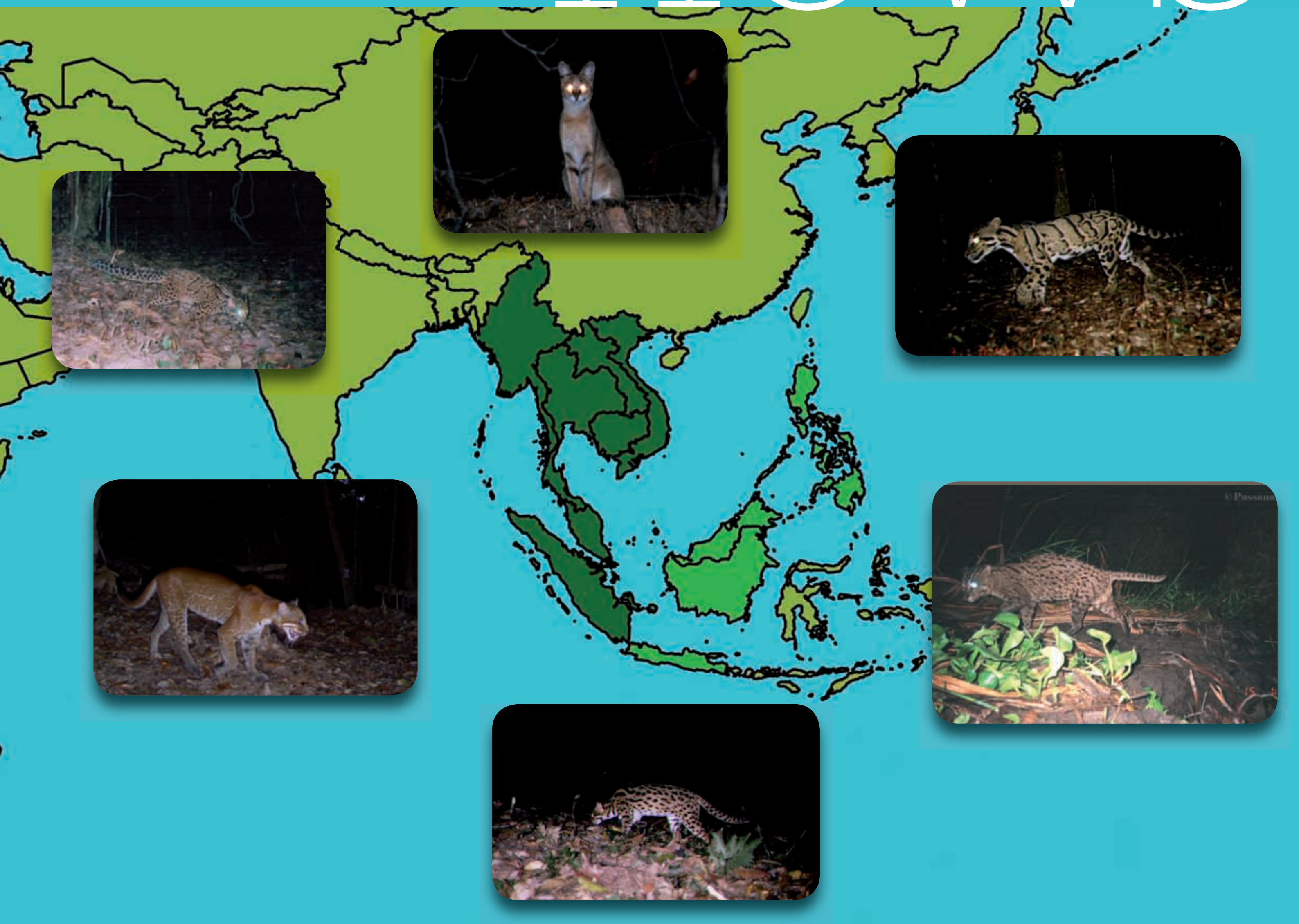
ISSN 1027-2992

Special Issue

N° 8 | SPRING 2014

CAT news

Non-*Panthera* cats in South-east Asia



SPECIES SURVIVAL COMMISSION

CAT SPECIALIST GROUP

CATnews is the newsletter of the Cat Specialist Group, a component of the Species Survival Commission SSC of the International Union for Conservation of Nature (IUCN). It is published twice a year, and is available to members and the Friends of the Cat Group.

