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Survival of reintroduced pygmy slow loris *Nycticebus pygmaeus* in South Vietnam

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ABSTRACT: From 2009 to 2012 thirteen wild-born pygmy slow lorises *Nycticebus pygmaeus* (in this paper referred to as pygmy lorises), confiscated from illegal trade, were radio-collared and released into secondary forest in South Vietnam. Pygmy lorises were monitored until death, recapture, or loss of collar; the longest monitoring period was 73 d. The mean (±SD) distances between consecutive sleeping sites were recorded for 324 consecutive days and averaged 122 ± 108.0 m. Mean distances between sleeping sites for males and females were similar at 110.7 ± 92.6 m for males and 128.8 ± 116.7 m for females, with the greatest distance covered by a female (793 m). Mean height of the sleeping sites was 8.54 ± 4.46 m (n = 60), in trees with a mean diameter at breast height of 75.2 ± 58.4 cm (n = 225). Mean height of the trees where lorises slept was 20.2 ± 9.0 m (n = 230). The pygmy lorises slept mostly in the >8 m band, the area of highest tree connectivity. Of the pygmy lorises studied 38% (5/13) were found dead, 7% (1/13) were returned to captivity due to severe loss of condition and for 23% (3/13) the outcome is unknown due to early collar loss. Causes of death included hyperthermia and natural predation. The remaining 30% (4/13), 2 males and 2 females, were in good condition when last tracked before premature collar drop-off, up to 73 d after release. From this limited data set, a 'soft' release, wet season release and consideration of predator density at the release site are recommendations for increasing chances of survival.

KEY WORDS: Pygmy loris · Rehabilitation · Radio-collared release · Vietnam

INTRODUCTION

The pygmy slow loris *Nycticebus pygmaeus* (hereafter: pygmy loris) is 1 of 8 species currently recognised within the genus *Nycticebus* (Groves 1998, Ravosa 1998, Roos 2004, Brandon-Jones et al. 2004, Chen et al. 2006, Nekaris & Bearder 2011, Munds et al. 2013) and is found east of the Mekong River in Vietnam, eastern Cambodia, Laos and southernmost China (Fooden 1996). The species occurs in primary forest, secondary forest, bamboo forest, degraded habitats (Ratajszczak 1998, Polet & Ling 2004, Starr 2011) and even on plantations (Nekaris et al. 2009). The animals occupy home ranges between 12 and 22 ha, with males having the larger home ranges (C. Starr & K. Nekaris unpubl. data). Pygmy lorises are predominantly solitary, but gatherings of up to 7 lorises have been observed (Starr 2011). Animals weigh on average 420 g, with no sexual dimorphism (Streicher 2004). Pygmy lorises are nocturnal, exudate feeders (Bearder 1999, Tan & Drake 2001, Streicher 2009, Nekaris et al. 2010, Starr & Nekaris 2013, Streicher et al. 2013), in addition to feeding on insects (Streicher 2009, Nekaris et al. 2010), avian eggs, small birds, buds and fruit (Duckworth 1994, Streicher 2004, 2009, Streicher et al. 2013).

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Systematic estimates of population densities of pygmy lorises have only become available in the last 10 yr (Nekaris & Jayewardene 2004, Coudrat et al. 2011, Starr et al. 2011). Surveys in 2007 and early 2008 in 3 major nature reserves in Mondulkiri Province, Cambodia, found mean encounter rates of 0.40 animals km^{-1} in Seima Protection Forest and 0.10 animals km^{-1} in Phnom Prich Wildlife Sanctuary, but no animals were observed in Mondulkiri Protected Forest. In north-east Cambodian forests encounter rates of 0.55 and 0.29 animals km^{-1} (Rawson et al. 2013) have been related in areas where interviews have confirmed high levels of loris hunting. The situation in Laos appears slightly better (Duckworth 1994), and in some areas lorises are the second most common species sighted in night surveys (W. Duckworth pers. comm., U. Streicher pers. comm.). Sightings in Vietnam, however, are very scarce (Vu Ngoc Thanh 2002, Fitch-Snyder & Vu Ngoc Thanh 2002, Haus et al. 2009).

The Red Data Book of Vietnam and the IUCN Red List of Endangered Species (IUCN 2013) list the pygmy loris as 'Vulnerable', which means that this species is believed to have undergone a decline of >30% over the last 3 generations (24 yr given a generation length of 8 yr), due primarily to hunting, but also as a result of habitat loss. This species may warrant listing in a higher category of threat if it is subsequently shown that the rate of decline is actually on the order of 50%.

