

Abundance of primates reveals Samkos Wildlife Sanctuary, Cardamom Mountains, Cambodia as a priority area for conservation

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Abstract We conducted a primate survey in Samkos Wildlife Sanctuary, western Cambodia, during the wet season in 2009. We visually confirmed the presence of five out of six primate species thought to occur in the area: Bengal slow loris *Nycticebus bengalensis*, Indochinese silvered langur *Trachypithecus germaini*, pileated gibbon *Hylobates pileatus*, pig-tailed macaque *Macaca leonina* and long-tailed macaque *Macaca fascicularis*. We did not find any sign of the stump-tailed macaque *Macaca arctoides* and suggest it is absent in Samkos Wildlife Sanctuary and possibly from the Cardamom Mountains. We provide the abundance measures for each primate species; the three most abundant species were Bengal slow loris, Indochinese silvered langur and pileated gibbon. We propose Samkos Wildlife Sanctuary as a priority for primate conservation in Cambodia.

Keywords Cambodia, Cardamom Mountains, *Hylobates*, *Macaca*, *Nycticebus*, presence/absence, survey, *Trachypithecus*

Introduction

Information on the distribution and status of Cambodia's wildlife is limited (Long & Swan, 2000), although information from surveys undertaken since the end of the 1990s has led to improved conservation plans for many species, including tigers and elephants (Daltry & Momberg, 2000; Long et al., 2000b). For primates, however, despite 10 of Cambodia's 11 taxa being categorized as threatened on the IUCN Red List (IUCN, 2010), few studies have quantified their abundance (Long & Swan, 2000; Traeholt et al., 2005). In particular, the Cardamom Mountains, west of the Mekong River, were inaccessible for c. 20 years because of the Cambodian civil war, and there have been only a few wildlife surveys in this region (Momberg & Weiler, 1999; Long & Swan, 2000).

Primates in South-East Asia are declining at a dramatic rate (Mittermeier et al., 2007) and up-to-date information on their populations is essential for determining their national and global conservation status. Six primate species

are reported to occur in the Cardamom Mountains (Table 1; Long & Swan, 2000). In Samkos Wildlife Sanctuary the pileated gibbon *Hylobates pileatus*, with an estimated 3,100 groups, is the only species that has been studied in detail (Traeholt et al., 2005). Simulations predict a dramatic decline of the population in the Sanctuary in the next 40–50 years because of habitat loss from illegal logging (Traeholt et al., 2005). In developing countries such as Cambodia infrastructure expansion and logging are major threats to forests and wildlife (Smith, 2001). We therefore carried out the first survey of all primate species in the Sanctuary since 2000, reporting novel data on their abundance in the rainy season. Because the distribution of primate species in Cambodia is still poorly known we also provide a review of their distribution, status and threats.

Study area

Our study took place in the lowlands of Samkos Wildlife Sanctuary (3,338 km²) in the Cardamom Mountains (10,000 km²) in south-west Cambodia (Fig. 1). The survey area comprises lowland evergreen and dry dipterocarp forests up to an altitude of 350 m. Mean annual rainfall is 3,000–4,000 mm, with a rainy season during May–October (Rollet, 1972; Daltry & Momberg, 2000). The fauna of the Cardamom Mountains includes a variety of threatened and/or endemic species of birds, mammals, amphibians and plants (Momberg & Weiler, 1999; Daltry & Momberg, 2000). Some illegal activities such as timber extraction and hunting persist and local people utilize the forest legally for resin, fruit and plant collection.

Methods

We surveyed for primates from 22 April to 31 May 2009 using line transects (Sutherland, 2000) combined with exploration of the forest not following any transect (tracking) to increase detection and acquire descriptive data on group size. Tracking and line transects are hereafter referred to as the census.

Ten randomly selected 1-km long transects were walked twice over 10 days at 08.00–11.00 and then 2 weeks later at 14.00–17.00, and twice over 10 days at 19.00–24.00 and 24.00–04.00. Transects 1–4 were in lowland evergreen forest and transects 5–10 in dry dipterocarp forest. Eight days were spent tracking diurnal primates starting at 08.00

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TABLE 1 Total number of sightings and encounter rate (groups per hour and individuals per hour) of each species sighted during the census (60 hours diurnal; 25 hours nocturnal) in Samkos Wildlife Sanctuary (Fig. 1).

