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Non-*Panthera* cats in South-east Asia

J. W. DUCKWORTH[1], ANTONY J. LYNAM[2] AND CHRISTINE BREITENMOSER-WÜRSTEN[3]

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), Giman 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
Catopuma badia	Bay cat	Borneo	Endemic to SEA	Evergreen forest
Catopuma temminckii	Asiatic golden cat	WR except Borneo, Java	Also north-east South Asia, and southern China	Evergreen forest +
Felis chaus	Jungle cat	Non-Sundaic	West to Egypt and north to central Asia	Open deciduous forest, grassland
Pardofelis marmorata	Marbled cat	WR except Java	Also north-east South Asia and southern China	Evergreen forest
Prionailurus bengalensis	Leopard cat	WR	West to India and north to Russian Far East	Evergreen forest +
Prionailurus planiceps	Flat-headed cat	Sundaic except Java	Endemic to SEA	Waterside
Prionailurus viverrinus	Fishing cat	Non-Sundaic, Java, ?Sumatra, ?West Malaysia	Also South Asia	Waterside
Neofelis diardi	Sunda clouded leopard	Sumatra, Borneo	Endemic to SEA	Evergreen forest
Neofelis nebulosa	Mainland clouded leopard	Mainland	Also north-east South Asia and southern China	Evergreen forest +
Panthera pardus	Leopard	Mainland, Java	Also north-east Asia, South, Central and West Asia, Arabia and Africa	n/a
Panthera tigris	Tiger	Mainland, Java, Sumatra	Also north-east Asia, South Asia, formerly Central and West Asia	n/a
Feral				
Felis catus	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
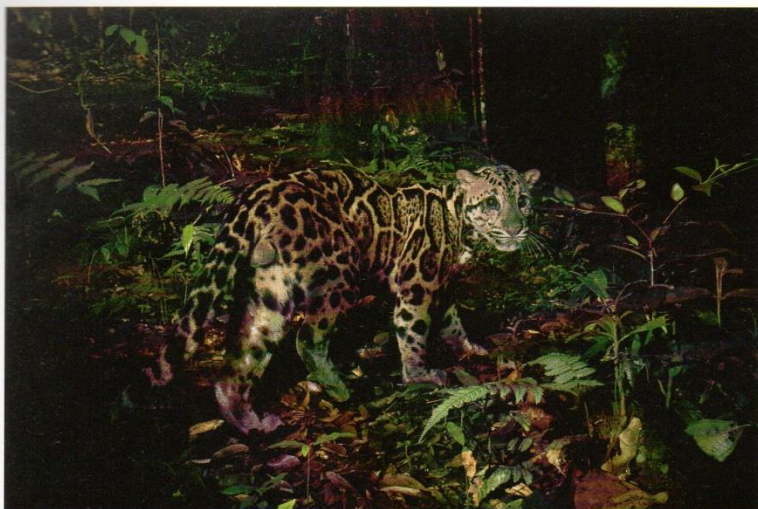
Fig. 1. Sunda clouded leopard (Photo S. Kennerknecht/Panthera).

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 Southeast 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 bycatch 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.

Acknowledgements

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[1] J. W. Duckworth Ltd, 6 Stratton Road, Saltford, Bristol, BS31 3BS, UK

*<willduckworthdprk@yahoo.com>

[2] Wildlife Conservation Society, Global Conservation Programs, 2300 Southern Boulevard, Bronx NY 10460, U.S.A.

[3] IUCN/SSC Cat Specialist Group, c/o KORA, Thunstrasse 31, 3074 Muri, Switzerland