Alarming numbers of lorises have been reported in the pet trade across Asia (Nekaris & Jaffe 2007, Nekaris & Nijman 2007, Starr et al. 2010). In Vietnam, lorises are hunted and traded for medicinal purposes or to supply pets; they are also hunted for food by some ethnic minorities (MacKinnon & Mackinnon 1987, Huy Huynh 1998, Vu Ngoc Thanh 2002).

Animal rescue centres and national and international non-governmental organisations have, in collaboration with the governments, increased surveillance of the illegal trade in primates, and laws are being more strictly enforced and more animals are being confiscated (Nijman 2009). Now rescue centres face difficult decisions on how to cope with the greater number of animals. Releases with little preparation and no monitoring are a common way of dealing with confiscated lorises (Moore 2012, A. Doughty et al. unpubl. data), partly due to governmental requests to return the animals to the wild (Streicher 2004), and well-implemented reintroductions following IUCN (2013) guidelines are still rare. Many rescue centres have returned confiscated lorises to the forest (A. Doughty et al. unpubl. data), but only a few have monitored them after release. The Endangered Primate Rescue Center (EPRC) at Cuc Phuong National Park in North Vietnam conducted the first structured reintroduction and post-release monitoring of pygmy lorises between 2000 and 2002, monitoring the release of 9 pygmy lorises into an area of plantations and secondary and primary forest (Streicher & Nadler 2003, Streicher 2004), and in 2010 International Animal Rescue (IAR) began a systematic reintroduction of Javan *N. javanicus* and Sumatran *N. coucang* slow lorises in Java and monitored the release of 11 individuals (Moore 2012).

The goals of the Dao Tien project were to carry out structured reintroductions of confiscated pygmy lorises rescued from the illegal wildlife trade. Valuable data were gathered, contributing to our knowledge in this field of conservation, and, importantly, the Vietnamese Forestry Protection Department was provided with standard practice guidelines for the future management of displaced pygmy lorises.

MATERIALS AND METHODS

Study site

In 2008 the Dao Tien Endangered Primate Species Centre (DTEPSC), at Cat Tien National Park (CTNP), South Vietnam, began the reintroduction of pygmy lorises. Between 2008 and 2012 reintroductions were implemented at CTNP and Vinh Cuu Biosphere Reserve (VCBR), which are both part of the Dong Nai Biosphere Reserve (DNBR) (Fig. 1). The DNBR is located in the south of Vietnam on the southern edge of the Annamite mountain range and comprises one of the few remaining lowland forests in Vietnam (11° 20′ 50″ N to 11° 50′ 20″ N and 107° 09′ 05″ E to 107° 35′ 20″ E). The reserve covers a total area of 969 993 ha, a mosaic of evergreen, semi-evergreen and bamboo forest. The climate is classified as tropical monsoon, with a dry season from November to April and a wet season from May to October. The mean annual temperature is 26.2°C, with maximum temperatures reaching 35°C and minimum temperatures reaching 18°C.

Habitat assessment

The identification of available habitat is a precondition for reintroduction. Surveys to assess the population status of pygmy lorises were undertaken at the intended release sites in CTNP. Unfortunately, no permission could be obtained for surveys in VCBR.