Primate species	Total no. of sightings	Mean group size*	Groups per hour
Bengal slow loris <i>Nycticebus bengalensis</i>	9	1	
Indochinese silvered langur <i>Trachypithecus germaini</i>	5	12.50	0.08
Pileated gibbon <i>Hylobates pileatus</i>	4	5.00	0.07
Pig-tailed macaque <i>Macaca leonina</i>	3	Not calculated	0.05
Long-tailed macaque <i>Macaca fascicularis</i>	1	12.50	0.02

*Calculated using all sightings throughout the study period

for 4–6 hours. Two people walked quietly at 1 km h⁻¹, stopping frequently to scan all forest layers. We recorded date, time, transect, coordinates with a global positioning system, weather, habitat and perpendicular distance of the first animal seen from the observer or transect.

For diurnal primates we used the encounter rate biodiversity assessment technique (Sutherland, 2000), calculating number of animals seen per survey hour. For the Bengal slow loris *Nycticebus bengalensis* we used the linear encounter rate per km (Nekaris et al., 2008) and density (D) of animals per km², calculated using $D = n/2wl$, where w is strip width, l is transect length and n is the number of lorises (Sutherland, 2000).

Results

We spent 60 hours conducting diurnal surveys and 25 hours conducting nocturnal surveys. We confirmed the presence of four diurnal and one nocturnal primate species

(Table 1). We sighted diurnal primates 18 times, 13 of which (72.2%) were during censuses and five opportunistically. Twelve observations (92.3%) were made during tracking and only one (7.7%) during transects (Table 1). All sightings of diurnal primates were in lowland evergreen forest. We encountered nine *N. bengalensis*. For the entire area surveyed the linear encounter rate was $0.45 \pm SE 0.64 \text{ km}^{-1}$ and density was $18.75 \pm SE 26.81 \text{ km}^{-2}$. More sightings (66.7%) occurred in dry dipterocarp forest, with a linear encounter rate of $0.50 \pm SE 0.63 \text{ km}^{-1}$ and density of $20.83 \pm SE 26.35 \text{ km}^{-2}$. In lowland evergreen forest (33.3% of sightings), linear encounter rate was $0.38 \pm SE 0.75 \text{ km}^{-1}$ with a density of $15.63 \pm SE 31.25 \text{ km}^{-2}$.

N. bengalensis was sighted most, followed by the Indochinese silvered langur *Trachypithecus germaini*, *H. pileatus*, pig-tailed macaque *Macaca leonina* and long-tailed macaque *Macaca fascicularis* (Table 1). We did not detect the stump-tailed macaque *Macaca arctoides*. We also heard *H. pileatus* daily between 09.00 and 10.00. Half of all diurnal species

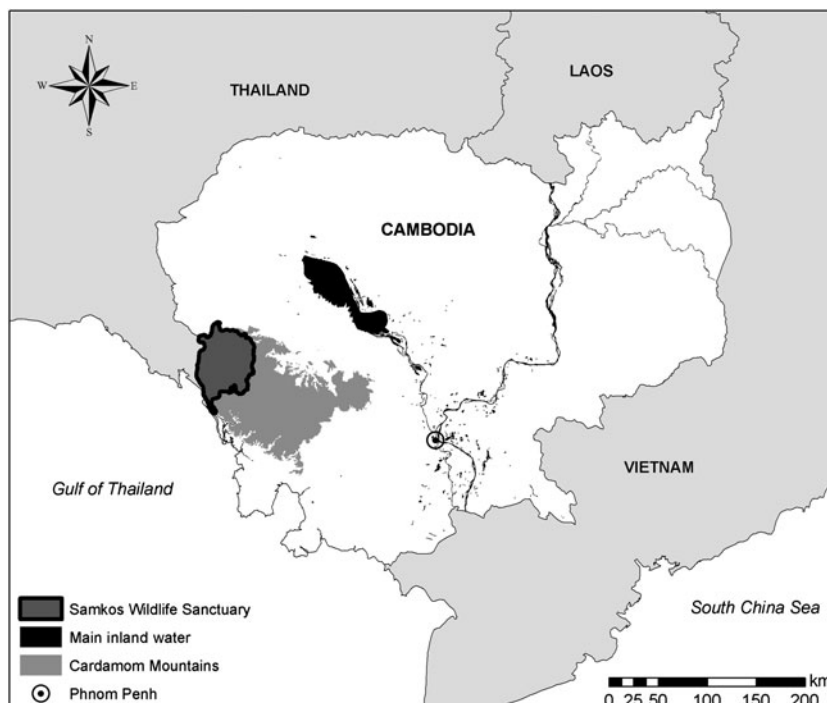


FIG. 1 Location of the Cardamom Mountains and Samkos Wildlife Sanctuary within Cambodia.

were sighted between 05.30 and 11.10 and half between 12.30 and 17.00. We observed lorises more or less equally during early and late night: 19.00–00.00 (56%) and 00.00–04.00 (44%).

