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Non-*Panthera* cats in South-east Asia





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Cover Photo: Non-*Panthera* cats of South-east Asia:
From top centre clock-wise
jungle cat (Photo K. Shekhar)
clouded leopard (WCS Thailand Prg)
fishing cat (P. Cutter)
leopard cat (WCS Malaysia Prg)
Asiatic golden cat (WCS Malaysia Prg)
marbled cat (K. Jenks)

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Non-*Panthera* cat species in South-east Asia

South-east Asia covers about 3% of the world's land area yet supports 30% (11) of the world's 36 cat species presently recognised by The IUCN Red List of Threatened Species (IUCN 2012; full citations are given in the reference list to the concluding article). The region's significance is heightened by three of these 11 species (flat-headed cat *Prionailurus planiceps*, bay cat *Catopuma badia* and Sunda clouded leopard *Neofelis diardi*) being confined to South-east Asia and another three (Asiatic golden cat *Catopuma temminckii*, marbled cat *Pardofelis marmorata* and mainland clouded leopard *Neofelis nebulosa*) occurring mostly there. High endemism in South-east Asia is typical of many taxonomic groups (Sodhi et al. 2010). Yet the region is changing very quickly, with rapid habitat change and intensive trade-driven hunting on a scale never seen anywhere else in the world. Many of its species are highly threatened with extinction (Duckworth et al. 2012).

One of the region's cats, tiger *Panthera tigris*, is among the highest profile species for the conservation world and the general public, and another, leopard *P. pardus*, has a huge world range. But the other nine species – here called non-*Panthera* cats, and the topic of this special issue – are barely studied anywhere in their range, historically or recently. Ironically, the one species researched in many countries, leopard cat *Prionailurus bengalensis*, is the only one of these species known to face no serious threat in South-east Asia. The others represented, until recently, a serious challenge even to detect, let alone study. Their populations are assumed to be declining at least in proportion to conversion of natural habitat into agriculture, human settlement and infrastructure, and probably through the effects of hunting, in part driven by illegal trade.

Wild animals have been camera-trapped since the 1890s (Kucera & Barrett 2011). This technique has exploded in use in South-east Asia since the mid 1990s. Non-*Panthera* cats are rarely camera-trap programme targets in the region, but many significant records are generated as bycatch, as evidenced by any issue of Cat News. Beyond the newsworthy individual records lies a vast, presently dissociated, pool of photographs of these cats. Most record species in their generally accepted geographic ranges so seem, perhaps, insignificant as individual records. But with few in-depth studies on these species' natural history and no conservation monitoring programme in place for any of them, these records, provided the identifications of non-target species are made correctly (at present this is not a safe assumption), represent a barely-tapped resource potentially to clarify several topics for each species:

- its present geographic range, with the opportunity to compare with past records;
- the habitats it uses (notwithstanding some difficulties of consistently classifying habitats);
- its encounter rates, which might, with due care, allow some inference on abundance; and
- the threats which it faces.

All these bear on a species' conservation status, that is, its survival prospects. Clear knowledge of these attributes helps design effective conservation programmes. This special issue includes nine contributions (Fig. 1): three (for Thailand, Myanmar and Vietnam) are countrywide reviews of available non-*Panthera* cat records, considering surveys of many sites. Five others digest information from individual survey landscapes. Finally, the concluding article combines information from all the surveys to discuss the regional conservation status of each species. It also speculates on the degree to which the conservation status of non-*Panthera* cats could be tracked by collation and analysis of by-catch records from camera-trapping programmes.

J. W. Duckworth, Antony Lynam and Christine Breitenmoser-Würsten

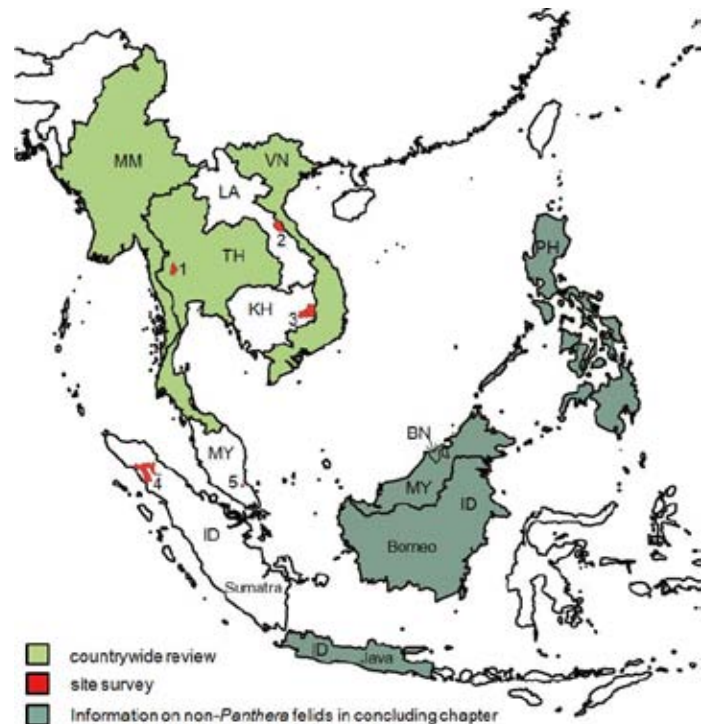


Fig. 1. Individual survey sites (1-5) and countries with reviews on non-*Panthera* cats territorywide. Survey sites: 1 Huai Kha Khaeng Wildlife Sanctuary, 2 Nakai-Nam Theun National Protected Area, 3 Cambodia's Eastern Plains Landscape (Mondulhiri Protected Forest and Phnom Prich Wildlife Sanctuary), 4 Gunung Leuser National Park, 5 Endau Rompin Landscape in Johor. Countries: MM Myanmar, TH Thailand, VN Vietnam, LA Lao PDR, KH Cambodia, MY Malaysia, ID Indonesia, BN Brunei Darussalam, PH Philippines.

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Small and medium sized cats in Gunung Leuser National Park, Sumatra, Indonesia

Small and medium cat diversity and spatio-temporal distribution in Gunung Leuser National Park, Sumatra, Indonesia, was recorded between March and October 2010. A pair of infra-red cameras was set up in each of the 68 locations resulting in 54 independent events of small and medium cats in 3,452 trap nights. Four of the five small and medium cat species confirmed to inhabit Sumatra were photographed: Asiatic golden cat *Catopuma temminckii*, Sunda clouded leopard *Neofelis diardi*, marbled cat *Pardofelis marmorata* and leopard cat *Prionailurus bengalensis*. Golden cat was the most frequently photographed species (0.72 independent event per 100 trap nights), followed by clouded leopard (0.41), marbled cat (0.23) and leopard cat (0.20). Golden cats were predominantly photographed in montane forests 1,800/1,900-2,400/2,500m (34%), marbled cats in medium elevation hills 400/500-800/900m (38%) and montane forests (38%), clouded leopards in medium elevation hills (43%) and leopard cats were mostly found in the lowlands <150m (100%). Golden cats seemed to be diurnal, clouded leopards and marbled cats were active at dawn/dusk, and leopard cats were strongly nocturnal. Trade in Medan of clouded leopard and golden cat (live and stuffed specimens) indicates some level of harvest of these small and medium cats, but data are insufficient to determine whether such harvest is a significant threat.

04

Sumatra is rich in mammal diversity: it is the only place in Asia where tiger *Panthera tigris*, Asian elephant *Elephas maximus*, Sumatran rhinoceros *Dicerorhinus sumatrensis*, and Sumatran orang-utan *Pongo abelli* live sympatrically. Wild cat diversity is no exception. Six species of wild cats are known from Sumatra: the Critically Endangered Sumatran race of tiger *P. t. sumatrae*, Sunda clouded leopard, leopard cat, Asiatic golden cat, flat-headed cat *Prionailurus planiceps* and marbled cat. There are unconfirmed indications of the occurrence of two others: leopard *Panthera pardus* and fishing cat *Prionailurus viverrinus* (van Strien 1996). Small and medium cats are defined here as all Sumatran cat species except those of the genus *Panthera*. Little is known about the conservation status of these small and medium cats on the island (Bezuijen 2000, Holden 2001, Hutajulu et al. 2007, Povey et al. 2009, Duckworth et al. 2009, Sanderson 2009, Wibisono & McCarthy 2010). Accurate assessment of their conservation status is difficult as only few field surveys specifically targeting the natural history of the island's small and medium cats have been undertaken (Povey et al. 2009) compared to big cats such as tigers.

The island of Sumatra is part of a distinctive biogeographical region known as Sundaland (Myers et al. 2000). Sundaland's once undis-

turbed natural forests are now restricted to isolated fragments that survived as a result of official protection. Three protected areas maintain assemblages of Sundaland's unique flora and fauna in Sumatra: Leuser Ulu Masen Ecosystem (including the Gunung - meaning Mount - Leuser National Park NP, 34,000 km²), Kerinci Seblat NP 15,000 km² and Bukit Barisan Selatan NP 3,600 km². These three national parks were designated by UNESCO in 1980 as a Clustered Natural World Heritage Site, reflecting their collective global importance for biodiversity conservation (UNEP 2007). Gunung Leuser NP is part of the larger area known as the Leuser Landscape (27,000 km²) mandated by the Presidential Decree No. 33/1998 for the conservation and restoration of Leuser biodiversity and ecosystem. Together with the Ulu Masen Landscape to the north-west, the area forms the largest natural forest area and biodiversity resource surviving in Sumatra, called Leuser-Ulu Masen Ecosystem (UNEP 2007), a Class I Tiger Conservation Landscape TCL with global priority (Wibisono et al. 2011). Gunung Leuser NP has a rugged forest interior bordered with human-dominated areas and covers various habitat types ranging from lowland forest at 5 m above sea level to the subalpine zone of Gunung Leuser at 3,445 m. This is the highest non-volcanic mountain

in Sumatra, located in the north-western corner of the park (van Strien 1985, Wind 1996, Whitten et al. 1997, UNEP 2007). Griffiths (1996) stated that the full species list of cats in Gunung Leuser was then unknown, but that tigers, clouded leopards, golden cats and leopard cats were already known to inhabit the area.

Three of the five small and medium cats in Sumatra are listed on The IUCN Red List of Threatened Species™ as Vulnerable, the exceptions being leopard cat which is listed as Least Concern and flat-headed cat listed as Endangered. The fishing cat whose presence is unconfirmed is also listed as Endangered. All the above species except leopard cat are listed in Appendix I of CITES (2012). At the national level, all the species are on the list of protected species according to Government Regulation No. 7 year 1999 on Preserving Flora and Fauna Species. Although this study did not gather evidence of targeted hunting, indirect evidence of local hunting is apparent from wildlife trade monitoring in Sumatra. Povey et al. (2009) suggested that some of these small and medium cats may be facing significant population declines due to habitat destruction and fragmentation, declining prey base and targeted hunting.

The conservation status of small and medium cats has not been investigated in North Sumatra. In recent decades, there has been an increase in studies using camera-traps in Sumatra, resulting in many records of small and medium cats. However, there has been little dissemination of these data, in part due to funding and government priorities (Povey et al. 2009). This paper presents the small and medium cat records from a six-month study using camera-traps in Gunung Leuser NP, targeting tigers. It comments on each species's natural history to the extent possible. Evidences of potential threats to small and medium cats in the park are also discussed.

Materials & Methods

This was a collaborative study of the Wildlife Conservation Society – Indonesia Program and Leuser International Foundation (LIF) in north-eastern Gunung Leuser NP (centred on 3°41'N/97°36'E). Infra-red cameras were set up in pairs in 68 stations (all *Panthera* V2Rev2, except one location with Bushnell game camera). The mean distance between nearest-neighbour cameras was 2.09 km (SE 1.04) with a density of 5.4 stations/100 km², within a 1,249 km² minimum convex polygon defined by the outer camera trap locations.

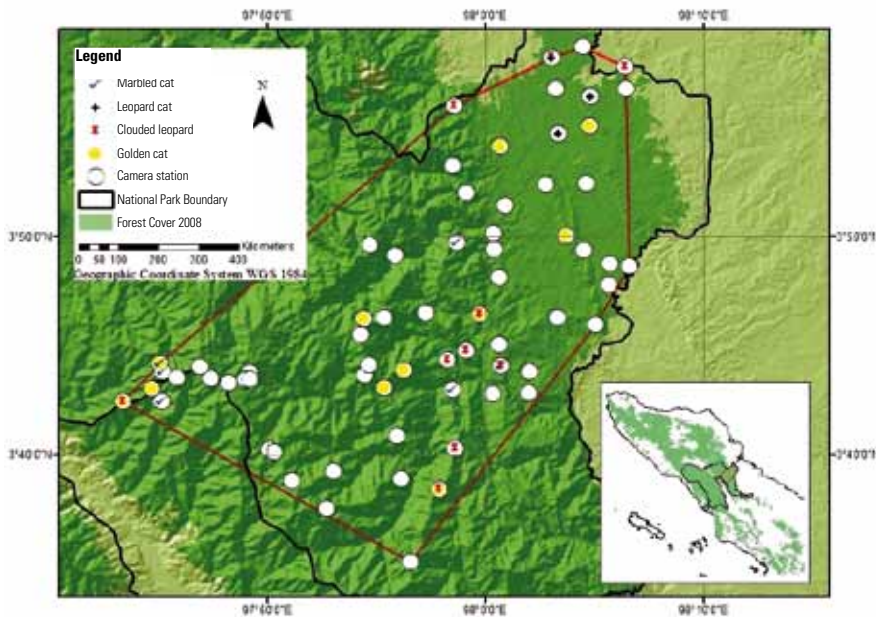


Fig. 1. The study area of Gunung Leuser NP, showing small cat record locations, March to October 2010.

Each camera was activated to photograph animals for 24 hours/day until it was retrieved by the field teams. On average, cameras were activated for 51 days. The cameras were specifically set up for tigers on trails in areas with the highest detection probability, i.e. areas with abundant tiger signs. The opposing cameras were set on a tree with the sensor direction perpendicular to the animal trail, ca. 45 cm above the ground and 4-5 m from the trail (8-10 m separation of the paired cameras). Baits and lures were not used. To prevent condensation within the cameras, they were not set in areas with a high contrast in temperature and humidity between night and day, such as forest gaps with direct sunlight facing the cameras.

Each station was equipped with a pair of cameras, so the total number of trap-nights per station was taken as the number of days that the longest-working camera was functional. Each animal photographed was identified to species: five people separately identified the cats photographed using a mammal identification guide to Borneo (Payne et al. 2000) which has an incomplete list of Sumatran cats. They then discussed uncertain identifications. This process was supervised by the author, with all photographs checked for identification by J. W. Duckworth and T. Lynam. All cat photographs were of sufficient quality for species identification. However, individual identification proved challenging, especially for marbled cats. Golden cats could not be individually identified due to the lack of complex pelage markings. In-

dependent events were defined following O'Brien et al. (2003) as: (a) different species, or consecutive photographs of different individuals from same species, (b) consecutive photographs of same species with time span between capture more than 30 minutes, and (c) non-consecutive individual photographs from the same species.

The set up did not take into account the ecology of arboreal cat species (marbled cat and clouded leopard), potentially affecting the detection probability. There probably is an under representation of species that are partly arboreal, or which avoid trails to a significant extent. Hence, the relative abundance of each cat species in the survey area cannot be deduced from these photographs alone.

Altitudinal zonation based on temperature and vegetation were classified according to Laumonier (1997): lowland (0-150 m), low elevation hills (150-400/500 m), medium elevation hills (400/500-800/900 m), submontane (800/900-1,300/1,400 m), lower

montane (1,300/1,400-1,800/1,900 m), montane (1,800/1,900-2,400/2,500 m) and tropical uppermontane and subalpine (>2,500 m). Altitudinal zonation was used as a proxy for spatial co-occurrence or general information on habitat use, though the limited number of records was insufficient for making a specific conclusion. Habitat use was evaluated based on the number of independent events of each species per habitat with the assumption that arboreal species showed no difference in habitat type use. This assumes that the proportion of time semi-arboreal species spent on the ground and in trees remains the same across the different habitats. Elevations were obtained from Digital Elevation Map SRTM 90 m (Jarvis et al. 2008) from the camera-traps positions measured using the Spatial Analyst Tools in ArcGIS ver. 9.3. Of the 68 locations ranging from 57 to 2,937 m; 23.5% were in lowlands (<150 m), 27.9% in low to medium elevation hills (150-900 m), and 48.5% in submontane to uppermontane (900->2,500 m). The date and time data are available for each picture. The activity period of each species was assessed using the percentage of independent events in each of three time-of-day divisions (Azlan & Sharma 2006): night-time (19:00 h - 05:00 h), day-time (07:00 h - 17:00 h) and dawn/dusk (05:00 h - 07:00 h and 17:00 h - 19:00 h). The activity period of small and medium cats was further defined as: strongly nocturnal (>85% with events between 19:00 h and 05:00 h), nocturnal (50-85% of events between 19:00 h and 05:00 h), dawn/dusk (up to 50% between 05:00 h and 07:00 h, and up to 50% between 17:00 h and 19:00 h), diurnal (50-85% records between 07:00 h and 17:00 h), and strongly diurnal (>85% events between 07:00 h and 17:00 h). This study recorded animals at ground level; therefore the percentage of arboreal activity in a 24 h period is unknown. Little is known about the threats to small and medium cats in Leuser. As preliminary infor-

Table 1. Small cats photographed during a camera trapping study in Gunung Leuser NP, March to October 2010.

Species	Total photographs	Independent events	Individuals	Location records
Asiatic golden cat	63	25	unknown	11
Sunda clouded leopard	38	14	5+	10
Marbled cat	15	8	4+	6
Leopard cat	8	7	3+	3
Total	131	54	-	30



Fig. 2a. Asiatic golden cat photographed on 20 May 2010.



Fig. 2b. Sunda clouded leopard photographed on 8 April 2010.



Fig. 2c. Marbled cat photographed on 14 June 2010.



Fig. 2d. Leopard cat photographed on 7 October 2010.

mation, records of wildlife trade collected by WCS's Wildlife Crime Unit between 2007 and 2011 were examined to describe the nature of illegal trade on these species in Gunung Leuser NP. The number of photo-trapped villagers was also used as an indicator of illegal human activity inside the park. Human activi-

ties without legal permit, other than those associated with park management, protection and research, are illegal according to Government of Indonesia Law No. 5 year 1990 on Conservation of Biological Natural Resource and Its Ecosystem.

Results

Four of the five small and medium cat species confirmed to inhabit Sumatra were photographed (Fig. 1, 2). A total of 3,452 trap-nights over eight months resulted in 54 independent events from a total of 124 photographs of small and medium cats: clouded leopard (14 independent photos; at least 5 individuals), golden cat (25; not determined), marbled cat (8; at least 4 individuals) and leopard cat (7, at least 3 individuals; Table 1, Supporting Online Material SOM T1).

Of these small and medium cat records, 20% were in lowland (<150 m), 29% in low to medium elevation hills (150-800/900 m) and 50% in the submontane to uppermontane (800/900->2,500 m). Golden cats were mostly recorded in montane (34% of 25 independent events) and lower montane forests (31%), clouded leopards were mostly in the medium elevation hills (43% of 14 independent events), marbled cats in montane forests (38% of eight independent events) and medium elevation hills (38%), and leopard cat records were restricted to the lowlands (100% of seven independent events; Fig. 3). Due to very few records, they may not reflect the actual altitudinal distribution of this species. Caution should be taken in inferring any biological patterns from this, particularly with the few records of marbled cat and leopard cat. Golden cats were mostly recorded by day (56%), clouded leopard and marbled cat records all suggested a cathemeral pattern with peak activity by day (43% and 50% re-

spectively), while leopard cats were mostly recorded by night (86%) (Fig. 4). Human activities were found only at two stations, both in lowland habitat.

Discussion

Our study area in Gunung Leuser NP, covering ca. 10% of the park, supports Asiatic golden cat, Sunda clouded leopard, marbled cat and leopard cat. Neither flat-headed cat nor fishing cat was detected; the former is known to occur on Sumatra while there is no confirmation of fishing cats inhabiting the island (Duckworth et al. 2009). Small and medium cat use of encroached and disturbed areas was not assessed: the survey area has mostly intact canopy, and only two of 68 locations had signs of illegal human presence. This perhaps reflects the difficult access to the study area due to its rugged terrain and long distance from surrounding villages.

Holden (2001) recorded golden cats only in the lowland forests of Kerinci Seblat NP, central Sumatra despite extensive survey in montane forest where clouded leopards and marbled cats were recorded. By contrast, golden cats in this study were more commonly recorded in montane forest and Griffiths (1996) also suspected that golden cats have a predilection for higher altitudes in Gunung Leuser NP. These contradictory results may simply reflect the chance patterns shown by small numbers of records, rather than any real difference between survey areas.

The present study found clouded leopards mostly in medium elevation hills and some up to 1,848 m. Griffiths (1996) recorded the presence of this cat from sea level to over 2,000 m, indicating a distribution over a wide range of elevations. The lack of records in higher montane forest in the present survey may have simply been due to chance. The marbled

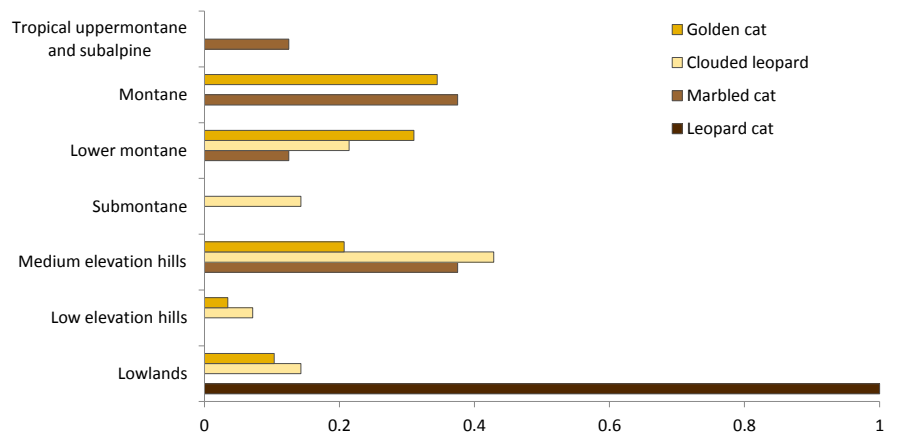


Fig. 3. Habitat records of small cats in GLNP, March to October 2010.

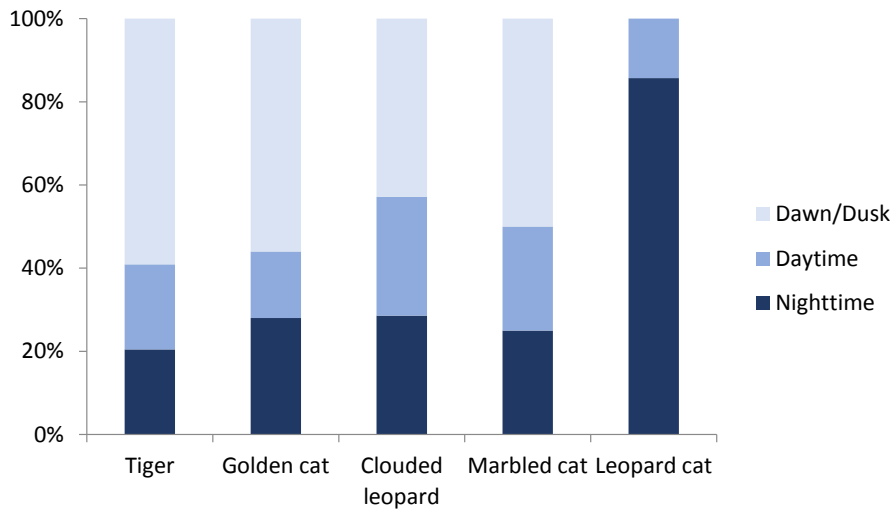


Fig. 4. Apparent activity patterns of cats in GLNP, March to October 2010.

cat is rarely found, with little published information on its ecology (Grassman et al. 2005, Macdonald et al. 2010, Wibisono & McCarthy 2010). In this study it had a lower encounter rate than did the golden cat or the clouded leopard, but the few records indicated a wide distribution from medium elevation hills to tropical upper montane and subalpine forest. The leopard cat was photo-trapped only in lowlands. The reason may be its tolerance or even its association with anthropogenic disturbance such as human settlements (Azlan & Sharma 2006, Povey & Spaulding 2009), and such areas are absent from the survey area's hilly interior. The small number of leopard cats recorded might also reflect the low numbers of cameras in disturbed areas.

Neither van Strien (1996) nor the unpublished data of the Leuser Management Unit 2004 (Povey et al. 2009) reported flat-headed cats in the park. There is no substantiated record of flat-headed cats in northern Sumatra, despite recent records in Southeast Sumatra and Kerinci Seblat (Bezuijen 2000, Holden 2001), as well as central Sumatra (Wilting et al. 2010). The occurrence of another wetland small cat, the fishing cat, in Sumatra, is still uncertain (Duckworth et al. 2009, Sanderson 2009). Siantar Zoo, ca. 200 km from the park, has a captive fishing cat, of unknown origin. The label on the cage informs visitors that it comes from Java (Fig. 5), but it is unclear if this refers to the origin of this individual or the occurrence of the species there. An inquiry at the zoo into the capture location did not return any result. Duckworth et al. (2009) also noted this cat, but similarly could not determine its origin. Flat-headed cat and fishing cat are both strongly associated with wetlands (Azlan & Sharma 2006, Melisch et

al. 1996). Whether these species inhabit the area cannot be determined. The presence or absence of these species was not established by this study as all stations were placed on ridges and not in their preferred habitat, close to water, still or riverine (Melisch et al. 1996). Similarly, there were no records of another riparian small carnivore, otter civet *Cynogale bennettii*, even though this is already known to inhabit the park (van Strien 1996). The south-western area of the park, close to the coastline adjacent to Singkil Barat Nature Reserve, comprises an area predicted to have a great potential for flat-headed cats (Wilting et al. 2010).

Griffiths & van Schaik (1993) suggested that human presence could alter the natural activity patterns of mammals. Our study area had a low level of human disturbance, so the data presumably reflect each species' natural activity period at ground level. The overlap of activity patterns among small and medium cats indicated a level of interspecific interaction of these sympatric carnivorous species. One potential factor influencing the temporal separation of sympatric species is their body size, with similar size animals tend to avoiding each other. Holden (2001) concluded that



Fig. 5. Fishing cat at Siantar Zoo (left) and sign on cage (right).

golden cats in Kerinci Seblat NP are cathe-
meral, and although in Gunung Leuser NP,
recorded activity was somewhat higher dur-
ing day time (Fig. 4) this could simply have
been sampling bias. Predominant diurnal
activity by day concurs with activity readings
from two radio-collared golden cats in Thai-
land's Phu Khieu National Park (Grassman
et al. 2005) and camera-trap records from
14 sites across Thailand (Lynam et al. 2013).
The radio-collar work is particularly informa-
tive because it does not have the camera-trap
bias of only recording activity at ground level.
Clouded leopards in this study tended to be
cathe-meral, with more daytime activity, un-
like those in Borneo (Cheyne & MacDonald
2011) and Thailand (Lynam et al. 2013), which
were nocturnal. Most camera trap records of
marbled cats have been by night (Grassman
et al. 2005, Macdonald et al. 2010, Lynam
et al. 2013); however in this study the few
records of marbled cats fitted a cathe-meral
activity pattern. With only seven independent
records, firm conclusions about leopard cat
activity patterns are unwise, but the noctur-
nal activity pattern suggested agrees with
findings by Macdonald et al. (2010), Cheyne
& MacDonald (2011), and Lynam et al. (2013).
Variation in temporal activity patterns be-
tween areas is largely driven by competition
between species. Therefore, investigating
interspecific interaction between species can
provide a more meaningful interpretation (Ri-
dout & Linkie 2009, Sunarto 2011).

All cameras were set for ground-dwelling
animals; therefore the degree of arboreal
tendency of each small and medium cat af-
fected the detection probability (Giman et
al. 2007, Cheyne & Macdonald 2011). This
is one of a number of reasons why differences
in encounter rates may not reflect patterns of
abundance between species. Similar to Hol-
den (2001) in Kerinci Seblat NP and WCS's
study in Bukit Barisan Selatan NP (WCS-IP,
unpubl. data), golden cat was the most fre-
quently photographed species, followed by

clouded leopard and marbled cat. Leopard cats were photographed least of all (Table 2). Tigers and golden cats are believed to be active mainly at ground level (Guggisberg 1975) and, if correct, tiger-focused camera-traps may be biased towards golden cats among the small and medium cats. Clouded leopards are to some extent arboreal (Grassman et al. 2005, Kitchener et al. 2006, Macdonald et al. 2010). Compared to conspecifics in Borneo, clouded leopards in Sumatra are believed to be more arboreal, hence less likely to be camera-trapped (Macdonald et al. 2010, Holden 2001), but evidence for this is not compelling. The measured abundance at one site in Borneo is much higher (9 adults/100 km²; Wilting et al. 2006) than at another site in Sumatra (1.29/100 km², Hutajulu et al. 2007), but as few sites have been studied caution is urged when assuming island-specific differences. Marbled cats are purportedly heavily arboreal, but again have been too poorly studied to be sure to what extent; they are camera-trapped more often than truly arboreal species like white-handed gibbons *Hylobates lar* and siamang *Symphalangus syndactylus* in Leuser, and appear to be relatively rare in Sumatra and Borneo (Macdonald et al. 2010).

WCS found evidence of medium cat poaching and trade near Gunung Leuser NP (SOM F6). In 2008, two stuffed specimens (one tiger and one clouded leopard) found in trade did not lead to legal prosecutions. In 2011, two live golden cats were found during a WCS-initiated ranger police raid after months of investigation. This case also included the trade of tiger bones and skins. The offenders were successfully prosecuted and imprisoned for 16 months as a result of legal support from the WCS – Wildlife Crime Unit. Both the trade cases were found in Medan, the capital of North Sumatra Province, an important centre for domestic and international wildlife trade (Shepherd et al. 2004). Although the field source of cats in trade is unknown, it is plausible that they came from Gunung Leuser NP. Several unconfirmed reports of small and medium cat trade were also received from villagers around Gunung Leuser NP.

Camera-trap records show low human activity in the study area (SOM F7). However, human pressure is considerably higher in other parts in the park, and leads to habitat destruction. Such areas include Langkat (Aceh's military operation refugee location), around the Kutacane – Blangkejeren road,

Table 2. Photo-trapped small cats at three sites in Sumatra.

Species	Independent events		Individuals	
	Bukit Barisan Selatan NP (WCS unpubl. data)	Gunung Leuser NP (this study)	Gunung Leuser NP (this study)	Kerinci Seblat NP (Holden 2001)
Golden cat	97	25	unknown	10+
Clouded leopard	57	14	5+	4
Marbled cat	46	8	4+	4
Leopard cat	33	7	3+	3
Total	233	54		21+

and the palm oil concession in Tripa swamp forest (PanEco Foundation et al. 2008). Although the park harbours one of the last three populations of Sumatran rhinoceros left on the island (MoF 2007), too few effective anti-poaching patrols are employed, especially given Gunung Leuser NP's proximity to Medan (Shepherd et al. 2004). The city has an international airport and seaport, and serves as Sumatra's primary port of entry and exit. Although we could not infer the impacts of trade on populations of small and medium wild cats in the park, any such trade is illegal under national law (Peraturan Pemerintah No. 7 tahun 1999, Government Regulation No. 7 year 1999). On an international scale all the species except leopard cats are listed on Appendix I of CITES.

After a tsunami hit Aceh province in December 2004, the conservation status of small and medium cats in the park may have deteriorated because of infrastructure reconstruction and oil palm plantation expansion (Povey et al. 2009). Rehabilitation of destroyed settlements relied mostly on local timber resources, resulting in forest degradation (UNEP 2007). The tsunami triggered reconciliation between the Aceh Liberation Movement and the Indonesian Government, thereby stimulating government approval of road-building plans, logging concessions, mineral exploitation and palm oil plantations in Aceh's forested areas. Before the reconciliation, these were strongly discouraged by military activity (UNEP 2007).

Although all small and medium cats are poorly known, more studies are needed to assess the potential occurrence of flat-headed cat and fishing cat in and around the park. Both these endangered species might be severely threatened locally (if either occurs at all), since their preferred habitats, water bodies, occur mostly in lowlands at the fringe of the park.

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Small-medium wild cats of Endau Rompin Landscape in Johor, Peninsular Malaysia

Six species of wild cats were camera-trapped in the Johor Endau-Rompin Landscape which comprises both a national park and Permanent Reserved Forests (PRF). The camera-trapped species were tiger *Panthera tigris*, leopard *Panthera pardus*, mainland clouded leopard *Neofelis nebulosa*, Asiatic golden cat *Catopuma temminckii*, leopard cat *Prionailurus bengalensis* and marbled cat *Pardofelis marmorata*. These records were the result of by-catch in a camera-trapping survey for tigers in this landscape. The geographical distribution of these cats, based on the camera-trap stations, is reported. Incidental information such as their activity patterns indicated that leopard cats and clouded leopards were largely nocturnal, whereas Asiatic golden cats seemed crepuscular and marbled cats diurnal. Such by-catch data from camera-trapping surveys are valuable and should thus be examined in detail as they can potentially be used as a means to focus enforcement efforts especially if the by-catch species is a target for poaching and is recorded with reasonable detectability by camera-trapping.

Peninsular Malaysia is the southernmost tip of continental Asia and is part of the Sundaic sub region of South-east Asia. General species distributions and descriptions of the carnivores, including cats (Felidae), found here include Medway (1969), Lekagul & McNeely (1977), Khan (1992) and Francis (2008). Localized distributions of some carnivores have been reported by Davison (1988), Chew (2007), and Chow (2010).

There are at least seven confirmed species of wild cats in Peninsular Malaysia (Medway 1969, Khan 1992, Francis 2008). In addition to those listed in the abstract, a seventh confirmed wild cat is the flat-headed cat *Prionailurus planiceps*. The presence of two other species has yet to be confirmed, i.e. fishing cat *P. viverrinus* (Kawanishi & Sunquist 2003) and jungle cat *Felis chaus* (Sanei & Zakaria 2010).

There are two records of fishing cat from Peninsular Malaysia, but the origin of these specimens is unclear (Van Bree & Mohd. Khan 1992, Duckworth et al. 2009). Meanwhile a mysterious cat resembling a fishing cat was camera-trapped in Taman Negara (Kawanishi & Sunquist 2003). The cat's picture was reported as 'strong but inconclusive evidence' of a fishing cat after the image was reviewed by various experts. Duckworth et al. (2009) also wondered if there was a misidentification of the fishing cat. Meanwhile Sanei

& Zakaria (2010) themselves concluded that there was a need for more studies to confirm the existence of the jungle cat in Malaysia, as their camera-trapped image was inconclusive.