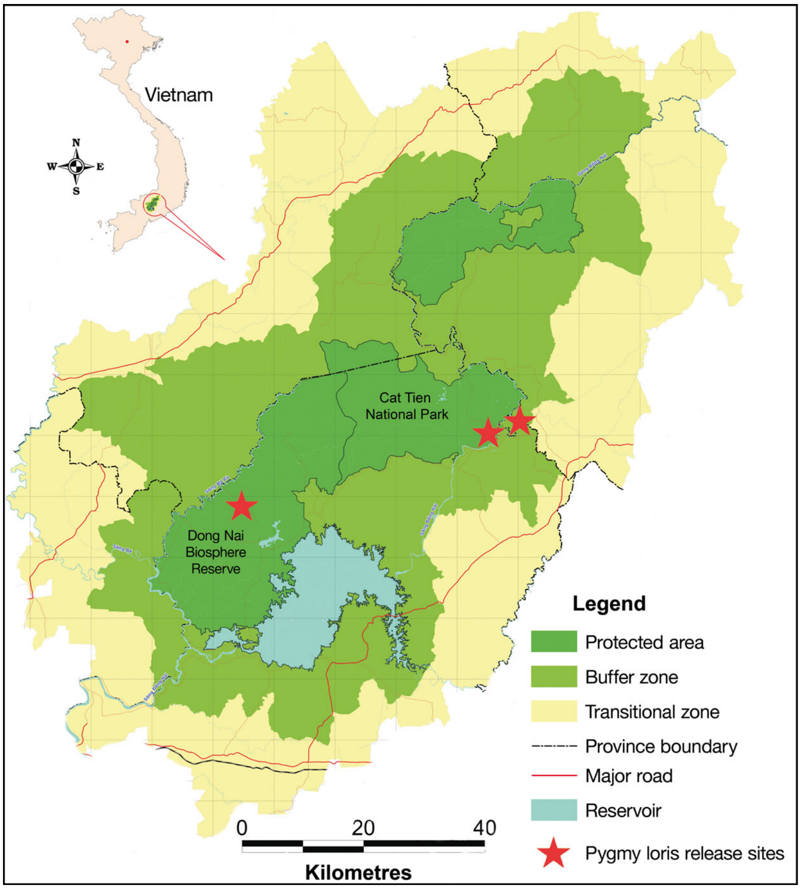

Fig. 1. Map of the release sites of *Nycticebus pygmaeus* within Dong Nai Biosphere Reserve, Vietnam

In CTNP we conducted line-transect surveys in March 2010 and April 2013, following as far as possible existing roads and forest trails, as described by Streicher (2010). The transects were laid through 3 habitat types — bamboo, semi-evergreen and mixed semi-evergreen (forest/grassland). Transects were walked from dusk, starting at 18:00 h and finishing at 22:00 h. Survey methods followed those established by Nekaris et al. (2008). A team of 2 to 3 surveyors walked slowly (500 to 1000 m h^{-1}) along the transect, with people spaced 10 m apart. All levels of the vegetation were scanned with a large torch with a red light filter to detect the animals' eye shine. Once a surveyor sighted an animal, a halogen spotlight and binoculars were used to identify the species, as in this area *Nycticebus pygmaeus* occurs sympatrically with *N. bengalensis*. Transect length, number of individuals sighted, height of individuals in trees and the diameter at breast height (DBH) of the tree were noted. Indices of abundance were calculated using the linear encounter rate (detected animals km^{-1}) as described in other studies of *Nycticebus* (Nekaris et al. 2008, Streicher 2010).

For habitat assessment we carried out habitat-structure surveys of one 0.25 ha habitat plot at each site. Percentage ground cover and DBH of all trees with a DBH >5 cm were measured. Basal area was calculated from DBH to compare the extent to which an area was occupied by trees (basal area is $0.00007854 \times DBH^2$). The basal area of the habitat plot was calculated as the sum of all the basal areas divided by the plot area. Forest connectivity was assessed, quantifying the availability of connections between trees or bamboo areas, which would allow lorises to travel horizontally without coming down to the ground (see the Appendix). The density of known pygmy loris feeding trees was not assessed.

Animal selection

The DTEPSC receives primates from the Forestry Protection Department (FPD) or from governmental rescue centres, such as the Cu Chi Wildlife Rescue Centre near Ho Chi Minh City. A primate veterinarian assessed the pygmy lorises at DTEPSC or at the sending rescue centre before transfer. The health checks were conducted under anaesthesia, and animals were examined for weight, signs of disease, dental status and general fitness for release. An intradermal tuberculosis test was conducted, a blood sample was taken and a microchip was implanted. A full set of data was collected on each animal, including species, sex, estimated age, several body measurements and origin. No behavioural assessment was conducted other than that the animals must not show any clear abnormalities, e.g. stereotypic behaviour.

Quarantine duration for newly arriving pygmy lorises was 6 wk, as recommended by the IUCN (Woodford 2001), and during quarantine all lorises were orally treated for parasites. From 2009 to 2012 four lorises were brought to DTEPSC directly by Dong Nai FPD, and one by FPD from VCBR. An additional 28 pygmy lorises were checked at the Cu Chi Wildlife Rescue Center in 2009 and 2010.

On arrival at DTEPSC pygmy lorises were transferred to quarantine cages located in a quiet area. The cages were constructed of 1 cm mesh, measured 200 × 100 × 200 cm, and were furnished with soil substrate, natural branching and foliage. No nest box was provided. One-third of the cage roof was covered by tarpaulin against the rain.

Prior to release, all pygmy lorises were fitted with a radio-collar (Holohil, PD-2C, 4 g). The collar was fitted using absorbable suture material inside rubber tubing, thus providing a weak link in the collar, ensuring collar drop-off (Fig. 2). The expected battery life of the transmitter was 6 mo, so we had previously tested different suture materials to find one that would take around 5 mo to degrade. Surgical suture material proved to be most suitable, as all other materials either degraded too quickly or not at all during the test period.