Most diurnal observations (n = 17) occurred during sunny days (94.4%); no sighting occurred during rain. The mean distance from observer for diurnal primates was 19.8 m ± SD 10.1, and 5.8 m ± SD 3.6 for *N. bengalensis*. Mean group sizes are presented in Table 1. Group composition of *H. pileatus* was one adult male and female with three juveniles; the four sightings were in the same area and were probably of one group. Sightings of *T. germaini* and *M. fascicularis* comprised all age classes. Only adult *N. bengalensis* were seen; on three occasions individuals were observed in proximity with conspecifics.

Discussion

Our survey confirms the presence of four diurnal primates and the nocturnal *N. bengalensis* in the Cardamom Mountains. Previous surveys of these species had relied on a combination of village interviews and forest and market surveys (Table 2).

To clarify the distribution of primate species in Cambodia we compiled records for all species known from the country (Table 3). Recent changes in classification of

T. germaini may increase its threat. Genetic data (Osterholz et al., 2008; Roos et al., 2008) separate *T. germaini* from *Trachypithecus margarita*, with the Mekong River a barrier between the two species (Roos et al., 2008). Previous surveys (Boonratana, 1999; Long & Swan, 2000; Long et al., 2000a) in the Cardamom Mountains identified *T. germaini* as *Trachypithecus cristatus*, consequently attributing it a much broader distribution in South-East Asia. If Roos et al.’s (2008) classification is accepted, conservation of this species in the Cardamom Mountains should be regarded as a priority.

As *H. pileatus* was more easily heard than seen, using their vocalisation to census the species seems a better method to estimate density (e.g. triangulation: Traeholt et al. 2005; occupancy modelling: Neilson, 2010). Traeholt et al. (2005) used triangulation and suggested that the Cambodian population of *H. pileatus* is the world’s largest and that the Cardamom Mountains are critical for the conservation of this species. Our results, with only one group sighted in an area of c. 470 ha, may be indicative that the density of the species in Samkos Wildlife Sanctuary has decreased since the study by Traeholt et al. (2005). Monitoring of this population by regular surveys is required.

Despite distribution data (Cobert & Hill, 1992; Rowe, 1996; Walston, 2001; Francis, 2008) suggesting the presence

TABLE 2 Summary of the results of this and previous primate surveys (with surveying dates and lengths in parentheses) in the Samkos Wildlife Sanctuary (Fig. 1). [Confirmed] indicates that the presence of the species was not confirmed by sightings.

Species	This study (5 weeks; c. 3 weeks of census)	Boonratana, 1999 (13 days)	Long et al., 2000a; Long & Swan, 2000 (24 Jan.–27 Mar. 2000)	Traeholt et al., 2005 (at least 5 days)
Bengal slow loris	Confirmed, sightings	Confirmed, dead specimen	Confirmed, hunted specimen & captive individual	
Indochinese silvered langur	Confirmed, sightings	[Confirmed], reports by local people, ‘further investigation needed’	Confirmed, 1 sighting, 1 hunted specimen	
Long-tailed macaque	Confirmed, sightings	Confirmed, 2 sightings	[Confirmed], reports by hunters	
Pig-tailed macaque	Confirmed, sightings	Confirmed, 2 sightings	[Confirmed], reports by local people and hunters, hunted specimen, captive individual	
Pileated gibbon	Confirmed, sightings, daily vocalizations	Confirmed, 1 sighting, vocalisations	Confirmed, 1 sighting, vocalizations, hunted specimen, captive pet individual	Confirmed, vocalizations (triangulation method)
Stump-tailed macaque <i>Macaca arctoides</i>	Unconfirmed	Unconfirmed	Unconfirmed	

TABLE 3 Confirmed records of primate species in Cambodia, with their Red List status and the areas where they have been observed, with references, west and east of the Mekong river.