According to the IUCN Red List of Threatened Species (2010), all the species reported here, except for the leopard cat, are considered threatened or near-threatened in various categories of risk (Table 1). These six species are listed as Totally Protected under the Malaysian Wildlife Conservation Act 2010 (WCA 2010). Under the WCA 2010, harming a Totally Protected species could mean a maximum

Table 1. List of camera-trap independent events for the cat species (and their conservation status) in the park and in the PRF. There were 29 camera-trap stations in the park and 12 in the PRF. Under IUCN Red List categories, the names to the acronyms are EN = Endangered, NT = Near Threatened, VU = Vulnerable, LC = Least Concern. TP means Totally Protected under the WCA 2010, and is the highest form of protection.

Species	Total number of independent events	Number of independent events in park	Number of independent events in PRF	IUCN	WCA 2010
Tiger	72	57	15	EN	TP
Leopard cat	69	23	46	LC	TP
Golden cat	42	40	2	NT	TP
Clouded leopard	22	22	-	VU	TP
Marbled cat	12	12	-	VU	TP
Leopard	11	11	-	NT	TP

fine of up to RM100,000 or imprisonment of not more than three years. The specific fine and jail sentence for harming a tiger is much higher. The different IUCN Red List categories are determined based on population size and trends, its geographic range, and qualitative analyses to show the probability of extinction in the future. This article focuses on small-medium cats outside the genus *Panthera*. However, records for *Panthera* are included in the compilation of tables and graphs for completeness and for comparison with the smaller species, but since they are covered in separate accounts (in preparation), there is no major discussion of them.

This work is part of a conservation and research initiative on tigers and their ungulate prey species under Tigers Forever (a Panthera-WCS collaboration with local partners, Johor National Parks Corporation, Department of Wildlife and National Parks and State Forestry Department of Johor). Although the research component was targeted at tigers, other animals appeared as by-catch in the camera-traps. The objective is to profile current distribution as well as incidental observations of these small-medium cats in the tiger survey area. It also serves to highlight the importance of the site in terms of cat diversity.

Study site

The 584 km² study site falls within the northern part of the Johor Endau-Rompin Landscape (<http://www.panthera.org/programs/tiger/tigers-forever/malaysia> and <http://www.wcs.org/saving-wild-places/asia/endau-rompin-malaysia.aspx>) which is also administratively known as the Johor Wildlife Conservation Project (JWCP) site. The total area of the project site is 2,534 km² (Fig. 1).

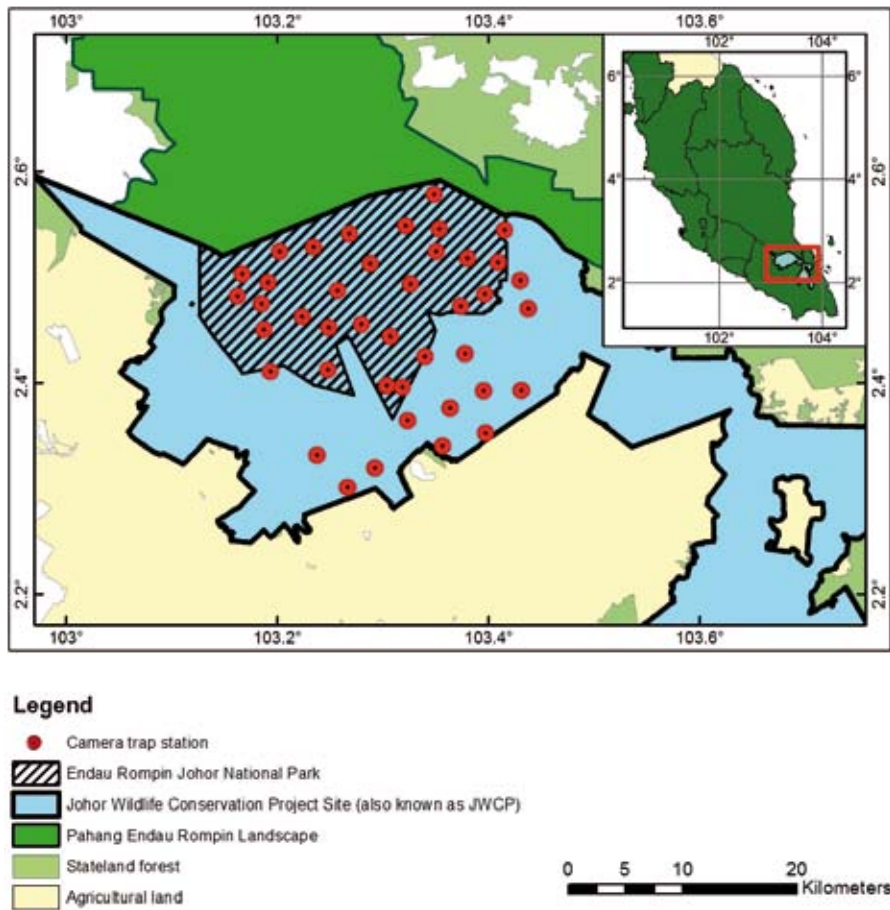


Fig. 1. Study site within the northern part of the Johor Wildlife Conservation Project Site or the Johor Endau Rompin Landscape. Locations of camera-trap sites are shown as red circles with a black dot. The JWCP is also part of the PRF.

There are two main management authorities in this project: Johor National Parks Corporation administering the 489 km² Endau-Rompin Johor National Park, and the State Forestry Department of Johor managing the Labis, Mersing, Kluang, Lenggor and Ulu Sedili Permanent Reserved Forests (about 2,000 km²; Fig. 1). The national park is a totally protected area where official logging in its fringes ceased in 1993 (Chew 2007). Certified sustainable logging practices (<http://www.mtcc.com.my/documents.asp>) are still conducted in the adjacent Permanent Reserved Forests (PRF) in the JWCP.

Endau Rompin Johor National Park (hereafter referred to as "the park") comprises largely of a hilly landscape of mainly volcanic ignimbrite overlain in places by layers of shale and sandstone. Fast-flowing rivers in the upper reaches become wider (about 200 to 300 m wide) in their lower reaches as they pass through the surrounding PRF. The highest peak in the study site is Gunung Besar at 1,029 m above sea level. The main forest type in the park is lowland and hill dipterocarp forest with small localised areas of tropical heath forest on the

sloping plateaus, fan palm forests on ridges and riparian forests bordering the rivers and larger streams. The PRF is also predominantly lowland dipterocarp forest with riparian strips. The vegetation assemblage is considered unique in Peninsular Malaysia but is somewhat similar to those on the west coast of Sarawak, in Borneo (Davison 1988).

As the project site is subjected to the north-east monsoon, it experiences heavy rainfall. For example in a four-day period in December 2007, the rain stations in Mersing and Kluang recorded between 400 and 600 mm of rain causing massive floods in the area, including in the park. Floods occurred again in late January 2011. The average minimum and maximum daily temperatures in the project site are between 23°C and 32°C although the minimum evening temperatures may be 3-4°C lower at the higher elevations (Chew 2007). The main threats to wildlife in the area are transformation of habitat from native forests to large-scale monocultures (oil palm and rubber; Heng 2012a,b,c) and poaching. Snares are the most common hunting equipment used by poachers (Gumal et al. 2012a).

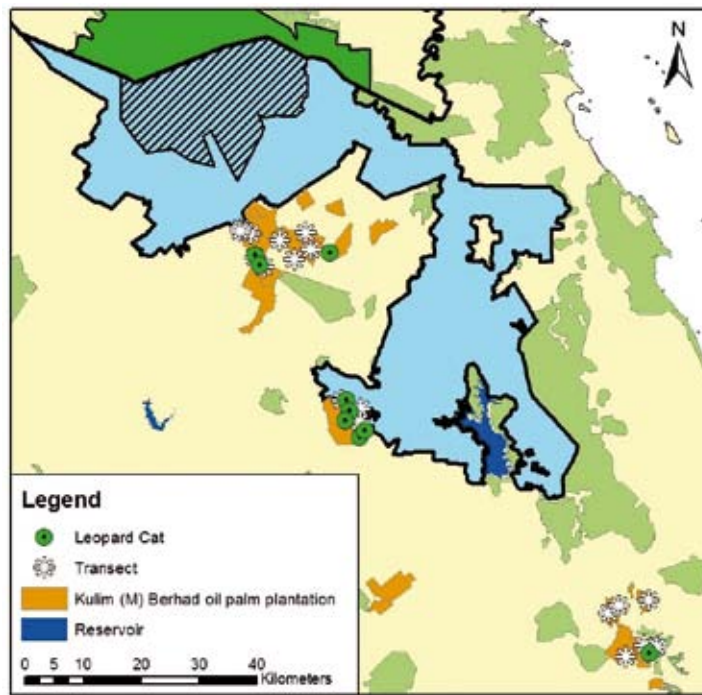
Methods and analyses

Images of small-medium cats mentioned in this article are from a systematic camera-trapping survey for tigers. Camera-trap locations were selected to maximise probabilities of capturing photos of tigers and these included existing trails, old logging roads, river valleys, and ridges, where signs of big cats (fresh scent-marking by big cats on trees, ferns and leaves, as well as tracks, scrapes and large scats) were detected during the sign survey. The field study was conducted between August 2009 and April 2010.

Forty-one camera-trap stations were set in the 584 km² study site (Fig. 1): 29 in the park and 12 in the PRF. Three of the 29 camera-trap stations in the park were on the border with the PRF. There were two camera-traps per station so as to obtain images of both the right and left flank of each animal. Cameras were placed almost opposite each other and were on average 4-7 m apart. Three types of camera-traps with passive infrared systems were used during the field surveys. Of these, two are commercially available: Sniper STC-V650 by Stealth Cam; and Wildeye Trail Camera by Wildtrack Photography. The third was manufactured by Panthera under the Tigers Forever initiative and is not commercially available. There was a rotation and mixing of cameras, for example in some stations, the Sniper was on one side and a Panthera camera on the other. In other stations, the Wildeye would be on one side and a Panthera camera on the other. Cameras which failed or were stolen were replaced, sometimes with other models. It is uncertain as to whether the cameras had similar reliability at detecting wildlife.

Camera-trap stations were about 3 km apart (minimum 2.3 km, maximum 4.69 km, on average 3.43 km apart). Camera-traps were mounted on trees or on artificially erected wooden poles when there was no suitable tree at the station. Each camera-trap was set at least 2 m away from the closest part of the trail in front of the camera-trap and its infrared sensor range was set at a height of 45 to 50 cm which is thought to be an ideal height for capturing tigers (Karanth & Nichols 2002). Cameras were set to record both day and night. This allowed inferences to be made on day-night activity patterns for frequently-photographed species. The results were subjected to the assumption (not yet tested) that they were not biased by systematic differences in activity levels between the ground (where animals are detected) and in the trees (where they are not). Baits were not used.

Fig. 2. Location of transects and observations of cats in plantations. Only the leopard cat was seen near the transects and all of these were at the oil palm plantations.



Several different people ran the camera-trapping survey. All team leaders, however, were trained by the same trainers, John Goodrich and Liang Song Horng. Both of them used similar protocols (including going through a checklist) in terms of site selection, searching for signs of big cats and camera setting. John Goodrich officially conducted two trainings. The same team and the trained leaders then worked their way across both the park and the PRF and chose similar field conditions in setting up the camera-trap stations. As in Than Zaw et al. (2008), it is thus assumed that this close control minimises the possibility of individual methodological differences which could influence patterns in results between the park and PRF sites.

Table 2. Survey effort at the study site. Photos triggered by sunlight, leaves and camera malfunctions are excluded from the calculation of photographic events. Photographic events are explained in the text.

Survey effort	PA	PRF
Number of camera trap stations	29	12
Total trap nights	3582	1194
Average trap nights	123	99.5
Number of photographic events of all wildlife	3380	945
Minimum trap night (for one site)	49	59
Maximum trap night (for one site)	187	150

Each camera-trap was set to take three sequential images when the camera detected motion and was triggered under adequate lighting conditions. The time-delay between each image capture is 0.3 seconds. These three images were considered as one trigger event. At low light, such as on very cloudy days or at night, the camera-trap was set to trigger once for any animal as it used the in-built flash and the re-charge time for the flash was 10 seconds. Thus, at low light, there was only one image for each trigger event, unless the animal was stationary in front of the camera for periods of more than 10 seconds.

All the wildlife images were reviewed by the team. J. W. Duckworth reviewed the identification of all images in September 2011. Various other people were also shown some of the images and helped with the identification: J. Hon, D. Kong, J. Mathai, E. Stokes, and J. Walston. Images that could not be positively identified to species were removed from the analyses.

A standard data collection format similar to Karanth & Nichols (2002: 183) was used to facilitate matching camera-trap triggers and associated non-independent and independent photographic events (time, location and picture ID) with the correct sampling occasion. As per Than Zaw et al. (2008), the non-independent events were cases where a camera-trap station recorded what may have been the same individual animal on multiple frames with successive trigger events. In this study, non-independent events were those separated by 30 minutes

or less (O'Brien et al. 2003, Linkie & Ridout 2011). Any number of animals of the same species on a frame constituted only one event.

Since the locations of camera-trap stations were chosen to maximise the chance of capturing tigers, smaller carnivores (and other mammals), which might be averse to tiger signs and scents, may avoid these stations and thus be un- or under-detected. There are, however no literature reports to justify this concern. Taller height settings (optimised for tigers) for the cameras might mean missing small carnivores when indeed they were present (Than Zaw et al. 2008), but again we have traced no investigation of the reality of this concern with these models of camera. For these and a host of other reasons and because these surveys were designed for tigers, there is a need for subjective interpretation of the results for these smaller animals.

The small and medium cat distributions presented in this note result from camera-trap captures on suspected tiger-biased trails or stations in the northern section of the project site. Due to concerns over poaching, and a Johor Ministerial directive, precise locations of the camera-trap sites are not included in this paper. The scale of the maps (Fig. 1) is small enough to keep the locations vague.

These data are supplemented by sightings of small cats observed during line transect walks for all wildlife (23 transects) by an experienced wildlife survey team, whilst attending to harp traps and mist nets during bat surveys in some of the plantations surrounding the project site (Fig. 2). There were a total of 53 survey days between June and December 2010. LED white-light head torches (powered by 3 AAA batteries) were used during the walks. Observer bias was reduced as the team members rotated walking the transects. The transects were walked between 04:00 h-10:00 h and 16:00 h-21:30 h each day and at a speed of roughly 500 m/hr, with the observer stopping for one minute every 100 m to observe animals. There were only two members in this experienced team: Daniel Kong, with over 25 years of Malaysian bird and mammal identification, and his Iban (indigenous) tracker, Lihon Singga who has worked on wildlife survey and identification projects since 1997. Both have handled various carcasses of wildlife, including leopard cat, flat-headed cat, banded linsang *Prionodon linsang*, common palm civet *Paradoxu-*

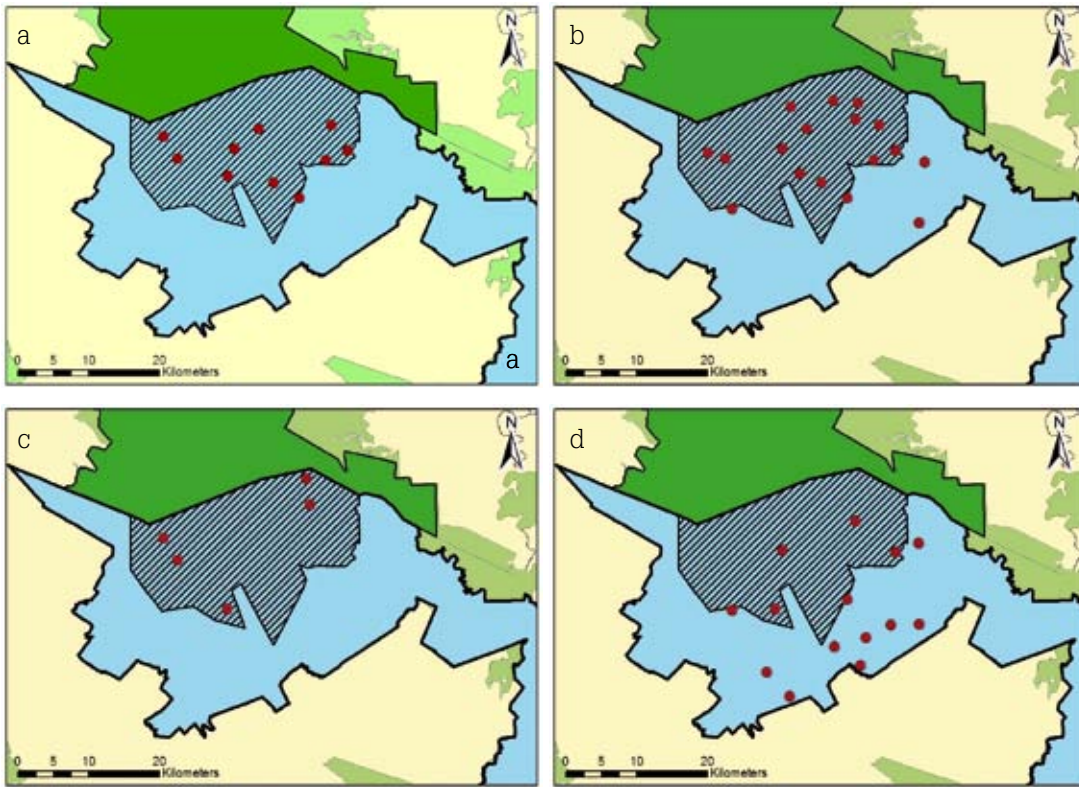


Fig. 3. Distribution based on these camera-trap stations showing the records of (a) clouded leopard, (b) golden cats, (c) marbled cats and (d) leopard cats. The other area keys are shown in Figure 1.

rus hermaphroditus, Sunda pangolin *Manis javanica*, large flying-fox *Pteropus vampyrus*, sun bear *Helarctos malayanus* and various squirrels (Sciuridae) in road kills or in hunting incidents involving villagers. Thus, although the direct sightings cannot be independently corroborated, they are as credible as the method allows, whilst acknowledging that transects are not a good tool for surveying carnivores in some places such as Borneo (Mathai et al. 2013).

Results

There were a total of 4,776 camera-trap nights during the seven-month period and over 4,325 photographic events (independent and non-independent events) of wildlife. The survey effort is shown in Table 2. There were 228 independent camera-trap events of all wild cat species during the seven-month period.

The largest non-*Panthera* cat was the clouded leopard and the smallest was the marbled cat. Although the marbled cat and the leopard cat are sometimes described to be almost similar in size (Sunquist & Sunquist 2002), the measurements reported by Medway (1969), Khan (1992) and Francis (2008) indicate that the former may be slightly smaller. The most common camera-trapped small-medium cat was the leopard cat (69 independent events). The full list of cat independent events is shown in Table 1. The combined distance

walked was 137.6 km. Only leopard cats were observed during the transect walks and were recorded 17 times (Table 3).

By-catch camera-trapped distribution

Asiatic golden cats and leopard cats were camera-trapped at 17 and 15 stations respectively (Table 3). Both species were detected in the park and PRF. However, clouded leopard and marbled cat were only recorded in the park and not in the PRF. Leopard cat was predominantly camera-trapped in the PRF rather than in the park. This is not a simple consequence of differential trapping effort in the two areas as the field teams used the same guidelines throughout the study site. A distri-

bution based on these camera-trap stations with records of the various small-medium cat species is shown in Fig. 3. Although leopard cat was camera-trapped more often than the Asiatic golden cat (Table 1), it appeared at fewer camera-trap stations (Table 3).

Activity patterns of various cat species

A breakdown of the numbers of independent events for the various small-medium cat species is shown in Figure 4. Leopard cats were largely recorded by night with highest numbers of independent events recorded between 22:01 h and 24:00 h. Asiatic golden cats seem to be almost crepuscular (active during dawn and dusk), although there was

Table 3. Camera-trapped cats in park (29 stations) and PRF (12 stations), and incidental observations in plantations. The table ranks the order of abundance for number of camera-trap stations recording each species. The figures in parenthesis show the percentage of total camera-trap stations which recorded the animals in the respective area.

Species	# of stations where species recorded	# of park stations where species recorded	# PRF stations where species recorded	Sightings in plantations
Tiger	20	15 (51.7%)	5 (41.7%)	
Asiatic golden cat	17	15 (51.7%)	2 (16.7%)	
Leopard cat	15	7 (24.1%)	8 (66.7%)	17
Clouded leopard	11	11 (37.9%)	0	
Leopard	6	6 (20.7%)	0	
Marbled cat	5	5 (17.2%)	0	

Table 4. Comparison of independent capture events for various species with two active cameras. The numbers in parentheses are the percentages of independent camera-trap events for each species.

	Numbers of independent events (%)					
	Tiger	Leopard	Clouded leopard	Asiatic golden cat	Marbled cat	Leopard cat
Two active cameras, one captured animal	25 (54.3)	3 (60)	7 (43.8)	14 (50.0)	5 (45.5)	27 (77.1)
Two active cameras, both captured animal	21 (45.7)	2 (40)	9 (56.3)	14 (50.0)	6 (54.5)	8 (22.9)

a small spike in records between 12:01 h and 14:00 h. Marbled cats were largely recorded by day, whereas clouded leopards appeared almost only by night.

Other incidental information

The camera-trap images did not reveal much of the diet of the cats, except for one, where a uniform-coloured Asiatic golden cat appeared to have a rodent in its mouth (Fig 5b). The image was taken along an old logging road at 22:55 h in the park, amid lowland dipterocarp forest.

Five different individuals of the Asiatic golden cat were photographed in the study with a distinctive coat-pattern looking as if they had been 'watermarked'. Out of a total of 43 independent events, five Asiatic golden cats were individually identifiable and the other 38 showed uniform-coloured animals. All five 'watermarked' individuals are shown in Figures 5a, c-f. The extent of watermarking varied. The most evident is seen in Figure 5a, whereas only some watermarking can be seen on the limbs of the other individuals in Figures 5c-5f. No other colour variations of this species such as the black, cold-brown or

grey were camera-trapped in the project site.

Dual cameras and independent capture events of various cat species

In an ideal situation at a station with two active cameras, both cameras should be triggered simultaneously when any target animal passes between them. This was assumed as the cameras were set at an ideal height for these animals thus supposedly improving their capture probability. However the unpredictability of some camera-traps and changes in microhabitat conditions can sometimes affect the triggering of the cameras. Table 4 shows the double-sided and single-sided camera-trapped, independent events of the various species when both cameras are active. As noted, even for tigers, only 45.7% of the independent events included both flanks of the animal.

The percentage of both camera-traps being triggered in independent events for all the species ranges from 22.9% (leopard cat) to 56.3% (clouded leopard). However, as seen in Table 4, the percentage of images with both flanks for leopard cats is almost half that of other species, including that of a similar sized animal, the marbled cat. As can be seen in

Figure 6, the sizes of the marbled cat and the leopard cat are almost equal. The image is from the same camera-trap station.

Discussion

Six of the seven wild cat species confirmed in Malaysia were recorded in the study site. The same number of cat species was observed by Kawanishi & Sunquist (2004) in Taman Negara and Jerangau Forest Reserve in Terengganu (Mohd. Azlan & Sharma 2006). Meanwhile, a rapid camera-trap assessment of tigers at nine sites in Peninsular Malaysia also showed the presence of these six cats (Lynam et al. 2007). The number of cat species recorded for each individual site by Lynam et al. (2007) ranged from three to five. A more recent camera-trapping survey at a study site of 40 km² at Temenggor Forest Reserve also yielded six cat species (Rufino et al. 2010). In the Rufino et al. (2010) study, however, while leopards were not detected, flat-headed cats were camera-trapped twice (Table 5). Camera-trapping studies in the Bala Forest (115 km², part of Thailand's Hala-Bala Wildlife Sanctuary), on the Thai-Malaysian border detected five cat species (Kitamura et al. 2010), while Simcharoen et al. (2014, this issue) detected six. Flat-headed cats were however not detected during these studies. It seems that the least detected wild cat in all the above studies is the flat-headed cat. However, flat-headed cats are not restricted to Temenggor as they have been recently reported further south as shown in a road kill in Kuantan District, Pahang (Syarifah Khadiejah et al. 2011) and in various states in Peninsular Malaysia (Lim & Nazim 2007). However, in all the other reported sightings and camera-trap photos of the flat-headed cat in Kuantan, Pekan, Upper Sungai Rompin, Krau Wildlife Reserve as well as Fraser's Hill, they have been found close to water-bodies such as rivers or peat swamps. Furthermore, as suggested by Wilting et al. (2010) camera-trapping focused on large cats, i.e. with stations placed on large roads and ridges, could be ineffective in detecting flat-headed cats as they are often reported along the edges of lakes, ponds or rivers (Gumal et al. 2010, Wilting et al. 2010). Large-cat based sampling may bias capture probabilities of flat-headed cats (Wilting et al. 2010). Interestingly, Rufino et al. (2010) designed their study to examine ground-dwelling mammal diversity and did not specifically target large cats and it yielded images of flat-headed cats. In contrast to this current work at the project site, Kawanishi & Sunquist (2004) found that

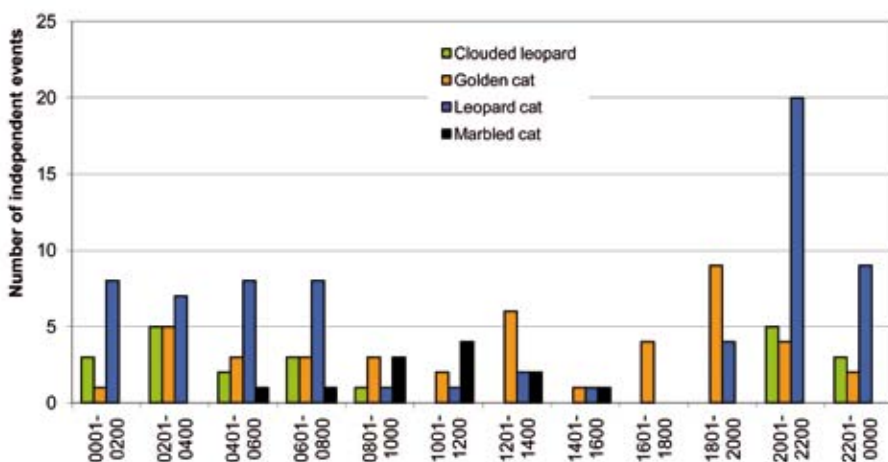


Fig. 4. Numbers of independent events of various non-*Panthera* cat species in camera-traps in relation of the time of capture.



Fig. 5a (left) and 5b (right). A 'watermarked' Asiatic golden cat is shown on the left as a comparison to the uniform-coloured form on the right. There were only five different 'watermarked' individuals found at the project site, during the study period. The rest of the 'watermarked' individuals are shown in Figures 5c – 5f. A rodent is seen in the mouth of the uniform-coloured golden cat on the right.



Fig. 5c to 5f (top left to bottom right). Images of four watermarked individuals. The images were enlarged and zoomed in by the team and verified to have different individual markings on the limbs as well as the tail. The fifth individual is shown in Fig 5a.

the most commonly camera-trapped cat was leopard, followed by leopard cat, tiger, Asiatic golden cat, marbled cat and clouded leopard (see Table 5). The order of abundance of independent events by species in this study was also slightly different from the order of abundance of images by species, recorded by Mohd. Azlan & Sharma (2006) and Rufino et al. (2010). Unfortunately nothing explicit can be inferred about the actual or true heterogeneity of the cat community between these sites as these differences could reflect, between the survey areas, genuine differ-

ences in relative abundance, differences in relative proportions of camera-trap effort at the macrohabitat scale, or difference in microhabitat location of the camera-traps, or, most probably, some combination of these factors. There is also the issue of images versus independent events (and there were different definitions of independence), that has an effect on the comparisons. Regardless, as all these six cat species are listed as Totally Protected under the WCA 2010, the project site is therefore an important area for the diversity of wild cats. Vigilance and en-

forcement must be maintained and probably enhanced in order to reduce levels of habitat disturbance such as clearance for oil palm or rubber plantations (Aziz et al. 2010, Heng 2012c) and poaching.

The activity pattern for clouded leopards, golden cats and leopards in the project site appears to be quite similar to those recorded by Mohd. Azlan & Sharma (2006) at Jerangau Forest Reserve. Kawanishi & Sunquist (2008) also reported a largely nocturnal activity pattern for golden cats in Taman Negara. The activity pattern for clouded leopard and Asi-

Table 5. Independent events of camera-trapped carnivores from the study site. The other columns show the total number of camera-trapped photographs of different cat species in (A) Taman Negara (Kawanishi & Sunquist 2004), (B) Jerangau Forest Reserve (Mohd. Azlan & Sharma 2006), (C) the nine Malaysian sites by Lynam et al. (2007) and (D) Temenggong Forest Reserve (Rufino et al. 2010) respectively. Comparisons should not be made between sites as the method in deriving number of 'photographs' is different for the various researchers. This table highlights the uncommon species such as the flat-headed cat.

Species	This study	A	B	C	D
Number of camera-trap nights	4,776	4,865	5,972	6,259	2,813
Tiger	72	61	151	51	7
Leopard cat	69	62	86	31	7
Asiatic golden cat	42	37	38	69	4
Clouded leopard	22	16	13	25	18
Marbled cat	12	16	1	10	20
Leopard	11	150	103	70	0
Flat-headed cat	0	0	0	0	2

atic golden cat in the project site appeared to be similar to those recorded in the nine sites studied by Lynam et al. (2007; WCS & DWNP, unpubl. data).

The activity pattern for marbled cats appeared to be diurnal, with a peak between 10:01 h to 12:00 h. Unpublished data from Kawanishi's 1999 to 2001, and 2010 to 2011 camera trap surveys of tigers in Taman Negara and the forests around the area (Main Range) also had more marbled cats camera-trapped during the day (82%) with a peak in the late afternoon (16:00 h to 18:00 h). No useful comparison could be made for marbled cats with the study by Mohd. Azlan & Sharma (2006) as they only recorded a single image, whereas the activity patterns for the other two studies were unreported. All of these assignments reliably refer only to ground-level activity. For reputedly semi-arboreal species (clouded leopards and marbled cats), the extent to which the observed patterns reflect overall activity cannot be determined as it is impossible to differentiate shifts between arboreal and ground activity periods.

In terms of occurrence in the various land use areas, the independent capture events of leopard cats in all the three areas (PA, PRF and plantations) seems to confirm the versatility of this species in these landscapes (Lim & Nazim 2007, Maddox et al. 2007). It is difficult to ascertain the distribution of Asiatic golden cats and marbled cats in plantations from this study. Even where camera-trapping records them frequently, the probability of having direct sightings of these species remains very low. Meanwhile marbled cats may exhibit greater diurnal behaviour, with a

peak after 10:00 h (Fig. 4) and as some of the transect walks are conducted at dawn and evening, direct sightings surveys in plantations might therefore be biased against seeing these animals. Another explanation could be that oil palm plantations may not be suitable for marbled cats and Asiatic golden cats in general (Maddox et al. 2007).

Various camera-trapping studies in Sarawak, Malaysia have shown marbled cat presence in non-logged areas in Selaan-Linau (Mathai et al. 2010) and in logged areas in Anap Muput (J. Hon, pers. comm.). In Peninsular Malaysia, they have also been reported in protected areas such as Taman Negara (Kawanishi & Sunquist 2004, Lynam et al. 2007), as well as the PRFs of Bintang Hijau and Gunung Tebu (Lynam et al. 2007) and were the most photographed cats in the logged forests in Temenggong (Rufino et al. 2010).

Clouded leopards were recorded in the park but not in the PRF. However, subsequent camera-trapping in a southern PRF (not part of the above study site), found clouded leopards at Bukit Lutong and Gunung Berlutum reserved forests. Laidlaw (2000) recorded them in logged PRF of Kemasul and Lynam et al. (2007) also found them in other Permanent Reserved Forests in Malaysia and also in protected areas such as Taman Negara, as did Kawanishi & Sunquist (2004). Meanwhile, Rufino et al. (2010) also recorded clouded leopard in the logged forests in Temenggong, and in fact, it was the second-most commonly recorded species.

Anecdotally, the 'watermarked' Asiatic golden cats have been camera-trapped in parts of the Sundaic region (J. W. Duckworth in litt. 2011), but we have traced no records

from the rest of the Asiatic golden cat range. These coats have not been observed by M. Rufino (pers. comm.) in Temenggong, although M. Darmaraj (pers. comm.) has some images with parts of their bodies and faces 'watermarked'. They have also not been observed in Taman Negara (K. Kawanishi, pers. comm.). The five 'watermarked' individuals in the project site are intriguing and the distribution of this form requires further investigation to determine if these watermarked coats are indeed more prominent here than elsewhere in Peninsular Malaysia.

It is uncertain why the percentage of images with both flanks for leopard cats is almost half of those from other species. A theoretical explanation of leopard cats being missed by one of the cameras could reflect their use of the edges of the animal trails or the logging roads thus passing below the camera sensors when they are closer to the camera. But, this is probably not plausible, because most of the images show leopard cats walking close to the middle of the trails or the roads. Another explanation would be the capture probability for smaller wildlife is less when compared with that of larger animals (Tobler et al. 2008). This does not explain why the percentages of images for single and both flanks of marbled cats are similar as compared with that of the leopard cat. As indicated in Figure 6, the sizes of leopard cats and marbled cats are approximately the same.

Despite the limitations to the uses of by-catch data, they can still be used for conservation purposes as they can at least provide local knowledge of the occurrence of the various species to forest and park managers. Very high survey efforts can record

actual distribution patterns which can be used by managers to increase enforcement efforts at priority stations thereby reducing poaching threats. This is important especially when snares are the preferred method used by poachers who are indiscriminate in their killing or capturing of wildlife (Gumal et al. 2012b). Currently, there are increased enforcement efforts at priority tiger-use stations since tigers are hunted assiduously for trade.

Finally, parts of the project site are under threat as there are plans to convert some of these logged PRFs to rubber plantations. Whilst this survey has not focused on this newer, human-made landscape, one should invariably be concerned as there is uncertainty over how these wild cats would fare in these anthropogenic, industrial monocultures. Intensive oil palm or rubber plantations tend to be 'managed and manicured' for production through the removal of scrub and understory which are thought to reduce the productivity of crops. Furthermore, scrub and understory are also potentially hazardous to the plantation workers as noted from the repeated tiger attacks at unkempt rubber small holdings in Jeli, Malaysia (Anonymous 2000a, Anonymous 2000b). Understory is potentially important for these larger cats, which use it to surprise their prey (Maddox et al. 2007, Sunarto et al. 2012). It will therefore be no surprise if, in the future, when the bulk of the native forests are whittled away and replaced by rubber (Aziz et al. 2010, Tan 2009, Tan 2010, Heng 2012c) or oil palm plantations (Koh et al. 2011), we find the West Malaysian landscape dominated by the most tolerant cat

species, perhaps only the leopard cat (Maddox 2007).

