Non-*Panthera* cats in South-east Asia
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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 WECOM 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. 2536 (A. D. 1992) (Wildlife Conservation Division 1992, Boonbootthara 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 1998), 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 WECOM. WECOM 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 WECOM, 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-
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

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.
non-Panthera cats in South-east Asia

dominant tree species in the crown layer include *Azizia xylocarpa*, *Tetrameles nudiflora*, *Lagerstroemia tomentosa*, *L. dulce*, *Shorea obtusa*, *S. siamensis*, *Dictyopteracrus obtusifolius* and *D. tuberculosis* (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 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 (WDECOM 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 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 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.

<table>
<thead>
<tr>
<th>Species</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiger</td>
<td>107</td>
<td>68</td>
<td>91</td>
<td>111</td>
<td>106</td>
<td>483</td>
</tr>
<tr>
<td>Leopard</td>
<td>133</td>
<td>138</td>
<td>139</td>
<td>115</td>
<td>128</td>
<td>653</td>
</tr>
<tr>
<td>Clouded leopard</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Asiatic golden cat</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Leopard cat</td>
<td>9</td>
<td>24</td>
<td>56</td>
<td>12</td>
<td>54</td>
<td>155</td>
</tr>
<tr>
<td>Marbled cat</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total camera-trap-nights</td>
<td>2,241</td>
<td>2,020</td>
<td>2,467</td>
<td>2,804</td>
<td>2,731</td>
<td>9,362</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Species</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiger</td>
<td>58</td>
<td>46</td>
<td>52</td>
<td>67</td>
<td>64</td>
<td>287</td>
</tr>
<tr>
<td>Leopard</td>
<td>77</td>
<td>61</td>
<td>76</td>
<td>61</td>
<td>63</td>
<td>338</td>
</tr>
<tr>
<td>Clouded leopard</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Asiatic golden cat</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Leopard cat</td>
<td>9</td>
<td>14</td>
<td>29</td>
<td>7</td>
<td>33</td>
<td>92</td>
</tr>
<tr>
<td>Marbled cat</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total camera-trap locations</td>
<td>155</td>
<td>136</td>
<td>156</td>
<td>180</td>
<td>186</td>
<td>682</td>
</tr>
</tbody>
</table>
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.

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

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