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The Conservation Status of Phayre's Leaf Monkey *Trachypithecus phayrei* in Lao PDR

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Abstract: Phayre's leaf monkey *Trachypithecus phayrei* had fewer confirmed 1990s records in Lao PDR than any other monkey known from the country, suggesting a general rarity there. This review collates records, historical and recent, to evaluate its national conservation status. Although in no area have surveyors regularly and readily seen the species, records come from a wide scatter of areas in and north/west of Nam Kading National Protected Area to the far north and west of the country. There are inconclusive indications of occurrence up to 120 km south of confirmed records, but this part of the country is well enough surveyed that the animal must be very rare there, if it occurs at all. Much of North Lao PDR comprises rugged highlands over 800 m altitude, but only one Phayre's leaf monkey field record is from above this height (at 1,125 m). Whether this apparent altitudinal restriction is a natural pattern or reflects heavy hunting is unclear. Despite their lower-lying locations, records are not associated with gentle terrain. Most records come from forest with a heavily broken canopy and much tall bamboo; none is from deep within extensive closed-canopy forest. This might simply reflect the paucity of such forest within the known Lao geographic and altitudinal range, but a genuine habitat association with broken canopy and tall bamboo is likely. The status of Phayre's leaf monkey in Lao PDR is less grim than was feared a decade ago, and it inhabits three national protected areas, which are benefitting from long-term external collaboration. Nonetheless, its status in Lao PDR cannot yet be considered secure. Lao populations are probably relatively insignificant to the global status of *T. phayrei* as here taxonomically constituted.

Key Words: conservation, distribution, geographic range, habitat, Laos, Phayre's langur, *Semnopithecus holotephreus*, *Trachypithecus crepusculus*

Introduction

Lao People's Democratic Republic (Lao PDR; Laos) is an inland country of 236,800 km² in South-east Asia, retaining a high proportion of natural and semi-natural habitats relative to most of its neighbors, and thus of high global conservation significance (for example, Thewlis *et al*. 1998). In a comprehensive review of the national status of the mammals of the country, Duckworth *et al*. (1999) found that Phayre's leaf monkey *Trachypithecus phayrei* had fewer confirmed recent (post-1988) records than did any other Lao monkey, despite its fairly wide Lao range. Similarly, Nadler *et al*. (2003) traced rather few reliable recent records from Vietnam, and considered it nationally to warrant the IUCN Red List category of Critically Endangered. Hunting, including of monkeys, is intense in these two countries (for example, Duckworth *et al*. 1999; Nadler *et al*. 2003), bringing some colobines to the brink of extinction (for example, Stenke and Chu 2004). Globally, Phayre's leaf monkey is categorized as Endangered by *The IUCN Red List of Threatened Species* (Bleisch *et al*. 2008). Here we review its conservation status in Lao PDR.

Throughout most of the latter half of the twentieth century, the gray leaf monkeys of northern Lao PDR were generally treated, with those of parts of Vietnam, Thailand, Yunnan province of China, and Myanmar, as a single taxon, *crespusculus* (type locality: Mount Muleiyit, Myanmar), conspecific with *T. phayrei* (type locality: Arakan, Myanmar), itself placed in various genera (*Trachypithecus*, *Semnopithecus* or *Presbytis*) and ranging into north-east India south of the Brahmaputra (Srivastava 2006). However, Brandon-Jones *et al*. (2004) chose a radically different system (earlier presented in Brandon-Jones [1984], but with minimal discussion), considering *crepusculus* a junior synonym of *holotephreus*, which taxon they treated as a race of *T. barbei*, placing *phayrei* as

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a race of dusky leaf monkey *T. obscurus*. This has not generally been followed, with, for example, Groves (2001, 2005) recognizing a fairly conventional *T. phayrei*, with *crepusculus* a constituent race.

Liedigk *et al*. (2009) proposed that *crepusculus* was so distinct that it would be best regarded as a full species, indeed as a distinct species-group within *Trachypithecus*. However, this was based only on mitochondrial DNA, on which character the analyzed animal(s) were more similar to François'-group leaf monkeys *T. francoisi* (*sensu lato*) than to *T. obscurus*, the oldest name in the species-group to which *T. phayrei* is generally seen to belong on morphological grounds (for example, Groves 2001). Based on morphology and nuclear DNA, Liedigk *et al*. (2009) considered *crepusculus* a typical member of the *T. obscurus* species-group, a result in conflict with that from mitochondrial DNA. Comparable cases in mammals of discordance between mitochondrial phylogeny versus nuclear phylogeny and morphology (for example, banteng *Bos javanicus*; Hassanin and Ropiquet 2007) have not resulted in proposals for segregation at species level. Furthermore, because other forms of *T. phayrei* were not included in the analysis, the reason to consider *crepusculus* highly distinct from *phayrei* itself, rather than, for example, both of them well separated from *T. obscurus*, is not apparent. Moreover, Liedigk *et al*. (2009) did not state the number or wild origin of *crepusculus* tested, but given that it or they came from the Endangered Primate Rescue Center (Cuc Phuong National Park, Vietnam), it seems likely to have been Vietnam. There is no particular reason to assume that *crepusculus* from the type locality (close to the western extent of its range, in Myanmar, and separated by several major rivers from northern Vietnam, and thus from the entire range of *T. francoisi* [*s.l.*]) would carry the same mtDNA as Vietnamese animals. Indeed, Wang *et al*. (1997) found surprisingly high mtDNA variation within the two animals they analyzed and identified as *T. phayrei* (no subspecies identification given) from Yunnan (Xishuangbanna and Hekou). Roos *et al*. (2007), using the preliminary results of Liedigk *et al*. (2009), already treated *crepusculus* as a distinct species, but excluded Myanmar from its range. Amid all this uncertainty, however, one fixed point is that *crepusculus* refers to the animals at Mount Muleiyit in Myanmar, and if those in Vietnam and perhaps other countries to the east are considered different, then (as pointed out by Pocock [1935]), they need another name. Thus, considerably more investigation is needed before the merits and application of the proposal of Liedigk *et al*. (2009) can be assessed, and here we continue to treat *crepusculus* as a race of Phayre's leaf monkey, reflecting the taxonomic treatment of *The IUCN Red List of Threatened Species* (Bleisch *et al*. 2008).