Conclusion

Six species of wild cats have been recorded at the study site, comprising both logged PRFs and the Endau-Rompin Johor National Park. The largest non-*Panthera* cat was the clouded leopard and the smallest, the marbled cat. Activity patterns based on independent events from camera-trap data showed the following: leopard cats were largely recorded by night with highest numbers of independent events recorded between 22:01 h and 24:00 h; Asiatic golden cats seemed to be almost crepuscular, although there was a small spike in records between 12:01 h and 14:00 h; marbled cats were largely recorded by day, and clouded leopards appeared almost only by night.

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Fig. 6. Images of a marbled cat (left) and leopard cat (right) at the same camera-trap station. The tree in the background serves as a common reference to both images. The sizes of both animals appears closely similar. Given that the marbled cat appears further away, it may actually be larger than the leopard cat. However, the leopard cat could be a juvenile. Direct comparisons are difficult if ages and sex of the animal are uncertain.

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The status of jungle cat and sympatric small cats in Cambodia's Eastern Plains

South-east Asia is a global hotspot for cat diversity with up to eight species occurring sympatrically. The Eastern Plains Landscape of Cambodia contains the largest extent of deciduous dipterocarp forest remaining in Indochina. Two protected areas within the Eastern Plains Landscape (Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary) were camera-trapped extensively (>220 locations; >18,500 camera-trap nights) between 2008 and 2012. Six cat species, leopard *Panthera pardus* (391 encounters), leopard cat *Prionailurus bengalensis* (122 encounters), jungle cat *Felis chaus* (19 encounters), marbled cat *Pardofelis marmorata* (four encounters), mainland clouded leopard *Neofelis nebulosa* (three encounters), and Asiatic golden cat *Catopuma temminckii* (two encounters) were photographed. Leopard cats were encountered equally frequently across forest types (deciduous dipterocarp forest and mixed deciduous/semi-evergreen forest) but jungle cats were photographed more often in deciduous dipterocarp forest. Activity patterns also differed between the two species with jungle cat more diurnal than leopard cat. This represents the first published analysis of jungle cat habitat preferences and activity patterns in South-east Asia and provides further evidence that jungle cat is a deciduous dipterocarp specialist in Indochina. With few areas of extensive undisturbed deciduous dipterocarp forest elsewhere in the species' South-east Asian range, the Eastern Plains jungle cat population is likely to be regionally significant.

Wild cats are amongst the most threatened families of land mammals with 24 of 35 species listed by IUCN as Threatened or Near Threatened. South and South-east Asia is a global hotspot for cat diversity with up to eight species occurring sympatrically in mainland South-east Asia and north-east India (Grassman et al. 2005a, Choudhury 2010). The lowland forests of northern and eastern Cambodia, and adjacent areas of southern Laos and western Vietnam, represent one of the largest and most remote areas of lowland deciduous forest remaining in mainland South-east Asia (Tordoff et al. 2005). Although studies of wild cats involving camera-trapping and radio-telemetry have been undertaken in mixed-deciduous and semi-evergreen forests in Thailand (Grassman et al. 2005a,b, Austin et al. 2007) there is little published information on the status, ecology or conservation of wild cats from the lowland deciduous forests of Indochina which might support a similar diverse assemblage of species.

Jungle cat occurs widely across tropical and sub-tropical Asia from Arabia and North eastern Africa to South-east Asia (Corbett & Hill 1992) with recent possible records from the Malay Peninsula (Sanei & Zakaria 2010). The species is listed by IUCN as Least Concern and, despite apparent declines in some ar-

reas, is generally regarded as the most common and widely distributed wild cat in the Indian subcontinent (Duckworth et al. 2005). However, Duckworth et al. (2005) reviewed the status of jungle cat in Indochina (*sensu* Cambodia, Laos and Vietnam) and documented considerably fewer historical and recent records than most other small-medium size cats in these countries (e.g. leopard cat, Asiatic golden cat, clouded leopard). Recent and historical observations were mostly from remote lowland deciduous dipterocarp forest in northern and eastern Cambodia. Duckworth et al. (2005) suggested that jungle cats were highly threatened in Indochina due to dependence upon heavily hunted, relatively accessible, lowland deciduous dipterocarp forest with no evidence of the species using closed semi-evergreen and evergreen forest which may act as source populations for other cat species. Given the lack of information on the species' ecology, habitat use and behaviour, together with the species' potentially perilous conservation status across Indochina, Duckworth et al. (2005) recommended that all jungle cat records from the region merited publication.

Extensive reconnaissance camera-trapping was undertaken across Cambodia, including the areas covered in this paper, between

1999 and 2007 and records of cats from that period in eastern Cambodia are dealt with in summary by Gray et al. (2012). Subsequently, since 2008, the World Wide Fund for Nature (WWF), in collaboration with the Cambodian government, has undertaken extensive biodiversity monitoring, primarily using camera-trapping and line transects, in two protected areas, Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary, in eastern Cambodia. This paper summarises camera-trap records of wild cats from this data-set to provide a preliminary assessment of their status and ecology within these protected areas.

Methods

Study Area

Mondulkiri Protected Forest (MPF; 3,630 km²; approximate location 12°08' N/106°05' E) and Phnom Prich Wildlife Sanctuary (PPWS; 2,200 km²; 12°40' N/107°00' E) form part of the transboundary Eastern Plains Landscape protected area complex (which also includes Seima Protection Forest and Lumphat Wildlife Sanctuary in Cambodia and Yok Don National Park, Vietnam; Fig. 1). The general elevation is under 300 m and both sites are dominated by deciduous dipterocarp forest (approximately 80% in MPF; 70% in PPWS) with smaller areas of mixed deciduous forest (in west and south-east MPF, 9% and throughout PPWS, 23%). Other habitats include, to a lesser extent, semi-evergreen forest in PPWS (9%) and small areas of MPF (1%). There have been few botanical studies published on the composition of the forest types in the study area but Pin et al. (2013) provides data on the species composition and stand structure of deciduous dipterocarp forest in MPF and PPWS.

Camera-trapping

Between December 2008 and December 2012 parts of central and western MPF and eastern PPWS were extensively camera-trapped using commercially available infra-red, digital camera units with passive in-frared motion detection (Reconyx RapidFire Professional PC90; WI, USA) in which all photographs are digitally stamped with date and time. Cameras were placed in locations (e.g. alongside roads and footpaths, dry stream beds and at seasonal waterholes) chosen to maximise chances of encountering large terrestrial mammals, primarily large carnivores (leopard and tiger *Panthera tigris*) and wild cattle (banteng *Bos javanicus* and gaur *Bos gaurus*). A total of 226 camera-trap locations (72 in Mondulkiri Protected Forest; 154 in Phnom

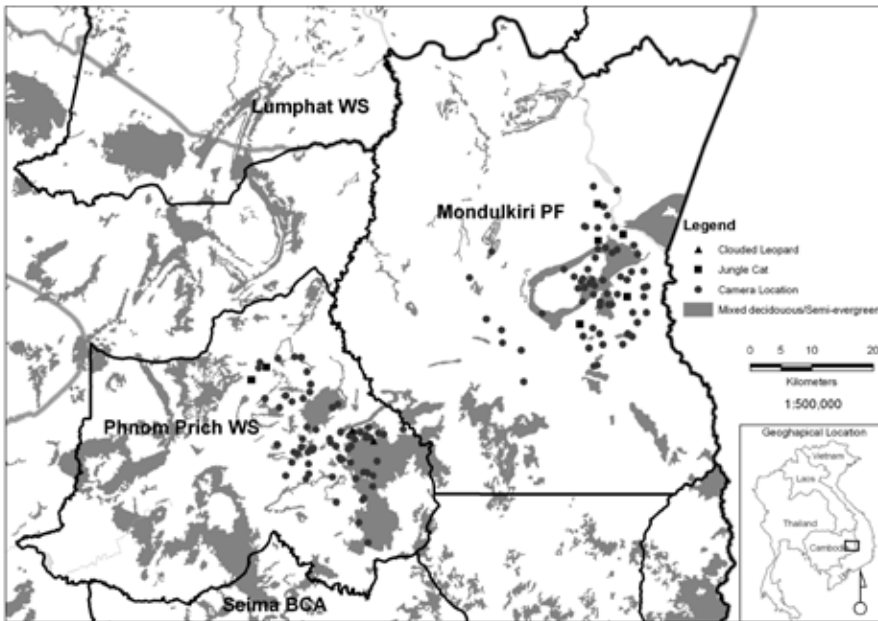


Fig. 1. Location of camera-traps (and all jungle cat and clouded leopard records) within Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary, eastern Cambodia. Extent of mixed deciduous/semi-evergreen forest indicated; all white areas within protected areas represents deciduous dipterocarp forest.

Prich Wildlife Sanctuary) were trapped for 18,952 camera-trap nights (Fig. 1).

No cameras were baited and all were continuously operational. All cameras were placed on trees between 20 and 150 cm (mean 50 cm) above the ground. All notionally independent encounters with wild cats, defined when successive photographs of the same species at the same location were separated by more than 30 minutes, were extracted from the camera-trap data and the date, time and camera-trap location were recorded. All species identifications from the photographs

were made by the lead author (TNEG). For any photographs where identification may have been unclear (for example some photographs of leopard cats which could be confused with fishing cats *Prionailurus viverrinus*) confirmation was sought from members of the IUCN SSC Cat Specialist Group.

Camera-traps were classified as located within either deciduous dipterocarp forest, mixed deciduous/semi-evergreen forest, or boundary areas (see below) as defined by remotely-sensed forest cover data-set (JICA 2003). Mixed deciduous and semi-evergreen

forests were combined as the remotely-sensed data-set used did not distinguish these two forest types consistently. Boundary areas, approximating the ecotone between forest types, included all camera-trap locations <2-km from habitat edge as indicated by the remotely sensed habitat classification. The classification of these camera-trap locations as boundary areas, although arbitrary, is necessary due to both potential inaccuracies in JICA habitat classification and to reflect that whilst camera-traps record a point in space, animal movements are more extensive. Therefore it is possible that home-ranges of individuals photographed in boundary areas encompass both deciduous dipterocarp and mixed deciduous/semi-evergreen forest. Based on all jungle cat and leopard cat encounters between 2008 and 2010 the corresponding encounter rates were calculated at each camera-trap location, defined as the number of independent encounters per 100 trap-nights. The mean and 95% confidence intervals of these encounter rates for both species were calculated for camera-traps located in deciduous dipterocarp forest (n=26), boundary areas (n=79) and mixed deciduous/semi-evergreen forest (n=36). Activity patterns for all cat species encountered between 2008 and 2012 were calculated based upon the time imprinted on photographs of each independent encounter. We assume that the time of day of encounters in camera-traps correlates with the species activity levels.

Results

In total, six cat species (leopard, leopard cat, jungle cat Fig. 2, marbled cat Fig. 4, Asiatic golden cat Fig. 3, and clouded leopard Fig. 7) were photographed during this study. Leopards were the most frequently captured cats with a total of 391 independent captures. Of the smaller cats, leopard cats were captured on 124 occasions from 32 locations: 13 in MPF and 44 in PPWS. Jungle cats were photographed on 20 occasions from eight camera-trap locations: six in MPF and two in PPWS (Supporting Online Material SOM T1, Fig. 1). Fifteen (75%) of the jungle cat captures came from three locations: two camera-traps located beside small vehicle roads in PPWS and one camera-trap at a seasonal waterhole (*trapeang*) in MPF (SOM T1). At three camera-trap locations, two in MPF and one in PPWS, both leopard cats and jungle cats were photographed.

Leopard cats were photographed by camera-traps located in dipterocarp forest, mixed de-



Fig. 2. Jungle cat in Mondulkiri Protected Forest, May 2009 in deciduous dipterocarp forest.

ciduous/semi-evergreen forest and boundary areas; capture rates were higher in deciduous dipterocarp forest (Fig. 5). In contrast, jungle cats were never photographed in mixed deciduous/semi-evergreen forest and showed a strong preference for deciduous dipterocarp forest (Fig. 5). The clouded leopard photographs came from mixed deciduous/semi-evergreen forest (2) and boundary areas (1) while marbled cat captures showed a similar pattern with photographs from within mixed deciduous/semi-evergreen forest (3) and boundary areas (1) (SOM T1). The single location in which an Asiatic golden cat was photographed, on two separate occasions, was from tall deciduous dipterocarp forest close to semi-evergreen forest classified as a boundary area, possibly reflecting the species' use of a variety of forest types. Activity patterns of leopard cat and jungle cat differed substantially; with jungle cat captures more often during the day and leopard cat more nocturnal (Fig. 6). Marbled cat (4:49 h; 5:15 h; 7:36 h; 18:54 h), clouded leopard (4:31 h; 20:42 h; 20:52 h), and Asiatic golden cat (5:34 h; 22:22 h) were captured one to three hours before and after dawn and dusk.

Discussion

The lowland deciduous forests of northern and eastern Cambodia are globally important for cat conservation (Tordoff et al. 2005, Rainey & Kong 2010, Gray et al. 2012). In our extensive camera-trapping within the core areas of Mondulkiri Protected Forest (MPF) and Phnom Prich Wildlife Sanctuary (PPWS) leopard was the most frequently encountered cat species (Gray & Prum 2012). In addition we photographed five other species of cat including the globally vulnerable clouded leopard and marbled cat and the near-threatened Asiatic golden cat. The Asiatic golden cat photographs represent the first camera-trap records of this species from Mondulkiri province although there are unconfirmed reports of sightings from both Seima Protection Forest and MPF. The only other eastern Cambodian records are from Virachey National Park where four camera-trap photographs were obtained between 1999 and 2001 (Gray et al. 2012). Despite the intensive camera-trapping, two cat species possibly present in the landscape (tiger and fishing cat) were not photographed.

The presumed extirpation of tiger within the study region has been discussed elsewhere (Gray et al. 2012, O'Kelly et al. 2012). The status of fishing cat in Cambodia is unclear with



Fig. 3. Asiatic golden cat in Mondulkiri Protected Forest, September 2011.

few confirmed records and none east of the Mekong River (Royan 2009, Rainey & Kong 2010). Indeed few records exist from South-east Asia away from coastal areas (Duckworth et al. 2010). However one confirmed camera-trap record of fishing cat from Kulen Promtep Wildlife Sanctuary in Preah Vihear's northern plains is from a deciduous dipterocarp dominated landscape, ecologically very similar to our study region (Rainey & Kong 2010). Regular verbal reports of *Kla Dtray* (literally fish cat or fish tiger) from local villagers and community rangers across Cambodia, including within our study area, seem likely to represent confusion over the Khmer name which, though often translated as 'fishing cat', seems likely to be used by local people

as a generic name for all small cats and even *Viverra civets* (Holden & Neang 2009). The continued lack of evidence of fishing cat presence in eastern Cambodia, despite camera-trapping in and around seasonal waterholes (*trapaeng*) and stream-beds (approximately 3,000 camera-trap nights from *trapaeng* and stream-beds in MPF; <500 camera-trap nights from stream-beds in PPWS) suggests that, if at all present, the species is extremely rare or localised. However the fact that the Asiatic golden cat was only captured on two occasions from a single camera-trap location indicates that species occurring at low densities or with strong habitat specificity might be missed.



Fig. 4. Marbled cat Phnom Prich Wildlife Sanctuary April 2012.

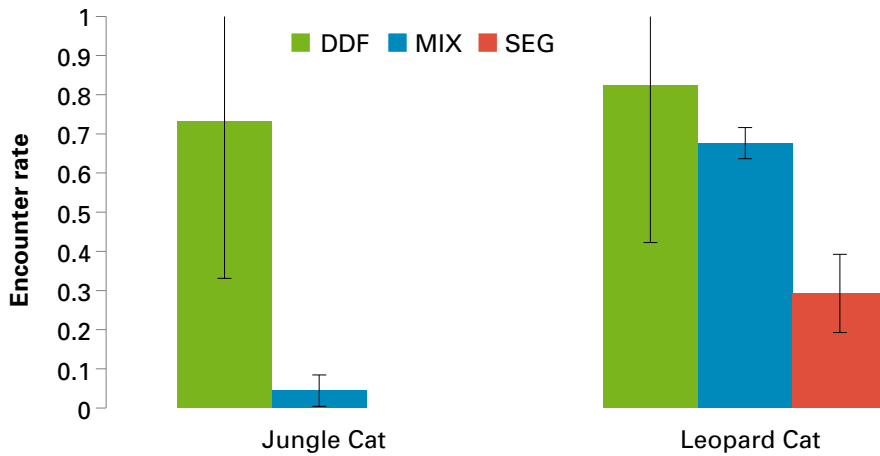


Fig. 5. Encounter rate (number of independent camera-trap encounters per 100-trap nights; \pm SEM, using per-camera encounter rate as the sample statistic) of jungle cat and leopard cat from camera-traps located in deciduous dipterocarp (DDF), boundary areas (MIX) and mixed deciduous/semi-evergreen (SEG) forest in Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary. Note no jungle cat encounters from mixed deciduous/semi-evergreen forest.

Clouded leopards and marbled cats were only photographed in PPWS; semi-evergreen forests are largely absent in MPF, possibly explaining the absence of records of these two species there. Examination of the clouded leopard photographs suggest that those from 2010 and 2011 (approximately 2 km apart) represent the same individual male (J. Kamler, pers. comm. 2013). Both species were previously recorded (clouded leopard three times; marbled cat once) in PPWS during camera-trapping in similar areas between 2002 and 2005 (Gray et al. 2012). Both have also been occasionally recorded during camera-trapping in evergreen forest of the Seima Protection Forest south of PPWS with two photographs of the same clouded leopard individual (2003) and four marbled cat photographs between 2002 and 2006 (WCS *in litt.* 2010). The status of jungle cat in Cambodia outside our study area is unclear, with few, if any, published records since

Duckworth et al. (2005). We do not know of any records from other sites in eastern Cambodia since 2005, when the species was photographed in western Seam Pang and Chhlong (Gray et al. 2012). Although there appear to be no published records from Lumphat Wildlife Sanctuary or Seima Protection Forest, it is likely that jungle cats occur here as the habitat is contiguous with the study area. There have been recent records from deciduous dipterocarp forest in Preah Vihear (anonymous reviewer two, *in litt.*) however these remain unpublished and highlight the need for the region's extensive camera-trap data to be shared and published.

Habitat preferences and activity patterns of leopard cat and jungle cat

Leopard cats were photographed in deciduous dipterocarp forest, mixed deciduous/semi-evergreen forest and boundary areas across both protected areas. They thus ap-

pear relatively widespread across a variety of forest types in the Eastern Plains Landscape. This matches studies published in mainland South-east Asia which suggest the species is a habitat generalist (Grassman et al. 2005b, Azlan & Sharma 2006, Austin et al 2007). In contrast jungle cats were encountered often only in deciduous dipterocarp forest and were never photographed in mixed deciduous/semi-evergreen forest. The camera-trap locations of all jungle cat photographs from boundary areas were also all in deciduous dipterocarp forest. Leopard cats were encountered more frequently in deciduous dipterocarp forest than jungle cats. This may be due to some specificity in jungle cat habitat preferences at a finer scale than the level of broad forest type which we investigated. Indeed 15 of the 20 (75%) jungle cat encounters were from three camera-trap locations (0.01% of all locations) strongly suggesting a patchy distribution or selection of microhabitats not represented in our camera-trap locations. We provide further evidence that the jungle cat is a deciduous dipterocarp and open country specialist in Indochina (Duckworth et al. 2005). With few areas of extensive undisturbed deciduous dipterocarp forest elsewhere in the species' South-east Asian range, the Eastern Plains jungle cat population is likely to be regionally significant. Studies on leopard cat in South-east Asia generally report nocturnal (Johnson et al. 2009, Kitamura et al. 2010) or cathemeral (Grassman et al. 2005b, Cheyne & Macdonald 2011) activity; our data, with the majority of encounters at night, match this trend. There is no published information on jungle cat activity patterns in South-east Asia. Our records indicate cathemeral activity but with the majority of encounters during day-light hours. Activity patterns of small cats are often related to prey availability (Rabinowitz 1990, Rajaratnam et al. 2007). Whether the differences in peak activity times between jungle and leopard cats in this study are an artefact of small sample size or represent partitioning of food resources warrants further study.

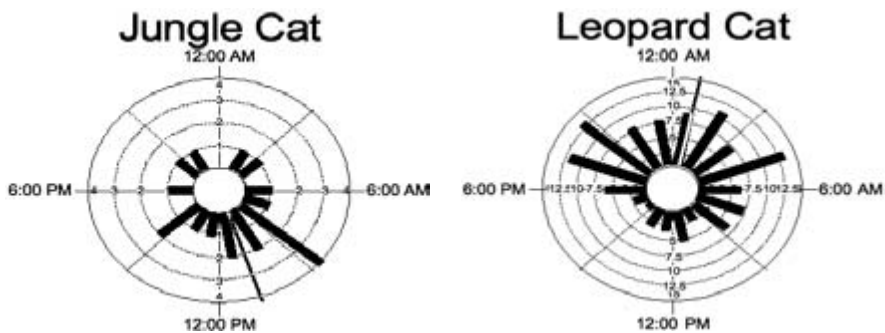


Fig. 6. Frequency histogram, by hour, of camera-trap photographs of jungle cat (A) and leopard cat (B) from camera-trap data in Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary.

Acknowledgements

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Fig. 7. Clouded leopard in Phnom Prich Wildlife Sanctuary, December 2012.

lency Cheng Kimsun, Men Phymean, Keo Omaliss, Song Keang and Keo Sopheak. Work in Phnom Prich Wildlife Sanctuary is with permission of the Ministry of the Environment and support from His Excellency Chay Samith, Sanrangdy Vicheth and Han Sakhon. Lien Kha, Kheav Oudom, Ing Seangrithy, Lien Nor, Vann Sonny, Men Samorn and Sary Tre assisted with camera-trapping. Tom Evans, Tony Lynam, Hannah O'Kelly, Hugo Rainey, Will Duckworth and Jeremy Holden provided useful information of wild cat status in their study areas. Barney Long, Ed Pollard, Rob Steinmetz, Jan Kamler, Alexander Sliwa, and Pete Cutler provided input into species identification of some cat photographs. Two anonymous reviewers provided valuable comments which improved the quality of the manuscript. Craig Bruce, Nick Cox, Keith Metzner, Seng Teak and Bivash Pandav assisted with project planning, logistics and funding.

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Supporting Online Material SOM Table T1 is available at www.catsg.org/catnews

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Status and distribution of smaller cats in Myanmar

Camera-trapping in many areas across Myanmar shows that of six smaller cat species, leopard cat *Prionailurus bengalensis*, mainland clouded leopard *Neofelis nebulosa* and Asiatic golden cat *Catopuma temminckii* remain widespread in the larger remaining forested landscapes. Marbled cat *Pardofelis marmorata* is somewhat less widely distributed or not so well documented by this survey method. Landscape-scale threats such as habitat fragmentation by mega-development projects may be significant threats to these four species. The remaining two species - fishing cat *Prionailurus viverrinus* and jungle cat *Felis chaus* – may need specific conservation actions to ensure their national survival. Most cats are completely protected by existing wildlife law in Myanmar, but the legal status of fishing cat, leopard cat and jungle cat should be clarified.

Myanmar (formerly known as Burma) in South-east Asia covers 676,581 km² within 9°53'–28°25' N/92°10'–101°10' E. It is 2,195 km from north to south and 948 km wide in the central part. Elevation varies from sea level to 5,881 m in the northern mountain ranges bordering China. As classified by MacKinnon & MacKinnon (1986), it contains parts of three sub-regions of the Indo-Malayan Realm: the Indian sub-region (6% of the country) bordering Bangladesh in the west and India in the north-west; the Indochinese sub-region (91%), with a long common border with China, Lao PDR and Thailand, and the Sundaic sub-region (3%), bordering Thailand. Myanmar retains large tracts of old forest, with 46–48% of the country's land area being for-

ested (Harris et al. 2012), among the highest proportion of forest cover of any South-east Asian country (Leimgruber et al. 2005, Stibig et al. 2007). The human population in 2001 was estimated to be 51.14 million, increasing at about 2% per year (Central Statistical Organization 2001). This high growth rate and the export of timber as a source of hard currency are causing rapid encroachment of some remaining natural habitats (Leimgruber et al. 2005, Tordoff et al. 2005). Many rural people in Myanmar trade and eat wildlife (Martin 1997, Rao et al. 2002, 2005, Tordoff et al. 2005). The country's common borders with China (itself a large sink for traded wildlife, including many small cat species; Li Yiming & Li Dianmo 1998, Li Yiming et al. 2000,

Bell et al. 2004) and Thailand (Martin 1997, Martin & Redford 2000, Shepherd & Nijman 2008) must be a powerful driver for wildlife hunting. Logging, overhunting, and destructive agricultural practices have spurred significant declines in wildlife and natural habitats (Rao et al. 2002). Eight species of wild cats (tiger *Panthera tigris*, leopard *Panthera pardus*, clouded leopard, marbled cat, Asiatic golden cat, fishing cat, leopard cat and jungle cat) are confirmed to occur in Myanmar. According to Myanmar's *Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law*, 1994 (Myanmar Forest Department 2003), five species of cats (tiger, leopard, clouded leopard, marbled cat and Asiatic golden cat) are "Completely Protected" (i.e. with penalties for illegally killing involving fines of up to 50,000 kyats, i.e. ca. 50 US\$, and up to seven years in prison). The second and third protection categories, that of "Normally Protected" and "Seasonally Protected Species", contain no cat species, leaving fishing cats, leopard cats and jungle cats unprotected. Reports or suggestions of occurrence of snow leopards *Panthera uncia* and flat-headed cats *Prionailurus planiceps* in Myanmar, while plausible, have not been confirmed (Rabinowitz & Saw Tun Khaing 1998, Wilting et al. 2010). This compilation of records from Myanmar discusses distribution range, natural history and conservation status of the six small cat species recorded in the country, based largely on previously unpublished data gathered between 1999 and 2011 by camera-trap surveys. It is supplemented by the examination of wild animal remains in hunting camps, villages and markets and other incidental information. Structured research on distribution, habitat preferences, ecological attributes and population status of small cat species has barely been conducted in the country.

Survey areas

The surveys covered areas in northern, western, central and southern Myanmar selecting habitat-blocks potentially able (based mainly on large extent of natural habitat) to support tigers (the main aim of survey at all sites excepting Hkakaborazi, Hponkanrazi and Naungmung; Lynam et al. 2006, 2009) and/or other threatened large mammals (Fig. 1). In total, 19 areas were surveyed in a roughly comparable manner. Two further areas were visited but not camera-trapped, Thaug Dut Reserved Forest and Nankamu Reserved Forest. Some large regions of Myanmar were

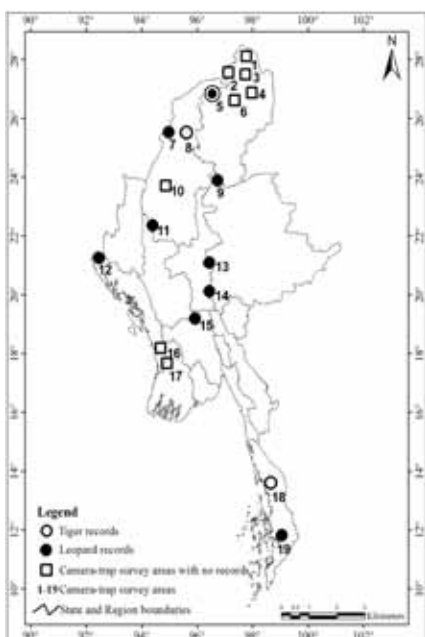


Fig. 1a. Recent locality records of tiger and leopard, based on camera-trap records.

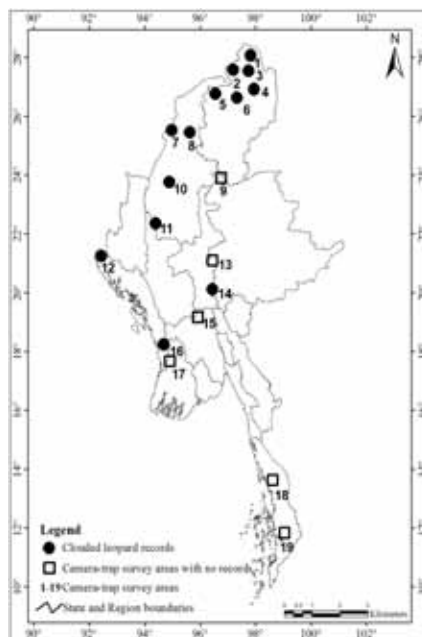


Fig. 1b. Recent locality records of clouded leopard, based on surveys in SOM T5.

not surveyed due to their inaccessibility at the time, notably most of the east, e.g. eastern Shan State, Kayah State, Kayah State and Mon State, and hence some regions potentially important to threatened large mammals were not covered. The wide altitudinal range of 20–3,750 m was surveyed. All survey areas were within large (at least several hundred square kilometers) tracts of evergreen or semi-evergreen forest except Lemyathna & Ingabu which are entirely deciduous, while Momeik & Mabein, Panlaung & Padalin and Bago Yoma Swa Chaung consist of (semi-) evergreen forest mostly restricted to riverine strips. Other survey areas were adjacent to large stands of deciduous forests, e.g. Mahmyaing and Alaungdaw Kathapa. Large areas of grasslands and wetlands occur only in Hukaung Valley and montane scrub/rock habitats in Hkakaborazi National Park. Smaller parts of several other areas include hill grass in Paunglaung catchment, seasonally flooded grasslands in Tanintharyi and montane scrub/rock in Saramati Taung. The Paletwa (Mayu river catchment) survey area has such extensive bamboo (*khayin-wa Melocanna bambusoides*) patches that bamboo covers nearly 60% of the total area; semi-evergreen forest occurs mostly in ravines. The Myinmoletkat Taung survey area (Pe Chaung Catchment) has only 30% evergreen forest, amid secondary growth from shifting cultivation (30%) and *Areca* palm plantation (40%). Even so, in all these areas except Lemyathna & Ingabu (which had a very low survey effort) and Panlaung & Padalin, camera-trapping was predominantly in the evergreen forest. Most areas held a mix of old-growth and recently disturbed vegetation, but Lemyathna & Ingabu and Tanintharyi both lacked extensive old-growth forest. Survey areas were under various land designations and, consistent with the purpose of the surveys, some sites were declared as protected areas as a result of the information generated. All are identified here under their current management status.

Methods

Camera-trapping

Camera-trapping was the primary survey technique, using heat-and-motion-sensitive CamTrakker™ units (Camtrak South Inc., Watkinsville, GA, U.S.A.). These were deployed in 19 survey areas between 23 June 1999 and 16 June 2011; some survey areas were visited more than once (Supporting Online Material SOM Table T1). Each survey area

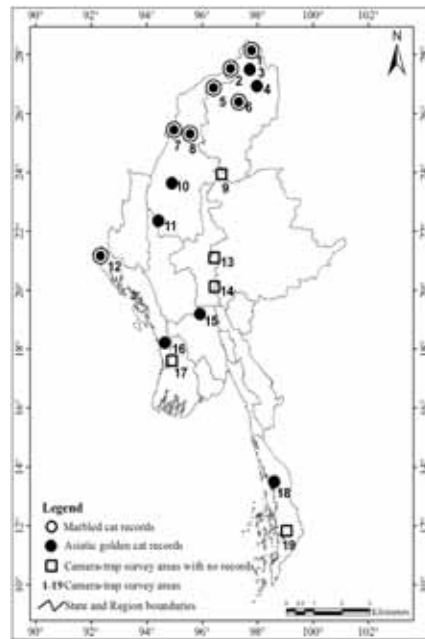


Fig. 1c. Recent locality records of marbled cat and Asiatic golden cat, based on surveys in SOM T6 and T8, excluding camera-trap records from Tanintharyi NR.

was so extensive, and, in many cases difficult of access, that only parts of it could be camera-trapped. Traps were deployed 1–3 km apart, with the co-ordinates of each recorded with, in the worst cases ± 100 m accuracy, using Global Positioning System (GPS) devices. Altitudes were calculated from these co-ordinates using the United States Geological Survey's SRTM 90 digital elevation model and should be regarded as indicative only. No habitat information relevant to the home-range scale was recorded specific to the camera-trap site. Microhabitats are revealed in the photographs, but because cameras were often selectively set along streambeds, trails and ridges, and at saltlicks, pools and other areas of good visibility, they are not highly informative on overall habitat usage. The date and time of exposure were imprinted on most images. Most camera-traps were set in relatively remote areas, in many cases at least several days' walk from the nearest road. Concentration in evergreen forest resulted in a low sampling of species from deciduous forest and non-forest habitats. Camera-traps were set at 45–50 cm above ground, an ideal height for tigers, and probably suitable for all cat species of Myanmar. They were set to function by day and night. Camera-trapping covered all seasons, but no individual site was surveyed around the year. The survey effort in most areas was from several hundred to several thousand

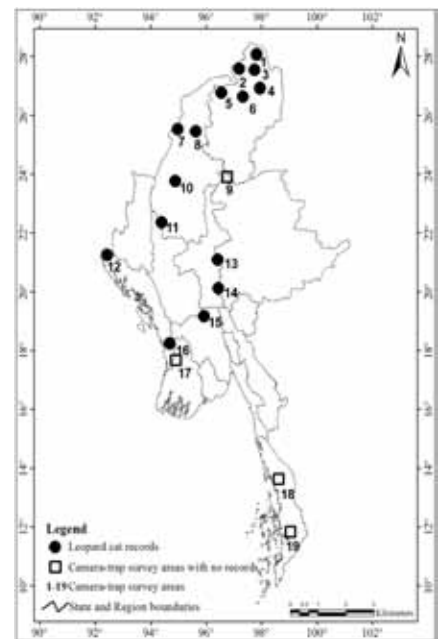


Fig. 1d. Recent locality records of leopard cat, based on surveys in SOM T10, excluding additional camera-trap records from Tanintharyi NR.

trap-nights (SOM T1). The surveys were not designed for small cats, so the results need to be interpreted with caution (Than Zaw et al. 2008). No baits/lures were used. Non-independent events were those where a given camera-site recorded what may have been the same individual animal on multiple frames with successive images separated by, arbitrarily, half-an-hour or less. All statistics of number of photographs refer to number of independent events, not the actual number of images. Any number of animals on a frame constituted only one event.