Areas (Province(s))	Silvered langur	Red-shanked douc <i>Pygathrix nemaeus</i>	Black-shanked douc <i>Pygathrix nigripes</i>	Pileated gibbon	Yellow-cheeked crested gibbon <i>Nomascus gabriellae</i>	Pig-tailed macaque	Long-tailed macaque	Stump-tailed macaque	Pygmy slow loris <i>Nycticebus pygmaeus</i>	Bengal slow loris
Red List status ¹	EN	EN	EN	EN	EN	LC	VU	VU	VU	VU
West of Mekong River										
Tonle Sap Plain (Battambang, Kompong Thom)	√						√			√
Kirirom National Park (Kompong Speu)	√			√		√	√	√		
Samkos Wildlife Sanctuary (Pursat)	√			√		√	√			√
Central Cardamoms (Koh Kong)				√		√	√			
Phnom Kulen National Park (Siem Riep)				√		√	√			√
Preah Vihear Protection Forest (Preah Vihear)	√			√		√	√			√
Kulen Promtep Wildlife Sanctuary (Siem Riep, Preah Vihear)	√			√		√	√			√
Phnom Tbeng (Preah Vihear)				√			√			√
Bokor National Park (Kampot)				√						
Botum-Sakor National Park (Koh Kong)	√					√				
Prey Long (Kratie, Steung Treng)				√		√	√			
East of Mekong River										
Mekong Channels: Kratie to Stung Treng Towns (Kratie, Steung Treng)	√						√			
Vonseï District (Ratanakiri)		√	√							
Virachey National Park (Ratanakiri)					√	√		√		
Seima Protection Forest (Mondulkiri)	√		√		√	√	√	√	√	
Snoul Wildlife Sanctuary (Mondulkiri)			√		√		√			

TABLE 3 (Continued)

Areas (Province(s))	Silvered langur	Red-shanked douc <i>Pygathrix nemaeus</i>	Black-shanked douc <i>Pygathrix nigripes</i>	Pileated gibbon	Yellow-cheeked crested gibbon <i>Nomascus gabriellae</i>	Pig-tailed macaque	Long-tailed macaque	Stump-tailed macaque	Pygmy slow loris <i>Nycticebus pygmaeus</i>	Bengal slow loris
Phnom Pritch Wildlife Sanctuary (Mondulkiri)	√		√		√	√	√	√	√	
Mondulkiri Protection Forest (Mondulkiri)	√		√			√	√		√	
Lumphat Wildlife Sanctuary (Mondulkiri)	√						√			
References ²	1; 2; 3; 9; 10; 20; 21; 22; 23; 25; 27; 28; present study; P. Channa, pers comm. 2009	11	9; 11; 16; CNZC, pers. obs. 2009	1; 2; 3; 4; 5; 6; 7; 8; 21; 24; 25; 26; present study	4; 9; 10; 12; 14; 13; 16; CNZC, pers. obs. 2009	1; 2; 3; 5; 6; 9; 10; 14; 15; 16; 22; 24; 25; present study	1; 2; 3; 5; 6; 9; 10; 14; 16; 20; 21; 23; 24; 25; 27; 28; present study; CNZC, pers. obs. 2009	9; 13; 16; 17; 21; T. Gray, pers. comm.	19; LDR, pers. obs. 2009; T. Gray, pers. comm.	18; 25; 28; present study

¹LC, Least Concern (i.e. not on the Red List); VU, Vulnerable; EN, Endangered (IUCN, 2010)

²1, Boonratana (1999); 2, Long et al. (2000a); 3, Long & Swan (2000); 4, Traeholt et al. (2005); 5, Daltry & Momberg (2000); 6, Emmet & Olsson (2005); 7, Neath et al. (2001); 8, Rawson & Senior (2005); 9, Pollard et al. (2007); 10, Rawson (2007); 11, Rawson & Roos (2008); 12, Channa & Gray (2009); 13, Conservation International (2007); 14, Timmins & Ratanak (2001); 15, Desai & Vuthy (1996); 16, Walston et al. (2001); 17, Pfeffer (1969); 18, Starr et al. (2010b); 19, Starr et al. (2011); 20, Campbell et al. (2006); 21, Kong Kim Sreng & Setha (2002); 22, Royan (2010); 23, Bezuijen et al. (2007); 24, ACCB data (M. Handschuh, pers. comm. 2010); 25, Wildlife Conservation Society data (H. Rainey, pers. comm. 2010); 26, Rainey et al. (2010); 27, Eames (2007); 28, Davidson (2006)