Conventions concerning locations

Areas and sites referred to in the text are marked on Figure 1. Place names are based on the 1985–1987 series of 1:100,000 maps of the RDP Lao Service Géographique d'État (RDPL SGE) maps with the minor modifications of Thewlis *et al*. (1998), except that the Nakai plateau and derivatives are spelled thus, not as Nakay, reflecting widespread current usage. Where there is no RDPL SGE map-name, the name in local usage is given, transliterated according to the original observer. Coordinates and altitudes, except where stated, are derived from the RDPL SGE maps. Considerable detail accompanies the distributional data, following the urging of Brockelman and Ali (1987) for such precision in primate records. Habitat types mostly follow those of the original source with no attempt to convert all into one classification system, because no such system is yet in wide use for the country (Rundel 2009).

Lao words incorporated in place-names: *Ban* = village (here, meaning the area surrounding the village, rather than the village itself); *Houay* = stream; *Muang* = administrative district of; *Nam* = river; *Pak* = river mouth; *Phou* = mountain or hill; *Sop* = river mouth; *Xe* = river.

Table 1. Historical (pre-1980) records of Phayre's leaf monkey from Lao PDR[1].

Site collected	Approximate location	Date	Collection and number	References
Ban Muangyo	21°31'N, 102°51'E	14 May 1929	FMNH 31757	Osgood 1932; Fooden (1976)
"	"	16 May 1929	FMNH 31758	"
"	"	15 May 1929	FMNH 31759	"
"	"	16 May 1929	FMNH 32546	"
Nam Ou, Ban Muangngoi – Louangphabang[2]	20°30'N, 102°30'E	21 May 1929	FMNH 31756	"
Xiangkhouang[2]	19°20'N, 103°22'E	8 Jan 1926	BMNH 1926.10.4.6	Thomas (1927); Fooden (1976); Napier (1985)
Ban Nale[2]	18°42'N, 101°34'E	1861	BMNH 1861.10.8.1	Brandon-Jones (1995)
Mekong forests 30 km upstream of Vientiane[2]	18°01'N, 102°24'E	Between 1963–1972	None	[3]Deuve (1972)
Khet Dong Hieng	17°53'N, 101°34'E	31 Jan 1920	ZRCS 4-546	Fooden (1976), Weitzel *et al*. (1988)

[1]Delacour (1940), followed by Duckworth *et al*. (1999), also listed "Muong Mo" as a Lao locality for this species; however, this is in Vietnam (Osgood 1932).
[2]Not safely assumable as originating particularly near the co-ordinates given, particularly for Ban Nale, which is only an inferred locality (Brandon-Jones 1995; Duckworth in press).
[3]Deuve (1972) has many elementary errors (for example, Duckworth *et al*. 2010), but this record seems reliable because the physical characters (bold white around the mouth, and pale gray around the eyes) of a single specimen from a specific locality were described. The date range is derived through the species not having been included in Deuve and Deuve (1963).
FMNH = Field Museum of Natural History, Chicago; BMNH = British Museum (Natural History); ZRCS = Zoological Reference Collection, Raffles Museum for Biodiversity Research, Singapore.

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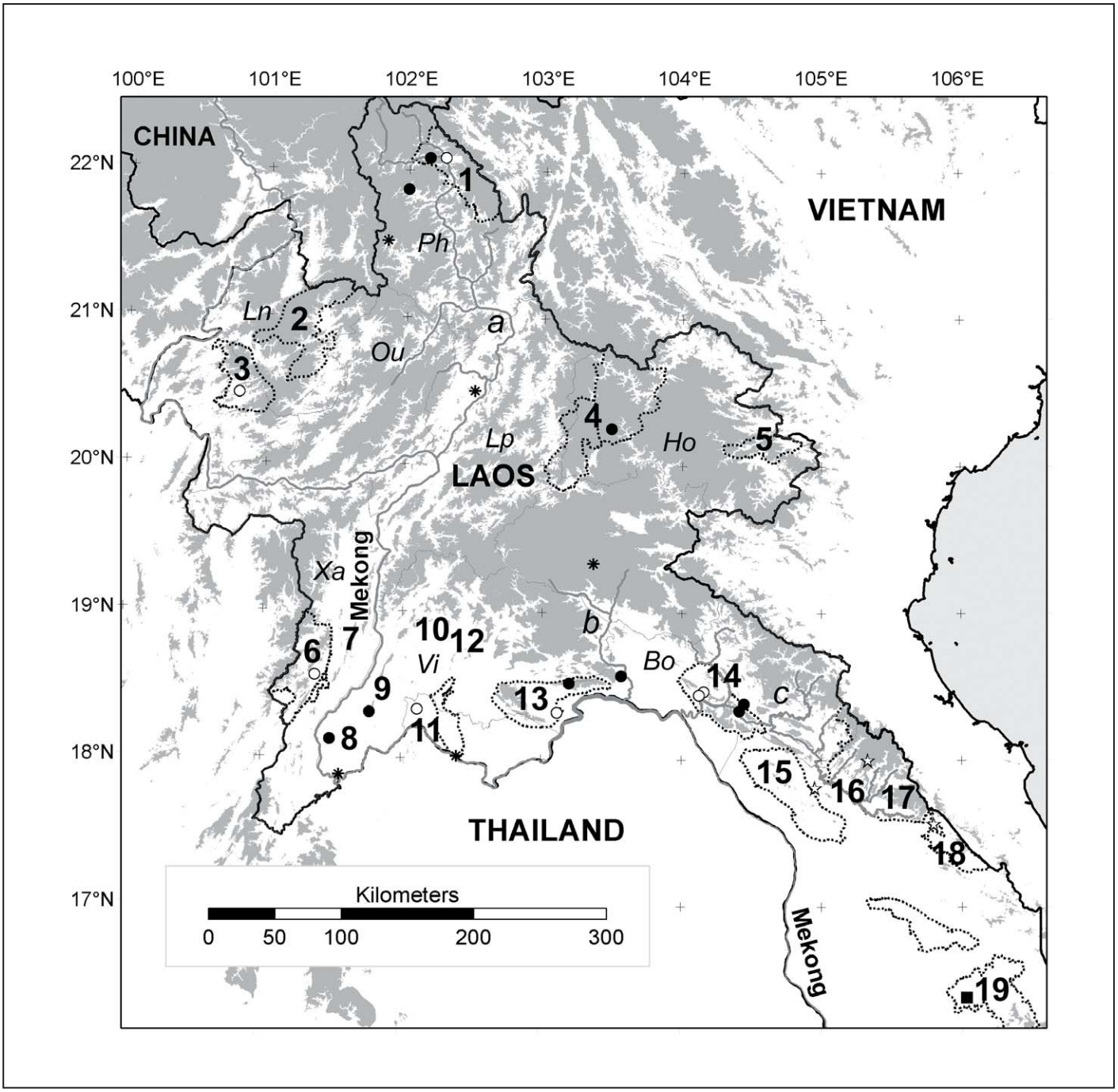