For joining the Friends of the Cat Group please contact Christine Breitenmoser at ch.breitenmoser@kora.ch

Original contributions and short notes about wild cats are welcome **Send contributions and observations to ch.breitenmoser@kora.ch.**

Guidelines for authors are available at www.catsg.org/catnews

This **Special Issue of CATnews** has been produced with support from the Taiwan Council of Agriculture's Forestry Bureau, Zoo Leipzig and the Wild Cat Club.

Design: barbara surber, werk'sdesign gmbh
Layout: Christine Breitenmoser, Jonas Bach
Print: Stämpfli Publikationen AG, Bern, Switzerland

ISSN 1027-2992 © IUCN/SSC Cat Specialist Group

Editors: Christine & Urs Breitenmoser
Co-chairs IUCN/SSC
Cat Specialist Group
KORA, Thunstrasse 31, 3074 Muri, Switzerland
Tel ++41(31) 951 90 20
Fax ++41(31) 951 90 40
<u.breitenmoser@vetsuise.unibe.ch>
<ch.breitenmoser@kora.ch>

Guest Editors: J. W. Duckworth
Antony Lynam

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)

MELVIN GUMAL[1*], ABU BAKAR BIN MOHAMED SALLEH[2], MOHD NAWAYAI YASAK[3], LIANG SONG HORNG[1], BENJAMIN P. Y-H. LEE[4,5], LOW CHEE PHENG[1], HASNIZAM HAMZAH[2], DANIEL KONG[1], DAVID MAGINTAN[3], DENNIS TEN CHOON YUNG[3], AHMAD ZULFI BIN ZALALUDDIN[1], AZIMA BINTI AZMI[1], NORHIDAYATI BINTI KHALID[1], THAI POH YEN[1], VOON MUFENG[1], FRANCIS CHEONG FOOK MENG[2] AND SYLVIA NG[1]

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 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).

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

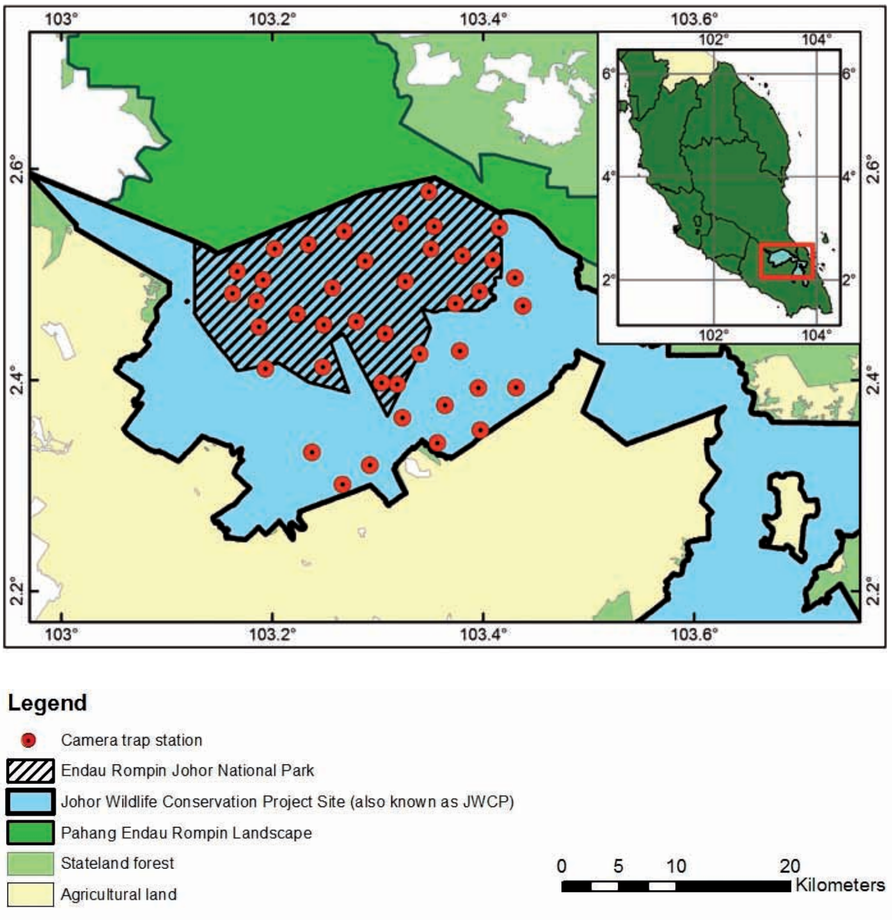


Fig. 1. Study site within the northern part of the Johor Wildlife Conservation Project Site or the Johor Endau Rompin Landscape. Locations of camera-trap sites are shown as red circles with a black dot. The JWCP is also part of the PRF.