No surveyor had access to a suitably large skin collection to make reliable identifications. Hence, original identifications of all cat photographs were reviewed by the team supported by J. W. Duckworth, S. I. Robertson and R. J. Tizard. Species presence in most of these camera-trapping survey areas was listed in Lynam (2003: Appendix IX) before this identification review. In case of discrepancies between this document and Lynam (2003), the present listing should prevail. All photographs are archived at the Wildlife Conservation Society's Yangon office.

Other sources of recent records

Additional information resulted from a non-systematic search for dead or live animals in villages, hunting camps, rural markets etc. Such records were used only when photographed, and with the identifications



Fig. 2. Asiatic golden cat, grey form recorded in Ali-aung village.



Fig. 3. Asiatic golden cat, tristis form recorded in Tahundam.

reviewed as with camera-trap photographs. Very old relics that could have come from anywhere are mostly not presented here. This method was particularly used in Hkakaborazi, Hponkanrazi and Naungmung. In other sites, the little time spent by survey teams in villages gave few opportunities to find such animals. Other potential non-invasive methods widely used with other mammal groups have major drawbacks with small cats. Signs are difficult to identify to species level in such a species-rich group. As with signs, there is no objective evidence that local reports of small cats to the species level are generally reliable (and abundant anecdotal evidence that gross errors are frequent), therefore such reports are not used here. Direct field observation of live animals by experienced observers could generate reliable data. However, small cats are very rarely encountered, limiting the suitability of such method. A search for other recent records of small cat species from Myanmar located only Su Su (2005), Thaint Thaint Myo (2007), Shepherd & Nijman (2008), Myint Maung (2011) and incidental mention in a few grey literature sources (Nay Myo Shwe 2011). Unpublished records were sought from experienced colleagues, to extend the information base for the country.

Historical records

Historical records were assembled from published sources mindful of the cautions discussed in Than Zaw et al. (2008), which source contains a gazetteer of coordinates of the historical localities. Localities not in-

cluded in Than Zaw et al. (2008) are provided in the supplementary gazetteer (SOM T2).

Results and discussion

Species accounts

Clouded leopard

Geographical distribution

Clouded leopard was the second-most commonly recorded cat with 111 independent events (SOM T3) from 13 survey areas (Fig. 1b). Additionally, there were two skins from Hkakaborazi, a skin from Hponkanrazi, three skins from Naungmung survey area (SOM T4) as well as previous records of skins and bones from this area (Rabinowitz & Saw Tun Khaing 1999). There are historical records from many places: Ya-ma-doung mountains (between Pegu and Arakan), Bhamo, locations eight miles west of Toungoo and Htingnan in the Triangle, Upper Myanmar (Pocock 1939, 1941), near Maingyaung, lower Chindwin (Wroughton 1916a), Tavoy, Tenasserim, on the bank of Kaukkwe Chaung (Tun Yin 1967), and the Carin Hills (Thomas 1891). Pocock (1933: 188) reported the species to be "very thinly distributed, and generally located in dense evergreen forests in the north and south of Burma".

Habitat and altitude

Photographs were taken in the altitudinal range of 20-2,650 m (SOM T5), supporting the wide altitudinal distribution reported by Rabinowitz et al. (1987) and Nowak & Paradiso (1983), with most images between 200 and 300 m. Given the intensive survey effort

in highlands, this may indicate genuinely greater numbers in the lowlands.

Behaviour

Of 111 independent events, 39 (35%) occurred in daylight (06:01 h - 18:00 h) including six (5%) in the early morning (06:01 h - 09:00 h), 72 (65%) at night (18:01 h - 06:00 h) including 15 (14%) in the late evening (18:01 h - 21:00 h; SOM Figure F1). All camera-trap records were of single animals on the ground. Diurnal and nocturnal activity with some increase at night is consistent with past statements on activity patterns at single sites (Austin et al. 2007a, Grassman et al. 2005, Azlan & Sharma 2006). This behaviour is also consistent with recent data from 14 sites across Thailand (Lynam et al. 2013, Tantipisanuh et al. 2014, this issue), despite other statements that this species is strictly nocturnal (Pocock 1939, Tun Yin 1967, Lekagul & McNeely 1977, Prater 1980, Kanchanasakha et al. 1998, Christiansen 2006), or much more diurnal (Guggisberg 1975). As suggested by Grassman et al. (2005), Rabinowitz et al. (1987) and Rabinowitz (1988), the many records on the ground questions generalised past statements that this species is highly arboreal (Selous & Banks 1935, Gonyea 1976, Taylor 1989). However, in the absence of any arboreal survey effort, it is not possible to speculate on just how arboreal the species truly is.

Asiatic golden cat

Geographical distribution

Asiatic golden cat was camera-trapped in 12 survey areas with 55 independent events (SOM T3, T6), occurring from the southernmost to the northernmost survey areas (Fig. 1c). It was the second-most widely recorded species, with clouded leopard, which is consistent with historical reports that it occurs throughout the country (Peacock 1933). Although no camera-trap photographs were recorded in Hponkanrazi or Hkakaborazi, skins were photographed in both places (SOM T7). Of these, a skin from Ali-aung village was grey (Fig. 2) and a skin from the village of Tahundam was of the 'tristis' form (Fig. 3): silver-grey in colour, with buff-speckled black spots on the back. Lord Cranbrook secured a similar skin from the Nam Tamai (Dollman 1932), as did Pocock (1941) referring to one, suggesting that this morph may be restricted to the far North Myanmar. Several other remains were recorded (SOM T7). Six independent photographs of black Asiatic golden cat were obtained in five survey areas (Fig.



Fig. 4. Asiatic golden cat, black form recorded in Bumphabum survey area.



Fig. 5. Asiatic golden cat, dark grey form recorded Htamanthi survey area.

4), and a dark grey one was photographed in Htamanthi (Fig. 5). These support previous records of black animals from the Nam Tamai Valley, dark grey skins from Myitkyina and the upper Chindwin River, a brown pelt from Sumprabum and an ochreous tawny one from Maymyo (Ryley 1914, Pocock 1939). Myint Maung (2011) camera-trapped one individual (two photographs) in Tanintharyi Nature Reserve at 14°32' N/ 98°15' E on 7 December 2010. Previous records were found from Htingnan, Shilingkhet and near Goletu village of Naungmung survey area (Pocock 1941), Victoria Point, Mergui and Taho, Carin State (Thomas 1891, Pocock 1939, Tun Yin 1967), and Pyinmana (Wroughton 1915), the latter being two skulls.

Habitat and altitude

Photographs came from 170-1,950 m, commonly across 300-1,200 m (SOM T6).

Previous records from Myanmar were in thick or moderately thick forest at altitudes between 760 m (Tun Yin 1967) and 1,300 m (Thomas 1891).

Behaviour

Of 55 independent events (including one record in Tanintharyi Nature Reserve), 19 (35%) were in daylight (09:01 h - 18:00 h) and 21 (38%) were at night (21:01 h - 06:00 h), excluding nine (16%) in the early morning (06:01 h - 09:00 h) and six (11%) in the late evening (18:01 h - 21:00 h); this species is cathemeral.

Although Pocock (1939) and many subsequent sources reported it as nocturnal, most other primary reports also indicate a generally high activity level during daylight (Grassman et al. 2005, Azlan & Sharma 2006, Lynam et al. 2013, Tantipisanuh et al. this volume). By contrast, Kawanishi & Sunquist (2008) found it to be predominantly nocturnal (69%). One camera-trap record from Hukaung Valley was of a duo while all other photographs were of single animals on the ground.

Marbled cat

Geographical distribution

Marbled cats were camera-trapped in seven survey areas with 25 independent events (SOM T1, T8), occurring from the far north to the southernmost records at about 21°N (Fig. 1c). Additionally, two skins and three fresh hunter's kills were recorded in this latitudinal range (SOM T9). Although Corbet & Hill (1992) mapped the distribution range of marbled cat in Myanmar only in the northern part and three previous records were indeed from the north, near the village of Ngawar, in the Nam Tamai Valley and at Naungmung (Pocock 1939, Tun Yin 1967, Rabinowitz & Saw Tun Khaing 1999), there are several recent records from much further south, in Tanintharyi Nature Reserve. Myint Maung (2011) camera-trapped one at 14°21' N/98°17' E on 19 February 2011 and Nay Myo Shwe (2011) photographed one crossing a forest road at 14°43' N/98°15' E in Aug 2008. Historically two skins were recorded from Toungoo (18°56' N/96°26' E), however they were already prepared when collected and their origin is not clear (Fry 1929).

Habitat and Altitude

Photographs were taken in the altitudinal range of 110-2,620 m, predominantly between 120-600 m (SOM T8); historical records in Myanmar were at 1,070-1,830 m (Tun Yin 1967).

Behaviour

Of 27 independent events (including two in Tanintharyi Nature Reserve), only three (11%) were late at night (21:00 h - 06:00 h) and two (7%) in the late evening (18:00 h - 21:00 h); the other 22 (81%) were in daylight (06:00 h - 18:00 h) including six (22%) in the early morning (06:00 h - 09:00 h). All camera-trap records were of single animals. This shows marbled cats to be predominantly diurnal, at least in ground-level activity, which is consistent with the findings of some other recent

studies (Lynam et al. 2013), although Pocock (1939), and after him, many other derivative sources such as Tun Yin (1967), described them as nocturnal animals.

Fishing cat

No fishing cats were recorded during these surveys. Five fishing cats were held in the Yangon Zoological Garden as of late 2011 (Fig. 6). These are reported to have been bred in captivity from animals collected in the Ayeyarwady delta more than ten years ago. A mount of unknown origin was found in a souvenir shop in Yangon in August 2011 (Fig. 7). A report of fishing cat (BANCA 2009) later proved to be a misidentified leopard cat skin. One of a duo of fishing cats was collected on the west bank of the Chindwin at Dawazup near Dalu (Taro), in 1935 (Morris 1936, Carter 1943). Pocock (1939), overlooking this record, considered that there were no Myanmar records. A recent intensive camera-trap effort in Dawazup which lies within the Hukaung valley did not record fishing cats. Deployments took place close to Dawazup (ca. 12 km) and to the Chindwin river (ca. 1.4 km). The lack of camera-trap records, however, does not necessarily suggest that the species has declined; habitat use of fishing cats in South-east Asia is poorly known (Duckworth et al.



Fig. 6. Fishing cat, held in the Yangon Zoological Garden (photographed by Robert Tizard on 4 September 2011).



Fig. 7. Fishing cat, a taxidermy mount of unknown origin found in a souvenir shop in Yangon (photographed by Aung Myo Chit on 19 August 2011).

2010, Rainey & Kong 2010) and the cameras may have been set outside suitable habitat, given the survey focus on tall forest.

Leopard cat

Geographical distribution

Leopard cat was the most commonly and widely recorded species (Fig. 1d), occurring from the southernmost to the northernmost survey areas, with 151 independent events coming from 15 survey areas (SOM T1, T10). There were 11 records of remains (SOM T11) and two sightings (SOM T12). On one occasion, Su Su (2005) spotted a leopard cat during extensive studies on small carnivores in Hlawga Park during 2000-2003. Thaint Thaint Myo (2007) camera-trapped eight in Alaungdaw Kathapa National Park during 2004-2006, and Myint Maung (2011) had three independent camera-trap records in Tanintharyi Nature Reserve, one at 14°32' N/98°15' E in December 2010 and two at 14°03' N/98°14' E in Jan 2011. Previous records include: six skins from

the region of Kindat, an unknown number of skins from Toungoo (Pocock 1939), a specimen from Pakokku, four from Bankachon, two from Huangyan and Pwepi (Wroughton 1915, 1916a,b,c), and a specimen from Htwagaw (Anthony 1941). Other specimens originated from Dalu (1) and Gora (1). Gam Majaw, Mantum, Nam Tamai, Goletu, Tasa Hku, Adung Long collectively had eight (Dollman 1932, Pocock 1941). Single specimens were recorded from Ruby Mines and Maymyo, Northern Shan state, (Ryley 1914). Further documentation showed specimens from Htamanthi, Naungmung, Hkakaborzai (Rabinowitz et al. 1995, Rabinowitz & Saw Tun Khaing 1999) and sightings on the river bank at Kindat as well as single males sighted in two locations 20 and 40 miles NE and NW of Toungoo (Fry 1929).

Altitude

Leopard cats were recently recorded at altitudes between 150 and 2,010 m (SOM T10), mostly within 200-400 m (58%). Previous records from Myanmar were in moderately thick forest, pine and rhododendron forest between 760 m and 1,830 m in altitude (Pocock 1941).

Behaviour

The 155 independent events (including four records in Tanintharyi Nature Reserve) comprised 131 (85%) at night (18:01 h - 06:00 h) including 24 (15%) in the late evening (18:01 h - 21:00 h) and only 24 (15%) in daylight (06:01 h - 18:00 h) including 10 (6%) taken early in the morning (06:01 h - 09:00 h; SOM F2). All records were of single individuals. Leopard cats are nocturnal with significant crepuscular activity, consistent with most reports (Duckworth 1997, Azlan & Sharma 2006, Lynam et al. 2013). However, Austin et al. (2007b) found uniform activity patterns during the day and night with crepuscular peaks.

Jungle cat

No jungle cats were recorded during these surveys. Single skins were photographed in the village of Hpu Lum, Khaunglanhpu area in April 2009 (Fig. 8; Aung Soe Than *in litt.* 2009), in the market of Mandalay in August 2008 (Fig. 9; Su Su Naing *in litt.* 2008), and (freshly hunted) in the Nawng Ya market in Loikaw in May 2008 (Ohn Mar Ohn *in litt.* 2008; all photographs stored at the WCS Myanmar Program office, Yangon). Su Su (2005) spotted a jungle cat only once during extensive studies on small carnivores in Hlawga park during 2000-2003; park staff reported the species had previously been

more common there. Thaint Thaint Myo (2007) recorded two skins in Alaungdaw Kathapa National Park during 2004-2006 and she also reported it to be common there but the basis for this assessment was not provided. Past specimen records came from: the Chin hills (thought to be common); Mt. Popa; Thayetmyo; Tagyigin and Yin in the Lower Chindwin; and Toungoo (Wroughton 1915, 1916c, Fry 1929). Elsewhere in Southeast Asia, jungle cats are strongly associated with open deciduous habitats (Duckworth et al. 2005, Gray et al. 2014, this issue). The lack of camera-trap and sighting records during these surveys reflects, at least to some extent, the focus of camera-trapping on tall forest habitats and a minimal effort in habitats suitable for jungle cats. This is consistent with findings by Than Zaw et al. (2008) for two other carnivore species which use similar habitats: small Indian civet *Viverricula indica* and small Asian mongoose *Herpestes javanicus*. However, clarification of this species' status in Myanmar is important. The low number of recent records across Lao PDR, Cambodia and Vietnam was interpreted by Duckworth et al. (2005) to indicate a genuine current rarity of the animal in these countries. It is possible that the same would be found to be true for Myanmar.

Concluding remarks

Conservation needs of cat species in Myanmar

Leopard cats, clouded leopards and Asiatic golden cats all seem to remain common and widespread within the larger (>1,000 km²) protected areas. Provided the protected areas do not suffer major habitat conversion or other challenges to their integrity, they may have no specific in-country conservation needs. However, as Myanmar develops, loss and fragmentation of some large intact forests is guaranteed and indeed has already begun with projects such as the Dawei - Kanchanaburi deep sea port and transportation corridor. Therefore, the status of these species and their habitats will need to be reassessed periodically. Fewer marbled cats were recorded in protected areas. Neither jungle cats nor fishing cats were recorded (with no recent records of the latter from any protected area), and it is plausible that these species are seriously threatened in Myanmar. Surveys in suitable habitat for these species are therefore important to understand their conservation needs. If snow leopards and/or flat-headed cats do occur in Myanmar, they are also likely to be highly threatened.



Fig. 8. Jungle cat recorded in the village of Hpu Lum, Khaunglanhpu area (photo taken by Aung Soe Than on 9 April 2009).



Fig. 9. Asiatic golden cat, leopard cat and jungle cat skins in the market of Mandalay (photo taken by Su Su Naing in 2008).

National cat species legal status

The legal status of fishing cats, leopard cats and jungle cats should be clarified in the Protection of Wild Life and Wild Plants and Conservation of Natural Areas Law (*State Law and Order Restoration Council Law No.583/94.1994*), as Shepherd & Nijman (2008) pointed out. Leopard cats remain common and probably do not need any species-specific legal protection (bearing in mind that all hunting is legally forbidden in large parts of the country, including the core zones of protected areas). Fishing cats and jungle cats warrant the highest level of legal protection given the rarity of recent records.

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Non-*Panthera* cat records from big cat monitoring in Huai Kha Khaeng Wildlife Sanctuary

A camera-trapping deployment for tiger *Panthera tigris* monitoring in Huai Kha Khaeng Wildlife Sanctuary HKK, in the Western Forest Complex WEFKOM of Thailand, was carried out intensively between 2005 and 2009. The deployment's annual setup included an average of 162 camera-trap locations with more than 2,000 trap-nights and covered almost 1,000 km². Many other wildlife species were photographed including small and medium (non-*Panthera*) cats. This analysis explores the potential use of the system to monitor cat species other than tiger and leopard *Panthera pardus*. In five years, leopard and tiger, major targets of the deployment, were camera-trapped in 653 and 483 notionally independent events respectively. Among non-*Panthera* cats, leopard cat *Prionailurus bengalensis* was the most common, with 155 events. Independent events of three other non-*Panthera* cats were rare: ten of Asiatic golden cat *Catopuma temminckii*, six of mainland clouded leopard *Neofelis nebulosa*, and only two of marbled cat *Pardofelis marmorata*. Leopard cat in HKK used mixed deciduous forest heavily and showed an obvious crepuscular and nocturnal activity pattern. The camera-trapping deployment for tigers in HKK could be used to monitor leopard cats, but different deployment designs would be necessary for other non-*Panthera* cats at this site.

South-east Asia is home to nine small and medium cat species (i.e. excluding genus *Panthera*). Of these, seven occur in Thailand (all those of mainland Southeast Asia): jungle cat *Felis chaus*, leopard cat, fishing cat *Prionailurus viverrinus*, flat-headed cat *P. planiceps*, Asiatic golden cat, marbled cat and clouded leopard (Wilson & Mittermeier 2009). In Thailand as in much of the world, non-*Panthera*

cats are under-represented in field studies (Grassman et al. 2005). Four of the seven species are categorised as globally threatened by The IUCN Red List of Threatened Species. In Thai law, marbled cat is listed as 'endangered' and the rest as 'protected' under the Wildlife Preservation and Protection Act B. E. 2535 (A. D. 1992) (Wildlife Conservation Division 1992, Boonboothara 1996). Besides the

law, Thailand's Office of Natural Resources and Environmental Policy and Planning has reported, based on expert opinions, the status of threatened species in Thailand and listed jungle cat and flat-headed cat as 'critically endangered', marbled cat as 'endangered', and clouded leopard, fishing cat and Asiatic golden cat as 'vulnerable' species; leopard cat is the only species considered nationally of least concern (Nabhitabhata & Chan-ard 2005).

Non-*Panthera* cats in the wild in Thailand have received less attention than the two large cats, tiger and leopard. Leopard cat was studied in HKK in the late 1980s (Rabinowitz 1990). From the late 1990s to mid 2000s came a string of publications: leopard cat in Kaeng Krachan National Park, Southern Thailand (Grassman 1998), clouded leopard in Khao Yai National Park, Northeastern Thailand (Austin & Tewes 1999), and leopard cat and marbled cat in Phu Khieo Wildlife Sanctuary, Northern central Thailand (Grassman & Tewes 2000, 2002, Grassman et al. 2005). Since 2005, resources and man power have been heavily invested in conservation of *Panthera* species especially tiger (Simcharoen et al. 2007, Lynam 2010, Stokes 2010), in Thailand's Western Forest Complex WEFKOM.

WEFKOM is categorised as a Tiger Conservation Landscape Class I (one that has habitat to support at least 100 tigers, evidence of breeding, minimal-moderate levels of threat, and conservation measures in place), and Global priority (highest probability of persistence of tiger populations over the long term; Dinerstein et al. 2006). Within WEFKOM, HKK is a core area where tiger and leopard ecology has been thoroughly studied, and populations estimated (Simcharoen et al. 2007, 2008). Camera-trapping started in a systematic manner in 2005, following the setup described in Karanth & Nichols (2002). Although designed for tigers, the deployment also photographed non-*Panthera* cats and many other species. This study uses by-catch from the long-term camera-trapping deployment in HKK to (1) examine the records of non-*Panthera* cats, and present what can be learned about status and natural history, and (2) discuss whether the programme generates sufficient non-*Panthera* cat records to allow these species' conservation status to be monitored using such deployments.

Study Area

Huai Kha Khaeng Wildlife Sanctuary (15°00'–15°50' N/99°00'–99°19' E) is one of the best-

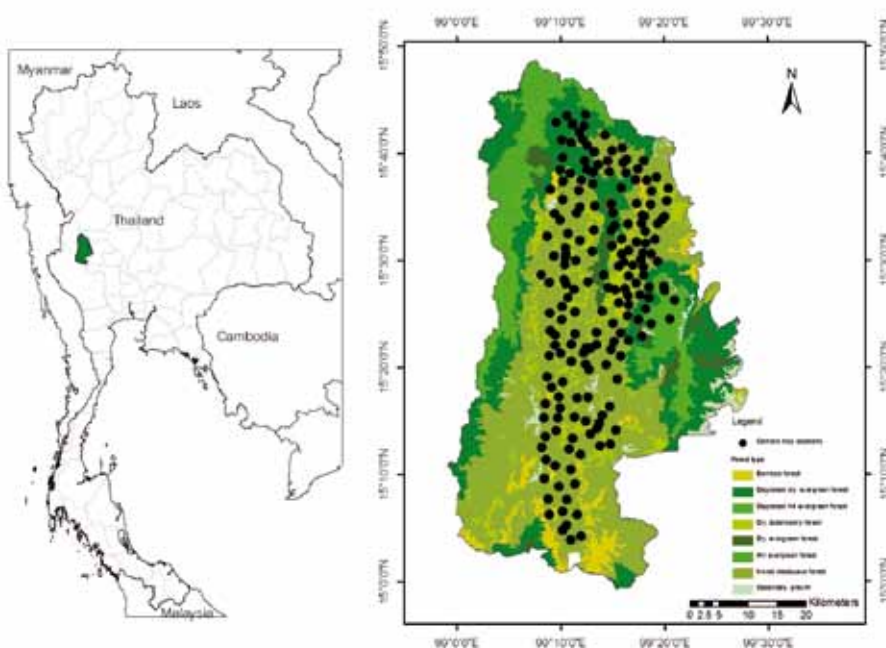


Fig. 1. Location of Huai Kha Khaeng Wildlife Sanctuary, the major habitat types, and the locations of camera-traps.

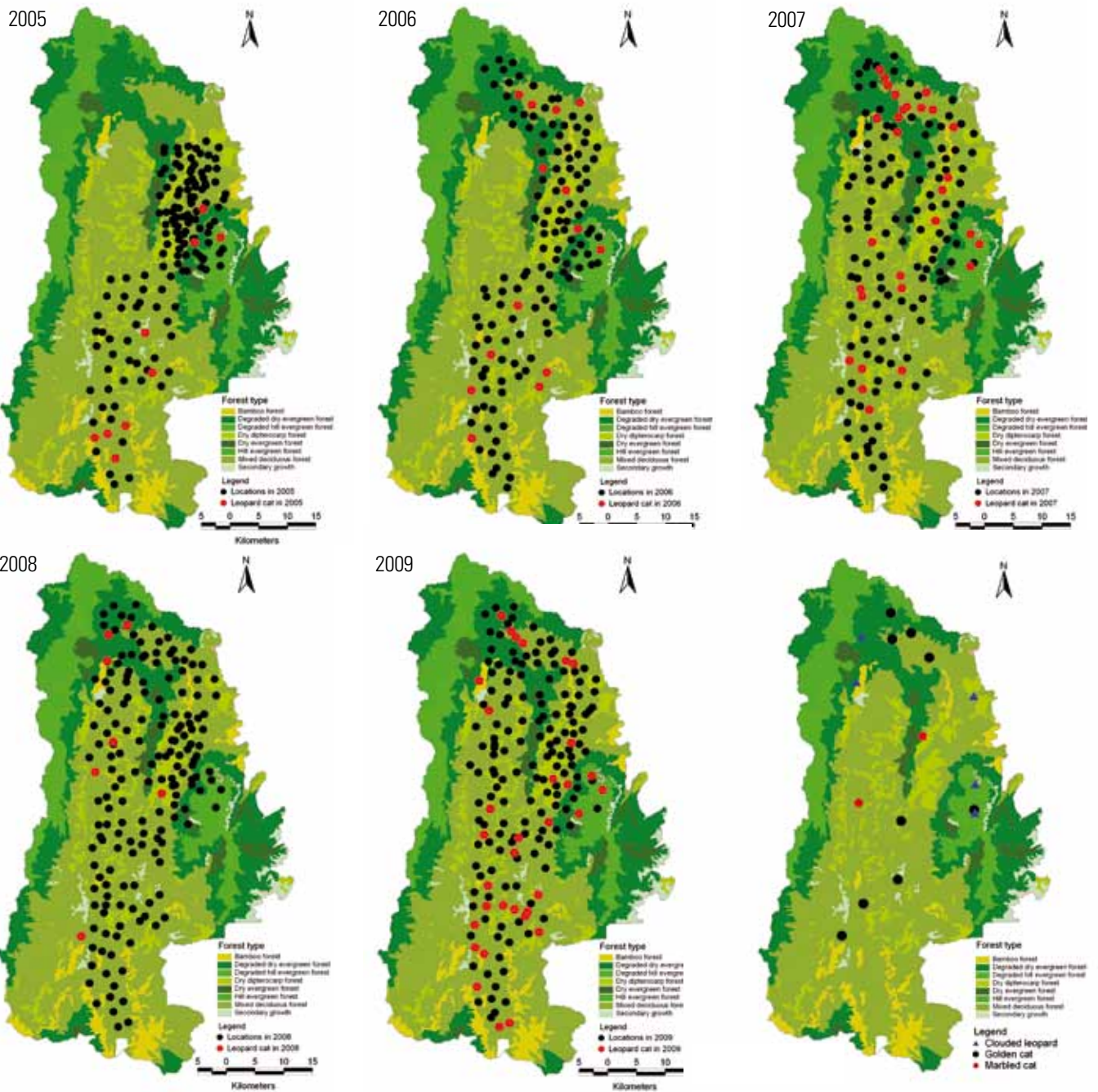


Fig. 2. Locations of camera-traps in Huai Kha Khaeng Wildlife Sanctuary showing where leopard cat was detected (red dots) and not detected (black dots) each year during 2005–2009. The background shows forest types.

Fig. 3. Camera-trap points where Asiatic golden cat, clouded leopard and marbled cat were detected in HKK WS 2005–2009.

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known protected areas in Thailand (WEFCOM 2004; Fig. 1). It covers 2,780 km² and is part of a much bigger (18,000 km²) protected area network called the Western Forest Complex WEFCOM. HKK was declared a wildlife sanctuary in 1972. Currently there are 19 ranger stations, located mostly along the eastern boundary, to protect HKK from poaching and land encroachment (WEFCOM 2004). HKK is part of the Dawna Range, north of the Tenasserim Range, separating northwestern Thailand from Myanmar. HKK topography is more mountainous to the north and west of the area, with ridges exceeding 1,000 m. This

mountain range plays an important role in blocking the southwest monsoon flowing in from Myanmar. The southern part of HKK is generally lower with many small hills of 700–800 m high (Forest Research Centre 1997). The climate is a mix of tropical and sub-tropical, has three seasons: the hot dry season of March–April with average temperature of 24°–38° C, the rainy season of May–October with 23°–34° C, and the cool dry season of December–February with 18°–21° C (Forest Research Centre 1997). The average annual rainfall is about 1,500 mm with the minimum in January and maximum in October. There is

more rain in the west and less in the east, a variation causing significant differences in vegetation type. HKK consists of mixed deciduous forest over almost half of the sanctuary. The other forest types include dry evergreen (25%), hill evergreen (14%), dry dipterocarp (7%) and bamboo forest (4%) (WEFCOM 2004). The open dominant forest types of mixed deciduous and dry dipterocarp occur at elevations of 450–900 m. The forest is sometimes mixed with bamboos (major bamboo species: *Bambusa arundinacea*, *B. burmanica*, *Dendrocalamus strictus*, *Gigantochloa albociliata*). The

dominant tree species in the crown layer include *Azelia xylocarpa*, *Tetrameles nudiflora*, *Lagerstroemia tomentosa*, *L. duperreana*, *Shorea obtusa*, *S. siamensis*, *Dipterocarpus obtusifolius* and *D. tuberculatus* (Forest Research Centre 1997).

Methods

For this study, data from camera-trapping collected between 2005 and 2009 were analysed. The deployments occurred mainly in the two open dominant forest types, given that the main target species was the tiger. Tigers prefer open forests where, with their grass base, large ungulates such as gaur *Bos gaurus* and banteng *B. javanicus* mostly reside (Prayurasiddhi 1997). The camera-trapping areas covered about 1,000 km² of this near-optimal tiger habitat. Almost 80% of camera-trap locations were in mixed deciduous and dry dipterocarp forests, 17% in degraded evergreen, and the rest in other vegetation types.

Several camera-trap models, including CamTrakker, Bushnell and Scoutguard, were set up following the standard method used for monitoring tigers, detailed in Karanth & Nichols (2002). Camera-traps were located mainly along forest roads and animal trails, and at salt licks. At each location camera-traps were set in a pair, each unit 3-5 m from the path and about 45 cm above ground. No bait was used. Camera-traps were set to function throughout the 24-hour cycle.

The spacing between camera-trap locations was about 3-4 km, based on female tiger home-range (Karanth & Nichols 2002). With about 180 camera-trap locations each year, trapping was divided into eight blocks of 20-25 trapping locations. The camera-traps were left in each block for 15-20 days before being relocated to another block. Two blocks were sampled simultaneously. Trapping normally started in January and finished by mid May. For an optimal setting of cameras, locations within a block were moved slightly between years. Thus, spacing between camera-trap locations used in different years was frequently well below 3-4 km, and the total number of camera-trap locations at which some species were found over the five years exceeded the 180 total camera-trap locations per year.

The total of camera-trap-nights is the sum of the number of nights each pair of cameras was open functioning at all camera-trap locations. Species identification from photographs was carried out by the project

Table 1. The number of notionally independent events for cat species during camera-trapping in Huai Kha Khaeng Wildlife Sanctuary during 2005-2009. When both cameras in a pair photographed an animal, this is recorded as only one record.

Species	Number of notionally independent events					Total
	2005	2006	2007	2008	2009	
Tiger	107	68	91	111	106	483
Leopard	133	138	139	115	128	653
Clouded leopard	2	2	1	0	1	6
Asiatic golden cat	0	3	1	2	4	10
Leopard cat	9	24	56	12	54	155
Marbled cat	1	0	0	1	0	2
Total camera-trap-nights	2,241	2,020	2,467	2,804	2,731	

staff, with support from two wildlife biologists, with more than five years of experience of camera trapping, in case of doubts. All photographs of cats were scanned, put into a database and identification of all photographs listed as non-*Panthera* were assessed independently by J. W. Duckworth. Records were calculated in terms of: 1) number of independent events, and 2) number of camera-trap stations detecting the species. To assess conservation status, the photographs at one camera-trap station are not independent if they show the same animal. This problem is reduced by presenting the number of camera-trap stations recording the species, although even this will not exclude non-independent records if multiple camera-trap stations are within a typical individual's home range. Notionally independent events are defined as one or more photographs of one or more animals of the same species at a given camera-trap location, separated by no more than 30 minutes.

Camera-trap locations were overlaid with a habitat map interpreted from LANDSAT 5 TM 2002 (WEFCOM 2004) to determine the vegetation cover at each location.

Results

Tiger-focussed camera-trapping in HKK between 2005 and 2009 captured four species

of small and medium cat (Table 1). No domestic cats *Felis catus* were captured during these surveys. Tables 1 and 2 also contain results for tiger and leopard, for comparison with the smaller species; detailed analysis of *Panthera* data will be published elsewhere.

Number of notionally independent events

Each year the camera-traps were deployed for more than 2,000 trap-nights with a total of 12,263 trap-nights over the five years. The numbers of independent events for non-*Panthera* cats are much lower than *Panthera* cats (Table 1). Leopard cat was the most frequently detected small cat. Clouded leopard and golden cat events ranged from very few to none per year; marbled cat was detected only twice (Supporting Online Material SOM Table T1).

Number of camera-trap stations detecting the species

Between 150 and 190 camera-trap stations were set each year, covering almost 1,000 km². Leopards and tigers were the most widely detected cat species (Table 2). Among non-*Panthera* cats, leopard cat had the widest detection, but even so each year less than one-sixth of camera-trap stations detected leopard cats. The other three cats were found at very few stations.

Table 2. The number of camera-trap stations recording each species in Huai Kha Khaeng Wildlife Sanctuary during 2005-2009.

Species	Number of stations where the species were recorded					Total
	2005	2006	2007	2008	2009	
Tiger	58	46	52	67	64	287
Leopard	77	61	76	61	63	338
Clouded leopard	1	2	1	0	1	5
Asiatic golden cat	0	3	1	2	4	10
Leopard cat	9	14	29	7	33	92
Marbled cat	1	0	0	1	0	2
Total camera-trap locations	155	136	156	180	186	



Fig. 4. Clouded leopard on 3 June 2006, 23:49 h. Habitat: Mixed deciduous forest.

Leopard cat habitat use and activity pattern

Leopard cat was the only small cat with sufficient camera-trap records (92 locations in five years) for an analysis of habitat use (SOM T2). Caution is required in interpretation because patterns may be biased by the selection of camera-trap locations, and refer only to the late dry season. Almost 70% of camera-trap locations with leopard cat detection were in mixed deciduous forest (SOM T2; Fig. 2), while the other two open canopy forest types, dry dipterocarp (10%) and degraded dry evergreen forests (15%) were used to a lesser extent.

Leopard cat was also the only small cat species with enough data to allow for the analysis of activity patterns. At least in the late dry season, it is nocturnal, with the main activity starting after 18:00 h and peaking during 19:00 h - 22:00 h and fluctuating from 22:00 h to 06:00 h. It is almost inactive by day (SOM Figure F1).

Morphology of Asiatic golden cat

Of the 10 records of golden cat, seven were of golden animals and three of grey ones.



Fig. 5. Leopard cat on 23 April 2006, 14:59 h. Habitat: Mixed deciduous forest.