Figure 1. Lao PDR, showing localities mentioned in the text and records. Background shading shows land over 800 m. All national protected areas (NPAs) in the area covered are shown, but only those national production forest areas (PFAs), provinces, districts and rivers referred to in the text, are shown.

● Modern record of Phayre's leaf monkey, identification confirmed

○ Modern record of Phayre's leaf monkey, identification provisional

☆ Modern report of leaf monkey potentially Phayre's leaf monkey, south of known range of the latter

* Historical record of Phayre's Leaf Monkey, identity confirmed, locality imprecise

■ Northernmost record of Indochinese silvered leaf monkey in Lao PDR

Provinces: *Bo* = Bolikhamxai; *Ho* = Houaphan; *Ln* = Louang-Namtha; *Lp* = Louangphabang; *Ou* = Oudomxai; *Ph* = Phongsali; *Vi* = Vientiane; *Xa* = Xaignabouli.
Rivers: *a* = Nam Ou; *b* = Nam Ngiap; *c* = Nam Kading

Numbered areas: 1 = Phou Dendin NPA; 2 = Nam Ha NPA; 3 = Nam Kan NPA; 4 = Nam Et–Phou Louey NPA; 5 = Nam Xam NPA; 6 = Nam Pouy NPA; 7 = Phou Phadam PFA; 8 = Muang Sanakham, Vientiane province; 9 = Phou Gnouey PFA; 10 = Nongpet–Naxeng PFA; 11 = Muang Sangthong, Vientiane municipality; 12 = Muang Vangviang, Vientiane province; 13 = Phou Khaokhoay NPA; 14 = Nam Kading NPA; 15 = Phou Hinpoun NPA; 16 = Nakai plateau; 17 = Nakai–Nam Theun NPA; 18 = Hin Namno NPA; 19 = Dong Phou Vieng NPA

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Methods

Many site-focused, direct-observation mammal surveys were undertaken across Lao PDR during 1992–2007, with survey effort characterized by Timmins and Duckworth (1999, 2008) citing the original, often internal, reports from each. Most consisted of a few weeks to a few months to assess general habitat type and condition, and to seek by direct observation (mostly during daylight) birds and large mammals (generally, those identifiable without the need for specimen procurement) of elevated national and, especially, global conservation concern. Monkeys were thus among the best covered groups of mammals. Results from these surveys were supplemented by the authors' own surveys in 2008–2010, and by enquiries for Lao records of the species from other wildlife surveyors.

Objective identification of Lao sightings of gray leaf monkeys as Phayre's leaf monkey needs care, because another gray species, Indochinese silvered leaf monkey *T. germaini* (also of disputed taxonomy), inhabits the country. There are too few Lao specimens of gray leaf monkeys to define even the coarse ranges of both these species (Table 1; also, Timmins *et al*. 2011). Although the two are readily separated with good views and careful observation, monkeys recorded during 1990s–2000s surveys in Lao PDR were typically shy, so views were often brief and partly obscured. Identification of all field records from these decades has, therefore, been checked during preparation of this review. Hamada *et al*. (2007: p.166) stated that Phayre's leaf monkey has an "insignificant pale colored "ring" around the eyes": this is incorrect, the ring being very bold in Lao animals (Figs. 2 and 5; also Duckworth *et al*. 1999: Plate 13), as reported by Francis (2008) for *crepusculus* throughout its range, and as portrayed for presumed Vietnamese animals in Geissmann *et al*. (2004) and Liedigk *et al*. (2009). However, Indochinese silvered leaf monkeys can have noticeable pale spectacles (Nadler *et al*. 2005; Timmins *et al*. 2011: Fig. 2), and the degree of overlap in strength with Phayre's is unknown (but may well be negligible). More importantly, the two differ greatly in the form of long hair tufts on the head, and the contrast in pelage tone across the body, particularly the limbs with the torso.

Figure 2. Phayre's leaf monkeys *Trachypithecus phayrei* at a mineral lick in Nam Et–Phou Louey National Protected Area, Lao PDR, 18 January 2005. (above) two animals resting; (below) one animal eating or drinking. Photographs by camera-trap operated by Nam Et–Phou Louey National Protected Area and WCS Lao Program.