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 northeast 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.

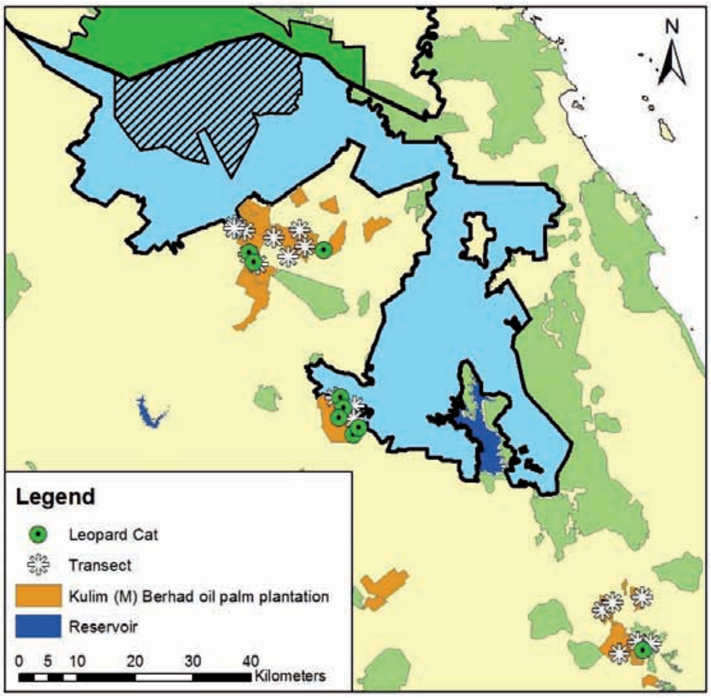


Fig. 2. Location of transects and observations of cats in plantations. Only the leopard cat was seen near the transects and all of these were at the oil palm plantations.