Discussion

Leopard cat

Leopard cat is the only small cat species so far studied intensively in multiple parts of Thailand (Rabinowitz 1990, Grassman et al. 2005). Similarly, it is the only species with enough camera-trap detections in HKK for a confident discussion of abundance and habitat use at the site, albeit only for the late dry season. It was photographed in many habitat-types, coinciding with its generally wide habitat use (Wilson & Mittermeier 2009). In HKK the high encounter rates in mixed deciduous forest may simply reflect disproportionate survey effort. However, the low encounter rate in dry dipterocarp forest relative to survey effort corroborates earlier findings in HKK that it uses mixed deciduous and dry evergreen forests more than dry dipterocarp forest with its lower dry-season grass base, and thus lower cover and prey (Rabinowitz 1990). Wet-season surveys, when dry dipterocarp forest has rich understorey growth, might reveal a very different habitat use.

These results found leopard cat to be crepuscular and nocturnal, with very few photographs by day. Radio-collared leopard cats in Phu Khieo Wildlife Sanctuary, northeastern Thailand, in more evergreen habitats, showed somewhat more daytime activity, while still being mainly crepuscular and nocturnal (Grassman et al. 2005).

Other non-Panthera cats

Fishing cat was reported in the Master Plan of HKK in 1989 (Thailand Faculty of Forestry 1989). It was not detected in the 2005-2009 camera-trap deployment, which covered large areas including near streams, and seems very unlikely to occur there presently. Because individuals of this species are often misidentified, (Duckworth et al. 2009), the

basis for the 1989 report warrants a review. Jungle cat apparently occurs predominantly in deciduous forest in South-east Asia (Duckworth et al. 2005), so parts of HKK might be expected to support it. However, no records were obtained from this intensive camera-trapping survey, mostly in deciduous forest, despite reasonable trapping rates described in other studies (e.g. Gray et al. 2014), suggesting that jungle cat is rare or even absent from HKK. The other small cat of Thailand, the flat-headed cat, does not occur this far north (Wilting et al. 2010).

Small cat community

In HKK, leopard cat is common but golden cat, clouded leopard and marbled cat were all recorded only rarely. Focused camera-trapping in HKK's evergreen forests might find these three species more often, but they are evidently rare in HKK's deciduous forest. Observations in other areas suggest that leopard cat population increases when larger predators, such as golden cat and clouded leopard, are eliminated (Wilson & Mittermeier 2009). Release of leopard cat population with reduction of interspecific competition from golden cat and marbled cat is plausible, because the three species presumably share similar small prey such as rodents, reptiles, birds, amphibians and insects. However, it is less likely for clouded leopard, which preys on larger animals such as porcupines (Hystricidae), pigs *Sus* spp., young sambar *Rusa unicorn*, muntjacs *Muntiacus* spp., chevrotains *Tragulus* spp. and palm civets (Paradoxurinae) (Wilson & Mittermeier 2009). In this study, clouded leopard seems to use evergreen forest more frequently than leopard cat, which is found more in deciduous forest.

Conclusions and management implications

Intensive camera-trap deployment for tigers in Huai Kha Kheang Wildlife Sanctuary from 2005 to 2009 captured six cat species: tiger, leopard, clouded leopard, golden cat, marbled cat and leopard cat. Tiger and leopard were recorded often. Of the non-*Panthera* cats, leopard cat was found commonly whereas golden cat, clouded leopard and marbled cat were rarely found.

Thus, camera-trapping for tigers in Huai Kha Kheang Wildlife Sanctuary provides useful data to study abundance patterns, activity rhythms, and habitat use of leopard cat, but data are too sparse for a similar analysis of clouded leopard, golden cat and marbled cat.

Moreover, annual numbers of leopard cat independent events fluctuated considerably during this five-year study, making it difficult to use this method to assess population trends during short periods of time.

To monitor clouded leopard, golden cat and marbled cat, other camera-trapping study designs would need to be experimented with, such as placing more camera-trap stations in evergreen forests, or around fruiting trees with high rodent concentration.

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Fig. 6. Asiatic golden cat on 16 March 2006 08:04 h. Habitat: Hill evergreen forest.

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Supporting Online Material SOM Tables T1, T2 and Figure F1 are available at www.catsg.org/catnews

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Recent distribution records, threats and conservation priorities of small cats in Thailand

Although small cats are presumed important as mesopredators in mammalian food chains, they have been largely ignored by biodiversity assessments of Thailand's protected areas. In November 2009, a workshop involving regional specialists and participants from local universities, conservation organizations and government agencies was convened to assess the current status and distribution of small carnivores. In this paper, we review the small cat by-catch from 24 camera-trap surveys primarily targeting tigers *Panthera tigris* and other large mammals, two radio-telemetry studies, and a small number of direct sightings from 16 protected areas across Thailand. These data were collected between 1996 and 2011 and form the most current available information on distribution and threats for small cats in the country. A total of seven small to medium cat species have been recorded in Thailand. No cat species is restricted to Thailand and while some (leopard cat *Prionailurus bengalensis*, mainland clouded leopard *Neofelis nebulosa*, Asiatic golden cat *Catopuma temminckii* and marbled cat *Paradofelis marmorata*) are evidently widespread across the country where habitat is available, abundance and ranging patterns in the recorded sites are poorly understood. Fishing cat *Prionailurus viverrinus*, jungle cat *Felis chaus* and flat-headed cat *Prionailurus planiceps* are each known from few Thai records and localities, and populations may be particularly threatened due to persecution, and loss and degradation of habitat. Small and medium cats in general may be persecuted but seldom appear in wildlife trade inside Thailand with the exception of the clouded leopard. A thorough review of Thai historical records of small cats, to look for patterns of range contraction and habitat use, is needed, with a focus on those species which have not been widely found today (fishing cat, flat-headed cat and jungle cat).

Thailand is part of the range of many mainland Southeast Asian carnivore species (Corbet & Hill 1992). Most of the country falls in the Indochinese division of the Indochinese sub-region. Sundaic and Indochinese faunas differ distinctly and there is a high latitudinal species turnover. Some Sundaic influences extend north to about 15–16°N, while some Indochinese species occur south through Thailand into Malaysia, with many species having range boundaries in the peninsula (Woodruff & Turner 2009). Over the last 50 years, Thailand has seen major forest conversion which continues today though at significantly reduced rates (FAO 2010). Based on 2007 data, >90% of lowland areas (0–200 m) are dominated by agriculture (mostly rice fields, fruit, rubber and oil palm plantations), settlements and industry. Most of remaining lowland forest habitats (>90%) are smaller than two square kilometres (N. Tantipisanuh, unpubl. data). Lowland rainforest, freshwater swamp forest and primary mangrove forest

have been almost completely lost (Woodruff 1990).

Aside from a few dedicated efforts to elucidate their distribution and abundance (Rabinowitz 1990, 1991, Kanchanasaka 2001a, b), small carnivores (including the smaller cat species) have largely been ignored by recent biodiversity assessments although they are presumed to be important as mesopredators in mammalian food chains due to their dependence on small mammalian prey (Lekagul & McNeely 1988, Sunquist & Sunquist 2002). However, due to increasing conservation interest, intensive surveys using camera-traps have been conducted for tigers across suitable remaining habitats within Thailand and these and other surveys have incidentally produced positively identifiable records of small cats and other carnivores.

A meeting was held in Bangkok on 26–27 November 2009 to collate records of small carnivores (defined there as all species in the Order Carnivora typically under 15 kg) in

Thailand and discuss their conservation and research needs (Chutipong et al. 2010). The review period is between January 1996 and August 2009 inclusive, although reports of exceptional interest from up to May 2011 are also included. All individuals working in government agencies, academic institutions and international NGOs, known to have undertaken extensive camera-trapping in Thailand in this period, were contacted; some were not able to attend or otherwise join in the record collation process. As far as we know, those who did not attend the workshop have conducted surveys in the same areas as those that we have reported here. However, there are significant parts of Thailand, where, from our knowledge, no camera-trap surveys have been conducted e.g. northern and the central plain of Thailand. We considered the current threats for all small carnivores and discussed the possible research and conservation needs for highly threatened species. This compilation covers all Thai cat species except tiger and leopard *Panthera pardus* whose statuses are treated elsewhere (Lynam et al. 2001, Lynam et al. 2006, Ngoprasert et al. 2007, Simcharoen et al. 2007, Simcharoen et al. 2008, Steinmetz et al. 2009, Lynam 2010 and Walston et al. 2010).

Methods

Study areas

Thailand comprises 513,115 km² of land between latitudes 5°37' N and 20°30' N (ca. 1,500 km north - south), ranging in elevation from sea level to 2,565 m. Climate varies between areas from a long, harsh dry season, to those with only a short, dry season, and all intervening stages. Most land areas were forested until the advent of commercial forestry after 1897 (Usher 2009). Terrestrial wildlife habitats can be divided into seasonal evergreen forest, mixed deciduous forest, deciduous dipterocarp forest, scrub, wetlands (of many types) and agricultural land. These main habitat types vary with elevation, although the extent to which mammals do so in Thailand is surprisingly poorly known (Steinmetz et al. 2008). There are no strictly marine species of small carnivore in Thailand, so marine (as distinct from littoral) habitats are not considered here.

Most areas of natural and semi-natural vegetation lie within the boundaries of 426 protected areas (see the map of Thailand's protected areas in the Supporting Online Material), with the coverage skewed towards higher elevations and not evenly spread across its

regions (Tantipisanuh & Gale 2013). These protected areas collectively cover 103,810 km² (ca. 20%) of Thailand. While there are some globally outstanding large protected area complexes, most notably the Western Forest Complex of 17 protected areas totalling 18,000 km² (Prayurasiddhi et al. 1999, Simcharoen et al. 2007), many other protected areas are small (more than 65% are less than 200 km²), feature proportionately larger areas of disturbed habitats around their perimeters, and are isolated from other natural habitats. Nine organisations conducted surveys in 16 of the larger protected areas chosen from the suite of available habitats (Fig. 1). There was no available survey data from the north and the central plain at the time of the workshop.

Camera-trap survey data

Before the workshop, a questionnaire was sent to researchers conducting camera-trap surveys in Thailand, asking for camera-trap records of all carnivores except bears, and basic information about the surveys which generated them. Details of camera trapping surveys, including species present, survey sites, survey period, survey effort (number of camera-trap-nights), number of camera locations, survey coverage (km²), habitat types, and their elevation range at each survey site, were sought (Supporting Online Material SOM Table T1). Survey coverage was estimated by creating minimum convex polygons around the outermost camera locations. For sites with multi-year surveys we calculated and reported survey coverage per year. We obtained elevation at each camera-trap location from the ASTER Global Digital Elevation Model (<http://www.ersdac.or.jp>) with the purported accuracy 7-14 m, with the majority of locations below 1,000 m (the original ASTER GDEM data is the property of METI and NASA).

We did not quantify area-specific survey-effort to a precise single figure due to the large variation between sites in study design as well as in numerous other characteristics. The surveys varied widely in other essential parameters affecting species caught and their capture probability, such as height above ground of the camera-traps, use of baits and lures, microhabitats selected for camera trap placement (such as on/off trails, beside/away from surface water), duration of camera-trapping at each position, model of camera-traps used, and their age/reliability. In part, this reflects the varying objectives of the different surveys and also the personal choice of individual researchers. In nearly all

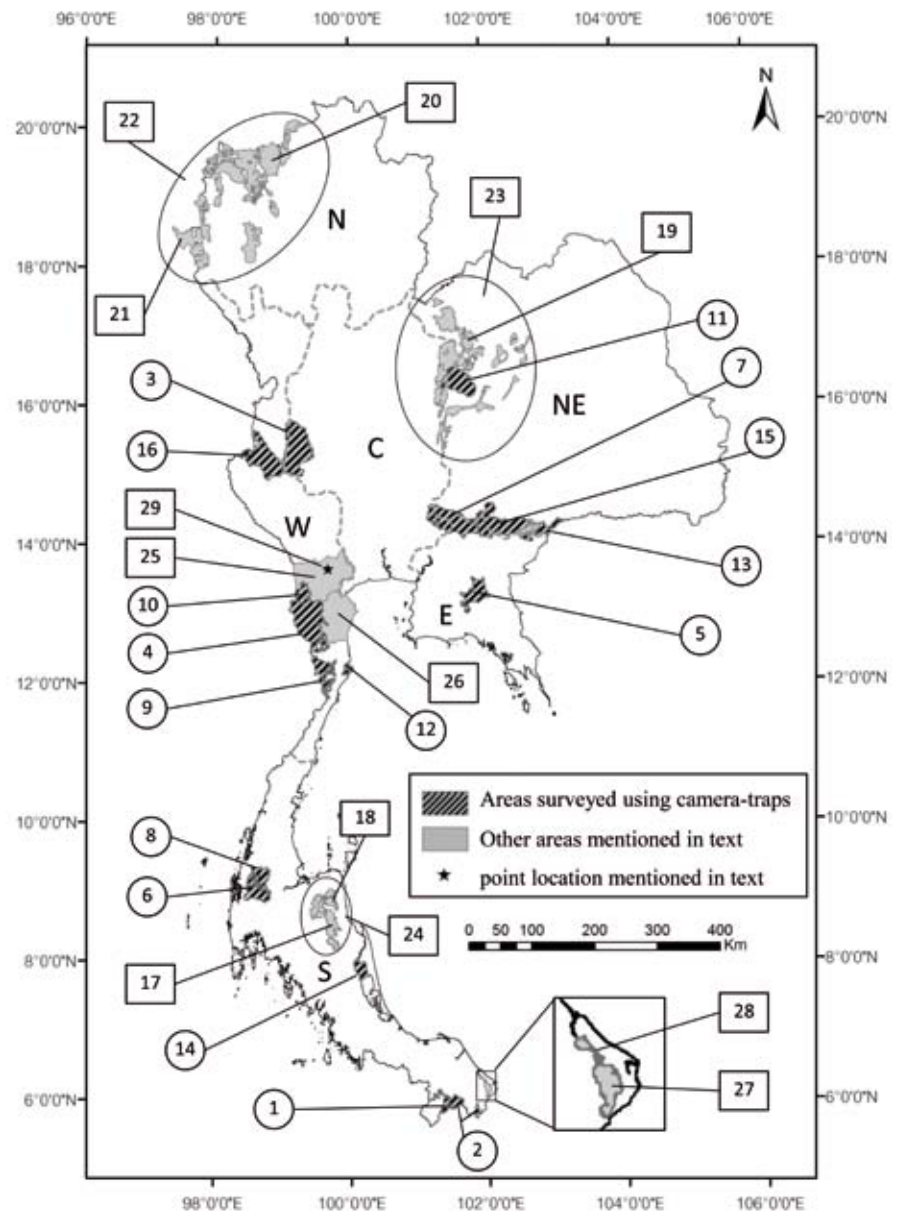


Fig. 1. Location of 16 protected areas in Thailand where the camera-trap data were gathered (circles) and 13 additional areas where cat records are given in the text (squares). (1) Bang Lang National Park NP, (2) Hala-Bala Wildlife Sanctuary WS, (3) Huai Kha Khaeng WS, (4) Kaeng Krachan NP, (5) Khao Ang Rue Nai WS, (6) Khao Sok NP, (7) Khao Yai NP, (8) Khlong Saeng WS, (9) Kuiburi NP, (10) Maenam Pachi WS, (11) Phu Khieo WS, (12) Khao Sam Roi Yod NP, (13) Ta Phraya NP, (14) Thale Noi Non-hunting Area, (15) Thap Lan NP, (16) Thung Yai Naresuan WS – West, (17) Khao Luang NP, (18) Khao Nan NP, (19) Phu Kra-dueng NP, (20) Doi Chiang Dao WS, (21) Salawin WS, (22) Lum Nam Pai-Salawin Forest Complex (hereafter FC), (23) Phu Khieo-Nam Nao FC, (24) Khao Luang FC, (25) Ratchaburi Province, (26) Phetchaburi Province, (27) Pru Toh Daeng swamp forest, (28) Su-ngai Padi District, (29) Khao Prathub Chang Wildlife Breeding Centre. Regions on the map: N=North, NE=Northeast, W=West, C=Central, E=East and S=South.

the study areas, nearly all camera-trap effort was in evergreen rather than deciduous forest, and in forests rather than scrub or grasslands. However, there were two surveys targeting fishing cat *Prionailurus viverrinus* in wetland habitats. Average camera trap spacing was $1.37 \pm \text{SE } 0.24$ km (range 0.5-2.8 km).

Because of the large variation between survey areas in camera-trap survey effort and methods, no between-survey area analyses were conducted: each of the many differences that would be found might reflect differences in survey methods rather than anything biologically meaningful. The results are therefore presented on a species-by-species

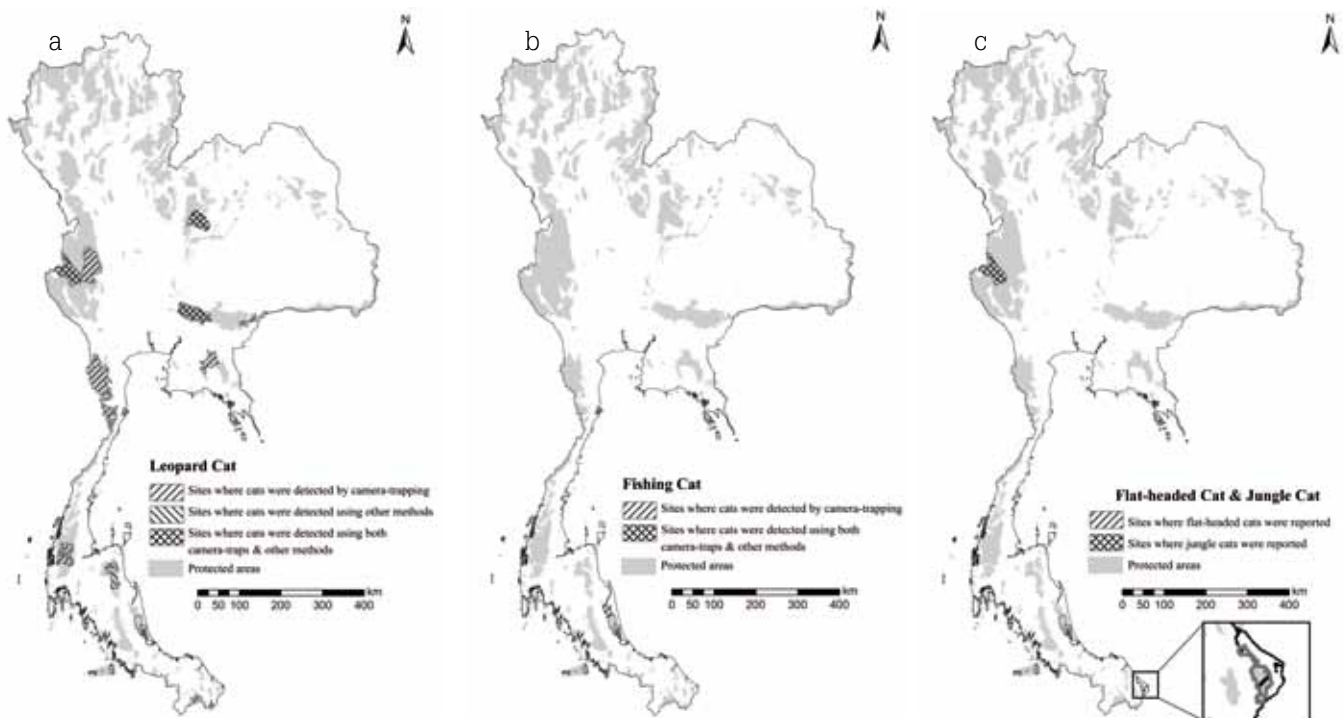


Fig. 2. Distribution maps of seven cat species: (a) leopard cat, (b) fishing cat, (c) flat-headed cat and jungle cat; next page: (d) Asiatic golden cat, (e) marbled cat, and (f) clouded leopard. The sources of the records were separated into 3 groups: (1) camera-trap only, (2) other sources, and (3) both camera-trap and other sources.

basis and while records of a given species at a given survey area confirm its presence, the lack of records does not confirm its absence. Camera-trap photographs of small cats were reviewed for identification ($n=219$) by eight surveyors, including several from outside Thailand but with extensive regional experience. This review found that the overall reliability of identifications was high (96.8%), suggesting that field surveyors motivated enough to participate in such a collaborative process are also careful in their identifications of small cats. Nonetheless, records that would have been of particular significance (notably any suggesting occurrence of a species at a protected area) with no available

photograph for validation were removed from the dataset. Non-validated photographs for species known to be present (by other available photographs) in that survey area at that time were retained.

Additional records from workshop

Records mentioned in the workshop with no specimen or photograph available for third-party validation have been included only after careful consideration. Direct sighting records have been included only for observers demonstrably familiar with the species of Thailand (either through extensive examination of museum skin specimens or camera-trapping).

Other records

In addition to records obtained during the workshop, other relevant records derived from Journal of Wildlife in Thailand (Faculty of Forestry, Kasetsart University) and second-hand reports (Department of National Park, Wildlife and Plant Conservation) were included only in exceptional cases after careful consideration because the reliability of such reports can rarely be determined.

Results

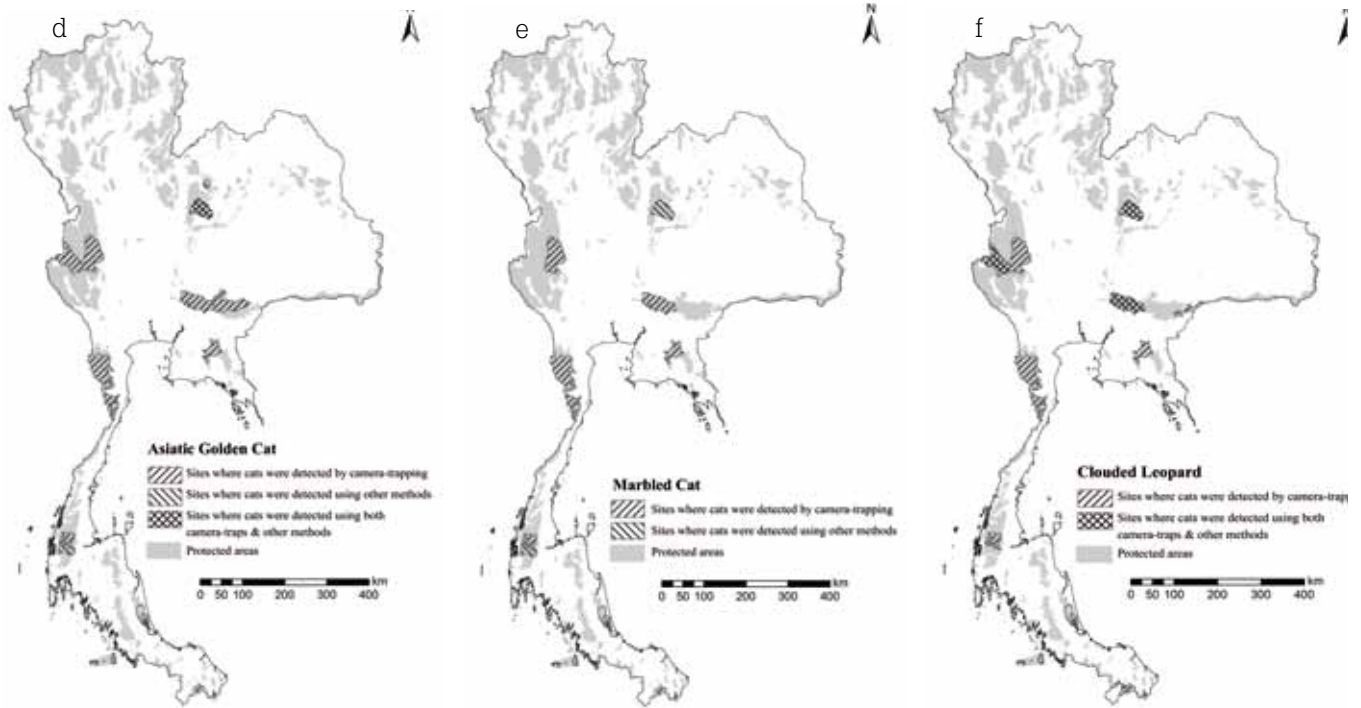
There are five species of cats with camera trap records and among these, three species (leopard cat, Asiatic golden cat and clouded leopard) occurred in over 50% of the 16 sites from which camera-trap survey data were available (SOM T1). When we incorporated the additional (non-camera trap) records, leopard cat (75% of sites), Asiatic golden cat (63%), clouded leopard (56%) and marbled cat (50%) were the most widely distributed in the surveyed sites. Fishing cat was much less widespread even though it was the survey target at several sites (25% of survey target sites had presence); there were no records clearly attributable to fishing cat at any of the 'non-target' sites.

Leopard cat

Records from workshop: Leopard cats are widely distributed in Thailand, being recorded by the camera-traps in 11 out of 16 sites (Fig.



Fig. 3. Leopard cat pictured in Thung Yai Naresuan Wildlife Sanctuary on 4.12.2007 (Photo W. Chutipong).



2a). In addition, there were direct sightings at Khao Sam Roi Yod National Park (P. Cutter, unpubl. data; Fig. 1). Leopard cats were found in various habitat types, both forest and non-forest and over a wide elevational range (96 m in Khao Ang Rue Nai WS to 1,345 m in Huai Kha Khaeng WS; SOM T1).

Other records: There are camera-trap records from Khlong Saeng Wildlife Sanctuary (Kanchanasaka 2001a) but they were not available for confirmation, and putative direct sightings at Khao Luang National Park and Khao Nan National Park (N. Bhumpakphan, unpubl. data; Fig. 1, 2a).

Fishing cat

Records from workshop: Records of fishing cat came from three sites (Fig. 2b). Khao Sam Roi Yod National Park is believed to be the site with the largest remaining population (P. Cutter, unpubl. data; Fig. 1). More than 20 individuals were identified from camera trap photographs and live-captures in the area. Camera trap evidence suggests occurrence in nearby wetlands adjacent to the south of Khao Sam Roi Yod National Park. Fishing cats in Khao Sam Roi Yod National Park were usually found in rice fields, where diverse prey are available, and in secondary mangrove forest. They appeared to be tolerant of human presence. Evidence suggests that the fishing cat may restrict its range to wetland habitat of lowland areas (<300 m; Cutter 2009). A camera trap record from Kaeng Krachan National Park (Phetchburi Province) in 2002 (Fig. 1) came from a camera set at 336 m in

mixed deciduous forest with distance to nearest water body of 1.9 km. However, a rehabilitated fishing cat was released near the survey area from a wildlife rescue centre in Phetchburi (E. Wieks, pers. comm.; Fig. 1) and so the wild origin of the camera-trapped cat is questionable.

Other records: Surveys at Khlong Saeng and Maenam Pachi Wildlife Sanctuaries (Fig. 1; using similar methods to those at Khao Sam Roi Yod) did not reveal evidence of fishing cats (Cutter & Cutter 2009). A sighting reported as a fishing cat from Khlong E Tow, 4 km west of the Khao Yai National Park Headquarters, in seasonal evergreen forest by T. Charoendong in 2000 (Lynam et al. 2006) remains unconfirmed. Camera trapping in previous and subsequent years, including in and around the location where

the observation was made, failed to detect the species (SOM T1) so the validity of the identification is considered questionable. A record of fishing cat from May 2007 was reported from Pattani Province in southern Thailand (www.fishing-cat.wild-cat.org). Two cats were caught in a patchy mangrove forest near Bangplamor Village, 15 minutes drive from the Pattani Campus of Prince Songkla University; one cat died in captivity and the other was released eventually (W. Karntanut, pers. comm.).

Flat-headed cat

Records from workshop: Flat-headed cat was not camera trapped in any of the 16 sites. This cat is very rarely recorded in Thailand, at least in part because its distribution in the country is limited to the extreme south.



Fig. 4. Fishing cat pictured in Thale Noi Non-Hunting Area on 15. 2.2007 (Photo P. Cutter).



Fig. 5. Asiatic golden cat pictured in Thung Yai Naresuan Wildlife Sanctuary on 24.12.2011 (Photo W. Chutipong).

Other records: Kanchanasaka (1995) reported the flat-headed cat from Pru Toh Daeng swamp forest (Fig. 2c). Kanchanasaka's survey team saw the cat in the evening at two locations: (1) near the Su-ngai Padi River and (2) an area between Melaleuca forest and swamp forest near Su-ngai Padi II road. In 2005, two flat-headed cats were confiscated from wildlife traffickers and brought to the Khao Prathub Chang Wildlife Breeding Centre where they were looked after (Fig. 1). They were suspected of being smuggled from Peninsular Malaysia for the pet trade (Manager Online 2005).

Asiatic golden cat

Records from workshop: Asiatic golden cat was recorded in nine of the 16 sites (Fig. 2d). In other parts of Thailand, there were direct sightings at Khao Sok National Park in 1996 (A. Lynam, unpubl. data; Fig. 1). Asiatic golden cats were recorded in various forest types both primary and secondary, and across a wide range of elevations (from 144 m in Khao Ang Rue Nai Wildlife Sanctuary to 1,310 m in Khao Yai National Park; SOM T1), suggesting that low to mid-elevations were not a limiting factor to the occurrence of this species.

Other records: Camera trap records from Khlong Saeng Wildlife Sanctuary were reported by Kanchanasaka (2001a) but were not available for confirmation (Fig. 1). In other parts of Thailand, there were putative direct sightings at Phu Kradueng National Park in 1983 (N. Bhumpakphan, unpubl. data; Fig. 1).

Marbled cat

Records from workshop: Marbled cat was camera-trapped in six of the 16 sites (Fig. 2e). A direct sighting was reported from the Khao Sok National Park (A. Lynam, unpubl. data; Fig. 1). One camera-trap record in this study came from the edge of secondary forest in Kaeng Krachan National Park (Ngoprasert & Lynam 2002; Fig. 1). In Phu Khieo Wildlife Sanctuary, one female marbled cat was radio tagged and its ranging pattern studied (Grassman et al. 2005; Fig. 1). Records of marbled cats came from elevations ranging from 95-1,097 m.

Other records: The species was reported from camera trap surveys in Khlong Saeng Wildlife Sanctuary (Kanchanasaka 2001a; Fig. 1), but the records were not available for confirmation.

Clouded leopard

Records from workshop: Clouded leopards were confirmed in nine of the 16 sites (Fig. 2f). All records of clouded leopards came from natural forest, but survey efforts in disturbed habitats were too limited to speculate on the extent to which the species uses them. Clouded leopards were found in a wide altitudinal range (from 90 m in Khao Ang Rue Nai Wildlife Sanctuary to 1,253 m in Huai Kha Khaeng Wildlife Sanctuary; SOM T1), suggesting that elevation is not a limiting factor for this species' distribution, at least in Thailand.

Other records: This cat species was documented by camera-traps in Khlong Saeng Wildlife Sanctuary (Kanchanasaka 2001a) and Kaeng Krachan National Park (Tanhikorn et al. 2008), but photos were not available for confirmation (Fig. 1).

Jungle cat

Records from workshop: There were no camera trap records of jungle cat and overall there are very few recent records in Thailand.

Other records: One direct sighting came from Thung Yai Naresuan Wildlife Sanctuary - West (Steinmetz & Mather 1996; Fig. 2c) in a sharp transition between semi-evergreen forest on level limestone and drier bamboo-dominated mixed deciduous forest at ca. 400 m, ca. 10 – 12 km from a village (Duckworth et al. 2005). Four specimens of jungle cat received in 1972 (two from Ratchaburi, one from Phetchaburi and one from a market; Fig. 1) are lodged at the Thailand Institute of Scientific and Technological Research TISTR (Duckworth et al. 2005). Historical records of jungle cats in Cambodia, Lao PDR and Vietnam were

compiled in Duckworth et al. (2005); a companion review for Thailand is warranted. Lekagul & McNeely (1988) suggested the species was common throughout Thailand including the northern parts, at the time of writing their book. Our survey data lacked coverage from northern Thailand, so we cannot confirm whether this is still true.

Discussion

Given the limited survey effort (less than 1,000 trap-nights) and/or spatial coverage (less than three to four home ranges) at seven of the 16 sites (SOM T1), and that leopard cats, Asiatic golden cats, clouded leopards and marbled cats were still found at more than 50% of sites suggests that they are widespread within the larger protected areas of Thailand. In contrast, there were no camera-trap records of jungle cat or flat-headed cat despite our compilation of camera trap records across a 15-year period, presumably in part because very limited sampling was done in open deciduous forest or scrub, or peat and/or swamp areas, the respective presumed favoured habitats for these species. Fishing cats, except for the questionable records in Kaeng Krachan and Khao Yai National Parks (Fig. 1), were found only in sites where surveys specifically targeted them (Khao Sam Roi Yod National Park and Thale Noi Non-hunting Area; Fig. 1). Specific surveys over a wider range of sites outside the protected areas surveyed in this study might be necessary to find evidence of presence of these three rare species. On the basis of these results, no strong conclusions can be made on their national status. However, bearing in mind the rarity with which each appears in captivity or trade, or are found by other incidental ways (road-kill, birdwatcher sightings, etc.), it is likely that none is common in the country and all may be very rare and therefore at risk of national extinction. This is especially true if they occur primarily outside protected areas and thereby receive little or no active protection against poaching or habitat disturbance or conversion.

The surveys collated here were mostly aimed at mammals larger than these cats and cameras were set mainly along forest roads and large trails, especially those actively used by tigers. Smaller carnivores might avoid such pathways due to their habitual use by larger carnivores (Di Bitetti et al. 2006), or people in the protected areas with large number of visitors and/or poachers. Larger carnivores sometimes kill small carnivores; for example leopard predation on leopard cat was recorded

in Kaeng Krachan National Park (Grassman 1997; Fig. 1) although it is unclear how regular this behaviour is. Therefore, surveyors of small cats should consider issues of trail avoidance by some small carnivores due to higher use of such trails by larger carnivores. The natural history of each species remains too poorly known to prescribe optimal survey techniques. As long as this is true, assessments of the small cat community composition needs camera traps to be deployed across a wide variety of habitats (including degraded areas) and include as many microhabitats as possible.