Reliable objective identification to species using local name is impossible with this species in Lao PDR. Echoing similar problems elsewhere (Choudhury 1988; Nadler *et al*. 2005), Duckworth *et al*. (2010) and Timmins *et al*. (2011) discussed the difficulties of this activity with colobines in Lao PDR. The name *khang* in wide use in the northern half of Lao PDR is commonly associated with this species, but is probably best seen as meaning simply *Trachypithecus*: towards the south of its area of common use, in Bolikhamxai province, it may well be used for François'-group leaf monkey and, reflecting Thai influence, it may at least occasionally be used for any leaf monkey right to the south of the country (Timmins *et al*. 2011). *Khang* needs careful distinction from *kang*, used for macaques *Macaca*, usually as *ling kang* (Duckworth *et al*. 2010). Questioning of rural people with pictures to try and determine species of leaf monkey present seems essentially a waste of time, with both Hansel *et al*. (1998b) and Hamada *et al*. (2007) finding that villagers in the Lao northern highlands generally selected silvered leaf monkey, not Phayre's, as the species present. They are unlikely to be correct, given the locations of the available Lao specimens and direct sightings for the genus as found here and by Timmins *et al*. (2011). Moreover, animals camera-trapped in the general area of reports to Hansel *et al*. (1998b) are typical Phayre's leaf monkeys in appearance (Fig. 2), as is the single specimen from nearby Xiangkhouang.

Records

Historical (pre-1980) records from Lao PDR are presented in Table 1. Modern records come from ten areas (seven confirmed and three provisional—the latter enclosed in square brackets), with imprecise village reports from various others.

Phou Dendin National Protected Area (= NPA). A group of at least six was seen along the Nam Ou in streamside forest between the mouths of the Nam Khang and Nam Toho (very roughly, 22°05'N, 102°09'E; 560 m) on 1 June 1995 (Evans *et al*. 2000; WGR). [A troop of 5–7 gray leaf monkeys was seen briefly, in the relatively mature riparian forest downstream of

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Ban Sopkhang, at 22°05'N, 102°16'E (560 m) on 17 March 2005 (Ruedi and Kirsch 2005). Interviews in 2004–2005 received widespread reports of gray, long-tailed, monkeys (as *khang* or *kang*: not noted which) persisting in the NPA (Duckworth *et al*. 2005b).]

Western Phongsali province. Along the Nam Ngay (21°52'N, 102°00'E; *c*.800 m) on 27 March 1996, a local guide shot and killed (after the animal fell, wounded, from the canopy) a male among a troop, in little-degraded semi-evergreen forest on a ridge above the river (Duckworth *et al*. 1999: Plate 13; WGR).

[*Nam Kan NPA*. In March 2010, J.-F. Reumaux (verbally to Robichaud *et al*. 2010) reported that a troop of 30 gray leaf monkeys is regularly seen at the tourist resort 'The Gibbon Experience' (20°28'21"N, 100°48'03"E, taken from Google Earth; altitude *c*.550 m) in fairly evergreen forest, degraded in places and near a river; villagers reported gray leaf monkeys, as *khang* in Lao, *xang* in Khmu, widely, suggesting they may be locally common in some parts of the NPA (Robichaud *et al*. 2010).]

Nam Et–Phou Louey NPA. During an intensive camera-trap program (Johnson *et al*. 2009), Phayre's leaf monkey was recorded at only one site (A. Johnson *in litt*. 2010), a mineral lick at 20°15'04"N, 103°29'31"E (taken from a GPS under WGS84 datum), at 1,125 m altitude, in a large rugged highland area. The mineral lick lies in montane forest with a broken canopy that reflects several episodes of cutting (S. Saysinghan and A. Johnson *in litt*. 2010); it is 6 km from the nearest land below 800 m, this being the narrow (800 m contours less than 1 km apart) Nam Neun valley dropping to 640 m locally. Photographs were taken 11 times between 08:10 and 13:34 on 18 January, thrice between 09:20 and 11:00 on 20 January, and at 12:25 on 4 February 2005 (Fig. 2). Hansel *et al*. (1998b) received village reports noted as of *kang* (but perhaps a transcription of *khang*) which apparently referred to gray leaf monkeys from several parts of the NPA. Since 2003, extensive conservation management activities, notably anti-poaching patrols, have generated very few reports of leaf monkeys (A. Johnson *in litt*. 2010), suggesting that they are rare or at best very localized in the NPA; consistent with this, a lengthy direct observation survey in the NPA in 1998 (Davidson 1998) did not observe the genus.

[*Nam Pouy NPA*. Boonratana (1997) reported observing three groups of Phayre's leaf monkey in this NPA in a short survey in 1997. However, two referred to village reports, and the other was not seen well enough for certain identification to species (R. Boonratana *in litt*. 2011): a group of at least 3–4, on 3 May 1997 when flushed in mixed deciduous forest on a ridge near to 18°33'30"N, 101°23'20"E (within 400–550 m asl). That any gray leaf monkey in this area can safely be assumed to be Phayre's on the basis of range is confounded by Boonratana (1998), who observed a group of what he identified as silvered leaf monkeys in the same protected area in 1998 (detailed in Timmins *et al*. 2011); unfortunately no notes were taken of identification, and identity of leaf monkeys here should best be left unresolved.]

Muang Sanakham, Vientiane province. A skin and head (Fig. 3) were seen at a hunters' camp beside the Houay Oum (18°07'20"N, 101°29'50"E; *c*.300 m) amid hills supporting extensive tall bamboo and riverine forest (Fig. 4) on 30 October 2000 (Hansel 2004, where the record was dated erroneously as 2004 in Table 1); the skull and a photograph of the skin were sent to the Natural History Museum, London, UK (registration number BMNH 2010.310). Although skulls are difficult to identify objectively to species (Pocock 1935), the overall gray color of the skin, especially of the tail, suggests *T. p. crepusculus* (D. Brandon- Jones *in litt*. 2011). A group of six (five adults and one young molting from orange to gray pelage) was seen in tall bamboo and secondary growth with remnant tall trees from semi-evergreen forest at Kok Kawdinpang (18°18'05"N, 101°46'49"E, taken from a GPS under WGS84 datum; *c*.500 m), east of Ban Phonsavat, in Phou Gnouey Production Forest Area (= PFA) on 6 April 2010 (Suford in press). Villagers reported near-daily

Figure 3. The head of a hunted Phayre's leaf monkey *Trachypithecus phayrei*, being cooked as part of professional hunters' haul of mixed wildlife. Muang Sanakham, Vientiane province, Lao PDR, 30 October 2000. Photograph by T. E. Hansel.