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-*

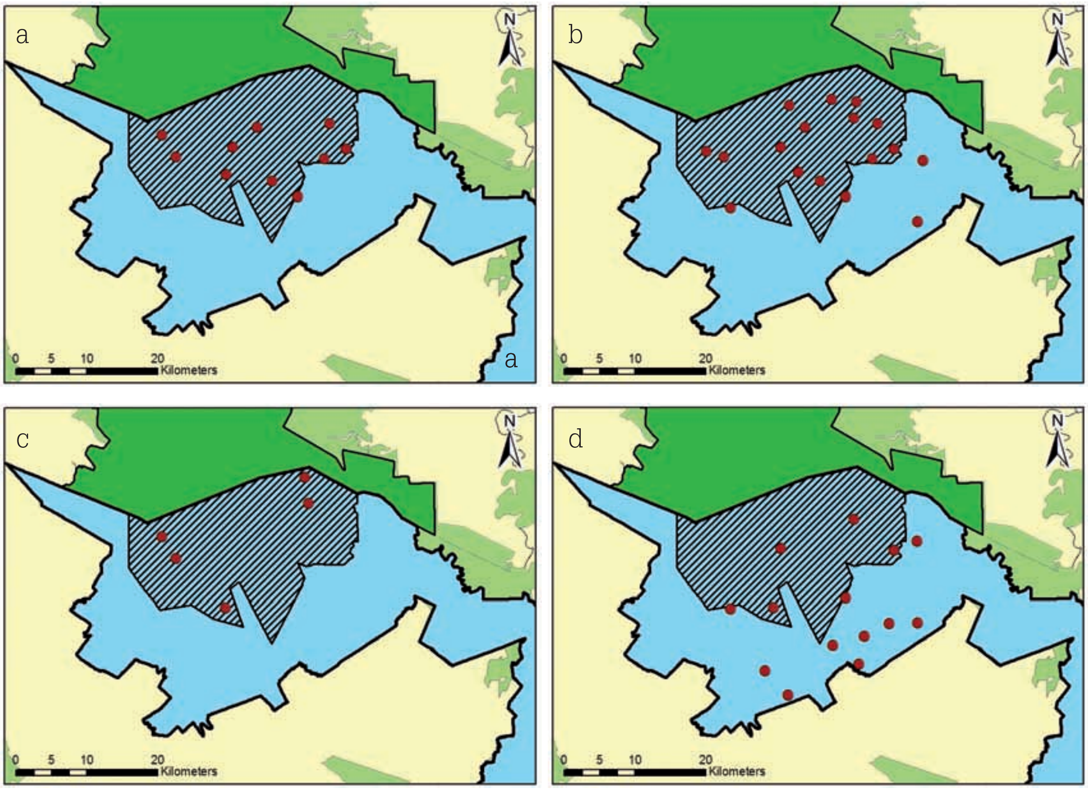


Fig. 3. Distribution based on these camera-trap stations showing the records of (a) clouded leopard, (b) golden cats, (c) marbled cats and (d) leopard cats. The other area keys are shown in Figure 1.

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 distribution 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.

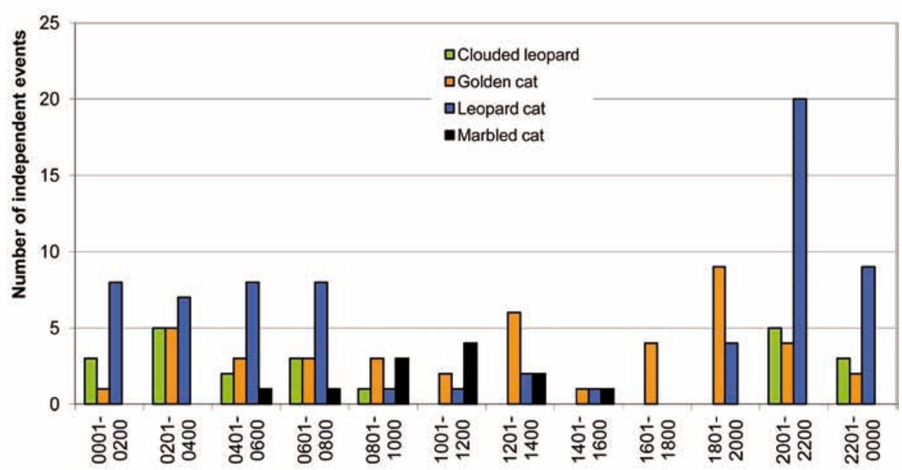


Fig. 4. Numbers of independent events of various non-*Panthera* cat species in camera- traps in relation of the time of capture.

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 km^2 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 km^2, 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. 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 differences 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 enforcement 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) Temenggor 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 Temenggor (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 Berlumut 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 Temenggor, 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 Temenggor, 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.

Acknowledgements

The permission to conduct this research was granted by the State Government of Johor through Johor National Parks Corporation, State Forestry Department of Johor and Department of Wildlife and National Parks, Peninsular Malaysia. Panthera, Johor National Parks Corporation, Department of Wildlife and National Parks Peninsular Malaysia and WCS are graciously acknowledged for their financial, logistical and as in-kind contribution not just to the camera-trapping work but to the field conservation and interventions. Special thanks are given to Department of Wildlife and National Parks Peninsular Malaysia for their approval and assistance for the joint camera-trapping surveys. Kelvin Lim from the Raffles Museum of Biodiversity Research is thanked for allowing access to examine specimens and records. The field survey would have been impossible without the hard work from all members of the field team who spent time out in the rain and sun, and also in the office, pouring over the images, creating maps and analyzing the data. M. Rufino and M. Darmaraj are thanked for their time in discussing relevant sections with us. Kae Kawanishi, Antony J. Lynam and Will Duckworth are thanked for their reviews and comments.

References

Annonymous 2000a. Problem tiger culled in Jeli, Kelantan by police. New Straits Times (August 2, 2000).

Annonymous 2000b. Tiger which killed rubber tapper caught. New Straits Times (December 5, 2000).

Aziz S. A., Laurance W. F. & Clements R. 2010. Forests reserved for rubber. Frontiers in Ecology and the Environment 8, 178.

Chew K. L. 2007. A pictorial guide to Endau Rompin Johor. Johor National Parks Corporation. Affa Trend Publication, Malaysia. 89 pp.