of *M. arctoides* no study has verified its presence in the Cardamom Mountains. Walston (2001) mistakenly cited Pfeffer (1969) as evidence of *M. arctoides* west of the Mekong River but Pfeffer's study was conducted in eastern Cambodia (Table 3). In 2000 three individuals of *M. arctoides* were sighted in Kirirom National Park, west of the Mekong River (Kong Kim Sreng & Setha, 2002) and reported as having been highly reduced in numbers by hunting. Little is known about this species and its distribution in South-East Asia is not clearly defined (Fooden et al., 1985; Choudhury, 2002; Htun et al., 2008). Although *M. arctoides* is generally found at high elevations (up to 2,700 m in India and China; Htun et al., 2008), in Cambodia it was recorded at c. 250 m in Virachay National Park (Conservation International, 2007), the same altitude as our survey site. Previous surveys in the Cardamom Mountains covered a wider range of habitat including hill evergreen forest (up to 1,200 m) but did not record this species. The continued absence of *M. arctoides* in surveys in the Cardamom Mountains indicates either that it does not occur there or that it does so at an extremely low density (cf. Pollard et al., 2007).

The only previous nocturnal surveys for *N. bengalensis* were conducted by Daltry & Momberg (2000). Other confirmations come from dead or captive individuals (Table 2). Starr et al. (2010b) conducted surveys for *N. bengalensis* throughout Cambodia but only sighted the species in Samkos Wildlife Sanctuary and Phnom Kulen National Park. The decline of this species in the wild and in traditional medicine markets, where it once was common, mean that the Sanctuary is also an important site for this species.

Previous diurnal surveys in the Cardamom Mountains were carried out during the dry season (c.f. Daltry & Momberg, 2000) when rivers dry up. Our survey, during the rainy season, was conducted next to a river that attracts some primate species, perhaps explaining why we observed some species not seen by previous researchers. Researchers often recommend to survey diurnal primates in the early morning (Sutherland, 2000) but we observed primates active throughout the day. All of our encounters occurred during non-rainy days.

Seasonality may also affect the results of nocturnal surveys. *N. bengalensis* was encountered in dry dipterocarp forest characterized by grassland that this non-leaping primate uses as a substrate to reach trees. During the dry season grassland is burnt by local people for access to resin trees (Starr et al., 2011), possibly adversely affecting this species. Slow lorises also reduce their activity during the cooler period of December–February and during these months other researchers have detected relatively few (Evans et al., 2000; Starr et al., 2011). Increased activity during our study period (April–May) could explain why *N. bengalensis* was the most often encountered primate.

Our study provides the first encounter rates of diurnal primate species for Samkos Wildlife Sanctuary, although

only an index of abundance. Given the difficult terrain, which made line transects difficult to establish and time consuming, we recommend for future research the use of occupancy surveys that use sampling of many points spread in different habitats, allowing the coverage of a large area (Royles & Nichols, 2003). This method also provides a detection probability for comparing different species and habitat types (MacKenzie et al., 2006), something lacking in our study. Presence sampling by sign (e.g. faeces, tracks, vocalization) may be particularly suitable for the Cardamom Mountains, and not only for primates. Occupancy surveys in combination with sign counts could be useful for estimating abundance of the area's many endemic birds (Shanahan & Possingham, 2009) and reptiles and amphibians (cf. Grismer et al., 2008). Other threatened taxa, including Endangered Asian elephant *Elephas maximus*, Vulnerable gaur *Bos gaurus*, and Endangered banteng *Bos javanicus*, all of which were detected during our study, leave tell-tale signs (Barnes, 1996).

Although rare and threatened species are protected by law from hunting and trade in Cambodia (Walston & Ashwell, 2005), wildlife is continually threatened by illegal activities. The end of the war was characterised by dramatic logging and increasing development of infrastructure such as roads (Momberg et al., 1999), factors that still persist. During our study we heard chainsaws twice a few kilometres from our camp; illegal logging is currently increasing in the region (T. Eastoe, pers. comm.). In the Cardamom Mountains hunting and illegal trade for food, pets and medicine also accelerated after the war (Momberg et al., 1999) and are still serious threats (N. Thy, pers. comm.); we saw an infant *T. germaini* for sale as a pet in Pramoy village. Capture of entire groups of primates such as macaques have been reported in Cambodia and could lead to local extinctions in some areas (Nijman, 2005; BUAV, 2008). Starr et al. (2010a) note the importance of *N. bengalensis* in Khmer traditional medicines. Previous visits to Samkos Wildlife Sanctuary encountered numerous hunted specimens in villages destined for medicinal use (Starr et al., 2010a).

Our study indicates the importance of Samkos Wildlife Sanctuary for primate conservation in Cambodia. We hope our findings will encourage further primate studies in the area and that the Sanctuary will become a priority for primate conservation in Cambodia.