Figure 4. Typical tall bamboo habitat of Phayre's leaf monkey *Trachypithecus phayrei*, Muang Sanakham, Vientiane province, Lao PDR, October 2000. Photograph by T. E. Hansel.

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sightings of *khang* in the same general area, during the survey, and said that scattered populations persisted across the region, including on large karsts west of the village (and outside the PFA).

[*Muang Sangthong, Vientiane municipality*. The fresh headless skin and skull of a gray leaf monkey, called *khang* (or *kang*), were seen along the Nam Sang (*c*.18°20'N, 102°07'E; 200 m) several kilometers upstream of Ban So, on 16 February 1996; the hunter said that he had shot it on 15 February from a group of about six, in logged streamside forest with much tall bamboo. Identification as Phayre's leaf monkey is provisional, based on range. *Khang/kang* was reported in various villages to remain locally common in the area (Duckworth 1996; JWD).]

Phou Khaokhoay NPA. A troop of *c*.20 was watched along the Nam Mang valley bottom forest, with extensive tall bamboo (18°31'N, 103°12'E; 260 m) on 9 November 1994 (Evans *et al*. 2000; JWD). [Two gray leaf monkeys were seen in a valley bottom around the Houay Namhi (very roughly, 18°19'N, 103°07'E; 250 m) one day during 5–10 September 1994 (Payne *et al*. 1995).] Both points of sighting contained more tall trees and a more contiguous canopy than many nearby areas of this generally broken-canopied landscape which had until the early 1990s been part of State Forest Enterprise 3.

Lower Nam Ngiap catchment. A shot animal (from a group of at least five) was photographed (Fig. 5) *c*.11 km north-west of Ban Namngiap, at 18°34'09"N, 103°34'25"E (taken from Google Earth; within 340–450 m asl) in rugged terrain with broken forest, within 200 m of a stream on 17 February 1999 (S. Watson *in litt*. 1999, 2010).

Nam Kading NPA. A group of about six was seen in degraded semi-evergreen forest and on adjacent karst north of the Nam Xouang (18°23'N, 104°27'E; 350 m) on 27 April 1995, and a single animal was seen in semi-evergreen forest with very uneven canopy and extensive bamboo on the south slope of Phou Ao (18°20'N, 104°25'E; 500 m) on 29 April 1995 (Evans *et al*. 2000; RJT). [In 2005, two sightings of gray leaf monkeys in the north-west sector of the NPA, north and west of the Nam Kading–Nam Mouan were, on the basis of range, presumably Phayre's (Timmins and Robichaud 2005): on 6 February at 18°27'54"N, 104°09'45"E (at or below *c*.500 m), and on 7 February at 18°26'26"N, 104°07'50"E (*c*.350 m). This area has very heterogeneous vegetation, with lots of tall straight smooth-culmed bamboo, sprawling bamboo, vines, and a very uneven, often very low, canopy, or no real canopy at all, and patches of tall forest (RJT).]

Areas where animals presumably this species have been reported by local people but there are no field records

Monkeys consistent in the stated morphology with gray leaf monkeys, and assumed to be Phayre's leaf monkey on range, have been reported during village interviews in the northern highlands in at least Nam Ha NPA (Johnson *et al*. 2003); Nam Xam NPA (Hansel *et al*. 1998a); Divisions 3 and 7 (in Xaignabouli and Vientiane provinces respectively) of the Hypa concession (HFI 1999); Phou Phadam PFA, Xaignabouli province (Suford in press); Nongpet–Naxeng PFA, Vientiane province (Suford in press); Muang Vangviang (Duckworth in press); and at 23 of 46 sites on a 1,450 km drive through Houaphan, Louangphabang, Oudomxai, Louang-Namtha and Phongsali provinces during 22–31 May 2006 by Hamada *et al*. (2007). The reports vary in their efforts to minimize problematic factors which confound their reliability and are listed for completeness, even including those with minimal safeguards in methodology.

Habitat Use

No Lao Phayre's leaf monkey record with habitat information comes from deep within extensive closed-canopy forest. Instead, records are from forests with broken canopy and extensive tall bamboo, such features perhaps resulting from human land-use ancient or recent, underlain by geological

Figure 5. Recently shot Phayre's leaf monkey *Trachypithecus phayrei*, Lower Nam Ngiap catchment, Lao PDR, 17 February 1999. Photographs by S. Watson / RMR.

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and climatic factors. The tall bamboo noted at many sites is a single structural type (perhaps even a single species): tall, weakly clumped with large gaps between clumps, stems dominating the ground layer vegetation, stems with little lower branching, and the stems reaching what would be sub-canopy, but the bamboo itself often forms the canopy because it is growing in areas with only sparse big trees overtopping it (Fig. 4). Various observations from India and Myanmar stress the importance of shoots of tall bamboos (for example, *Melocanna*) in this leaf monkey's diet or at least the frequency with which monkeys are seen in such bamboo (for example, Green 1978, Mukherjee 1982, Choudhury 1994a, 1994b, Gupta and Kumar 1994, Raman 1996, Srivastava 1999, 2006, Platt *et al*. 2010). At least in Lao PDR, such bamboos seem to indicate past (sometimes perhaps ancient) cultivation and/or fire (a topic worthy of further investigation), and some of the Lao records are from areas with a very uneven canopy and heavy recent logging. Deeper analysis (which would require more records) might even find it to be more common in the latter than within closed-canopy tall forest. This use of degraded areas is well known for Phayre's leaf monkey in India and surrounds (Green 1978; Gupta and Kumar 1994; Raman 1996; Srivastava 1999, 2006), although information specific to *crepusculus* remains too scant to confirm its applicability to that taxon. The number of Lao records far from any canopy-breaking stream shows that the species is not strongly associated with such habitats, in apparent contrast to Indochinese silvered leaf monkey in southern Lao PDR (Timmins *et al*. 2011); the Lao Phayre's leaf monkey records from streamsides simply reflect the preponderance of survey effort along them.