Chow V. K. K. 2010. Echoes of life: Sungai Pulai and beyond. MPH Group Publishing Sdn. Bhd., Malaysia. 212 pp.

Davison G. H. W. 1988. Endau Rompin: A Malaysian heritage. Malaysian Nature Society, Malaysia. 221 pp.

Duckworth J. W., Shepherd C. R., Semiadi G., Schauenberg P., Sanderson J., Roberton S. I., O'Brien T. G., Maddox T., Linkie M., Holden J. & Brickle N. W. 2009. Does the Fishing Cat inhabit Sumatra? Cat News 51, 4-9.

Francis C. M. 2008. A field guide to the mammals of Southeast Asia. New Holland Publishers (UK) Ltd. 392 pp.

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.

Gumal M. T., Kong D., Hon J., Ngumbang J. & Ng S. 2010. Some observations of the flat-headed cat from Sarawak, Malaysia. Cat News 52, 12-14.

Gumal M., Voon M., Liang S. H., Azmi A. & Muhamad A. 2012a. Endau-Rompin Landscape: Winning small battles. MYCAT Tracks: Malaysia's progress towards 1000 tigers 4, 25-29.

Gumal M., Kawanishi K., Lee B., Schaedla W., Liang S. H. & Cheong F. 2012b. Silence of the lands, the muted ghastly screams from wildlife. Malaysian Naturalist 65, 52-54.

Heng N. 2012a. Losing ground. The Star (July 10, 2012).

Heng N. 2012b. Shrinking refuge. The Star (July 10, 2012).

Heng N. 2012c. Logging begins at Sembrong: No environmental management plan yet but trees in forest are being felled. Sunday Star (August 26, 2012).

IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>. Downloaded on October 21, 2012.

Karanth K. U. & Nichols J. D. 2002. Monitoring tigers and their prey: A manual for researchers, managers and conservationists in tropical Asia. Centre for Wildlife Studies, Bangalore, India. 193 pp.

Kawanishi K. & Sunquist M. 2003. Possible new records of fishing cat (*Prionailurus viverrinus*) from Peninsular Malaysia. Cat News 39, 3-5.

Kawanishi K. & Sunquist M. E. 2004. Conservation status of tigers in a primary rainforest of Peninsular Malaysia. Biological Conservation 120, 329-344.

Kawanishi K. & Sunquist M. E. 2008. Food habits and activity patterns of the Asiatic golden cat (*Catopuma temminckii*) and dhole (*Cuon alpinus)* in primary rainforest of Peninsular Malaysia. Mammal Study 33, 173-177.

Khan M. M. 1992. Mamalia Semanjung Malaysia. Jabatan Perlindungan Hidupan Liar dan Taman Negara, Kuala Lumpur. 182 pp.

Kitamura S., Thong-Aree S., Madsri S. & Poonswad P. 2010. Mammal diversity and conservation in a small isolated forest of Sourthern Thailand. The Raffles Bulletin of Zoology 58, 145-156.

Koh L. P., Miettinen J., Liew S. C. & Ghazoul J. 2011. Remotely sensed evidence of tropical peatland conversion to oil palm. Proceedings of the National Academy of Sciences, USA, 108, 5127-5132.

Laidlaw R. 2000. Effects of habitat disturbance and protected areas on mammals of Peninsular Malaysia. Conservation Biology 14, 1639-1648.

Lekagul B. & McNeely J. A. 1977. Mammals of Thailand. Kurusapha Ladproa Press, Bangkok, Thailand. 758 pp.

Lim B. L. & Nazim T. 2007. The flat-headed cat, *Prionailurus planiceps* (Vigors & Horsefield, 1827) of Peninsular Malaysia: Distribution, food habits and parasite pattern. Journal of Wildlife and Parks 22, 1-9.

Linkie M. & Ridout M.S. 2011. Assessing tiger-prey interactions in Sumatran rainforests. Journal of Zoology 284, 224-229.

Lynam A. J., Laidlaw R., Wan Shaharuddin W. N., Elagupillay S. & Bennett E. L. 2007. Assessing the conservation status of the tiger *Panthera tigris* at priority sites in Peninsular Malaysia. Oryx 41, 454-462.

Maddox T., Priatna D., Gemita E. & Salampessy A. 2007. The conservation of tigers and other wildlife in oil palm plantations: Jambi Province, Sumatra, Indonesia. ZSL Conservation Report No. 7. The Zoological Society of London, London. 62 pp.