Fig. 2. *Nycticebus pygmaeus* radio collaring

Release

Individuals considered fit for release were released according to different protocols (Table 1).

The first releases were conducted in the wet season of August 2009 as soft releases from cages that were kept *in situ* at the release site for >2 mo prior to release. Supplementary feeding was provided in an open area next to the cage for 1 wk, with no evidence of lorises returning to the release site. The following dry season, in February 2010, three more pygmy lorises were released under the same protocol followed in 2009, with an additional 3 individuals released in the main forest of CTNP. The 3 pygmy lorises released in the main forest were transferred in 1 d and released with no supplementary feeding ('hard' release protocol was selected, based on concerns for predator attack by mammals, such as rats, while individuals were confined in the release cage). In 2010 a semi-wild area was established on the premises of the DTEPSC to allow pygmy lorises to learn natural behaviours before release. It allowed for more natural foraging of insects, gouging for gum and movement between sleeping sites. The enclosure had a perimeter fence constructed of heavy black plastic and covered an area of 40 m^2 of second-

Table 1. *Nycticebus pygmaeus* confiscation, rehabilitation and release data from Dao Tien Endangered Primate Species Centre (DTEPSC; 2009–2012). FPD: Forestry Protection Department; CWRC: Cuchi Wildlife Rescue Centre; DT: Dao Tien; CTNP: Cat Tien National Park (release sites a and b); DNBR: Dong Nai Biosphere Reserve; M: male; F: female. (Table continued across page)

No.	Sourced from	Sex	Est. year of birth	Arrival weight at DTEPSC (g)	Est. total time in captivity (mo)	Time spent at DTEPSC (mo)	Rehabilitation methods
1	FPD	F	2008	320	<12	8	Cage/*in situ* release cage
2	CWRC	M	2008	400	<12	2	Cage/*in situ* release cage
3	CWRC	F	2007	445	>12	5	Cage/*in situ* release cage
4	CWRC	M	2005	460	>12	5	Cage/*in situ* release cage
5	CWRC	F	2006	520	>12	5	Cage/*in situ* release cage
6	CWRC	M	2005	375	>12	5	Small cage
7	CWRC	F	2004	420	>12	<1	Small cage
8	CWRC	M	2009	260	<2	<1	Small cage
9	CWRC	F	2009	300	>12	1	Cage/semi-forested enclosure *ex situ*
10	CWRC	M	2005	410	>12	1	Cage/semi-forested enclosure *ex situ*
11	FPD DNBR	M	2010	375	<12	10	Cage/*in situ* release cage
12	Surrender	F	2009	325	<12	4	Cage/*in situ* release cage
13	FPD	F	2008	400	<12	11.5	Cage/*in situ* release cage

ary forest. Trees inside the semi-wild area had no connection to trees on the outside to prevent escapes (the perimeter fence and a pygmy loris in the enclosure are shown in Fig. 3). In 2011, releases were conducted in April, at the start of the wet season, as hard releases, after training for a period of 1 mo in this *ex situ* semi-wild enclosure. The 3 pygmy lorises released in August 2012 were transferred to an *in situ* release cage (Fig. 4) for 2 d prior to release, with supplementary feeding provided for 30 d. Eventually, all releases were implemented as soft releases, with the animals placed in release cages at the release site a minimum of 2 d prior to release. Release protocols evolved based on experience from previous releases, and comparable data were collected throughout the 4 yr.

Monitoring of movements, sleeping sites and behaviour

Pygmy lorises were monitored by telemetry and direct observation. Staff from DTEPSC, CTNP and FPD were trained in radio-tracking methods. We intended to track the sleeping positions and then observe the pygmy lorises from the moment they started night time activities, as suggested by Streicher & Nadler (2003). Unfortunately, the pygmy lorises often slept in bamboo thickets and cutting into these areas in order to directly observe the animals would have meant considerable disturbance. So if triangulation of the radio signal indicated that a pygmy loris slept in a bamboo thicket, we only noted the location and did not attempt direct observations to avoid stress to the newly released animal. The pygmy lorises were tracked every

Fig. 3. (A) Semi-wild enclosure fence line. (B) *Nycticebus pygmaeus* in the semi-wild area on Dao Tien island, Vietnam

Table 1 (continued)