One record came from limestone karst, in Nam Kading NPA, a habitat a little further south in Lao PDR supporting François'-group leaf monkeys (Duckworth *et al*. 2010). More generally, most records with precise locality were in hilly landscapes, but nearly all land within Phayre's leaf monkey's Lao range and on gentle terrain is converted to agriculture with remaining forest patches so small that hunting-sensitive species have been eradicated. Even the few larger tracts are too heavily used by people for the species's use of plains in Lao PDR to be evaluated. It is, however, certainly not tied to precipitous regions in the way that François'-group leaf monkeys in Lao PDR seem to be (Duckworth *et al*. 2010). Karst use has been reported from Thailand (Lekagul and McNeely 1977) and Vietnam (Nadler *et al*. 2007).

Altitudinal Range

Lao Phayre's leaf monkey records are not spread across the altitudes of the survey, but neither the true pattern nor the reason(s) behind it are clear. Various records came from altitudes as low as any in the general survey area in question (with the lowest at 260 m). The highest recorded altitudes were only 1,125 m, *c*.800 m and 560 m; and while precisely located records are too few to propose a typical upper limit in the country, the paucity of records from above 800 m suggests this monkey is not common in higher-lying areas. Direct-observation survey effort specifically in areas with Phayre's leaf monkey records has been too limited above *c*.800 m to speculate on altitude use in them, even in Phou Dendin NPA with the best coverage of higher altitudes (Fuchs *et al*. 2007). Discounting areas uninformative about leaf monkeys because habitat is so fragmented that they are likely to have been hunted out if they were ever present (for example, Duckworth *et al*. 2002; Duckworth in press), the considerable direct-observation survey effort within the general Lao range of this species over 800 m unfortunately comes mostly from several areas where Phayre's leaf monkey has not been found in the adjacent lower-lying forest either: Nam Et–Phou Louey, Nam Xam and Nam Ha NPAs (Tizard *et al*. 1997; Davidson 1998; Showler *et al*. 1998). None of these areas was well enough surveyed in lower-lying areas to comment on the species's likely status at such altitudes. Therefore, the lack of these surveys' records from above 800 m, while suggestive, is not strong evidence of altitudinal patterns: perhaps the species is simply not in those areas, or is very rare in them. The record at 1,125 m in Nam Et–Phou Louey NPA proves at least occasional occurrence well above 800 m, and, because the site is 6 km from any land below 800 m, it seems that some groups do live well above 800 m. The record was at a mineral lick, which Phayre's leaf monkeys will travel at least ½ km outside the usual group range to use (Pages *et al*. 2005), and in rugged terrain such diversion could take them well outside their normally occupied altitudinal range.

Historical records also suggest rarity at high altitude. In 1929, the Kelley–Roosevelts' expedition spent a fortnight each based at Ban Khomen (*c*.1,100 m; no land anywhere near lies below 800 m) and at Ban Muangyo (680 m) in Phongsali province (Bangs and Van Tyne 1931): in the former they collected no Phayre's leaf monkeys, but at the latter, four, and they collected a further one on their journey down the Nam Ou, probably also in the lowlands. While far from conclusive, this is consistent with this monkey being rare in Lao PDR over about 800 m altitude. Set against this, Lowe (1947: p.30) wrote that in December 1925 he saw grey leaf monkeys (presumably this species) some way east of Ban Nonghet (19°30'N 103°59'E), that is, just on the Vietnamese side of the Lao–Vietnam border, by the road through the forest apparently "at higher levels" (presumably well above 800 m); but the description of these sightings as "at times" on the journey gives some doubt as to whether they were specifically "at higher levels" or not. His team's specimen from Xiangkhouang, which lies at about 1,100 m, lacks precise information on the animal's origin, although it was evidently fresh when acquired, given the specimen tag notes on skin colors. The collecting team (under J. Delacour) acquired animals in local markets and were sometimes highly imprecise over locality (for example, Duckworth *et al*. 2005a): David-Beaulieu (1944) already pointed out (under his species account for Large Scimitar Babbler *Pomatorhinus hypoleucos*) that the altitude of (Ban) Xiangkhouang for some of the specimens to which Delacour assigned this locality was well above his

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own (very substantial field) experience with these species in this area.

The pattern of altitudinal records may reflect at least partly the effects of hunting on large quarry species. The surveys of Nam Ha, Nam Et–Phou Louey and Nam Xam NPAs, each of highlands within the known range of Phayre's leaf monkey but which did not record the species, all saw few or no macaques, gibbons *Nomascus*, black giant squirrel *Ratufa bicolor* and large hornbills (Bucerotidae), whereas some or most of these other hunted species of similar body size were found (although generally much less often than in similar habitats of southern Lao PDR) by broadly comparable surveys in each of several areas also with leaf monkey direct-sighting or field remains records: Phou Dendin NPA, Muang Sangthong, Phou Khaokhoay NPA and Nam Kading NPA (Duckworth 1996, 2008; Tizard *et al*. 1997; Davidson 1998; Showler *et al*. 1998; Thewlis *et al*. 1998; Duckworth *et al*. 2005b; Timmins and Robichaud 2005; Fuchs *et al*. 2007; Timmins and Duckworth 2008, in prep.). Another northern highland area with Phayre's leaf monkey records, Nam Kan NPA, has not had enough surveys to evaluate populations of these hunting-sensitive species, but retains anomalously many gibbons in a northern highland context (Geissmann 2007). Most significant is that the 1990s direct observation surveys of Nam Ha, Nam Et–Phou Louey and Nam Xam NPAs saw very few macaques (in total, eight sightings in 30 person-weeks; Timmins and Duckworth in prep.). Macaques were undoubtedly present in all areas, but were very shy, presumably through hunting. The 1990s surveys in Lao PDR outside the northern highlands recorded macaques far more frequently than they did leaf monkeys (Ruggeri and Timmins 1997), and this simple comparison suggests the possibility that leaf monkeys were present but overlooked in these three NPAs with a highland survey focus. There is certainly enough risk of this to prevent firm deductions about altitudinal usage by Phayre's leaf monkey in Lao PDR.