Leopard cat: The absence of leopard cat from four study sites (SOM T1) was possibly due to the low survey effort (less than 1,000 trap-nights) and coverage (less than three to four home ranges; Maffei & Noss 2008, Tobler et al. 2008). However, this is possibly not the case for Bang Lang (SOM T1) where the survey detected the presence of clouded leopard (4 photographs) despite the low survey effort and coverage. The absence of leopard cat from the survey at Bang Lang could have several explanations. There is a strong possibility that it is due to the low abundance and relatively low intensity of trapping effort leading to the species being missed at Bang Lang (<700 trap-nights). A trapping effort at Hala Bala with just over 1,000 trap-nights also failed to detect leopard cats but a later survey with over 10,000 trap-nights did record the species (SOM T1). Moreover, the Bang Lang and earlier Hala Bala surveys targeted tigers and trap locations were placed where tiger signs were detected; these locations may be avoided by leopard cats. Leopard cats were also missing from surveys that employed the same tiger-optimized survey design and camera-trap placement at Temenggong and Bintang Hijau in northern Malaysia (Lynam et al. 2007). Camera trap surveys at Khlong Saeng in 2012 (L. Gibson, unpubl. data) confirmed the species presence there.

Asiatic golden cat: Historical records suggested a wide distribution for the Asiatic golden cat in Thailand (Lekagul & McNeely 1988). The distribution map produced from these records as well as our work is probably incomplete mainly due to limitations in coverage of the surveys and the relatively low survey effort (based on number of trap-nights). Therefore, more camera-trap surveys should be conducted, in particular, in the forest areas in northern Thailand such as the Lum Nam Pai-Salawin Forest Complex, the Phu Khieo-Nam Nao Forest Complex, Doi Chiang Dao and



Fig. 6. Clouded leopard pictured in Ta Phraya National Park on 31.08.1998 (Photo WCS Thailand).

Salawin Wildlife Sanctuaries, and also the Khao Luang Forest Complex in southern Thailand (Fig. 1) where its presence has been suggested but unconfirmed (Nowell & Jackson 1996). Camera trap surveys at Khlong Saeng in 2012 (L. Gibson, unpubl. data) confirmed the species presence there.

Flat-headed cat: Degradation/alteration of Pru Toh Daeng swamp forest (Fig. 1) could significantly impact the survival of the flat-headed cat population in Thailand. A recent habitat model for this species across the entire species range predicted Pru Toh Daeng swamp forest to be the last probable viable habitat for flat-headed cats in Thailand (Wilting et al. 2010).

Marbled cat: The lack of camera trap records of marbled cat may not be an actual reflection of local status, but rather a result of semi-arboreal behaviour. A study in Borneo, where both camera-trap and spotlighting surveys were employed, encountered marbled cats by spotlighting survey twice, but the cat was never detected by camera-trapping (Mohamed et al. 2009), suggesting partly arboreal behaviour may partly explain the low camera trap success rates. Records of marbled cat in this study came from elevations below 1,100 m; however, there are records of these cats in Lao PDR up to at least 1,900 m (Johnson et al. 2009), and from the Himalayan region up to 3,000 m (Sunquist & Sunquist 2002). This suggests that the distribution of the marbled cat is not limited by elevation in other parts of its range and that it is simply overlooked in higher-altitude surveys in Thailand. Camera trap surveys at Khlong Saeng in 2012 (L. Gibson, unpubl. data) confirmed the species presence there.

Clouded leopard: Failure to detect clouded leopards in Huai Kha Khaeng (Fig. 1) in repeat surveys 10 years after their presence was confirmed, requires further consideration (SOM T1). It is likely that the species was absent in the second survey due to a combination of differing density, spatial coverage, and survey effort compared with the first survey rather than changes in status. At Ta Phraya, surveys in 1998 recorded multiple individual clouded leopards but in 2012 only a single camera-trap set far (>10 km) from the forest edge detected clouded leopard (M. Baker, unpubl. data; Fig. 1). As the latter survey covered a wider sampling area and used more camera-traps, it is likely this reflects a real contraction in range for the species, or a reduction in density. The location of the camera-trap that detected the animal is consistent with distribution models from Khao Yai suggesting that clouded leopards are more likely to occur away from the forest edges (Ngoprasert et al. 2012).

Jungle cat: The paucity of jungle cat records in this study is not a strong indication that the species is rare, since edge/non-forest habitats which may support the species were not adequately surveyed. However, it is consistent with the almost complete dearth of recent records in Thailand (e.g. Graham & Round 1994). Given the ongoing paucity of records, a complete review is urgently needed to identify their possible habitats in Thailand. Based on a complete review by Duckworth et al. (2005) and historical distribution from Lekagul & McNeely (1988), future surveys should focus on dry forest (e.g. dry dipterocarp forest, mixed deciduous forest) in north and northeast Thailand (e.g. Lum Nam Pai-Salawin Forest Complex, Phu Khieo-Nam

Nao Forest Complex, Fig. 1). However, forest areas in northern Thailand have been heavily fragmented and ground-dwelling mammals over hunted (Pattanavibool & Dearden 2002). This is similar to the situation in some Lao protected areas (Coudrat et al. 2014, this issue) and it is likely that small and medium cat species at best might occur at very low densities there.

Possible threats to small cats

Rapid economic development over the last 40 years (National Economic and Social Development Board 2011) has brought paved roads to nearly all parts of the country and this, in combination with the long land borders with Malaysia, Myanmar, Lao PDR and Cambodia, provides high connectivity for the regional wildlife markets (Shepherd & Nijman 2008a, Nijman 2010). Domestic legislation protects all wildlife occurring inside protected areas including cats (Ministry of Natural Resources and Environment 2003). While some protected areas are now evolving effective protection for high-trade-value species such as tiger (Simcharoen et al. 2007, Steinmetz et al. 2009, 2010), most are not, and many species are still heavily and illegally hunted throughout most of their Thai range (Lynam 1999, Tungittiplakorn & Dearden 2002, Lynam et al. 2005, 2006, Brodie et al. 2009). There is an enormous regional trade in wildlife and wildlife products, including various small carnivores, to supply the luxury restaurant trade in China and Vietnam (Bell et al. 2004, Lau et al. 2010, Xu & Compton 2010). Due to a mix of inconsistent legal policies, lack of law enforcement, and poorly trained or inadequately funded staff, Thailand has been repeatedly found to be a crucial node in the international wildlife trade (Nijman & Shepherd 2007, Nijman 2010, Nijman & Shepherd 2010). Many parts of larger cats (tiger, leopard), clouded leopard and Asiatic golden cat (mostly skin and some meat, bone or other organs) are illegally sold at border markets, suggesting threats to their populations in Thailand and neighbouring Myanmar and Lao PDR (Srikosamatarata & Suteethorn 1994, Shepherd & Nijman 2008b, Oswell 2010). However, recent wildlife meat trade surveys in towns and villages near Kuiburi National Park (Fig. 1) revealed that the only small carnivores in the meat trade were palm civets (Paradoxurinae) (R. Steinmetz, unpubl. data). Similar surveys conducted around the Western Forest Complex (Fig. 1) also found no cases of small cats (A. Pattanavibool, pers. comm.).

This conflicting evidence suggests that (1) meat trade for wild cats in Thailand may not be locally significant because cat meat is relatively less desirable (W. Chutipong, pers. obs.), (2) trade found along borders may stem from neighbouring countries, (3) trade in wild cats within the country e.g., pelt trade, if any, was overlooked by the two surveys as they were conducted in towns – far from border where most of trades usually occur, and (4) the absence of wild cat meat trade around the two forest complexes may be an indicator of critically low population status.

Persecution may be a more serious threat to some species than others, especially fishing cats which are frequently killed (but rarely reported) by villagers when they prey on fish and chickens (P. Cutter, unpubl. data).

Due to a relatively aggressive management of forest boundaries around the edges of Thai parks and sanctuaries (Albers & Grinspoon 1997), forest encroachment rates are generally lower than in some neighbouring countries (Sodhi et al. 2010). Felid responses to the impacts from degradation of existing habitats inside protected areas, especially historical logging practices, and land-use change are poorly understood. Therefore, establishing appropriate practices for species conservation is difficult. However, the range of sites from which the four widespread smaller cats were recorded gives no suggestion that current habitat conditions are threatening the survival of any of them.

Conservation priorities

A thorough review of Thai historical records of small cats, to study patterns of range contraction and habitat use, with a focus on those species which cannot be widely found today (fishing cat, flat-headed cat and jungle cat), is needed. Current information on occurrence and geographic distribution of small cats is lacking from the more disturbed areas in northern Thailand where at least one species, jungle cat – currently considered national critically endangered (Nabhitabhata & Chanard 2005), was formerly reportedly common (Lekagul & McNeely 1988). Similarly, there are only a few scattered records of small cats from the central plains and the Gulf of Thailand coastline. These gaps are serious because this implies that for fishing cat, which may be among the most threatened cats in tropical Asia and whose status remains poorly known, it is not clear what conservation management is needed. In addition, jungle cat, fishing cat and flat-headed cat do not seem to signifi-

cantly share distribution with larger cat species which are subjects of intensive survey and conservation efforts inside several of the larger protected areas. Therefore unless dedicated surveys and conservation measures are attempted, these species are unlikely to be recorded or conserved, and so might disappear without our knowledge. Using a precautionary view, these three species should be considered to be at risk of national-level extinction in Thailand.

In general, the largest blocks of secondary forests, wetlands, shrub and non-forest areas that lie outside protected areas amid the lowest human population densities with historical and recent confirmed records should be intensively surveyed to elucidate the status and distribution of fishing cat, flat-headed cat and jungle cat. In addition, similar habitat types believed to be suitable for these species should be targeted in the hopes of finding additional breeding populations worthy of protection. These include wetland habitats of Inner Gulf of Thailand for fishing cat, and peat swamp forests in peninsular Thailand for flat-headed cats (Wilting et al. 2010). Individuals of these three species found in wildlife rescue centres and captive breeding centres, and road kills should be the subject of investigation to determine their origin. This may lead to the discovery of sites still supporting them, which could then be surveyed intensively to determine population status. For these three species, specimens such as animals killed for retribution, hunted/traded specimens of known locality warrant publication and wherever possible, photographic documentation should be opportunistically collected to add to the collection in the Thailand National Science Museum.

Forest-dwelling species such as Asiatic golden cat, marbled cat and clouded leopard are potentially sensitive to the impacts of edge effects, habitat degradation and forest encroachment. Assessments of their responses should be carried out as these factors have been found to be important influences on the distribution and the extinction proneness of other Thai forest mammals (Lynam 1995, Ngoprasert et al. 2007).

National funding agencies (e.g. National Research Council of Thailand, National Science and Technology Development Agency) should be encouraged to fund such countrywide investigations for small cats, and such investigations should be a part of wildlife research programmes undertaken by relevant government agencies such as the Department of

National Parks, Wildlife and Plants Conservation (DNP).

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Supporting Online Material SOM Table T1 and Figure F1 are available at www.catsg.org/catnews

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Non-*Panthera* cats in Nakai-Nam Theun National Protected Area, Lao PDR

Small and medium-sized wild cat species (2 - 20 kg, non-*Panthera* species) in Laos remain little known. So far, four species are known to occur in the country: Least Concern leopard cat *Prionailurus bengalensis*, Near Threatened Asiatic golden cat *Catopuma temminckii*, Vulnerable marbled cat *Pardofelis marmorata* and Vulnerable mainland clouded leopard *Neofelis nebulosa*. Although all four were confirmed in the Nakai-Nam Theun National Protected Area NNT NPA during a camera-trap survey of 20,452 camera trap-days, from March 2006 to January 2011, only 21 images were captured of these species. In contrast, all these species were found with much lower survey efforts in NNT NPA in the 1990s and continue to be readily camera-trapped in other evergreen forest sites in South-east Asia. In combination, these factors indicate that the present low encounter rate is likely to represent recently reduced density in NNT NPA. Although the area supports over 3,000 km² of largely little-encroached forest, hunting pressure from Lao and mostly Vietnamese poachers is probably responsible for the vanishing populations of these now-rare species in the area. This is a consequence of the remarkable amount of non-selective ground snares used throughout most of the area, a situation typical for most forest areas in Laos and Viet-nam. Because of its size and habitat condition, NNT NPA should be one of the most important areas in the country and the region for the conservation of small carnivore species including wild cats, but this importance is rapidly eroding. Therefore, action is urgently needed to control illegal hunting in the area for the conservation of non-*Panthera* wild cat species.

Table 1. Camera-trapping survey effort in Nakai Nam Theun NPA from 2006 to 2011. * survey blocks in which cats (non-*Panthera*) were recorded; ^a faulty cameras are excluded; for (9) in 2009, only data from three cameras were available from the database, although more were deployed. ^b Includes test, unidentified, photos with no objects, wildlife and human photos. CTD=camera trap days.

Area (# on map)	time period	Total cameras ^a	CTD	Total photos taken ^b
Khamkeut - Nam San (1)	Mar-May 06	49	2,233	1,109 *
Nam On - Boualapha (2)	Oct-Nov 06	49	1,406	357 *
Nam On - Gnomalath (3)	Dec 06-Feb 07	49	1,754	344
Khamkeut - Thong Pae (4)	Mar-May 07	48	2,181	721 *
Nam Chae - Makfeuung (5)	Nov 07-Jan 08	50	2,359	624 *
Nam Chae - Navang (6)	Jan-Mar 08	47	1,894	601 *
Phou Vang - Houay Nam Heuy (7)	Apr-Aug 08	32	1,719	1,013
Thong Khouang/Xet (8)	Nov 08-Jan 09	24	1,242	344 *
Nam Mon - Thong Kacheng (9)	Mar-May 09	3	186	1,222
Nam Theun - reservoir (10)	Nov-Dec 09	40	1,676	585 *
Nam Mon - Thong Kacheng (9)	Mar-May 10	45	2,450	2,219 *
Khamkeut - Nam San (1)	Dec 10-Jan 11	33	1,352	126
Total	Mar 06-Jan 11	469	20,452	9,265

Wildlife surveys across many parts of the Lao People's Democratic Republic (Lao PDR or Laos) in the 1990s improved knowledge of the country's wildlife status and distribution (Duckworth et al. 1999). However, information on wild cats firmly identified to species was scarce, mainly due to the difficulty of detecting these inconspicuous animals with the general wildlife survey methods used at the time (direct opportunistic day-time and night-time observation). Most information collected purportedly about cats is from signs (tracks and scats, both difficult to identify at species level by visual inspection, and sometimes even to identify as Felidae), interview reports from villagers (which similarly cannot be confirmed at species level for small cats and are often demonstrably unreliable) and/or live or dead animals found in markets or villages (for which the exact, and often even the general, source locality is uncertain). Field sightings did occur for some species in the 1990s (Duckworth 1996, 1997, 1998, Showler et al. 1998, Duckworth et al. 2005, 2010), but direct field sightings by competent faunal surveyors in the 2000s were extremely rare, with the exception of leopard cat. In addition, very limited camera-trapping in the 1990s, which did not target small carnivores, yielded two camera-trap photographs of non-*Panthera* cats (one each of golden cat and clouded leopard) (WCS 1997).

Automatically triggered camera-traps have been increasingly used in the past two decades to survey cats worldwide (Karanth 1995, Karanth & Nichols 1998, Yasuda 2004, Maffei et al. 2004, Kawanishi & Sunquist 2004, Soisalo & Cavalcanti 2006, Heilbrun et al. 2006, Jackson et al. 2006, Shek et al. 2007, Tobler et al. 2008, Royle et al. 2009, Lynam et al. 2009). The use of camera-traps has led to local records of various Lao species poorly known across their small world ranges, e.g. saola *Pseudoryx nghetinhensis* (Robichaud & Stuart 1999, Hardcastle et al. 2004), large-antlered muntjac *Muntiacus vuquangensis* (Dersu 2008, Johnson & Johnston 2007, Duckworth et al. 2010, Rasphone 2010), Annamite striped rabbit *Nesolagus timminsi* (SurrIDGE et al. 1999, Johnson & Johnston 2007, Duckworth et al. 2010), and Owston's civet *Chrotogale owstoni* (Johnson et al. 2006, Sivilay et al. 2011). Conservation projects in Laos started using camera-traps in the late 1990s in a few forest areas, with larger-scale deployment in the 2000s to attempt population monitoring and to inform conservation management, e.g. in Nam Et-

Phou Louey NPA (Johnson et al. 2006, 2009), Nakai-Nam Theun NPA (WCS 1997, Robichaud & Stuart 1999, Johnson & Johnston 2007, WMPA unpubl. data), or Laving-Laveun Provincial PA (Duckworth et al. 2010).

Laos may hold up to eight wild cat (Felidae) species, with status according to the IUCN Red List of Threatened Species (IUCN 2012): Least Concern LC leopard cat, Near Threatened NT Asiatic golden cat, Vulnerable VU marbled cat, VU clouded leopard, Endangered EN tiger *Panthera tigris* and NT leopard *Panthera pardus* are all confirmed. The occurrence of EN fishing cat *Prionailurus viverrinus* and LC jungle cat *Felis chaus* remains unconfirmed by specimens or photographs, although at least the latter is highly likely to occur, or to have done so until recently, and its occurrence in the country has not been seriously questioned (Duckworth et al. 2005, 2010). Data on small and medium-sized cat species (up to 20 kg, non-*Panthera*) are scarce and their national status has been classified as either 'At Risk' or 'Little Known' in Laos, except for leopard cat, which in the 1990s was clearly widespread and common (Duckworth et al. 1999). Little information has been obtained since the 1990s; records with credible species-level identification and known locality come only from camera-traps, and only rarely in most of the few areas thus surveyed, except Nam Et Phou Louey NPA with a large number of records (Johnson et al. 2006, 2009). The small number of recent records of non-*Panthera* cat species in Laos certainly reflects at least partly the scarcity of field surveys after 1999, but there is also the disconcerting possibility that it may reflect a substantial decline in abundance of these animals in the country's forests.

Nakai-Nam Theun National Protected Area NNT NPA in east-central Laos was found to hold six cat species in 1996–1997 (WCS 1997, Duckworth 1998), supplemented by plausible reports of fishing cat and jungle cat in nearby areas (Duckworth et al. 2005, 2010). In 2005, relating to the imminent construction of a hydroelectric power dam at the edge of the NPA, a Lao government institution (the Nam Theun 2 Watershed Management Protection Authority, or WMPA) was created to manage, protect and monitor biodiversity in the area, and reduce poverty among local human residents. Part of WMPA's mandate has been to monitor the area's wildlife systematically via transect and camera-trap surveys (NT2 WMPA 2005).

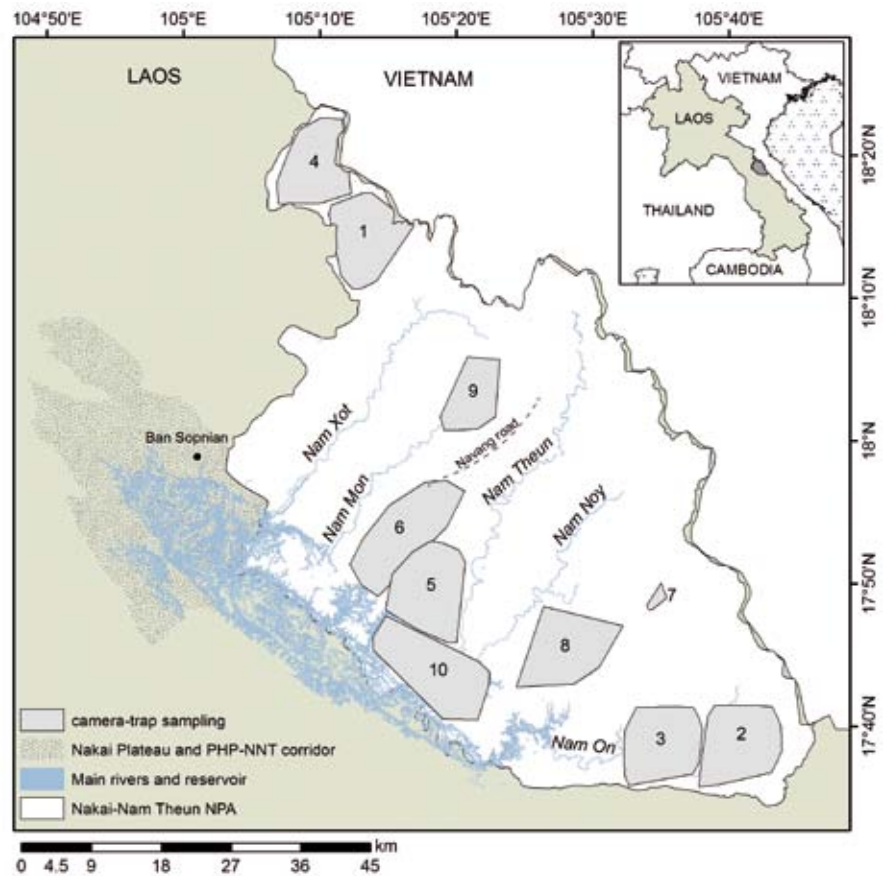


Fig. 1. 1. Camera-trap sampling areas in Nakai-Nam Theun NPA in 2006–2011. The Nakai Plateau and Phou Hinpoun–Nakai-Nam Theun NPAs corridor (PHP-NNT), Ban (=village) Sopnian and Navang road, from which records are also reviewed (Table 4), are indicated on the map. Numbers for each area indicate chronological order of sampling (c.f. Table 1): 1: Khamkeut - Nam San; 2: Nam On – Boualapha; 3: Nam On – Gnomalath; 4: Khamkeut - Thong Pae; 5: Nam Chae – Makfeuung; 6: Nam Chae – Navang; 7: Phou Vang - Houay Nam Heuy; 8: Thong Khouang/Xet; 9: Nam Mon – Thong Kacheng; 10: Nam Theun – reservoir.

Although the area is one of the largest blocks of contiguous evergreen/semi-evergreen forest in mainland South-east Asia outside Myanmar, it suffers from high levels of illegal, commercial hunting typical of much of Laos and Vietnam. Ground snares, usually made from wire, are widely used in NNT NPA; most seem to be set by cross-border Vietnamese poachers (Coudrat 2012). The low cost and effort combined with a relatively high catch render the use of snares attractive to hunters in many regions of the world (Noss 1998, Fa & Yuste 2001). Ground snares are non-selective and wasteful, with high proportion of caught animals lost to scavengers, predators or decomposition (Noss 1998). Snares are typically made out of wires set along man-made or natural animal trails (Noss 1998, Newton et al. 2008, Coudrat 2012). In NNT NPA, thousands can be collected on a single few-day field trip at one site, and the remains of trapped animals are often encountered (Johnston & Saengphavanh 2006, W. G. Robichaud, pers.

comm. 2011, Coudrat 2012). Therefore, the current status of cats in NNT NPA is particularly informative about the regional risks they may face from hunting.

This paper presents the records of non-*Panthera* cat species from the camera-trap surveys in NNT NPA from 2006 to 2011, and reviews other records between the 1990s and present day from NNT NPA and adjacent Nakai Plateau and corridor area. This information will help evaluate the state of these species' populations in this little-degraded and legally protected large forest block in Laos.

Methods

Nakai-Nam Theun National Protected Area (Fig. 1) is about 4,000 km² (including recent extensions) with altitudes ranging from 500 to >2,200 m. Around 80% of the area remains covered in forest (Robichaud et al. 2009). It is dominated by old growth, mainly undisturbed dry-evergreen forest, with other localised habitat including pine/semi-evergreen and

upper-mountain and wet-evergreen forest (Timmins & Evans 1996). Thirty-one villages (with ca. 6000 people, NT2 WMPA 2005) are located within the NPA with an average population growth rate that has been estimated at 3.8% (Chamberlin 1997). Each village is allocated subsistence-use forest areas, where residents are allowed to harvest non-timber forest products, including some common wildlife species, according the Wildlife and Aquatic Law and Forestry Law (National Assembly Lao PDR 2007a; 2007b). The area shares an international border with Vietnam of ca. 160 km, about one-third of which is contiguous with a national park on the Vietnamese side (Vu Quang National Park). The remaining adjacent land in Vietnam is unprotected. Camera trap data were obtained from systematic surveys during 2006 to 2011 conducted in NNT NPA by staff of Nam Theun 2 Watershed Management and Protection Authority NT2 WMPA with technical assistance from the Wildlife Conservation Society WCS from 2006 to 2008. The sampling program was designed by WCS, which also provided training to NPA staff for the long-term implementation of the program (Johnson et al. 2005, Johnson & Johnston 2007). From March 2006 to January 2011, camera traps were set in 10 survey blocks (Table 1, Fig. 1), selected to represent the different habitats within NNT NPA and to monitor the status of ground animal populations as an indicator of the impact of management interventions (Johnson & Johnston 2007). Up to 50 passive infrared film or digital camera traps were set by a team of four to five people per survey block (one camera per location), with cameras placed ca. 1 km apart. Cameras were positioned on trees at a height of ca. 45 cm (targeted for large mammals),

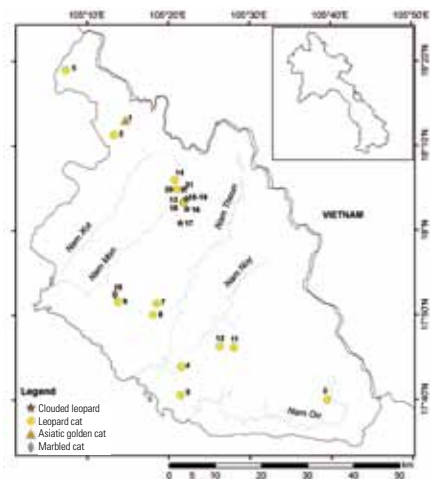


Fig. 2. Locations of photo records of cat species within Nakai Nam Theun NPA during the 2006-2011 survey period.

Table 3. Number of sites, photo records, altitude and times of cat species recorded in NNT NPA during 2006-2011 camera-trapping survey.

Species	# survey blocks where recorded (N=10)	# trap-sites (N=469)	# 'independent' photos	time range
Leopard cat	8	14	14	17:11 h - 00:30 h + 12:28 h
Clouded leopard	1	4	5	19:39 h - 05:56 h
Asiatic golden cat	1	1	1	18:09 h
Marbled cat	1	1	1	10:46 h

beside animal trails or small streams, and/or at other arbitrary open understory locations. No lures or bait were used. Each camera was programmed to operate 24 hours a day and to take photos at 20-second intervals when triggered by a passing animal. Most of the cameras (96.8%) had a maximum capacity of 36 film photos (@CamTrakker), therefore survey effort ceased when 36 photos had been taken. The remaining cameras were digital with a capacity of >600 photos (@Reconyx), which was never exceeded before removal of the camera. Survey effort for each camera was calculated from the day it was set to the day of the last photo taken (for the 36 photos capacity-cameras, when full), or the day of camera removal (for the >600 photos capacity-cameras when not full). Total survey effort (in camera trap days, CTD) is the sum of days cameras were operational, for all cameras. Data from faulty cameras (i.e. cameras for which only the first test-photo was taken, and were found to have stopped functioning when collected) were excluded from analysis. For each camera, available data included geographic coordinates (datum, Indian Thailand, initially recorded as UTM) elevation (m a.s.l. taken with Garmin GPS60 or Garmin 12 units; though it is not known how regularly these were calibrated) and the date and time of each photo.

Of all the photos taken (N=9,265; including tests, unidentified photos with no apparent objects and all wildlife and human photos) during the survey time period, the non-*Panthera* cat species (referred to as 'cat species', hereafter) photo records were identified with the assistance of J. W. Duckworth (Supporting Online Material SOM Table T1). To derive the number of photograph records for each species and reduce the risk of double counting, for each single species only notionally 'independent photos' were included, defined as consecutive photographs of individuals of the same species taken more than 30 min-

utes apart (there were no cases of a same individual photographed consecutively for over 30 minutes) and non-consecutive photos of individuals of the same species (following O'Brien et al. 2003). Records of cat species are shown in Fig. 2. Other cat species records (field sightings, remains, pre-2006 camera-traps) for NNT NPA and adjacent areas are presented in SOM T2. These were compiled from survey reports, other grey literature or opportunistic records.

Results

Photographs from 469 camera-trap-sites obtained between March 2006 and January 2011 were examined. These were in ten survey blocks, of which two were camera-trap surveyed twice (Table 1). Survey effort (camera trap days, CTD) over the survey period totalled 20,259 CTDs, during which 9,265 photos were taken (including tests, non-object and object photos; Table 1). Survey blocks ranged in size from ca. 5 hectares (NM-TKC Mar-May 09) to ca. 50 km² (NC-NV Jan-Mar 08).

Of the 9,265 photos, 21 were of 'independent' photo records of non-*Panthera* cat species (SOM T1). These involved four species: Asiatic golden cat (AGC, 1 photo), leopard cat (LC, 14 photos, 14 sites), clouded leopard (CL, 5 photos, 4 sites) and marbled cat (MC, 1 photo; Table 2, SOM T1, Fig. 2); there were no photos of *Panthera* cats nor of feral/domestic cats. Cats were recorded in eight survey blocks (Table 1, SOM T1). None of the trap sites (N=469) recorded more than one species of cat. Most photos of cats were taken between late afternoon (17 h) and early morning (06 h); two photos were taken during mid-day (10:46 h and 12:28 h, of a marbled cat and a leopard cat, respectively; Table 2).

Discussion

Surveys in NNT NPA during the 1990s confirmed the presence of at least six cat species, including four non-*Panthera* species: marbled cat, clouded leopard, Asiatic golden cat and



Fig.3. Leopard cat pictured in Nakai-Nam Theun NPA, 5 April 2007, 17:34 h.

leopard cat. From March 2006 to January 2011, systematic camera-trapping within the area photographed all of these four non-*Panthera* species (although neither of the *Panthera* species). Given the high total survey effort in 2006-2011, the frequency of records for the four species was very low: lower than any other camera-trap survey of evergreen forest in mainland Southeast Asia, for which the results were traced (SOM T3). These numbers are likely to indicate a low density of these species in NNT NPA, rather than any methodological factor causing them to be overlooked, as other camera-trapping studies that used similar methodology had more frequent records of cat species (Datta et al. 2008, Brodie & Giordano 2012, Johnson et al. 2009). The leopard cat (Fig. 3) was the most photo-recorded species, with 14 independent photos, from 14 trap sites. This species has the widest global distribution range of all small Southeast Asian cats, and is generally found from sea level up to 3,000 m a.s.l. in various habitat types (Sunquist & Sunquist 2002, Sanderson et al. 2008). In Laos, it has been the cat species most widely and commonly recorded in the country (Duckworth et al. 2005). In the early and mid 1990s, over 25 records of the species (sightings, captive and remains) occurred, including 12 direct sightings during field surveys (Duckworth 1997). Photo records in NNT NPA during 2006-2011 occurred between altitudes of 500-1,500 m, in semi-evergreen and evergreen forest. Throughout Laos, leopard cat has been found from 200 to ca. 2,300 m (probably not actual altitudinal range limits) and from heavily degraded to almost undisturbed (semi-

evergreen forests (Duckworth 1997, Johnson et al. 2009). The species is evidently largely nocturnal in NNT NPA, which is corroborated by earlier records elsewhere in the country (Duckworth 1997, Johnson et al. 2009).

Clouded leopards (Fig. 4) were camera-trapped on five independent photos, from four trap sites (but the photos did not allow clear identification of the number of individuals). The species' status and distribution in Laos is little known; its national distribution has been hypothesised through nationwide village interviews but there are too few firm records to confirm this (Duckworth et al. 1999). Numerous confusions during village discussions, however, indicate low reliability of interview information without parts for reference identification, so its occurrence in most of Laos has to be seen as unconfirmed, although plausible. Camera-trap surveys confirmed its presence in Nam Et-Phou Louey NPA (Johnson et al. 2006). Only two certain direct sightings in the wild by surveyors have ever occurred; one in NNT NPA (Duckworth 1998, Table 4) and one in Dong Ampham NPA (Davidson et al. 1997, Schaller 1997). Its status in Laos is considered 'At Risk' (Duckworth et al. 1999). It was first camera-trapped in NNT NPA in 1997, which was apparently the first wild photograph of clouded leopard anywhere (WCS 1997).

Asiatic golden cat (Fig. 5) was photographed only once, in the north. It was camera-trapped in NNT NPA also in 1997 (WCS 1997) and probably sighted in 1999 (Robichaud & Stuart 1999). In Laos, the species' distribution remains uncertain but it probably occurs across the country in suitable habitat. It ap-

pears to inhabit various habitat types, from lowlands to at least 2,300 m, and nationally was the second-most frequently recorded small cat (from sightings and remains) during the 1990s (Duckworth et al. 1999). The species was the most photographed cat species in Nam Et-Phou Louey NPA between 2003 and 2006 (Johnson et al. 2009). The species' national status is considered 'Little Known' in Laos (Duckworth et al. 1999).

Likewise, marbled cat (Fig. 6) was photographed only once. It has been previously sighted in Laos in the wild only twice: once each in NNT NPA and in Nam Xam NPA (Duckworth 1998, Showler et al. 1998). In Nam Et-Phou Louey NPA, the 2003-2006 camera-trap survey yielded 39 independent images from 24 trap sites (Johnson et al. 2009), the largest camera-trap-haul of the species for the country. The species seems in Lao to be primarily diurnal and to have an affinity with hilly (~700-2000 m) evergreen forest. Due to the paucity of information available on the species, its status is considered 'Little Known' in Laos (Duckworth et al. 1999).

Of the two other small to medium-sized cats perhaps inhabiting Laos, the jungle cat is unlikely to occur within NNT NPA given its association with open, deciduous, grassland areas. These habitats are rare in the NPA, and are more susceptible to overhunting than are forests. Although the species was reported from the adjacent Nakai Plateau in lowland pine/deciduous dipterocarp forest in several sources, none gave conclusive or convincing supporting evidence or detail. Reports from villagers cannot be used conclusively for the species, as the same Lao wording – *meo paa*, literally jungle/forest cat – is commonly used for unspecified non-domestic cats (Duckworth et al. 2005). It was reportedly sighted in open flat land in 1999 in degraded mixed deciduous forest in Boulapha District, outside the southern part of the NPA (Duckworth et al. 2005), but a description of the animal sighted was not given. The observer stated that he is still confident with his identification (R. J. Tizard in litt. 2012); the body structure was the exact same as his recent (2012) sighting of the same species in Gujarat, India, and the fur colouration of the individual sighted in Laos was similar to the photograph he saw of a dead jungle cat from Myanmar. The observer noted in particular the distinctiveness of the ears of the Boulapha animal.

Fishing cats are generally assumed to inhabit dense wetlands, primarily in lowland areas

(Sunquist & Sunquist 2002, Mukherjee et al. 2010), but the single plausible though unconfirmed sighting of the species occurred to the north of NNT NPA, in the then Nam Theun Extension proposed NPA in a habitat similar to NNT NPA hilly evergreen forest (Duckworth et al. 2010). Given the apparent rarity of the species throughout the country and absence of remains or live animals records, if it has ever occurred in NNT NPA, it might not be present anymore.