Release season, year	Release site	Release weight (g)	Forest type released into	Average distance (m, ±SD) between consecutive sleeping sites post-release	Outcome (days post-release)
Wet, 2009	DT	350	Bamboo	147 ± 104, max. = 417, min. = 5 (n = 24)	Collar loss (62), survived
Wet, 2009	DT	450	Bamboo	193 ± 95, max. = 404, min. = 23 (n = 20)	Collar loss (58), survived
Dry, 2010	DT	550	Bamboo	75 ± 61, max. = 198, min. = 7 (n = 10)	Died (20)
Dry, 2010	DT	480	Bamboo	69 ± 48, max. = 160, min. = 2 (n = 20)	Collar loss (10)
Dry, 2010	DT	564	Bamboo	55 ± 37, max. = 126, min. = 2 (n = 19)	Intervention (22)
Dry, 2010	CTNP (a)	375	Mixed	121 ± 95, max. = 306, min. = 16 (n = 8)	Predator (14)
Dry, 2010	CTNP (a)	420	Mixed	93 ± 60, max. = 206, min. = 22 (n = 9)	Collar loss (12)
Dry, 2010	CTNP (a)	260	Mixed	24 ± 15, max. = 48, min. = 3 (n = 7)	Collar loss (7)
Wet, 2011	CTNP (b)	340	Mixed	140 ± 93, max. = 390, min. = 0 (n = 21)	Predator (21)
Wet, 2011	CTNP (b)	450	Mixed	99 ± 71, max. = 200, min. =.1.2 (n = 12)	Predator (12)
Wet, 2012	DNBR	420	Mixed	101.33 ± 90, max. = 437, min. = 10 (n = 67)	Collar loss (67), survived
Wet, 2012	DNBR	390	Mixed	137 ± 142, max. = 793, min. = 0 (n = 71)	Collar loss (73), survived
Wet, 2012	DNBR	350	Mixed	177 ± 48, max. = 502, min. = 29 (n = 36)	Predator (38)

Fig. 4. *In situ* pre-release cage (2012) in Vinh Cuu Biosphere Reserve, Vietnam

day, except during heavy rainfall. GPS location, height in tree, DBH of tree, maximum tree height and bole height of the sleeping trees were recorded. Once the pygmy lorises started activities in the evening their behaviour was monitored as far as possible, but often the animals fled immediately and observation possibilities were limited.

RESULTS

Habitat assessment

Though all release sites were protected at the time of the releases, their histories of protection were different. The first releases in CTNP took place on Dao Tien Island, where the DTEPSC is located. The island has only been protected as part of CTNP since 2007, and has only been protected since 2008 from hunting and logging. The other 2 release sites in CTNP have been protected since 1978, first within a nature reserve and, since 1998, within a national park. The later release site was located in VCBR. This location was a logging concession until 2004, when it received protection as a nature reserve, but strict protection measures were only implemented after 2007, and in 2011 the area was designated part of the DNBR.

Surveys to assess the availability of empty habitat could only be conducted at the sites in CTNP. The surveys at the release site on Dao Tien Island found no evidence of pygmy lorises. At the second and third release sites in the main forest of CTNP we found pygmy lorises at a linear encounter rate of 0.19 animals km^{-1}.

The release site on Dao Tien Island had only recently been protected from logging and contained only a few large trees, and vegetation consisted of dense ground cover dominated by bamboo thickets. The main forest of CTNP, with >40 yr of protection from logging, had a greater number of larger trees and less dense ground cover (Table 2). The tree connectivity was high at all sites. Based on their protection status, survey results and the good quality of the habitat, the areas were considered suitable release sites. It is important to highlight, here, that some lorises were received from the National Park authorities with the directive that they be returned to these areas.

Animal selection

Of the 5 pygmy lorises that were brought by FPD authorities or private people directly to DTEPSC, 4

Table 2. Habitat measurements for *Nycticebus pygmaeus* release sites in Cat Tien National Park (CTNP; 2009–2011). DBH: mean diameter at breast height. Mode: the value that occurs most often

Release site	Trees with DBH >5 cm		Ground cover (%)		Mean ± SD connectivity grade (m) per stratum layer		
	No. of trees	Basal area (m^2)	Bamboo	Rattan	0–2	2–8	>8
Dao Tien (2009/2010)	10	0.00024	60	0	3.72 ± 0.46, Mode 4	3.28 ± 0.16, Mode 3	4 ± 0, Mode 4
CTNP, Site a (2010)	46	0.0118	2	2	3.72 ± 0.61, Mode 4	3.72 ± 0.46, Mode 4	3.84 ± 0.37, Mode 4
CTNP, Site b (2011)	73	0.00256	6	10	3.24 ± 0.77, Mode 4	3 ± 0.87, Mode 3	3.72 ± 0.46, Mode 4

passed health checks and 1 female failed, based on lack of teeth. The health checks conducted at Cu Chi Wildlife Rescue Center, however, found only 50% suitable for release; 15 failed due to poor dental status and 4 due to old age and general condition. The 9 animals suitable for release were transferred to DTEPSC. Of the 14 pygmy lorises obtained by DTEPSC, 13 were eventually released.