It is plausible that these two factors operate in combination, with higher altitudes providing suboptimal habitat and so hunting pressure, which is intense across all altitudes, has been more damaging to leaf monkeys there. The altitudinal distribution of the tall bamboo from which many Lao Phayre's leaf monkey records come seems not to have been documented; but from the authors' memories it may be scarce above 800–1,000 m, which suggests a possibility that the distribution of records across altitude in fact does reflect the real occurrence of the monkey. The observed pattern of altitudinal records in Lao PDR is consistent with observations in northeast India, with upper limits there stated to be about 800 m (Srivastava 1999) or 1,000 m (Choudhury 2001).

Distribution

Recent Lao records of Phayre's leaf monkey are all from the northern part of the country (Fig. 1). Their distribution polygon includes the historical locations (Table 1) except the most southwesterly record, the area around which has not been investigated recently. Nearly all records are close to the Mekong and its major tributaries, the Nam Ou and Nam Kading. This leaves the main northern highlands a large area conspicuous for the paucity of records: a historical specimen from the former town of Xiangkhouang, and a camera-trap location from Nam Et–Phou Louey NPA. There are two plausible, non-exclusive, reasons behind this pattern—altitude and hunting—but it is just possible that it is simply an artifact of survey coverage (see 'Altitudinal Range').

The direct sightings presented here extend the known range somewhat to the south-east of the specimens, although the record from furthest south remains that from the west of the country, from Khet Dong Hieng at 17°53'N. Three field sightings, from Phou Khaokhoay NPA in November 1994 and from Nam Kading NPA in April 1995 (Evans *et al*. 2000), involved prolonged, close views of the animals, and the detailed field notes confirm identification. There is no record of any gray leaf monkey in Lao PDR south-east of these localities until the silvered leaf monkeys in Dong Phou Vieng NPA (Timmins *et al*. 2011). From this large (*c*.300 km, north–south) record-less swathe come, however, some inconclusive indications of gray leaf monkeys.

Duckworth (1998) assigned provisionally, based on range, to Phayre's leaf monkey two animals seen along the Navang logging road (Nakai–Nam Theun NPA; *c*.18°00'N, 105°20'E) in 1996; neither facial pattern nor crest characters were visible (N. L. Ruggeri verbally 1996). François'-group leaf monkey was not considered in the 1996 identification at the time because there is no karst anywhere near the sighting location; however, in 1999 that species was found far from karst within the NPA, and there are now various other non-karst records from further south in Lao PDR (Duckworth *et al*. 2010). Thus, this 1996 leaf monkey sighting could have referred to either Phayre's or a François'-group leaf monkey. That there are no further claims of Phayre's leaf monkey from this NPA, despite the many lengthy surveys there (cited in Duckworth *et al*. 2010), suggests that the animals were the latter.

In and around Phou Hinpoun (= Khammouan Limestone) NPA, Steinmetz (1998) received reports in January 1998 of a pale leaf monkey known as *taloung* from four villages, all in or close to massive karst, along the eastern edge of the NPA, two of which said it was extirpated, one of which said it was very rare, and the other reported it persisted; extensive interviews elsewhere in the NPA stimulated no reports of it (R. Steinmetz *in litt*. 2010). Yet further south (about 120 km south of confirmed records), Timmins and Khounboline (1996) considered that village reports in Hin Namno NPA (at Ban Vangngnow; 17°34'N, 105°48'E) of a long-tailed monkey, *taloung*, with white on lips and chin (indicated spontaneously, without reference to pictures), and living in forests on sandstone rather than the area's extensive karst (Duckworth *et al*. 2010: Table 4), probably referred to Phayre's; however, body color was said to be as François'-group leaf monkey (with which the informants were likely to be highly familiar, given its status in the general area). There remains

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no information from this area allowing solid identification, or even proof that any form of gray leaf monkey occurs there.

Thus, the true southerly extent of Phayre's leaf monkey in Lao PDR remains highly uncertain. The lack of records from intensive surveys in several areas south of its known records but north of known Indochinese silvered leaf monkey occurrence means that gray leaf monkeys can at best be only very rare in this region, at least nowadays. Timmins *et al*. (2011) pointed out that the parts of Lao PDR south of the northern highlands that lack confirmation of gray leaf monkey presence match well the distribution of red-shanked douc *Pygathrix nemaeus*. However, simple competitive exclusion may not be the whole explanation, because on the Nakai plateau, among the areas most intensively surveyed by direct observation for large mammals in the country (Dersu 2008), doucs are rare (Dersu 2008) and gray leaf monkeys unrecorded. This 1,250-km² area may have been suitable habitat for Phayre's leaf monkey as characterized above. It lies at 520–560 m, and (despite 25% of it being inundated for a reservoir in 2008) has a mosaic of semi-evergreen forest types including many rather open areas, and was crossed by a network of canopy-breaking streams and rivers. Tall bamboo was, however, localized and, overall, rare on the plateau although common on adjacent slopes. When surveyed most intensively, in 1994–1996, the plateau held populations of hunting-sensitive quarry species less depleted than those in most other surveyed parts of Lao PDR, with many records of macaques and gibbons (Evans *et al*. 2000; Dersu 2008), and it is highly implausible that Phayre's leaf monkey had previously occurred commonly but had already been hunted out.

Phayre's leaf monkey's known southern limit in Lao PDR (17°53'N; or even to 17°34'N, based on village reports) compares with occurrence in Vietnam south to southern Pu Mat Nature Reserve (*c*.18°46'N) as confirmed by recent records (Nadler *et al*. 2003); a skull lacking date of collection or identity of collector, labeled as from Tuyen Hoa district, Quang Binh province, suggests occurrence south to *c*.17°53'N (Fooden 1996; Nadler *et al*. 2003), matching well the Lao records. A claim of presence way further south, from the Kon Cha Rang – Kon Ka Kinh area (Gia Lai province; 14°09'–35'N, 108°16'–39'E) lacking any primary detail (Lippold 1995, 1998) is generally disregarded (Fooden 1996; Nadler *et al*. 2003). To the west of Lao PDR, in Thailand, there are solid records from much further south than in Lao PDR or Vietnam, to *c*.14°40'N in the west and to *c*.14°55'N in the east (Geissmann *et al*. 2004).