The presented records for NNT NPA and eastern adjacent areas probably represent all confirmed records of cats from biological surveys in the NPA for the 1990-2011 period; if any have been missed, the number is few. Despite regular field visits in NNT NPA (transect surveys, camera-trap setting and removal trips, patrolling, research) by management staff and other researchers since 2005, none of the above cat species has ever been directly sighted in its habitat since then, although the noisy and otherwise conspicuous behaviour of such teams renders sightings fairly unlikely. Captive leopard cats were occasionally seen in villages, mostly young animals, reportedly caught after killing the mother for food, during 2006-2007 (C. Nanthavong pers. obs.). The only confirmed direct sightings of wild cats of any size in NNT NPA date back to 1996: during a 3½-week direct-observation survey for large mammals, two leopard cats, one clouded leopard, one marbled cat and one tiger were seen. Surveyors of other groups had two leopard and two additional tiger sightings in that year. All these sightings occurred along an intended logging road (which had been abandoned, before construction had finished and before it was ever used for logging) above Ban Navang, in the Nam Chae-Navang zone (Duckworth 1998). The camera-trap photographs of golden cat and clouded leopard in 1997 were taken on the same abandoned road (WCS 1997).

Although the methods used in 1996-1997 and in 2006-2011 in the NNT NPA were different, relevant survey effort was far higher in the latter period than the former, and should have produced many records of cats judging by the rates at which they were recorded in 1996 by direct observation and in 1997 by exploratory camera-trapping. During many direct-observation-based surveys in Laos in the 1990s, no other survey area produced records of cats at anywhere near the rate found in NNT NPA in 1996, other than leopard cats. Duckworth et al. (1999) reported all Lao cat records between 1992 and early 1999 with clear locality



Fig. 4. Clouded leopard pictured in Nakai-Nam Theun NPA, 29 March 2010, 19:39 h.

and using credible methods, except for leopard cats, which were too commonly found for such detail. Individual records up to the end of 1996 were given in Duckworth (1997).

Most comparably Nam Et-Phou Louey NPA also had a direct-observation-based survey (but involving very little spotlighting) in the 1990s (Davidson 1998), and then intensive camera-trapping in the 2000s (Johnson et al. 2009). The 1990s survey recorded no direct sightings of cats, while many records were obtained by camera-trapping.

The large number of sightings along the Navang logging road in NNT NPA reflects in part the exceptional visibility along the road within little-degraded forest and the attraction of roads for some wild cat species (for resting or walking). Another important factor could be the then low hunting pressure. Observers could then stand under trees holding monkeys, gibbons or yellow-throated martens *Martes flavigula* without their showing evasive action, and muntjacs *Muntiacus* spp. walked along the road within 15 m of one surveyor (J. W. Duckworth in litt 2012). Clearly, the area then supported high numbers of cats, suggesting the suitability of NNT NPA's habitat for these species.

Variability in sampling design (e.g. camera set-up, use of bait, camera model, sample size) and species' behavioural ecology (e.g. home range, habitat use), which in turn vary across space and time, influence each species' detection probability in camera trap studies (Sollmann et al. 2013). Nonetheless, we believe the 2000s' extremely low camera-trap encounter rates of cats in NNT NPA reflects their actual status in the

area. Although there might be some other unknown factors responsible for the recent low encounter rates of cats in NNT NPA, hunting is most likely the main driving factor behind these apparent low densities. Traditional hunting for local consumption may have already been responsible for population decrease by the mid-1990s in areas around villages. However, the trade-driven snaring that has intensified since its inception in the early and mid-1990s has evidently decreased today's populations in much of the interior of NNT NPA. Other small carnivore species (mongooses, civets, linsangs, mustelids) in NNT NPA were camera-trapped at relatively higher rates (Coudrat et al. 2014), suggesting cats are more sensitive to hunting than them, even perhaps to the less intensive traditional hunting.

The survey block with the largest encounter rates for cats (Thong Kacheng), was the only survey block where no snares were encountered at the time of the camera-trap set up (C. Nanthavong, pers. obs.). The latter site remains today one of the few sites within NNT NPA where intensive snaring does not occur, probably due to its remoteness from both the Vietnam border and Lao villages (Coudrat 2013).

Comparing the 2006-2011 NNT NPA camera-trap results with other areas in Southeast Asia where snare hunting seems to occur at a much lower intensity (or not at all), camera-trap encounter rates of cats are generally much higher in these others (Table 3): Deramakot forest reserve, Sabah, Malaysia (Mohamed et al. 2009); Taman Negara National Park, peninsular Malaysia (Kawanishi



Fig. 5. Asiatic golden cat pictured in Nakai-Nam Theun NPA, 18 March 2006, 18:09 h.

& Sunquist 2004), and Nam-Et Phou Louey NPA, Northeastern Laos (Johnson et al. 2009), where during a 5-month field survey in 2010 (19 sites visited across the NPA) not a single snare was encountered (Scotson 2010), which is inconceivable in NNT NPA. The difference may lie in part in NNT NPA's longer border shared with Vietnam.

As wildlife has dramatically decreased throughout Vietnamese forests due to deforestation and overharvesting (Bennett & Rao 2002, Milner-Gulland et al. 2002, Sodhi et al. 2004, Sodhi et al. 2009), targeted species have gained in trade value and therefore suffer increased hunting pressure. Illegal hunting in NNT NPA by Lao villagers has increasingly been for trade, not local consumption. Lao villagers sell wildlife to Vietnamese, who regularly visit their villages, within the NPA (Nooren & Claridge 2001, Robichaud et al. 2009, Johnston 2010, Coudrat 2013). There is no evidence that any

of these non-*Panthera* cats are specifically targeted by trade-driven hunters in NNT NPA, or elsewhere in Laos (equally, it is not known that they are not), but the main method used, snaring, is non-selective and catches many individuals of untargeted species and is likely to have contributed to the decrease of cat populations within the area. All wild cat species in Laos are classified under the Prohibition category of the Lao hunting regulation, which includes species which are "rare, near extinct, high value and are of special importance in the development of social-economic, environmental, educational, scientific research" (National Assembly Lao PDR 2008: Article 11, p. 4), their hunting is not permitted at any time and anywhere. However, these rules were little enforced during the survey period.

Wild cats are regularly encountered in the trade in Southeast Asia (e.g. Duckworth et al. 1999, Nooren & Claridge 2001, Shepherd & Nijman 2008). For example, several Lao cat species are openly sold in Myanmar, in Tachilek city, at the Lao-Thai-Myanmar border (Shepherd & Nijman 2008); while the origin of vendors' stock is uncertain, some may come from Laos. The demand for wildlife hunted in Laos indeed comes principally from neighbouring countries, in particular Thailand, Vietnam and China (Srikosamatara et al. 1992, Compton et al. 1999, Nooren and Claridge 2001, Singh et al. 2006). Wild cats are generally used as trophies (e.g. stuffed, skins, pelts) or medicine (processed body parts; Martin 1992, Le Trong Trai 2007, Shepherd & Nijman 2008, Ashwell & Walston 2008).

The data collected in the Nakai-Nam Theun NPA suggests that even in the large primary forest blocks remaining in Southeast Asia, density reduction of these cat species may

not be prevented where hunting for trade occurs. Compared with other forest blocks in Indochina where trade-driven, intensive-snaring hunting is common (e.g. Vietnam; Wilcox et al. 2012), NNT NPA, given its size and habitat condition, retains far more potential for the long-term conservation of these species. NNT NPA is among the key biodiversity areas of the Indo-Burma hotspot (Tordoff et al. 2012). Given the few Lao NPAs currently receiving funding and that have received technical assistance to develop conservation plans, the NPA is one of the country's best hope to preserve rare and threatened animals, including wild cats, if management strategies are well designed and implemented. All hunting with snares within conservation zone forests is unambiguously illegal in the NPA and this prohibition needs to be urgently enforced if small cats are to be saved from further decline. To be achieved, given the large area, priority zones need to be designated to focus all available resources and ensure that illegal hunting is strictly controlled. Only realistic, long-term conservation planning and committed actions in the area will ensure the survival of these species.

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Table 3. Number of independent photos of small-medium sized cats taken during camera-trap surveys in Southeast Asia. LC leopard cat, AGC Asiatic golden cat, CL clouded leopard, MC marbled cat, PA protected area. -: figures for the species are not provided in the cited work; n/a out of species's geographic range; CTD Camera trap days.

LC	AGC	CL	MC	Area (country)	survey period	CTD	reference
14	1	5	1	Nakai-Nam Theun National PA (Laos)	2006-2011	20,259	this study
24	48	40	39	Nam-Et Phou Louey National PA (Laos)	2003-2006	8,499	Johnson et al. 2009 A. Johnson, pers. comm.
-	n/a	44	-	Tangkulap-Pinangah and Segaliud Lokan Forest Reserves, Sabah (Malaysia)	Apr-Sept 2009; Jan-Apr 2010	5,328	Wilting et al. 2012
-	n/a	59	-	Maliu Basin Conservation Area (Malaysia)	Jan-Apr 2010	2,003	Brodie & Giordano 2012
62	37	16	16	Taman Negara National Park (Malaysia)	1999-2001	14,054	Kawanishi & Sundquist 2004
183	n/a	10	0	Deramakot Forest Reserve, Sabah (Malaysia)	Jul 08-Jan 09	1,916	Mohamed et al. 2009
-	-	2	-	Namdapha National Park (India)	Oct 2006- Jan 2007	1,537	Datta et al. 2008

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Fig. 6. Marbled cat pictured in in Nakai-Nam Theun NPA, 26 February 2008, 10:47 h.

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Supporting Online Material SOM T1 and T2 are available at www.catsg.org/catnews

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The decline of non-*Panthera* cat species in Vietnam

Vietnam is likely to have once supported globally significant populations of leopard cat *Prionailurus bengalensis*, Asiatic golden cat *Catopuma temminckii*, marbled cat *Pardofelis marmorata* and mainland clouded leopard *Neofelis nebulosa*, and probably also fishing cat *Prionailurus viverrinus*. Jungle cat *Felis chaus* is also recorded for Vietnam but the limited extent of the species's preferred habitat type, deciduous forest, means that it is unlikely to have ever been widely distributed in the country. The current conservation status of all these small cat species in Vietnam is poorly understood. All traceable verifiable small cat field records from 1 January 1995 to 31 October 2013 were collated and reviewed, as were the results of camera-trap surveys that did not record any cats at all. Only leopard cat had a sizeable number of confirmed records. Several surveys of >1,000 camera trap nights did not record any other species of small cat. Indiscriminate cable-snare trapping is likely to have caused significant declines in Vietnam's non-*Panthera* cat species, and probably extirpated Asiatic golden cat, mainland clouded leopard and marbled cat from plausibly many of Vietnam's protected areas. Vietnam is unlikely to still hold globally significant populations of these three species and immediate conservation efforts should focus on the two countries in Indochina that are still likely to: Cambodia and Lao PDR. The last confirmed fishing cat record for Vietnam is now 13 years old, but given this species's relative tolerance to human-induced habitat changes, and the relatively low amount of snare-trapping in its preferred wetland mosaic habitats, targeted searches for this species in Vietnam are warranted and are a regional conservation priority.

Vietnam lies in the Indo-Burma hotspot (Myers et al. 2000, CEPF 2012), among the most biodiverse regions on Earth. It covers approximately 330,000 km² of land from sea level to 3,000 m, with one of the longest coastlines in the region (3,260 km) and two large deltas: the Mekong in the south and the Red River in the north. The Annamite Mountains, along much of the country's western border, are recognised for their high endemism (Baltzer et al. 2001, Sterling et al. 2006, CEPF 2012). In the North, the Hoang Lien Mountain Range, seen by some as the Himalayas' eastern extremity, contains several Sino-Himalayan plant and animal species. Vietnam has a diverse range of habitats including evergreen, semi-evergreen and deciduous forests, limestone karsts, and various types of wetland including *Melaleuca cajuputi*-dominated peat-swamp forest.

Historical records of non-*Panthera* (hereafter 'small') cats in Vietnam comprise six species (e.g. Osgood 1932, Delacour 1940; Supporting Online Material SOM T1). Based on habitats occupied by each species elsewhere in South-east Asia, the country previously would have supported large populations of at least four of these; however, jungle cat was plausibly confined in Vietnam to its restricted

deciduous dipterocarp forests (Duckworth et al. 2005) and fishing cat may have been mostly coastal, as has been suggested for some other South-east Asian range countries (Duckworth et al. 2010).

Vietnam is within a national species extinction crisis. Javan rhinoceros *Rhinoceros sondaicus*, kouprey *Bos sauveli*, hog deer *Axis porcinus*, and Bengal florican *Houbaropsis bengalensis* (Platt & Ngo 2000, Brook et al. 2011, IUCN 2013) were extirpated from Vietnam during the late twentieth century and early twenty-first century. Other species perilously close to extirpation include Asian elephant *Elephas maximus*, giant ibis *Thaumatibis gigantea*, and tiger *Panthera tigris* (IUCN 2013).

These losses, and ongoing declines in many others, are driven by wildlife hunting and in some cases exacerbated by habitat loss. Vietnam's human population is high (93 million) and much lowland evergreen forest, grassland and wetland are now agriculture (Wege et al. 1999, Brooks et al. 2002, Sodhi et al. 2004). Even the higher altitude forest types, better protected by natural factors, still suffer severe human-induced disturbance.

Vietnam's pernicious wildlife trade includes animals ranging in size from tokay gecko

Gekko gecko to Asian elephant (Bell et al. 2004, Robertson 2007, Venkatararam 2007). Very heavy indiscriminate snaring and targeted hunting are driven by a demand for wild meat, exotic pets, pelts, and for body parts, some to be used in traditional medicine. Urban Vietnam consumes so much wildlife, in part as a symbol of wealth and status, that local subsistence use of wild mammals is increasingly rare (Robertson 2007, Venkatararam 2007, TRAFFIC 2008, Drury 2011). Much is also exported, notably to China.

Impacts of these factors on Vietnam's small cats are unclear. Most small cats are elusive, low-density species and therefore hard to detect, and so are rarely targeted during field surveys and are outside the focus of most mainstream conservation initiatives. This review collates modern verifiable records for Vietnam's non-*Panthera* cats, to clarify each species's national conservation status.

Methods

Wildlife surveys during the 1990s were generally reconnaissances of the conservation significance of declared or potential protected areas. Most focused on diurnal land vertebrates and lasted less than a month. Such surveys are poorly suited to elusive, low density, partly nocturnal animals such as small cats. Their verifiable small cat records were mostly of captive animals and hunted remains where a local provenance seemed likely; a few were direct sightings.

Camera trapping, among the best methods for verifiable records with accurate locations, was used effectively from 1998 onwards. Most of the large-scale such surveys aimed to establish a site's conservation significance for mammals and birds. Few surveys targeted small carnivores. Camera trap-use declined from 2005, and few surveys ever exceeded one year, hindering assessment of these species' population trends.

Hence to inform small cat conservation status in Vietnam, this review collates all traceable field records for small cats (excluding domestic cat *F. catus*) in Vietnam from 1 January 1995 to 31 October 2013. Records were compiled from direct observations, camera trap images, and remains and captives in villages within and near natural or semi-natural areas, where origin was explicitly investigated. Direct observations were only considered confirmed if supported by photographic evidence and/or supporting notes, with the exception of leopard cat records which seem very rarely erroneous. Notes were not requir-



Fig. 1. Asiatic golden cat camera trapped on 28 March 2004 in Pu Luong NR, North Vietnam (Photo PL-CP, FFI/FPD Vietnam).

ed for observers with significant experience examining small cat museum specimens and a known cautious approach to identification. Reports from local villagers/hunters were not collated. In Vietnam, single species can bear multiple local names, and several species can be grouped under one name e.g. 'meo rung', literally 'jungle/forest cat', is also the most commonly used Vietnamese name for leopard cat. Interviewees evidently readily apply names for types of 'cat' inconsistently between biological species and even between cats and other taxonomic groups such as civets (Viverridae). Interviews for superficially similar small carnivore species are thus extremely unreliable (see Sampaio et al. 2011) and are not used here.

Identification of field signs (e.g. footprints, faeces, prey remains) from small carnivores in Vietnam is extremely difficult. Footprints can sometimes be identified as those of small cats, but with several similarly sized cat species potentially present anywhere, identification to species is irresponsible. Faeces offer reliable records only if identified using DNA analysis (see references in Duckworth et al. 2010). Therefore, sign records identified visually were excluded from this review.

Species accounts

Marbled cat

A marbled cat was reportedly observed at 600 m outside the core area of Pu Mat Nature Reserve NR. No identification details were given, the authors stated (Frontier Vietnam 1995: 23) that their team lacked experienced mammal surveyors, and leopard cat and marbled cat have somewhat similar pelage. The record must thus be considered provisional. A recently killed marbled cat, reportedly caught locally, was seen in Dac Plo com-

mune, west of the northerly part of Ngoc Linh proposed NR, Kon Tum province (Le Trong Trai et al. 1999). A marbled cat 'specimen' was observed during village interviews in Cham Chu proposed Nature Reserve, Tuyen Quang province (Le Khac Quyet et al. 2001). No details were provided on whether the 'specimen' was freshly killed or a preserved skin or other part, but the report states that it had a 'known location of capture and caught within the previous year'. No supporting notes or photographs could be traced for these records, and therefore both have been considered provisional.

One 'captured animal' was observed in the village of Phu Nhieu on 24 September 1998, approximately 2 km from the border of Phong Nha Khe Bang National Park NP, Quang Binh province (Timmins et al. 1999). The marbled cat was reported by hunters to have been cable-snared in Khe Lan valley. Though the exact locality of Khe Lan valley could not be traced, it seems likely, based on the village's proximity to the protected area, that the marbled cat was caught either in Phong Nha Khe Bang NP or forest near the NP.

A marbled cat was camera trapped at 2,060 m a.s.l. in upper montane forest (21°39'0.3"N/104°04'53"E), in Mu Cang Chai district, Yen Bai province on 23 October 2004 (Flora and Fauna International, Vietnam Programme, unpubl. data). This was the only traced camera record for this species.

Asiatic golden cat

Asiatic golden cat has been camera trapped in three sites: Pu Luong NR (Do Ngoc Cuong 2004; Fig. 1), Pu Mat NR (SFNC 2000) and Song Thanh NR (Long 2005). The latter site had two locality records, one each within the Nam Giang Main and Phuoc Son West Forest Management Units FMUs in Long (2005). Both of these records are within Song Thanh NR (B. Long in litt. 2014). The Pu Luong NR record was on 28 March 2004 on 'a valley floor near a water source' at ca. 600 m (Do Ngoc Cuong 2004). Camera trapping in Pu Mat NR gave four records from three locations (SFNC 2000). Two were from one camera trap (in the Khe Toi survey sector) and could have been of the same individual (SFNC 2000). Only one had an elevation given: ca. 400 m in the Khe Khang survey sector (SFNC 2000). The fourth, final, record was added in proof and was taken in the Khe Bu survey sector; no further details were available.

The only direct sighting traced was one at approx. 5 m distance in secondary forest in

Ba Na NR (Frontier Vietnam 1996). No further details on the observation could be traced, so this record is treated as provisional.

A captive animal and remains were observed in Ben En NP in 1997 and 1998 respectively (Frontier Vietnam 2000), and a 'specimen' (age and body part unclear) was observed in Mu Cang Chai Species/Habitat Conservation Area SHCA, Yen Bai province (Le Trong Dat & Le Minh Phong 2010). These three records lacked photographs or supporting notes so all are treated as provisional. Single confiscations were reported in 2004 and 2005, near or within Chu Yang Sin NP (Birdlife International 2010). That in December 2004 was reportedly from a hunter in Hoa Phong commune, which forms part of Chu Yang Sin NP; the animal was released in January 2005. The 2005 confiscation was transferred to Saigon Zoo, Vietnam and a photograph of this animal is included in the report (Le Trong Trai in litt. 2013).

Clouded leopard

One was camera trapped on 19 December 2003 in primary evergreen forest on limestone at 610 m in Pu Luong NR (20°32'09"N/105°05'52"E; Do Ngoc Cuong 2004; Fig. 2). In February 2001 one was directly observed in Hang Toong Chung forest, Yen Bai province (Le Trong Dat et al. 2001, Long et al. 2001, Swan & O'Reilly 2004, where located in Mu Cang Chai SHCA), for a few seconds at 05:00 h resting on the branch of a large tree (Le Trong Dat in litt. 2013). On 5 March 2001 a fresh skin was observed in Che Thao village, Yen Bai province (Le Trong Dat et al. 2001, Long et al. 2001) of an adult recently trapped from Che Thao forest (Le Trong Dat in litt. 2013), which is within the Mu Cang Chai SHCA. All these records are treated as confirmed following the production of additional record details. One other 'specimen' record was traced for Mu Cang Chai SHCA (Le Trong Dat & Le Minh Phuong 2010) but as there were no record details in the report and none could be traced, it has been treated as provisional.

Jungle cat

Duckworth et al. (2005) traced only two pre-2003 records for jungle cat in Vietnam, both mounted skins: one reportedly from Kon Tum province (undated), the other bought in a market in Gia Lai province in the mid-1990s.

On 23 March 2009 a juvenile and a female jungle cat were photographed 200 m apart during a spotlighting survey in Phu Quoc Island (Huong Trung Thanh et al. 2009, includ-

ing photographs of both). A juvenile was sighted at the same location on 24 March 2009. The juvenile shows large pointed ears and white cheek patches typical of jungle cat, but the photograph of the female is less clear (S. Mukherjee in litt. 2013), even on the original photographs. Domestic cats observed by DHAW in the Mekong Delta superficially resembled jungle cat (relatively short banded tail, golden brown coat with mostly faint markings bolder on the upper forelegs and black tips to solid-coloured ears), suggesting the possibility of past hybridisation. Therefore these individuals might not be pure jungle cats and a particularly cautionary approach should be used when identifying this species, especially outside its core range.

These sightings were at approximately 350 m a.s.l. in lowland evergreen forest, a habitat type not used extensively by the species in SE Asia (Duckworth et al. 2005, Gray et al. 2014, this issue). A claim of golden jackal *Canis aureus* from Phu Quoc Island (Dang Huy Huynh 1994) and unconfirmed records (no indication of source in the report and could be based on interviews) of dry forest/open habitat birds, including rufous-winged buzzard *Buteo liventer* and white-rumped falcon *Pollhierax insignis* (Nguyen Xuan Dang 2009) suggest that the island may contain more typical jungle cat habitat, perhaps the open 'savannah-like habitat' with sparse *Melaleuca* of Abramov et al. (2007). Most survey effort to date focused on the island's savannah, so the current extent of this habitat type and whether it does support a suite of dry forest species is unknown. Huong Truong Thanh et al. (2009) gave a (datum-less) UTM locator but all likely datums place the record inland in Kien Giang province, precluding any assessments of the record's proximity to more typical habitat on Phu Quoc Island.

Jungle cat is/was probably mainly restricted in Vietnam to the provinces of Gia Lai, Kon Tum and Dak Lak, which support most of the country's deciduous forest (Duckworth et al. 2005). However, this may not necessarily all have been suitable habitat. Long-term camera trapping in deciduous forest in Huai Kha Khaeng Wildlife Sanctuary WS, Thailand, failed to detect the species (Simcharoen et al. 2014, this issue). The absence of records from Huai Kha Khaeng WS has been suggested to reflect the site's more hilly deciduous forest; sites that jungle cat formerly used in Thailand (which have now all been cleared), were typically lower and on flatter land, supporting scrub and deciduous forest, or agri-

cultural mosaics. It is therefore plausible that similar, as yet unknown, factors influence jungle cat distribution in deciduous forest in Vietnam, which is higher and less plains-like than the deciduous forest on the Cambodian side where jungle cat is still regularly recorded (Gray et al. 2014, this issue). The species might thus be naturally either very rare in or now absent from Vietnam.

Other possible habitats that may have formerly supported jungle cat populations are the shrub/thicket formations that occur at various places along Vietnam's coast, and the coastal dry forests (in lowlands and lower hill slopes) of Khanh Hoa, Ninh Thuan and Binh Thuan provinces. Jungle cat populations are unlikely to persist in these habitats in Vietnam (if they were ever there at all); the human population density along Vietnam's coastline is high, and nearly all of Khanh Hoa, Ninh Thuan and Binh Thuan's lowlands have been converted to agriculture. A possible exception is Nui Cha NP, Ninh Thuan province, which does contain examples of lowland scrub habitats and has been under-surveyed for fauna. The probability of jungle cat persisting in a 250 km² protected area that has 30,000 people living inside it (BirdLife 2004), a large proportion of which are likely to depend on natural resources (including wildlife) for subsistence during the province's long and harsh dry season, seems low.

Leopard cat

Of 28 locations with 34 leopard cat records (SOM T2, F1), 19 are formally protected, two are proposed nature reserves, three are production forests (State Forest Enterprises SFEs and Fishery and Forestry Enterprises FFEs) of varying levels of activity, two are ambiguous, and one was in agricultural land in the Red River Delta. Most records (32) were based on direct observation and/or camera trap photographs. Three site records were based on remains and captives for which a local provenance is likely: one freshly dead, near Tam Dao NP (Nguyen Xuan Dang et al. 2006), a captive near Pu Hoat NR (Frontier Vietnam 2000), and a 'specimen' caught within the last year observed near/within Cham Chu NR (Le Khac Quyet et al. 2001).

Within a few kilometres of Hanoi's city centre along the Red River (approximately 31°03'14"N/105°50'55"E), a duo was seen at 14:09 h on 16 November 2012 (Fig. 3), and, 400 m away, in May 2013, in riverine scrub and grass amid a complex mosaic of crops,



Fig. 2. Clouded leopard camera trapped on 19 December 2003 in Pu Luong Nature Reserve, North Vietnam (Photo PL-CP, FFI/FPD Vietnam).

small trees and fallow land (SOM F2, S. Delonglee in litt. 2013).

These cats could conceivably have been released or escaped animals (or descendants of such) brought to Hanoi by people. Leopard cats are traded, amongst other reasons, as pets in Vietnam (Carnivore and Pangolin Conservation Program CPCP, unpubl. confiscation data). Vietnam's Forest Protection Department FPD often releases animals confiscated from illegal holdings or trade into the nearest natural or semi-natural habitat, even if this be outside the species's known distribution. Releases are usually into well-known forested protected areas: the nearest such areas to Hanoi, Ba Vi NP and Tam Dao NP, are both approximately 60 km from the sighting.

On the day of the November sighting, a known hunter at this site, and farmers who live and work in the area, all suggested long-term presence of leopard cat (S. Delonglee in litt. 2012). The area is heavily hunted for resident and migratory birds, using mist-nets and guns; cable snaring is apparently not used there.

This site, and its surrounds, has never been surveyed for small carnivores so it is unknown whether it historically supported a leopard cat population. However, degraded habitats support leopard cats in other parts of Vietnam, including active forestry enterprises (U Minh Ha FFEs; DHAW pers. obs., La Nga SFE; Nguyen Xuan Dang et al. 2004a), and protected areas with significant levels of human-induced habitat disturbances (e.g. Le Trong Trai et al. 1999, Frontier Vietnam 2000, Nguyen Xuan Dang et al. 2004b), and in agricultural landscapes in other range countries (e.g. Rajaratnam et al. 2007, Lorica & Heaney 2013). This, in combination with the lack of snaring at the Red



Fig. 3. An uncropped photograph of a leopard cat seen on 16 November 2012 along the Red River, Hanoi (Photo S. Delonglee).

River site, the substantial distance from likely FPD release sites, and the local people's information all suggest that these sightings are plausibly wild leopard cats, not of escaped/released animals.

Leopard cat is the most commonly recorded small cat species in Vietnam with confirmed field records from both protected and non-protected sites and a wide range of habitats including; *Melaleuca* dominated swamp forest (Fig. 4), secondary and degraded habitats, deciduous forest, semi-evergreen forest, and evergreen forest at various altitudes from lowland to upper montane. Altitudes were rarely stated, but vary from a few metres above sea level (U Minh Thuong NP; Nguyen Xuan Dang et al. 2004b) to at least 2,200 m a.s.l (Hoang Lien Son-Van Ban NR; Swan & O'Reilly 2004).

Fishing cat

Fishing cat was camera trapped on five dates (21 March, 8, 10 and 21 June and 4 August 2000) in U Minh Thuong NP (Nguyen Xuan Dang et al. 2004b). Additionally an animal identified as fishing cat was watched along Canal KT1 (9°36'40"N/105°05'46"E) at 14:24 h on 11 November 2000. On 19 November an adult female was found dead along Canal 120 (9°37'50"N/105°03'58"E), possibly having succumbed to rat poison. U Minh Thuong NP, dominated by *Melaleuca cajuputi*, has a core zone of 85 km² and buffer zone of 133 km². The area is <1 m altitude, and is surrounded by intensive rice farming (Safford et al. 1998, Sage et al. 2004).

Further surveys in the U Minh Wetlands in 2008 and 2010 failed to record fishing cat

(CPCP, unpubli. data). The former focused on U Minh Ha NP whilst the latter focused on the U Minh Ha FFEs, an area of active SFEs. Both sites contain habitat types similar in structure and plant species composition to U Minh Thuong NP, though neither has any extensive open swamp. All three comprise the U Minh Wetlands, but connectivity is limited. All three are surrounded by agriculture, and the relatively large town of U Minh separates U Minh Ha NP from the FFEs. The 2008 and 2010 surveys used camera traps, spotlighting and diurnal observations to record small carnivore species, methods comparable to those of Nguyen Xuan Dang et al. (2004b), and to a greater total survey effort. Fishing cat was recorded in neither 2008 nor 2010. Hoang Trung Thanh et al. (2009) listed three occurrences for fishing cat in U Minh Thuong NP in '2007', but two were based on local reports and the one specimen referred to had been collected in 2000. Therefore fishing cat has not been reliably recorded in the U Minh area since 2000.

Discussion

Records of small cat species in Vietnam

Leopard cat was by far the most commonly recorded small cat in Vietnam during 1995-2013, in a wide range of habitats; it seems to be a habitat generalist, as in other parts of its range (Duckworth et al. 2005, Rajaratnam et al. 2007, Lorica & Heaney 2013). Its persistence where most, if not all, similar sized and larger mammal species are extirpated e.g. Red River Delta, suggests relative tolerance of anthropogenic pressures, including hunt-

ing. Compared with other small cat species, spotlighting can detect this species effectively (see SOM T2). Leopard cat plausibly remains relatively common in Vietnam, persisting in various natural/semi-natural habitats and in agricultural landscapes where there is some connectivity to the latter; leopard cats that are killed in cleared/mostly agricultural areas can be replaced by animals diffusing out of more densely forested habitats. Areas of land with high-intensity agriculture and with little or no connectivity to more natural/semi-natural habitats, which now make up a large proportion of Vietnam's lowlands, might be less likely to support any leopard cat populations. Leopard cat is one of the most frequently recorded small carnivore species in Vietnam's illegal wildlife trade (Education for Nature Vietnam's ENV wildlife crime bulletins, November 2006 - August 2013; CPCP confiscation data). The offtake that it can withstand is unknown, so there might be long-term conservation issues for species in Vietnam.

No other small cat had many confirmed records. Three site records were traced for golden cat, as well as several provisional records. Elsewhere in the region golden cat is, after leopard cat, amongst the more frequently recorded small cat species (Duckworth et al. 2005, Tantipisanuh et al. 2014, this issue). Marbled cat had the fewest confirmed records of evergreen forest species, as is also regionally typical.

Jungle cat is unlikely to have ever had a wide distribution in Vietnam: deciduous forest is relatively limited, whilst widespread hunting presumably excludes it from scrub and agriculture it might otherwise occupy (Duckworth et al. 2005). In contrast to leopard cat, jungle cat lacks populations in dense forest that could diffuse out to replace animals killed in agricultural/cleared habitats.

Even if Phu Quoc is later confirmed to hold jungle cat, the island's population is likely to be small and perhaps not a conservation priority; the island is small (574 km²), dominated by evergreen forest, historically probably had only little scrub/open forest and thus few jungle cats, and is now threatened by unregulated tourism development. Similarly, even if Gia Lai, Kon Tum and/or Dak Lak provinces hold jungle cat, populations would probably be of low global significance: much larger areas of deciduous forest in Cambodia still contain a suite of dry forest specialist species extinct or close to local extinction in Vietnam (Gray et al. 2014, this issue). Efforts to

conserve jungle cat in Indochina should thus focus on Cambodia.

The multiple fishing cat records from U Minh Thuong NP during a short survey in 2000 (Nguyen Xuan Dang et al. 2004b), and the lack of records in Vietnam from forest habitats that have been well surveyed using camera traps placed along forest trails, salt licks, in natural clearings etc., suggest that this species may be very localised, perhaps primarily close to watercourses or wetlands. The failure of more recent surveys in U Minh Ha NP and the intervening U Minh Ha FFEs (CPCP unpublished survey data) to produce any fishing cat records is of concern: thirteen years have passed since the records from U Minh Thuong NP. Recent confirmed records of this species in small remnant patches of wetland in Howrah, a city district of Kolkata, India (Adya 2011), do not suggest that fishing cat is a forest obligate that needs large intact areas of forested wetland. Though small in size and depauperate compared to some of the region's wetlands, Vietnam's U Minh wetlands might thus still support a significant fishing cat population. Clarification of whether fishing cat persists in the wider U Minh wetland landscape is urgently needed. All surveys, even the camera trap surveys, reviewed here were too brief to conclude that the small cat species not recorded were genuinely absent from the site. However, comparable camera-trapping elsewhere in South-east Asia typically detects clouded leopard, golden cat, leopard cat, and jungle cat frequently when in suitable habitat. Marbled cat is typically found less often than these species, but still regularly and widely. All these five small cat species can be recorded using camera traps set for other species including tiger and large ungulates (e.g. Holden 2001, Azlan & Sharma 2006, Datta et al. 2008, Gray et al. 2012, Tantipisanuh et al. 2014, this issue). The great paucity of small cat records (excepting leopard cat) from camera trap surveys in Vietnam, even those with efforts exceeding 1,500 effective camera trap nights amid large extents of suitable habitat, thus reflects small cats' genuine scarcity in these areas (SOM T3; Fig. 5). Of particular concern is that camera-trap surveys were undertaken in several of the largest remaining evergreen forest blocks. Three recent targeted small carnivore surveys, two surveys for Edwards's pheasant *Lophura edwardsi* and one ongoing saola *Pseudoryx nghetinhensis* survey in Vietnam, in habitat suitable for clouded leopard, golden cat and marbled cat, had camera trap

survey effort that should have been, based on encounter rates in other countries, sufficient to record these species if present at comparable densities. They recorded only leopard cat. The lack of post-2000 fishing cat records requires specific consideration. Very few fishing cat records are produced from camera trap 'by-catch' anywhere in South-east Asia. The lack of incidental fishing cat records in the region suggests a distribution largely outside (at major habitat and/or microhabitat scale) that targeted during camera trap surveys for e.g. tigers, and/or rarity within the region. The great rarity of camera trap 'by-catch' records of this species anywhere combined with relatively recent records in Vietnam strongly urges targeted searches for fishing cat in the country.

