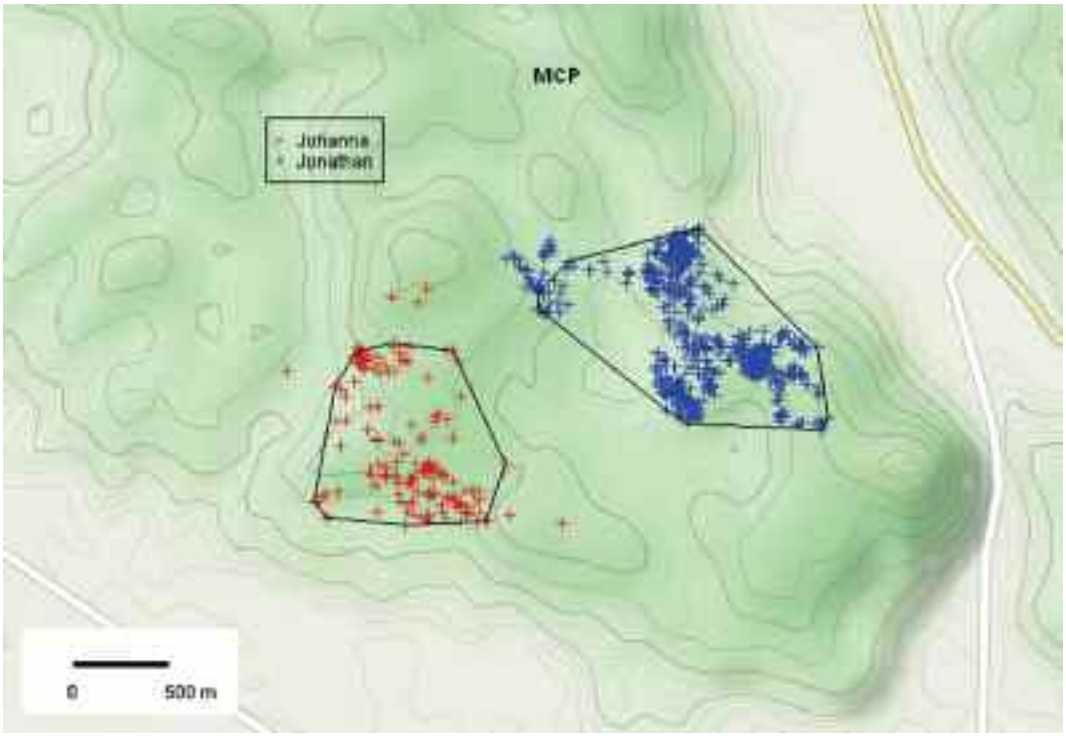

Fig.8. Home range size based on the Minimum Convex Polygon method (95 % of all locations) comprises for the female "Johanna" 60 ha (Jan.-Feb.) and for the male "Jonathan" 80 ha (Feb.-May).