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References

- BARNES, R. (1996) Estimating forest elephant abundance by dung counts. In *Studying Elephants* (ed. K. Kangwana), pp. 38–48. African Wildlife Foundation, Nairobi, Kenya.
- BEZUIJEN, M.R., TIMMINS, R. & SENG, T. (2007) *Biological Surveys of the Mekong River Kratie and Stung Treng Towns, North-east Cambodia, 2006–2007*. WWF Greater Mekong–Cambodia Country Programme, Phnom Penh, Cambodia.
- BOONRATANA, R. (1999) A preliminary wildlife survey in the Cardamom Mountains region of south-western Cambodia. In *Conservation Status of the Cardamom Mountains in South-western Cambodia: Preliminary Studies* (eds F. Momberg & H. Weiler), pp. 11–27. Fauna & Flora International, Indochina programme, Hanoi, Vietnam.
- BUAV (BRITISH UNION FOR THE ABOLITION OF VIVISECTION) (eds) (2008) *Cambodia—The Trade in Primates for Research*. BUAV, London, UK.
- CAMPBELL, I.C., POOLE, C., GIESEN, W. & VALBO-JORGENSEN, J. (2006) Species diversity and ecology of Tonle Sap Great Lake, Cambodia. *Aquatic Sciences*, 68, 355–373.
- CHANNA, P. & GRAY, T. (2009) *Status and Habitat of Yellow-Cheeked Crested Gibbon* *Nomascus gabriellae*. Phnom Pritch Wildlife Sanctuary, WWF–Cambodia Program, Phnom Penh, Cambodia.
- CHOUDHURY, A. (2002) Status and conservation of the stump-tailed macaque *Macaca artoidea* in India. *Primate report*, 63, 63–72. <http://dpz.eu/pr/pr63/choudh.pdf> [accessed 19 July 2009].
- COBERT, G.B. & HILL, J.E. (1992) *The Mammals of the Indomalayan Region: A Systematic Review*. Natural History Museum Publications and Oxford University Press, Oxford, UK.
- CONSERVATION INTERNATIONAL (2007) *Preliminary Report Virachey National Park*. Rapid Assessment Program, Conservation International, Phnom Penh, Cambodia.
- DALTRY, J.C. & MOMBERG, F. (eds) (2000) *Cardamom Mountains Biodiversity Survey 2000*. Fauna & Flora International, Cambridge, UK.
- DAVIDSON, P.J. (2006) *The Biodiversity of the Tonle Sap Biosphere Reserve 2005. Status Review*. UNDP/GEF-funded Tonle Sap Conservation Project, Phnom Penh, Cambodia.
- DESAI, A.A. & VUTHY, L. (1996) *Status and Distribution of Large Mammals in Eastern Cambodia. Results of the First Foot Surveys in Mondulakiri and Rattanakiri Provinces*. IUCN/Fauna & Flora International/WWF. Large Mammal Conservation Project, Phnom Penh, Cambodia.
- EAMES, J. (2007) *A Rapid Evaluation of Lomphat Sanctuary*. BirdLife International Indochina Programme, Phnom Penh, Cambodia.
- EMMETT, D.A. & OLSSON, A. (2005) *Biological Surveys in the Central Cardamom Mountains*. Conservation International Cambodia Program and Forestry Administration, Phnom Penh, Cambodia.
- EVANS, T.D., DUCKWORTH, J.W. & TIMMINS, R.J. (2000) Field observations of larger mammals in Laos, 1994–1995. *Mammalia*, 64, 55–100.
- FOODEN, J., GUOQIANG, Q., ZONGREN, W. & YINGXIANG, W. (1985) The stump-tailed macaques of China. *American Journal of Primatology*, 8, 11–30.
- FRANCIS, C.M. (ed.) (2008) *A Field Guide to the Mammals of South-East Asia*. New Holland Publisher, London, UK.
- GRISMER, L., NEANG, T., CHAV, T., WOOD, P.L., OAKS, J.R., HOLDEN, J. et al. (2008) Additional amphibians and reptiles from the Phnom Samkos Wildlife Sanctuary in north-eastern Cardamom Mountains, Cambodia, with comments on their taxonomy and the discovery of three new species. *The Raffles Bulletin of Zoology*, 56, 161–175.