Mathai J., Hon J., Juat N., Peter A. & Gumal M. 2010. Small carnivores in a logging concession in the Upper Baram, Sarawak, Borneo. Small Carnivore Conservation 42, 1-9.

Mathai J., Jathanna D. & Duckworth J. W. 2013. How useful are transect surveys for studying carnivores in the tropical rainforests of Borneo? Raffles Bulletin of Zoology, Supplement 28, 9-20.

Medway (Lord). 1969. The wild animals of Malaya and offshore islands including Singapore. Oxford University Press, London, United Kingdom. 127 pp.

Mohd. Azlan J. & Sharma D. S. K. 2006. The diversity and activity patterns of wild felids in a secondary forest in Peninsular Malaysia. Oryx 40, 1-6.

O'Brien T.G., Kinnaird, M.F. & Wibisono, H.T. 2003. Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. Animal Conservation 6, 131-139.

Rayan M. D. & Sharif W. M. 2009. The importance of selectively logged forests for tiger *Panthera tigris* conservation: A population density estimate in Peninsular Malaysia. Oryx 43, 48-51.

Rufino M. B. M., Magintan D., Ngau C., Ismail A. Z., Hamidi Jamaludin H., Zainal A. M., Rasdi I., Abu Hashim A. K., Ten D. C. Y. & Fauzul Azim Z. A. 2010. Mammals of Temenggor Forest Reserve: Evidence through camera trapping. *In* Proceedings of the National Biodiversity Seminar, 2008. Department of Wildlife and National Parks, Kuala Lumpur, pp. 7-16.

Sanei A. & Zakaria M. 2010. Possible first jungle cat record from Malaysia. Cat News 53, 13-14.

Simcharoen S., Umponjan M., Duangchantrasiri S. & Pattanavibool A. 2014. Non-*Panthera* cat records from big cat monitoring in Huai Kha Khaeng Wildlife Sanctuary. Cat News Special Issue 8, 31-35.

Sunarto S., Kelly M. J., Parakkasi K., Klenzendorf S., Septayuda E. & Kurniawan H. 2012. Tigers need cover: Multi-scale occupancy study of the big cat in Sumatran Forest and plantation landscapes. PLoS ONE 7, e30859.

Sunquist M. & Sunquist F. 2002. Wild cats of the world. University of Chicago Press, Chicago, U.S.A. 462 pp.

Syarifah Khadiejah S. M. K., Zainal Z. Z. & Fauzul Azim Z. A. 2011. Roadkill of a flat-headed cat in Pahang, Peninsular Malaysia. Cat News 54, 1-9.

Tan C. L. 2009. Sanctuaries sacrificed. The Star (July 7, 2009).

Tan C. L. 2010. Losing ground to rubber estates. The Star (August 10, 2010).

Than Zaw, Saw Htun, Saw Htoo Tha Po, Myint Maung, Lynam A. J., Kyaw Thin Latt & Duckworth J. W. 2008. Status and distribution of small carnivores in Myanmar. Small Carnivore Conservation 38, 2-28.

Tobler M. W., Carrillo-Percastegui S. E., Pitman R. L. & Mares R. 2008. An evaluation of camera traps for inventorying large- and medium-sized terrestrial rainforest mammals. Animal Conservation 11, 169-178.

Van Bree P. J. H. & Mohd. Khan M. K. 1992. On a fishing cat, *Felis* (*Prionailurus*) *viverrina* Bennett, 1833, from continental Malaysia. Z. Saugetierkunde 57, 179-180.

Wilting A., Cord A., Hearn A. J., Hesse D., Mohamed A., Traeholdt C., Cheyne S. M., Sunarto S., Jayasilan M. A., Ross J., Shapiro A., Dech S., Breitenmoser C., Duckworth W., Sanderson J. & Hofer H. 2010. Modelling the species distribution of flat-headed cats (*Prionailurus planiceps*), an endangered South-eat Asian small felid. PLoS ONE 5, e9612.

[1] Wildlife Conservation Society-Malaysia Program *<mgumal@wcs.org>

[2] Johor National Parks Corporation

[3] Department of Wildlife and National Parks, Peninsular Malaysia

[4] National Parks Board, Singapore

[5] Durrell Institute of Conservation & Ecology, University of Kent, United Kingdom