On release the pygmy lorises weighed between 260 (a sub-adult) and 520 g, with a mean (±SD) adult weight of 414 ± 83.19 g, they were 2 to 6 yr old, and 8 of the 13 animals had spent >1 yr in captivity. After release pygmy lorises were monitored for their condition whenever observation was possible until death or loss of collar or until they obviously were in a condition that made intervention inevitable to ensure the animal's survival.

Monitoring of movements, sleeping sites and behaviour

The longest period monitored before collar drop-off was 73 d. Distances between sleeping sites were recorded for 324 consecutive days. Distance between sleeping sites ranged from 0 to 793 m, with a mean (±SD) distance of 122 ± 108.0 m (n = 324). This is only the horizontal distance between sleeping sites, and does not take into consideration the actual path travelled during the night. Mean distances between sleeping sites were similar for males and females at 110.7 ± 92.6 m and 128.8 ± 116.7 m, respectively, with the greatest distance covered by a female (793 m). The mean (±SD) height of the sleeping site was 8.54 ± 4.46 m (n = 60), in trees with a mean (±SD) DBH of 75.2 ± 58.4 cm (n = 225). Pygmy lorises slept in trees with an average (±SD) maximum height of 20.2 ± 9.0 m (n = 230) (Table 3), mostly in the >8 m band, which was the area of highest connectivity. The 2 pygmy lorises monitored for the longest period (73 and 68 d) chose sleeping sites consistently within a 10 ha area.

Of the 13 released pygmy lorises, only 4 (2 males, 2 females) were confirmed to have survived for at least ca. 2 mo before collar loss. There were 5 confirmed fatalities, of which 3 occurred in the first 2 mo and were suggested to be the results of predation. One was suspected to be a case of bird predation, based on the fractures of the femur (J. Keeling pers. comm.). A second pygmy loris appeared to have been predated by a monitor lizard, as the radio signal followed a monitor lizard, and the collar with no broken suture was later found in a pool, above which the monitor lizard had been observed sleeping. In a third predation case the carcass was found with bite wounds and a small carnivore was suggested as predator. Of the 2 remaining fatalities, 1 was found several days after death, preventing a post-mortem investigation. One pygmy loris died due to assumed hyperthermia; this young female was found dead at the edge of the river in the open grasslands. Post-mortem investigation revealed heart failure and lung congestion, most likely as a result of hyperthermia. Finally, 4 pygmy lorises disappeared with unknown fates, as their collars dropped off prematurely within the first 2 wk after the release.

DISCUSSION

Habitat assessment

From the surveys it was found that 1 of the release sites had no resident pygmy lorises, with densities of 0.19 animals km^{-1} at the other 2 sites. This is a low encounter rate compared to values found in surveys in Cambodia and Laos. From surveys in Cambodia, areas with a healthy population of pygmy lorises can have densities of 0.4 to 0.5 animals km^{-1} (Streicher 2010, Iseborn 2011, Starr et al. 2011, Rawson et al. 2013), and the low encounter rates in CTNP could be a result of hunting in the past. It was concluded that the low encounter rates represented an abundance of empty habitat for reintroduced individuals.

Table 3. Total reintroduced *Nycticebus pygmaeus* sleeping site height, sleeping tree height, diameter at breast height (DBH) and connectivity grade in Dong Nai Biosphere Reserve (DNBR; 2009–2012)

	Sleeping site			Connectivity grade per stratum layer		
	Height (m)	Max. tree height (m)	DBH of sleeping tree (m)	<2 m	2–8 m	>8 m
Mean ± SD	9 ± 5	20 ± 9	75 ± 58	2 ± 1	2 ± 1	3 ± 1
Min.	1	2	5	1	1	1
Max.	20	40	414	4	4	4
n	60	230	225	35	35	35

Following the assessment of connectivity and ground cover, and taking into account the adaptability of lorises to a wide range of habitats (Streicher 2010, Iseborn 2011, Starr et al. 2011), all sites were considered suitable release sites. The presence of bamboo is assumed to be an important factor for the presence of pygmy lorises in Cambodia (Starr et al. 2010), although high encounter rates have also been found in areas entirely without bamboo (Streicher 2010). Whilst Starr et al. (2011) reported high encounter rates in deciduous forests, Streicher (2010) found higher encounter rates in evergreen forests.