In 1995, leopard cat was seen in a brief survey of Ke Go NR (Le Trong Trai et al. 1999) but the much more intensive specific small carnivore surveys in October 2006 - March 2007 and January - July 2010 failed to record any cat species (CPCP, unpubl. data). This is probably because of the widespread intensive hunting: approximately 1,200 cable-snare traps were collected during the survey and active hunting/logging camps were seen on nearly every major pathway. Hunting at Ke Go NR has, based on camera trap data and incidental records collected during the survey, reduced populations of similar sized and larger mammal species including relatively tolerant species such as common palm civet *Paradoxurus hermaphroditus* (four records) and wild pig *Sus scrofa* (no records) (CPCP unpublished survey data). Wild pig had been previously recorded in Ke Go NR (Le Trong Trai et al. 1999). Similarly in Phong Nha - Khe Bang NP no cat records resulted from approximately 1,800 camera trap nights; 500 cable-snare traps were collected there over 30 days, and wildlife hunting is assumed to be the main reason for population declines suspected in a wide range of mammals there (Nguyen Xuan Dang et al. 2012).

Despite Cat Tien NP's failure to protect Javan rhinoceros (Brook et al. 2011), it still boasts several globally threatened mammal and bird species including green peafowl *Pavo muticus*, gaur *Bos gaurus* and black-shanked douc *Pygathrix nigripes*, and several small carnivore species are readily camera trapped and spot-lit. An ongoing small carnivore survey in the Nam Cat Tien sector of the park has so far confirmed at least nine small carnivore species by these methods (Nguyen The Truong An in litt. 2013). Over 2,000 camera



Fig. 4. Camera-trap photograph of a leopard cat at the edge of an active *Melaleuca* plantation in the U Minh Ha FFEs taken on the 10 September 2010 (Photo Carnivore and Pangolin Conservation Program).

trap nights recorded only leopard cat. A previous survey in 2006-07 in the same sector recorded seven small carnivore species during approximately 3,500 camera trap nights (Shih-chih Yen 2009). Again, only leopard cat was recorded.

Hunting might be the main factor behind the absence of records for other cat species in Cat Tien NP. Although the main tourist trails and areas close to the FPD headquarters have little if any visible hunting, 500 cable-snare traps were collected in approximately 6 km² on Nam Cat Tien's periphery in 2013 (Nguyen The Truong An in litt. 2013). Relative to Vietnam's other protected areas, hunting in Nam Cat Tien is generally still low, and this incident remains the only significant hunting observation in nearly a year's survey effort, though most survey effort has focused on or near the main tourist routes. The current lack of other small cat records at this relatively well protected site despite a targeted and high survey effort, and an apparently healthy prey base of small-medium sized mammals, reptiles and ground-dwelling bird species, does not bode well for the status of these species at this site. However, it is also possible that species other than leopard cat are naturally absent; Polet & Ling's (2004) extensive compilation also traced records of only leopard cat, and small carnivore distribution in the region is only known at the course-habitat scale for the majority of species. Another possible reason for the apparent absences/very low densities

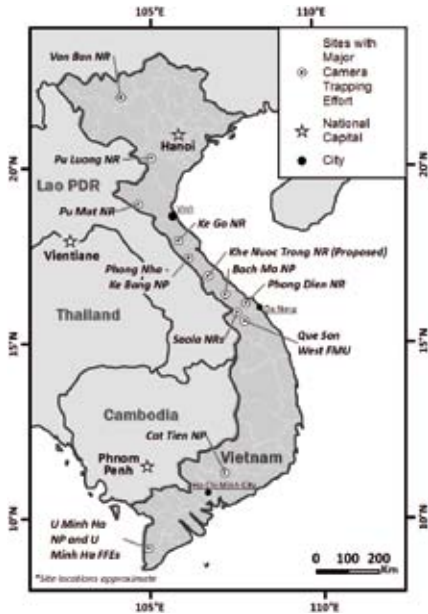


Fig. 5. Approximate location of sites listed in SOM T3. Bach Ma NP and Phong Dien NR are indicated separately on this map but are part of the WWF 'Green Corridor Forest Landscape' that runs approximately north-south across Hue province (Dickinson & Van Ngoc Thinh 2006). Likewise with Que Son West FMU, which was one of several survey sites in Quang Nam province in Long (2005), but has been shown as single site for clarity.

of small carnivores that ought to be present and in some cases relatively common at this site, is the as yet unknown indirect effects of the defoliants that were sprayed over the area now comprising Cat Tien NP during the America-Vietnam war (Polet & Ling 2004).

Threats to small cat species in Vietnam

Although historical information is too patchy to be sure of past small cat status in Vietnam, it seems likely that all species were formerly considerably more common. Though the more tolerant and widespread leopard cat is still relatively easily observed in parts of Vietnam (Table 2), even its numbers are likely to have declined. Hunting, notably indiscriminate snaring, is doubtless the main factor behind these suspected declines, as it is for many threatened mammal, bird and reptile species in the country (CEPF 2012). Vietnam's only areas afforded some respite from hunting are those that are naturally barely accessible (Eberhardt 2012), and the vicinities of FPD headquarters and the main tourist trails in protected areas, which do at some sites show signs of wildlife recovery. Crucially though, these areas have not yet

shown any cat recovery; however, this has only been well tested at Cat Tien NP where other possible factors (discussed earlier) may be at play.

Few survey reports reviewed quantified threats (notably excepting Timmins & Trinh Viet Cuong 2001, Long 2005, Nguyen Xuan Dang et al. 2012), but nearly all described hunting pressures at their respective sites as 'high'. Ground-level trapping, usually in the form of cable-snares, is widespread in Vietnam's forests and there are several reports of thousands of snares confiscated annually from some individual PAs (Birdlife International 2010, CPCP, unpubl. data), and in some cases tens of thousands (WWF 2013). The only sites not intensively targeted with this hunting method appear to be areas where most ground-dwelling fauna has already been depleted, such as in Cuc Phuong NP and Ngoc-Son Ngu Luong NR where hunting methods have switched to those suitable for arboreal species i.e. guns and crossbows (DHAW pers. obs.), or where the habitat only supports using this method for part of the year e.g. the seasonally flooded U Minh Wetlands in the Mekong Delta (DHAW pers. obs.).

Cable snares are usually placed in lines along man-made pathways, sometimes in the hundreds, with drift fences of cut vegetation alongside to funnel fauna across the snares' triggers. This unselective method seems likely to be an extremely effective way to hunt small cats. Trail use varies between ecologically similar species (Harmsen et al. 2010), but leopard cat, clouded leopard, Asiatic golden cat, jungle cat and marbled cat have all been recorded along such trails by camera traps (e.g. Grassman 2003, Do Ngoc Cuong 2004, Kawanishi & Sunquist 2008, Wibisono & McCarthy 2010, Majumder et al. 2011), and so are presumably vulnerable to this hunting method.

Several potential small cat prey items e.g. macaques *Macaca*, wild pig, chevrotains *Tragulus*, and red junglefowl *Gallus gallus*, are hunted in protected areas in Vietnam to supply the illegal wildlife trade. Whilst intensive hunting pressures, particularly unselective cable-snaring, have caused apparent population declines in some of these prey items at some sites (e.g. the Ke Go-Khe Net Lowlands; CPCP, unpubl. data), other sites included in this review seem to retain relatively healthy prey bases of small to medium sized animals, yet among cats have only recorded leopard cat e.g. Cat Tien NP (Shih-chih Yen 2009), and the Saola NRs (WWF-Vietnam,

unpubl. data), or no cats at all e.g. Phong Nha Khe Bang NP (Nguyen Xuan Dang et al. 2012). Though the ecology of most of these small cat species is poorly known, several of the smaller possible prey items e.g. murid rodents, still appear relatively abundant in the majority of Vietnam's protected areas. Few of these smaller prey items are targeted for the wildlife trade, at least at an international level, and the impact of ground-level trapping on small animals (i.e. <1 kg), especially those species that are semi-arboreal/arboreal, is likely to be negligible. It therefore seems unlikely that prey depletion is a main threat to Vietnam's small cats, at least not to the extent it is for larger carnivores in South Asia (e.g. tiger; Datta et al. 2008, Barber-Meyer et al. 2013). Clouded leopard does take larger prey than Vietnam's other five small cat species, including primates (Matsuda et al. 2008), which are targeted for the illegal wildlife trade (Geissmann et al. 2000). The extent to which this species is dependent on species themselves depleted by overhunting is however unknown.

Despite all cat species in Vietnam being afforded full legal protection, none is unaffected by illegal wildlife trade there. Leopard cat is most frequently traded, apparently in demand as an exotic pet (TQP pers. obs.). Confiscated golden cats both live and dead/frozen (ENV 2010, 2011, 2013a, 2013b) have been recorded. These two species were the most frequent small cats observed in the wildlife trade based on CPCP confiscation data and confiscation reports published by Education for Nature Vietnam ENV from 2006 onwards. Only two possible trade records for clouded leopard were traced during the same time period, and none for the other three species (a single live leopard cat, misidentified as fishing cat was confiscated July 2011; DHAW examined the original photographs and confirmed identification). A two-month survey on bear (Ursidae) bile trade covering Traditional Medicine outlets in all Vietnam's major cities recorded only one species of small cat: leopard cat (TRAFFIC, in press). Since 2011 there have been three records of dead golden cats confiscated from the illegal wildlife trade in Vietnam painted to resemble tiger.

All small cat species have been recorded in the illegal wildlife trade in South-east Asia (Duckworth et al. 1999, 2005, Shepherd & Nijman 2008), with clouded leopard in high demand because of its striking coat pattern (Shepherd & Nijman 2008, Sanderson et al. 2009). The

few recent trade records for clouded leopard in Vietnam are unlikely to reflect decreasing or low demand, which is likely to be increasing as numbers grow of wildlife consumers/users in Vietnam, i.e. middle-class urbanites (Robertson 2007, TRAFFIC 2008). More plausibly there are simply fewer animals to hunt and trade. That leopard cat and golden cat are the small cat species most frequently recorded in the illegal wildlife trade corroborates the field records relative to the other small cat species. Though leopard cat is probably relatively resistant to hunting pressures, it is likely to have gone through significant declines in Vietnam, in part still appearing to be 'common' in the trade because the species's starting population (i.e. prior to the growth of the illegal wildlife trade) was much larger and more widespread, relative to the other small cat species.

Conclusion

The most plausible explanation of the great rarity in Vietnam of recent records of small cats, except leopard cat, is that they are in serious decline in the country and are plausibly being extirpated from an increasing number of protected areas. The rapid loss of natural habitat is unlikely to have been an important driver of current status, even the more forest dependent species, because of the lack of records from even large blocks of surviving and little-degraded habitat.

Targeted hunting of some prey items and indiscriminate cable-snaring of others may have resulted in a depleted prey base for clouded leopard populations at some sites in Vietnam. However, several camera trap surveys at sites with suitable habitat and relatively healthy populations of known prey items have failed to record the species. Hunting, particularly cable-snare trapping, which is widespread and intensive within and outside nearly all of Vietnam's accessible natural and semi-natural areas, irrespective of whether a site is formally protected or not, is surely the main cause of decline in Vietnam's small cats.

Vietnam's protected areas are mostly under 500 km², limiting the resilience of their fauna to hunting. The country may no longer hold significant populations of any globally threatened small cat species, although were hunting controlled, the present habitat could be reoccupied by large and significant numbers of small cats.

Conservation Recommendations

Surveys in U Minh Thuong NP, the last site with confirmed fishing cat records in Viet-

nam, are urgently needed to clarify that species's present status. Any population is likely to warrant direct conservation intervention as it could potentially be of regional significance. Surveys should use camera traps in the same locations as Nguyen Xuan Dang et al. (2004) as well as additional locations to ensure a sufficient coverage of the site.

Targeted surveys for fishing cat in the U Minh landscape as well as other sites in the Mekong Delta are also warranted. In other countries, fishing cat does not need pristine or large areas of habitat to persist, even using small highly modified wetland-agriculture mosaics (Adhya 2011, Mukherjee et al. 2012). The Mekong Delta may thus hold other fishing cat populations. Mui Ca Mau NP is a priority site for a targeted survey as it contains suitable habitat and remains little-surveyed. Vietnam is extremely unlikely to retain globally significant populations of clouded leopard, golden cat, marbled cat or jungle cat. National populations of each are clearly not now large, and there is no suggestion of taxonomic distinctiveness of Vietnamese populations. Both Cambodia and Lao PDR have many fewer people than Vietnam and much larger areas of wild habitat. Crucially, the intensive industrial-scale snare trapping presumed to be the main factor behind the decline in Vietnam's small cat population is not yet widespread in Cambodia (S. Mahood in litt. 2013) and even some areas of Lao PDR remain to be affected (Coudrat et al. 2014, this issue).

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- Supporting Online Material SOM T1-T3 and F1-F2 are available at www.catsg.org/catnews

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Non-*Panthera* cats in South-east Asia: present knowledge and recommendations

The conservation status of South-east Asia's nine species of non-*Panthera* cat is imprecisely known. Flat-headed cat *Prionailurus planiceps*, bay cat *Catopuma badia* and Sunda clouded leopard *Neofelis diardi* are confined to South-east Asia, while Asiatic golden cat *Catopuma temminckii*, marbled cat *Pardofelis marmorata* and mainland clouded leopard *Neofelis nebulosa* occur mostly there. The recent great increase in camera-trapping is generating many verifiable records of non-*Panthera* cats, usually as by-catch to the surveys' foci. Inspection of such records from Myanmar, Thailand and Vietnam (whole country reviews) and Cambodia, Lao PDR, Malaysia and Sumatra (Indonesia; single-landscape reviews) show that the evergreen forest species – the two allopatric *Catopuma* species, the two parapatric clouded leopard species, leopard cat *Prionailurus bengalensis* and marbled cat *Pardofelis marmorata* – are all recorded widely. In well-protected areas of suitable habitat they are found mostly commonly; but densities are much reduced, even in large little-fragmented and little-degraded landscapes, where snaring is heavy (Vietnam and Nakai–Nam Theun, Lao PDR). Leopard cat is considerably more resilient than are the others. By contrast, only Cambodian dry forest was found to hold many jungle cats *Felis chaus* (apparently suitable habitat in Myanmar is poorly surveyed); fishing cat *Prionailurus viverrinus* records are exceptional outside surveys specifically for them, and the species seems to have a small, fragmented and vulnerable range in South-east Asia; flat-headed cat has been found widely, but rarely, within its (also fragmented) range. These last three, particularly fishing cat, are served poorly by South-east Asian protected areas. The global priority species for South-east Asia are arguably flat-headed cat because it occurs nowhere else, and fishing cat because no large populations are known from anywhere. By contrast, jungle cat is still apparently numerous outside South-east Asia. With no major near-term increase in conservation attention likely for these nine cat species, regular reviews, duly attending to misidentification risk, of their camera-trap by-catch records could help track, coarsely, seven species' status. Fishing cat, however, requires directed monitoring because of both its apparent perilous status and its non-overlap with typical camera-trap areas; flat-headed cat would also benefit strongly from this.

On current taxonomy, South-east Asia (the mainland plus Greater Sundas; Fig. 1 in introductory article) holds 11 species of wild felids (Table 1). The nine outside the genus *Panthera* are this special issue's focus. The surveys reported come from across most of South-east Asia except Java, Borneo and the Philippines. The Philippines support only one wild cat species, the resilient and non-threatened leopard cat (e.g. Fernandez & de Guia 2011, Lorica & Heaney 2013). Java supports only leopard cat and fishing cat, for which latter no new information was traced. No contribution was sought from Borneo, because status reviews of all species on the island are in preparation following a symposium held on Bornean carnivores in 2011. Important recent sources of cat records on Borneo include Matsubayashi et al. (2006), Gimán et al. (2007), Yasuda et al.

(2007), Azlan et al. (2009), Cheyne & Macdonald (2011), Rustam et al. (2012) and Wearn et al. (2013).

The surveys reported here, and other recent surveys in the region, show that five of the nine South-east Asian species of non-*Panthera* cats are widespread and, at least in places, commonly recorded: Asiatic golden cat, leopard cat, marbled cat and the two clouded leopard species, mainland clouded leopard and Sunda clouded leopard (Fig. 1). These are referred to below as 'the standard four': 'four' because at any given locality, only one of the clouded leopards occurs. The other four species (bay cat Fig. 2, fishing cat, flat-headed cat Fig. 3 and jungle cat) are only patchily and generally rather infrequently camera-trapped. The extent to which a further species, feral domestic cat *F. catus*, oc-

curs in the region is unclear. These cats are commonly kept at protected area headquarters and outstations, and border/interior villages in South-east Asia (JWD pers. obs; W. Chutipong in litt. 2013, D. Ngoprasert in litt. 2013, D. H. A. Willcox in litt. 2013). None of the surveys reported here recorded domestic cats within large forest landscapes, finding them only where camera-trapping occurred close to human habitation (e.g. Khao Sam Roi Yod NP, Thailand; P. Cutter in litt. 2013). It seems plausible that domestic cat occurrence in natural habitats of South-east Asia is localised to the vicinity of human habitation, and that truly feral (self-supporting) populations are unusual, if they occur at all.

Status and conservation needs of the rarely-recorded species

The 'standard four' – and bay cat – show a fundamental natural history difference from all of fishing cat, flat-headed cat and jungle cat. None of the latter is a denizen of typical evergreen forest, which is the main or at least a common habitat of the other six (Table 1). Fishing and flat-headed cats are associated with watersides; while the first does occur around them within evergreen forest (Wilting et al. 2010), the extent to which fishing cat does so requires clarification. Jungle cat is strongly associated with deciduous dipterocarp forest, at least in South-east Asia (Gray et al. 2014, this issue). The relationship with evergreen forest is significant in two ways. Before extensive clearance by people, such forest was South-east Asia's predominant habitat, so species not using it would have been naturally more restricted in occurrence than those that do. And it is by far the best surveyed habitat in the region, meaning that today's paucity of records of fishing cat, flat-headed cat and jungle cat might not necessarily reflect true rarity.

Bay cat

Bay cat, endemic to Borneo, is by definition not widespread in South-east Asia. While formerly thought a great rarity (e.g. Sunquist et al. 1994, Mohd-Azlan & Sanderson 2007), camera-trapping has revolutionised understanding of its distribution, habitat use and status. Its Bornean (and thus global) conservation status will be considered in depth in the proceedings of the Borneo Carnivore Symposium. This traced records from many forest-types, spread widely across the island. Some records were from degraded forest (e.g. Wearn et al. 2013), but none was traced

Table 1. Cats of South-east Asia with their range in South-east Asia and in the world, and their preferred habitats in South-east Asia. Habitats assigned from the works in this issue. Ranges based on Nowell & Jackson (1996) and IUCN (2012).

Species	English name	SE Asia range	World range	Habitat
<i>Catopuma badia</i>	Bay cat	Borneo	Endemic to SEA	Evergreen forest
<i>Catopuma temminckii</i>	Asiatic golden cat	WR except Borneo, Java	Also north-east South Asia, and southern China	Evergreen forest +
<i>Felis chaus</i>	Jungle cat	Non-Sundaic	West to Egypt and north to central Asia	Open deciduous forest, grassland
<i>Pardofelis marmorata</i>	Marbled cat	WR except Java	Also north-east South Asia and southern China	Evergreen forest
<i>Prionailurus bengalensis</i>	Leopard cat	WR	West to India and north to Russian Far East	Evergreen forest +
<i>Prionailurus planiceps</i>	Flat-headed cat	Sundaic except Java	Endemic to SEA	Waterside
<i>Prionailurus viverrinus</i>	Fishing cat	Non-Sundaic, Java, ?Sumatra, ?West Malaysia	Also South Asia	Waterside
<i>Neofelis diardi</i>	Sunda clouded leopard	Sumatra, Borneo	Endemic to SEA	Evergreen forest
<i>Neofelis nebulosa</i>	Mainland clouded leopard	Mainland	Also north-east South Asia and southern China	Evergreen forest +
<i>Panthera pardus</i>	Leopard	Mainland, Java	Also north-east Asia, South, Central and West Asia, Arabia and Africa	n/a
<i>Panthera tigris</i>	Tiger	Mainland, Java, Sumatra	Also north-east Asia, South Asia, formerly Central and West Asia	n/a
Feral				
<i>Felis catus</i>	Domestic cat	Unknown	Worldwide but poorly documented	Apparently synanthropic

from deep within plantation monocultures. Much of Borneo was predicted likely to hold the species. Other than its small range, nothing obviously distinguishes its natural history from the standard four. It may have been much overlooked, perhaps through some peculiarity of its natural history reducing encounters by camera-trap as typically set (Wearn et al. 2013).

Flat-headed cat

Flat-headed cat is restricted to Sundaic South-east Asia, giving the region special relevance to its global survival. Recent records come from most of its range, but it inhabits mainly lower-altitude gentle terrain. Heavy clearance of forest on such land threatens it (Wilting et al. 2010). Although perhaps somewhat under-recorded through camera-placement in suboptimal microhabitats, targeted survey would certainly find this species threatened. It is arguably the region's highest conservation priority among the non-*Panthera* cat species.

Jungle cat

A decade ago there were very few then-recent records of jungle cat in South-east Asia (Duckworth et al. 2005). It has since been found often in Cambodia's deciduous dipterocarp forest. The wide spread of jungle cat records there suggests a population of consid-

erable regional significance (Gray et al. 2012, Gray et al. 2014, this issue). Current status in Myanmar, where camera-trapping focussed on evergreen habitat, is unclear; there are some records from encroached and/or more deciduous margins of evergreen areas, despite low search effort (Than Zaw et al. 2014, this issue). The ongoing scarcity of records in Thailand (Tantipisanuh et al. 2014 this issue), Lao PDR (Coudrat et al. 2014a, this issue) and Vietnam (Willcox et al. 2014, this issue) suggests that in these countries it is now at best very rare. In Thailand, heavy survey effort in Huay Kha Khaeng's deciduous forests found no jungle cats (Simcharoen et al. 2014, this issue), suggesting that, at least in South-east Asia, selectivity in its use of deciduous forests. Very large connected landscapes might therefore be needed to ensure enough of its optimal habitat persists. This allows no complacency for its Cambodian future: the very landscapes in which it has been confirmed face, despite nominal conservation management, heavy threat of large-scale clearance, primarily for concession cultivation of rubber and cassava. Major habitat change is also accelerating in Myanmar's lowlands. Finally, the extent to which hybridisation with domestic cat might threaten the populations, mostly small, remaining in South-east Asia has not been assessed. Jungle cat is thus of high regional conservation concern, but, given its

wide range outside South-east Asia, of arguably less global concern than is flat-headed cat.

Fishing cat

Globally, fishing cat's presently documented South-east Asian status is the most alarming of the non-*Panthera* cat species. Modern records come from few South-east Asian sites, mostly from small isolates of sometimes quite heavily encroached habitat in coastal or deltaic areas (e.g. Melisch et al. 1996, A. Compost in Duckworth et al. 2009, Cutter & Cutter 2009, Tantipisanuh et al. 2014, this issue), with none shown to hold large numbers. Only two records (Royan 2009, Rainey & Kong 2010) come from the sorts of landscape in South-east Asia typically attracting long-term international collaboration: large, mostly little-degraded forest-tracts demonstrably important for multi-species mammal and/or bird conservation. If this absence of records from most of South-east Asia's well-surveyed conservation landscapes reflects genuine wide absence of the animal, not simply suboptimal camera-trap placement, then of all South-east Asian non-*Panthera* cats, its present distribution probably overlaps the least with high profile conservation targets like tiger, Asian elephant *Elephas maximus* and wild cattle *Bos* spp. It would thus be unlikely to be conserved incidentally to general conservation activities. It requires specific



Fig. 1. Sunda clouded leopard (Photo S. Kennerknecht/Panthera).

focus, and the areas in which it is presently known are used by many people with high pressure on surviving fishing cats (e.g. Cutter & Cutter 2009). Fortunately, conservation interventions for it need not tackle the knotty issues inherent in retaining large expanses of little-degraded forest or in reducing trade-driven hunting across large areas. Large areas of potential habitat remain unsurveyed, so there is a small chance that more (mostly small, isolated) populations remain to be found. The species is also highly threatened in South Asia, although at least in the lowlands south of the Himalayas it does occur in 'typical' conservation landscapes, some with high management priority through populations of species like tiger and great Indian rhinoceros *Rhinoceros unicornis* (e.g. Mukherjee et al. 2012).

Survey needs of the rarely-recorded species

For these four species, particularly fishing cat, the paucity of current information limits efficient targeting of conservation resources for them. Wherever possible, camera-trap surveys should consider these species during planning, in terms of large-scale habitat for jungle cat, and microhabitat focus for flat-headed and fishing cat. How bay cat might be specifically considered is not clear but it is possible that its generally low prevalence in camera-trapping surveys is more a reflection of typical camera-trapping style than of genuine scarcity (Wearn et al. 2013).

Status of the widely-recorded species

Golden cat, leopard cat, marbled cat and the two clouded leopard species ('the standard

four') were found widely and, in many areas, fairly often. The large differences between species and sites in the rates at which animals are camera-trapped do not necessarily reflect patterns in animal density: many other factors affect encounter rates (Sollman et al. 2013). For cats, two pertinent factors are their degree of off-ground activity and the extent to which they follow trails (Harmsen et al. 2010). Camera-trapping in most surveys here presented focused around obvious pathways (human or wildlife) through the habitat, and was universally undertaken at ground level. The more a species climbs and the less it follows trails, the less it will have been photographed. Within a species, the degrees of arboreality and trail-following may differ between habitats, sites and seasons. Thus, while marbled cat is the least recorded of 'the standard four' in many surveys, the relative roles of scarcity and lower detection probability are unclear. Few studies have quantified such factors' effects, but one in Borneo camera-trapped leopard cats off roads at rates only 3.6–9.1% of those along roads in the same area (Mohamed et al. 2013).

The persistence of 'the standard four' in many survey areas suggests healthier conservation status than for the rarely-recorded species. However, the surveys collated in this issue, and those published elsewhere, come from a non-random selection of sites. Long-term wildlife studies may tend to occur in areas with reasonable conservation management. This is certainly true for the intensive single-site surveys in the Endau Rompin landscape, Gunung Leuser NP and Huai Kha Khaeng Wildlife Sanctuary (Gumal et al. 2014, this

issue, Pusparini et al. 2014, this issue, Simcharoen et al. 2014, this issue) and increasingly so for Cambodia's Eastern Plains Landscape (Gray et al. 2014, this issue).

Fortunately – for the purposes of this comparison, if not for the cats there – one intensive survey area, Nakai-Nam Theun NPA, is evolving its conservation management capacity, and the surveys reported here (Coudrat et al. 2014a, this issue) come after 15–25 years of essentially unrestrained intensive hunting (e.g. Robichaud et al. 2009). While apparently not targeting non-*Panthera* cats, this poaching's non-selective methods catch them incidentally. Encounter rates in this area of 'the standard four' are now very low. This does not represent inappropriate survey technique (various other small carnivores were found commonly; Coudrat et al. 2014b) or inherent unsuitability of the area's habitat for these cats. Forest cover has remained roughly stable, with the area's increasing human population engaging in an essentially one-off bonanza in wildlife trade rather than in expanding agriculture (Robichaud et al. 2009). Recent poaching-driven declines are the most plausible explanation for the paucity of cat records. Nakai-Nam Theun NPA is on the Vietnamese border. The collation of records from Vietnam (Willcox et al. 2014, this issue), where hunting is typically even more heavy as in Nakai-Nam Theun NPA and has been widespread for many years, found very few records of any species other than leopard cat in the last 15 years. Although hunting is not proven to be the cause of the low numbers of recent records in Vietnam, the situation there echoes that in heavily-hunted southern China where three of these non-*Panthera* cat species occur: mainland clouded leopard and Asian golden cat are at great risk of regional extirpation, although leopard cat is relatively secure (Lau et al. 2010). The viability of cat populations reduced so much that detections are so rare is unclear: but it must be possible that they are severely threatened.

Nakai-Nam Theun NPA covers 4,000 km² of mostly rugged terrain with very limited road access, which abuts other large areas under conservation designation. Over most of its interior, bulk extraction of forest resources is economically worthwhile for those of only the highest trade value. The driving forces for this heavy hunting lie outside the protected area, mostly within urban Vietnam and China. The currently insatiable demand means that similarly intensive hunting is likely to expand across South-east Asia, especially where

hunting is strongly culturally ingrained. Nakai-Nam Theun NPA is 5-10 times the size of the typical South-east Asian protected area, and is set within a natural habitat landscape 10-15 times typical of that in the region. That cats suffer hunting-driven declines even within this large rugged landscape, difficult of access, means that even the 'common' wild cat species are, mostly, likely to decline rapidly in density wherever trade-driven intensive snaring is employed.

Leopard cat is probably the only South-east Asian non-*Panthera* cat not regionally threatened. It persists in anthropogenic landscapes which hold too few other mammals of comparable size (or bigger) for extirpation of these leopard cat populations through by-catch to be likely (e.g. Lau et al. 2010, Willcox et al. 2014, this issue; W. Chutipong in litt. 2013). Only directed hunting would be likely to remove them. This might occur if all the region's other cat species are reduced to remnant populations in secure protected areas, but market demand remains for wild cats or their parts.

Conservation needs of the widely-recorded species

Although marbled cat, golden cat and the clouded leopards remain widespread in the region, effective management of protected areas and other tracts of natural habitat, in particular the prevention of illegal hunting, is the overwhelming priority for these evergreen forest species. Without it, the situation prevalent today in Vietnam and south China can be expected to spread more widely in South-east Asia. Presently, these species remain sufficiently widespread that many sites could conserve each. The limited resources for conservation overall, particularly for focussing on single-species, mean that conservation of these species might sensibly come through general strengthening of protected areas and species conservation initiatives with higher public profile, rather than specific interventions for them.

Information on each species's natural history remains too scanty to determine the minimum landscape size each needs, and how much forest degradation and fragmentation (as distinct from conversion, which evidently is tolerated only by leopard cat) each can accommodate. South-east Asian forest has been encroached too fast for simple inspection of which species persist in forest-blocks of different sizes to be useful: many populations left over from former optimal conditions



Fig. 2. Borneo bay cat (Photo S. Kennerknecht/Panthera).

may now have reproductive output too low to persist in the long-term (see Kuussaari et al. 2009). Commercial hunting patterns add a further complication to predicting the size-class of forest landscape needed to retain these cats. Only directed research into their natural history is likely to provide this information. However, such research is arguably a lower priority than is finding and conserving populations of fishing cat and flat-headed cat in the region. Neither species is likely to be carried particularly well by 'situation normal' conservation, whereas the 'standard four' probably will be, at least into the mid-term.

Possibilities for tracking conservation status of South-east Asia's cats

The practicality of monitoring the conservation status of non-*Panthera* cat species in South-east Asia as an 'add-on' to camera-trapping for other reasons is not simply answered. Outside evergreen forest, it is not appropriate except where jungle cat persists. The only other species numerous in these habitats is leopard cat (Gray et al. 2014, this issue, Simcharoen et al. 2014, this issue), which is too common to warrant use of conservation resources in its interest. In evergreen forest, with survey effort-levels typical of tiger conservation projects, 'the standard four' cat species may be found often enough for some sort of monitoring to be theoretically possible.

Population monitoring based on encounter rates would need to disentangle from abundance all the other factors that affect encounter rate (see Sollman et al. 2013). The intensive research necessary to do this (if it

were possible at all) would sensibly be put into methods involving fewer and less plastic assumptions, such as capture-recapture population estimation. Given the complexity of their coat patterns, marbled cat, the clouded leopards, leopard cat, and even perhaps golden cat, should all be monitorable through capture-recapture methods similar to those used for tiger (see Karanth et al. 2011). The colossal effort to develop reliable tiger population monitoring required detailed knowledge of its natural history; for example, cameras must be positioned across a survey area at a separation reflecting the target species's spatial use (Karanth et al. 2011). The almost total ignorance of these non-*Panthera* species' spatial ecology precludes assessment on the extent to which they could be confidently monitored by tiger monitoring programmes without significant modification. Species with smaller home ranges, for example, would require additional cameras within the optimal tiger-spacing grid.

In the interim, there may be some possibility for tracking species conservation status simply and coarsely. Among the stiffest difficulties of using encounter rates at the individual site level is that major changes in them between years might simply reflect differences in survey technique. Frequent personnel turnover in conservation projects (e.g. for Cambodia: Gray et al. 2012) is typical across the region, and people tend to vary in the exact way they do things. And the exact way a camera-trap is set has a large bearing on what it records. However, misleading trends would be less likely to result from information collated from multiple sites. Patterns shared across many sites in a



Fig. 3. Flat-headed cat (Photo A. Wilting & A. Mohamed).

year, particularly if they continue in multiple years, would be unlikely to arise from methodological changes, which are more likely to generate conflicting trends between years and sites. Such a collation might detect major changes in abundance. While no substitute for a specifically designed – but therefore specific resource-demanding – monitoring programme, the present baseline alternative is no monitoring at all.

Species identification – an issue requiring more care

Any measurement of a species's conservation status with camera-traps requires the correct identification of images to species. This is a poorly documented aspect of camera-trapping. No dataset in this issue had major problems at time of submission, as shown by the independent check on identification. However, it would be rash to assume this was typical of camera-trapping in the region. Firstly, authors were aware of the checking process and may have taken more care than normal; in two datasets the identifications made for the relevant project report/database were still visible, and contained frequent errors. Camera-trap datasets riddled with errors are not uncommon in the region. JWD quantified one for non-cat small carnivores and found that of 214 photographs labelled with a species identification, 46 (21%) were not safely identifiable as any species or were incorrectly identified (in the case of 17 of the 46); records from this dataset had been published without caveat in various places. R. J. Timmins (in litt. 2013) examined many camera-trap holdings from northern South-east Asia (e.g. Timmins

2011) and found that with few notable exceptions, datasets typically had many identification errors: both evidently accidental mislabelling, and genuine errors where the identifier's best effort was wrong. The net result is that he would "no longer take at face value any mammal identifications excepting those from people my own experience shows to take due care over this aspect". And in a recent comparison of mammal camera-trap rates across the tropics (Ahumada et al. 2011) at least one constituent dataset (Lao PDR) comprised many errors: this one is unusual because the team creditably put the images onto the internet with public access, allowing independent checking. There evidently remains a strong need for improved species identification by camera-trap programmes, including those badging themselves as species inventory rather than single-species focused.

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