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

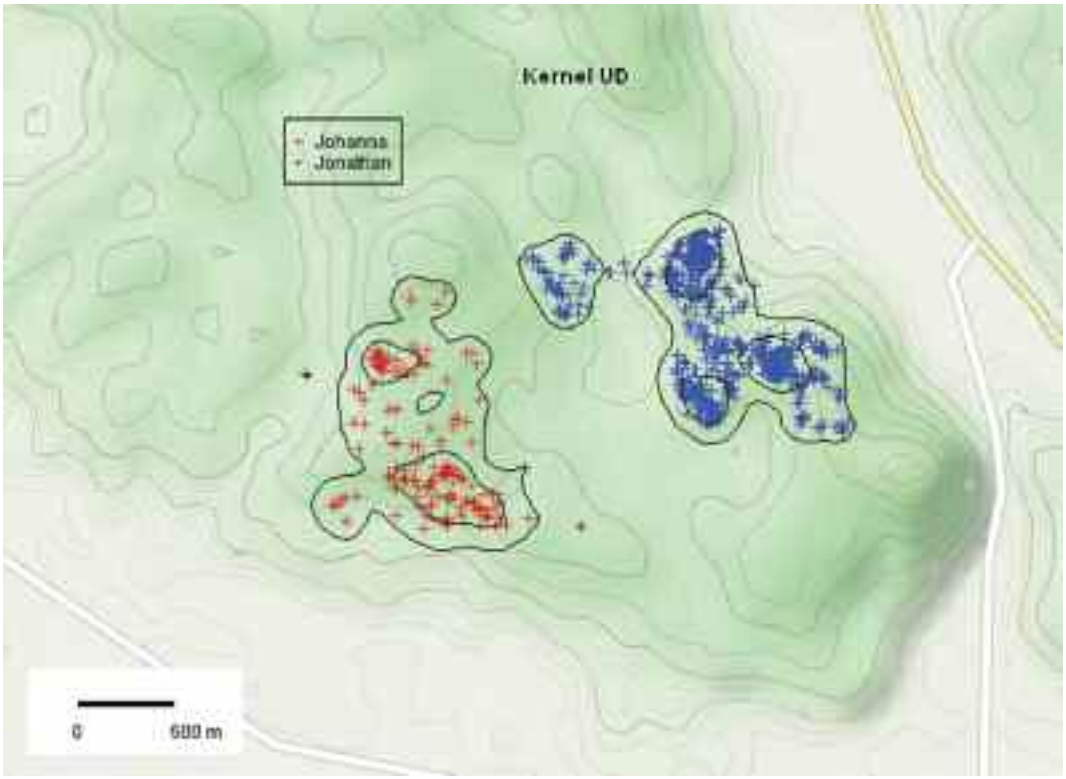

Fig.9. Home range size based on the Kernel density estimation with 50 % (inner lines) and 95 % (outer lines), smoothing factor h = 60, comprises for the female "Johanna" 77 ha (Jan.-Feb.) and for the male "Jonathan" 74 ha (Feb-May).

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 m ± 404 m. Jonathan covered a total distance of 55 km in 208 days. Jonathan's mean daily path length amounted to 254 m ± 152 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).

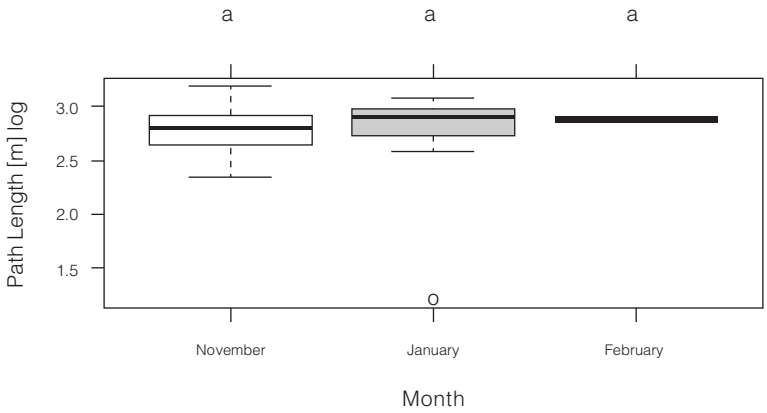

Fig.10. Johanna's mean monthly path length indicates no significant difference of path length between months. Groups with the same letter (a) don't have significantly different means.

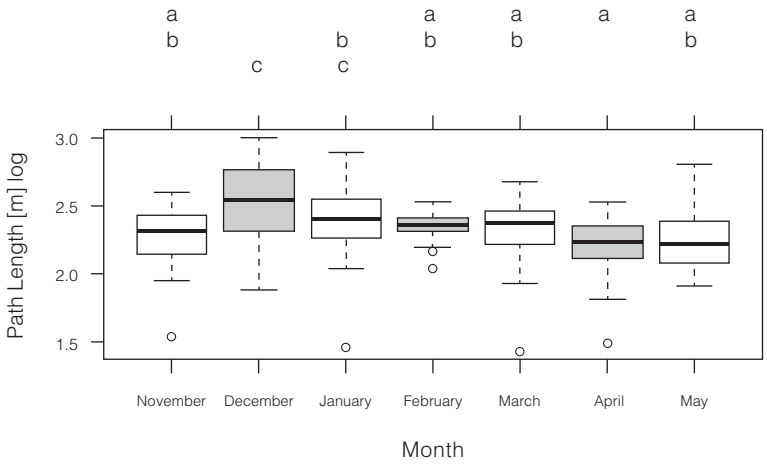

Fig.11. Jonathan's mean monthly path length indicate similarities of path lengths between months. Groups with the same letter (a, b, c) do not have significantly different means.

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.