Animal selection

The main reason why pygmy lorises had to be excluded from reintroduction was their dental status. Incisors, canines and premolars are clipped or pulled to prevent biting when animals are brought into the pet trade (Fig. 5). Pygmy lorises consequently are unable to feed on harder or tougher food, such as gum, small reptiles and arthropods. In Java, 64 % of the slow lorises arriving at the rescue center of IAR had their teeth cut or removed (Moore 2012). Of 33 pygmy lorises assessed during our project in Vietnam, 16 were excluded from reintroduction based on their dental status. Pygmy lorises confiscated in the north of Vietnam usually have not had their teeth extracted or clipped, which increases their suitability for release (Streicher 2009). This suggests that regionally different management of pygmy lorises is indicated and warrants further investigation.

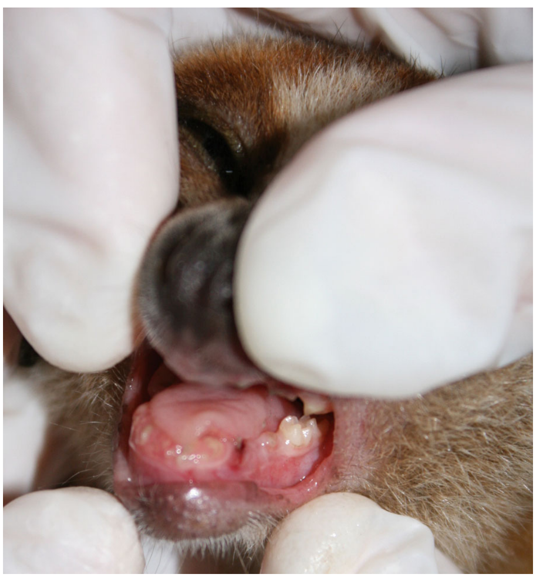

Fig. 5. *Nycticebus pygmaeus* with teeth removed

Release protocols

The release protocol strongly influenced the survival rate of the individuals immediately after release; 50 % of the 8 individuals that had spent time in a cage at the release site prior to release with supplementary feeding after release survived the monitoring period, but, of the 5 pygmy lorises handled as hard releases, with no support after release, no animal survived for even 1 mo. When a soft release was used, with a cage at the release site, the animals had a significantly higher chance of survival, even if they were only kept in the cage for a short time (i.e. 2 d). This confirms experiences by IAR in Java, where animals are also kept in temporary cages at the release site (Moore 2012). Allowing animals to adapt to a new environment is a means of reducing the stress associated with release. Lorises were identified long ago as being very susceptible to stress (Schulze 1993, Fitch-Snyder et al. 2001, Schulze et al. 2004). The situation encountered in trade often involves crowded conditions, a proximity to conspecifics, or unsuitable group compositions, which may cause severe stress in prosimians (Perret 1982). At DTEPSC this is addressed by housing the pygmy lorises alone during quarantine and prior to release, but the actual reintroduction, with handling, adaptation to the new area, unfamiliarity of food sources and possible encounters with resident conspecifics, nevertheless involves a series of stressors that may have a negative effect on the chances of survival (Teixeira et al. 2007). Aside from organic problems, stress also impacts behaviour and can compromise learning abilities, threat perception and decision-making processes (Teixeira et al. 2007), all vital for survival post-release. Thus, a period of time to settle in a cage at the release site is an important step to reduce stress and increase the animal's chance for survival. This highlights how important it would be to make soft releases the standard protocol.

With limited data we cannot assess whether the additional time in the semi-free enclosure at DTEPSC had a positive effect on the survival rate after release. Individuals that spent time in the semi-free area were subsequently dealt with as hard releases, so it is likely that the stress of the hard release outweighed potential benefits. It still needs to be assessed whether benefits are gained from semi-wild training or whether pygmy lorises possibly retain sufficient self-preservation behaviours, if the time of captivity is short. Results from golden lion tamarin reintroductions (Beck et al. 1991) show that many vital behaviours — tree climbing, foraging and crypsis — were maintained for at least up to 1 yr, even if the animals were kept in small cages, but, for lorises, no comparable information is available on how long certain behaviours may be retained.