- HTUN, S., TIMMINS, R.J., BOONRATANA, R. & DAS, J. (2008) *Macaca arctoides*. In *IUCN Red List of Threatened Species v. 2010.4*. <http://www.iucnredlist.org> [accessed 27 January 2011].
- IUCN (2010) *IUCN Red List of Threatened Species v. 2010.4*. <http://www.iucnredlist.org/> [accessed 27 January 2011].
- KONG KIM SRENG & SETHA, T. (2002) *A Wildlife Survey of Kirirom National Park, Cambodia*. Wildlife Conservation Society–Cambodia Program, Phnom Penh, Cambodia.
- LONG, B., ROTH, B., HOLDEN, J. & UCK, S. (2000a) Large mammals. In *Cardamom Mountains Biodiversity Survey 2000* (eds J.C. Daltry & F. Momberg), pp. 49–68. Fauna & Flora International, Cambridge, UK.
- LONG, B. & SWAN, S.R. (2000) *Cambodian Primates: Surveys in the Cardamom Mountains and North-east Mondulakiri Province*. Fauna & Flora International, Hanoi, Vietnam.
- LONG, B., SWAN, S. & MASPHAL, K. (2000b) *Biological Surveys in North-east Mondulakiri, Cambodia*. Fauna & Flora International, Indochina Programme, and the Wildlife Protection Office, Department of Forestry, Phnom Penh, Cambodia.
- MACKENZIE, D.I., NICHOLS, J.D., RYLE, J.A., POLLOCK, K.H., BAILEY, L.L. & HINES, J.E. (2006) Occupancy in ecological investigation. In *Occupancy Estimation and Modelling—Inferring Patterns and Dynamics of Species Occurrence* (eds D.I. MacKenzie, J.D. Nichols, J.A. Ryle, K.H. Pollock, L.L. Bailey & J.E. Hines), pp. 25–52. Elsevier, Burlington, USA.
- MITTERMEIER, R.A., RATSIMBAZAFY, J., RYLANDS, A.B., WILLIAMSON, L., OATES, J.F., MBORA, D. et al. (2007) Primates in peril: the world's 25 most endangered primates, 2006–2008. *Primate Conservation*, 22, 1–40.
- MOMBERG, F. & WEILER, H. (eds) (1999) *Conservation Status of the Cardamom Mountains in South-western Cambodia: Preliminary Studies*. Fauna & Flora International, Indochina programme, Hanoi, Vietnam.
- MOMBERG, F., WEILER, H. & HARDKE, M. (1999) Introduction. In *Conservation Status of the Cardamom Mountains in South-western Cambodia: Preliminary Studies* (eds F. Momberg & H. Weiler), pp. 6–10. Fauna & Flora International, Indochina programme, Hanoi, Vietnam.
- NEATH, N., SETHA, T., BUNNAT, P. & STUART, B. (2001) *A Wildlife Survey of Bokor National Park, Cambodia*. Wildlife Conservation Society, Phnom Penh, Cambodia.
- NEILSON, E. (2010) *The use of singing behaviour to model the occupancy of pileated gibbons (Hylobates pileatus) in the Cardamom Mountains, Cambodia*. MSc thesis, Oxford Brookes University, Oxford, UK.
- NEKARIS, K.A.I., BLACKHAM, G.V. & NIJMAN, V. (2008) Conservation implications of low encounter rates of five nocturnal primate species (*Nycticebus* spp.) in Asia. *Biodiversity and Conservation*, 17, 733–747.
- NIJMAN, V. (2005) *In Full Swing: An Assessment of Trade in Orang-utans and Gibbons on Java and Bali, Indonesia*. TRAFFIC South-East Asia, Petaling Jaya, Selangor, Malaysia.
- OSTERHOLZ, M., WALTER, L. & ROOS, C. (2008) Phylogenetic position of the langur genera *Semnopithecus* and *Trachypithecus* among Asian colobines, and genus affiliations of their species groups. *BMC Evolutionary Biology*, 8, 1–12.