There is neither published nor, so far as we can trace, any specimen basis for Groves' (2001: p.268) statement that Phayre's leaf monkey extends to "southwestern Laos". However, there does seem conclusive evidence from two areas of Thailand (which lacks doucs) of very close approach and, in one, apparently, overlap of gray leaf monkey species (Geissmann *et al*. 2004: Fig. 3) so there may be surprises yet to be uncovered in Lao PDR in this group's distribution. Certainly, identifications as to the form of gray leaf monkey should not be made yet solely on the basis of locality.

Abundance

Only broad suggestions of abundance can be made pending specific study. These are based on contact rate in the various lengthy, direct-observation surveys in the species' Lao geographic range below 800 m altitude and on village opinion, on the assumption that all gray leaf monkeys within the species's Lao range are indeed Phayre's leaf monkeys. The several records from surveys with limited direct observation and/or focus on degraded areas, coupled with village information, suggest that the animal remains widespread in its Lao range. There tend to be only one or two records per survey area, and most villagers expressing opinion indicated scarcity of and/or large declines in this monkey (Hypa concession, HFI 1999; Nam Ha NPA, Johnson *et al*. 2003; Muang Vangviang, Duckworth in press; Phou Phadam, Phou Gnouey and Nongpet–Naxeng PFAs, Suford in press; and the lower Nam Ngiap, S. Watson *in litt*. 1999). No villagers seem to report stable or increasing populations, but many documents gave no information on this topic.

There is, therefore, no evidence of locally abundant populations of Phayre's leaf monkey presently in Lao PDR. Although there is insufficient historical information to be sure that it was ever markedly more common than it is now, the rate at which the Kelley–Roosevelts' expedition collected it in 1929 (Table 1) suggests that it may well have been. There is also no evidence of high-density populations in Vietnam, where hunting pressures on monkeys are very high (Nadler *et al*. 2003). It can, however, be very common elsewhere; for example, in the part of Phu Khieo Wildlife Sanctuary, Thailand, surveyed by Borries *et al*. (2002) it was by a fair lead the most common diurnal primate, and in North-east India, it is locally common although overall scarce (Choudhury 2001).

The questions most intriguing for conservation are perhaps "do the current generally low densities and apparent patchy distribution of Phayre's leaf monkey in Lao PDR reflect hunting, habitat/altitude factors, or both?", and thus, "were hunting relaxed, would populations expand significantly into habitats here considered unoccupied, or largely so?" The paucity of records of this monkey, and their opportunistic nature, prevents meaningful answers to these questions so far.

Conservation status

The number of Lao records in the 2000s, despite a decline in direct-observation survey since the 1990s (Duckworth 2008), indicates that the national conservation status of Phayre's leaf monkey is not as grim as feared by Duckworth *et al*. (1999). However, records are rather few, reflecting (and probably caused by) a general pattern of heavy hunting. Phayre's leaf monkey seems to survive in Lao PDR in most large tracts of forested land with significant areas below 800 m north/west of, and including, Nam Kading NPA. The large size of some such areas suggests that some large populations may persist. Given the differences in survey style, duration and personnel across the northern highlands in the

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1990s–2000s, it is not possible to compare results from each site to pinpoint individual areas of special significance. Certainly, no relation should be taken between the number of records from an area and its likely importance to the species's survival prospects in Lao PDR.

The occurrence of this monkey in rugged landscapes, where hunting is less efficient and therefore less damaging than on the plains, probably is the major factor behind its healthier national conservation status than that of the congeneric Indochinese silvered leaf monkey. Nonetheless, under current hunting patterns, declines are likely to intensify and be followed by widespread extirpation. There are some large karst landscapes in the northern highlands which could offer better mid-term security even under current hunting (cf. Lao leaf monkey *T. laotum*; Steinmetz *et al*. 2011), but it is unclear whether Phayre's leaf monkey reaches comparable densities within them, or even occurs; they have been barely surveyed for mammals. Three of the NPAs with records (one only provisional) have active ongoing management-support projects: Nam Kading NPA (WCS 2010) and Nam Kan NPA (Robichaud *et al*. 2010) may support relatively large populations given their altitude and habitat, whereas Nam Et–Phou Louey NPA (WCS Lao Program internal documents) lies mostly over 800 m, and mostly well above this altitude.

Phayre's leaf monkey has an ambiguous legal status in Lao PDR. It is not explicitly mentioned by English or scientific name in the national Wildlife Law, but probably the listing given in Roman script as "silvered leaf monkey *Semnopithecus cristatus*", under the Lao name of "*khang* (*taloung*)" is best seen as for gray leaf monkeys of all species.

Even taking as the unit of analysis *T. p. crepusculus*, Phayre's leaf monkey numbers in Lao PDR are probably of rather little significance to global conservation compared with those in Thailand, which holds at least one high-density population over a large area (Borries *et al*. 2002). Lao populations of taxa like Lao leaf monkey and allies, red-shanked douc, and various *Nomascus* gibbons, are of far higher global significance, because the country holds most, in some cases the overwhelming majority of, surviving animals and retains much more extensive suitable habitat than does any other country (Timmins and Duckworth 1999; Duckworth 2008; Duckworth *et al*. 2010; Steinmetz *et al*. 2011). Additionally, Indochinese silvered leaf monkey is now very rare in Lao PDR, and its national extinction is probably looming without specific action to prevent it (Timmins *et al*. 2011). Phayre's leaf monkey is thus a lower priority than these species for specific action in the country. Fuller global contextualization of the significance of the Lao populations requires resolution of the uncertain taxonomy: in an east-of-Mekong context, Lao populations are probably much greater than those in Vietnam and China (see Zhang *et al*. 1992, Nadler *et al*. 2003).

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