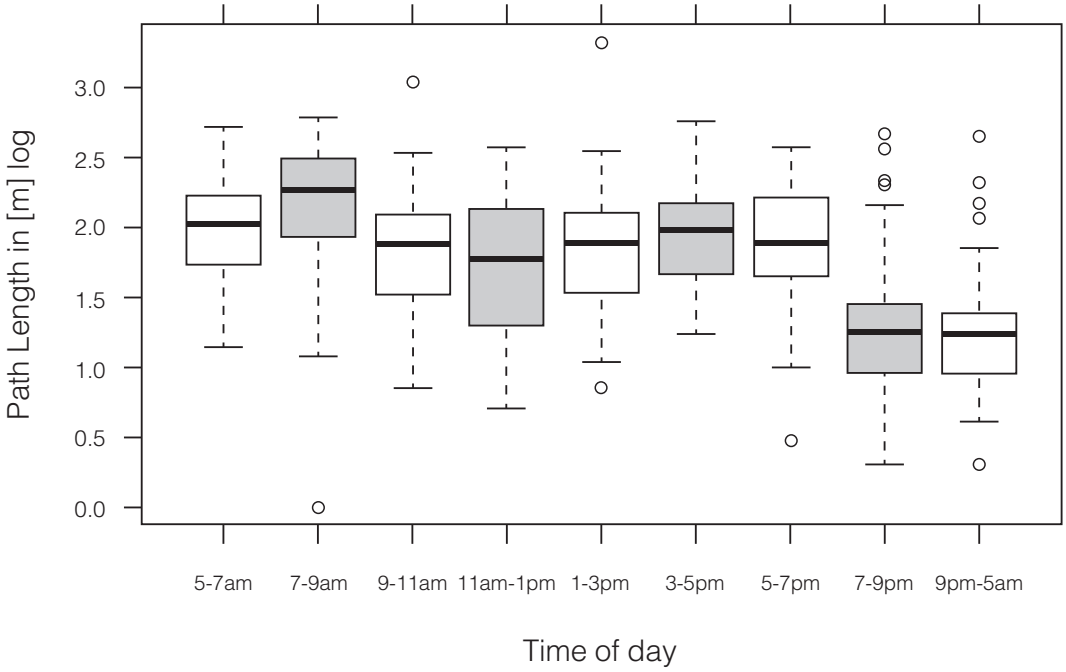

Fig.12. Johanna's mean path lengths during different daytimes. Groups with the same letter (a, b, c) do not have significantly different means.

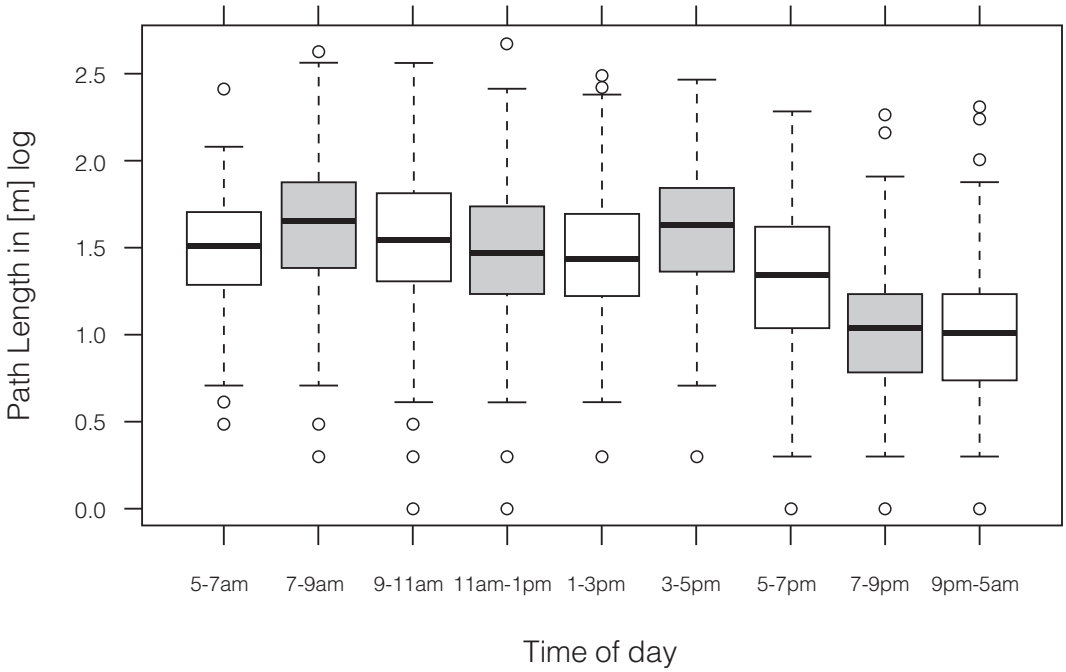

Fig.13. Jonathan's mean path lengths during different daytimes. Groups with the same letter (a, b, c, d) do not have significantly different means.

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.

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