- PFEFFER, P. (1969) Considération sur l'écologie des forêts claires du Cambodge oriental. *Terre et Vie*, 1, 3–24.
- POLLARD, E., CLEMENTS, T., HOR, N.M. & KO, S. (2007) *Status and Conservation of Globally Threatened Primates in the Seima Biodiversity Conservation Area, Cambodia*. Wildlife Conservation Society, Cambodia Program, Phnom Penh, Cambodia.
- RAINEY, H., CLEMENTS, T., SETHA, T., SOKHA, T., VANN, R. & TYSON, M. (2009) *Large Mammal Surveys in Preah Vihear Protected Forest, Cambodia 2006–2009*. Wildlife Conservation Society, Phnom Penh, Cambodia.
- RAWSON, B. (2007) *Surveys, Trade and Training in Voensei Division, Ratanakiri Province, Cambodia*. Conservation International, Hanoi, Vietnam.
- RAWSON, B. & ROOS, C. (2008) A new primate record for Cambodia: *Pygathrix nemaus*. *Cambodian Journal of Natural History*, 1, 7–11.
- RAWSON, B. & SENIOR, B. (2005) *Pileated Gibbon (Hylobates pileatus) Status in Preah Monivong 'Bokor' National Park, Cambodia*. WildAid, Bangkok, Thailand.
- ROLLET, B. (1972) La végétation du Cambodge. *Bois et Forêt des Tropiques*, 144, 3–15; 145, 23–38; 146, 3–20 (3 parts).
- ROOS, C., NADLER, T. & WATER, L. (2008) Mitochondrial phylogeny, taxonomy and biogeography of the silvered langur species group (*Trachypithecus*). *Molecular Phylogenetics and Evolution*, 47, 629–636.
- ROWE, N. (ed.) (1996) *The Pictorial Guide to the Living Primates*. Pogonias Press, East Hampton, USA.
- ROYAN, A. (2010) Significant mammal records from Botum-Sakor National Park, south-west Cambodia. *Cambodian Journal of Natural History*, 1, 22–26.
- ROYLES, J.A. & NICHOLS, J.D. (2003) Estimating abundance from repeated presence-absence data or point counts. *Ecology*, 84, 777–790.
- SHANAHAN, D.F. & POSSINGHAM, H.P. (2009) Predicting avian patch occupancy in a fragmented landscape: do we know more than we think? *Journal of Applied Ecology*, 46, 1026–1035.
- SMITH, J. (ed.) (2001) *Biodiversity, the Life of Cambodia—Cambodian Biodiversity Status Report 2001*. Cambodia Biodiversity Enabling Activity, Phnom Penh, Cambodia.
- STARR, C.R., NEKARIS, K.A.I., STREICHER, U. & LEUNG, L.K.-P. (2011) Field surveys of the Vulnerable pygmy slow loris *Nycticebus pygmaeus* using local knowledge in Mondulki Province, Cambodia. *Oryx*, 45, 135–142.
- STARR, C.R., NEKARIS, K.A.I., STREICHER, U. & LEUNG, L.K.-P. (2010a) Traditional use of slow lorises *Nycticebus bengalensis* and *N. pygmaeus* in Cambodia: an impediment to their conservation. *Endangered Species Research*, 12, 17–23.
- STARR, C.R., ROGERS, L.D., NEKARIS, K.A.I. & STREICHER, U. (2010b) Preliminary field surveys of the northern slow loris (*Nycticebus bengalensis*) in Cambodia. In *Conservation of Primates in Indochina* (eds T. Nadler, B. Rawson & Van Ngoc Thinh), pp. 43–52. Frankfurt Zoological Society–Endangered Primate Rescue Centre–Conservation International Indo-Burma Program, Hanoi, Vietnam.
- SUTHERLAND, W.J. (2000) Assessing biodiversity. In *The Conservation Handbook: Techniques in Research, Management and Policy* (ed. W.J. Sutherland), pp. 3–20. Blackwell Science, Oxford, UK.
- TIMMINS, R.J. & RATANAK, O. (2001) *The Importance of Phnom Prich Wildlife Sanctuary and Adjacent Areas for the Conservation of Tigers and Other Key Species*. WWF Indochina Programme, Hanoi, Vietnam.
- TRAEHOLT, C., BANTHAEUN, R., RAWSON, B., SAMUTH, M., VIRAK, C. & VUTHIN, S. (2005) *Status Review of the Pileated Gibbon Hylobates pileatus, and Yellow-Cheeked Crested Gibbon, Nomascus gabriellae, in Cambodia*. Fauna & Flora International, Cambodia Programme, Phnom Penh, Cambodia.
- WALSTON, J. (2001) Mammals of Cambodia. In *Biodiversity, the Life of Cambodia—Cambodian Biodiversity Status Report 2001* (ed. J. Smith), pp. 133–152. Cambodia Biodiversity Enabling Activity, Phnom Penh, Cambodia.
- WALSTON, J., DAVIDSON, P. & SORIYUN, M. (2001) *A Wildlife Survey of Southern Mondulki Province, Cambodia*. Wildlife Conservation Society, Phnom Penh, Cambodia.
- WALSTON, N. & ASHWELL, D. (eds) (2008) *An Overview of the Use and Trade of Plants and Animals in Traditional Medicine Systems in Cambodia*. TRAFFIC South-East Asia, Greater Mekong Programme, Hanoi, Vietnam.

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