One problem for which the pygmy lorises were clearly not prepared was predation. One way to decrease predation risk to the released pygmy lorises is to include the prevalence of predators at the release site in the assessment. In the present study all pygmy lorises that survived were released into sites with estimated low predator densities. Interestingly, in other studies of lorises in the wild, significantly fewer lorises have been sighted within protected areas with potentially higher predator levels than have been sighted outside them (Nekaris & Jayewardene 2004), but, in other areas, densities of lorises were very high, despite equally high densities of predators (Streicher 2010). So far no attempt has been made to correlate the densities of lorises and the densities of predators or to assess natural levels of predation. Observations of predation levels in primate literature are often anecdotal rather than quantitative (Hart 2007), but, for example, in *Microcebus* populations, Goodman et al. (1993) estimated an annual predation rate of 25%. The number of pygmy lorises killed by predators was also high in reintroductions at the EPRC, and it was suggested that unsuitable canopy structure frequently forced the reintroduced pygmy lorises to use the ground, where they were easy prey for predators (Streicher 2004).

It has been pointed out that choice of the release season is crucial for success (Streicher 2004). In our case, pygmy lorises were released in February, April and August. This is in South Vietnam where April is the start of the rainy season and August is the middle of the rainy season, and at a time when food sources like insects are abundant. Animals released in this time initially have fewer difficulties finding food, and the relatively high survival rate of animals released in this month may reflect this. February, on the other hand, lies at the end of the dry season in South Vietnam when food is at an absolute minimum. Supplementary feeding was provided for 3 of the individuals released at this time, but the pygmy lorises did not stay in this area, and no food was taken.

In the dry season, 1 female was recaptured and returned to DTEPSC after a noticeable decline in condition and the end of movements. Periods of reduced activity and torpor have been observed in captive pygmy lorises in North Vietnam at extremely low temperatures and are a natural adaptation to overcome times of food shortage (Streicher 2004). A period of reduced mobility has also been observed in pygmy lorises in the wild in Cambodia (C. Starr & K. Nekaris unpubl. data). Dry season weight loss and inactivity are also known from Malagassy primates (Fietz 1998, Fietz & Ganzhorn 1999, Fietz et al. 2001) as an adaptation to overcome seasonal food shortage. So the possibility exists that weight loss and reduced mobility in the released animal are actually a normal process, but, as no long-term observations on lorises in South Vietnam have been conducted, this is currently unknown.

Aside from careful consideration of all above parameters before release, post-release monitoring is fundamental for successful reintroduction. Small-sized transmitters attached to collars are presently the method of choice. The tracking period is determined by 2 factors — battery life span and breakage of the weak link of the collar. The weak link guarantees that the collar will drop off and not pose a risk for the animal long term, but, with the weak link we selected, drop off was highly unpredictable and in some cases the collar dropped off as early as 2 wk after deployment, allowing only limited monitoring. A monitoring period of 3, or ideally 6 mo, has been suggested for lorises after release to determine success (K. Nekaris pers. comm.). At IAR, collars without a weak link are used; these rely on successful recapture of the animal to remove the collar. The inaccessibility of the dense bamboo forest and the nervous, flighty nature of pygmy lorises made recapture in our study unfeasible. Another possible solution for the future would be subcutaneous tracking devices, with no need for removal, but, to assess reproduction after release as the ultimate sign of successful reestablishment in the wild, pygmy lorises would need to be tracked for up to 2 yr, a length of time which still poses some technical difficulties.

CONCLUSIONS

From data for surviving pygmy lorises in 2009 and 2012, within the short monitoring periods, large distances between sleeping site selections still existed, indicating searching behaviour. The different survival rates of animals with a short time in captivity, in comparison to individuals from illegal trade, highlights the need for more detailed assessment regarding the suitability of the site, time and animals for reintroduction. Soft releases increase survival and should be considered standard protocol.

We present our project here as it evolved over 4 yr, adapting and developing within the available logistics, infrastructure and political framework, constantly sharing experiences with comparable projects. All data, whether relating failures or successes, will advance this field of conservation; we hope our findings will contribute to further improvements of reintroduction practices.

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Appendix 1. Connectivity assessment of forest strata at the release sites (2009–2012)

Stratum layer height	Forest description
<2 m	Dense cover, not possible to walk without cutting
	Dense cover, but possible to walk without cutting
	50 % covered, low shrubs, easy walking
	Open bare ground
2–8 m	75–100 % trees and vines connected in canopy, difficult to see the sky
	50–75 % trees and vines connected in canopy
	25–50 % trees and vines connected poorly, large gaps
	0–25 % trees and vines not connected, open
>8 m	75–100 % trees and vines connected in canopy, difficult to see the sky
	50–75 % trees and vines connected in canopy
	25–50 % trees and vines connected poorly, large gaps
	0–25 % trees and vines not connected, open

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