Flat-headed cats, *Prionailurus planiceps* – a literature review of their detection-rate in camera-trap studies and failure to re-detect them in Pasoh Forest Reserve, Malaysia

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Abstract

The flat-headed cat, *Prionailurus planiceps*, is globally endangered. In spite of the proliferation of camera-trap studies in Southeast Asia, few studies have detected the flat-headed cat and information on previous detections remains scattered. We combined literature review and fieldwork to (1) compile available information on previous flat-headed cat camera-trap detections, (2) try to re-detect flat-headed cat in Pasoh Forest Reserve, Malaysia, previously detected in 2013, and (3) compare three different camera-trap arrangements. Our literature review yielded a total sampling effort of 105,866 camera-trap nights and 46 flat-headed cat detections from six different areas of Borneo, Sumatra, and Peninsular Malaysia; but no camera-trap detections from Thailand and Myanmar. Re-detecting flat-headed cat more than twice only occurred in 50% of the areas. We found no previous camera-trap study that explicitly targeted flat-headed cat. Our camera-trapping in Pasoh Forest Reserve failed to re-detect flat-headed cat, even when using fish food as a bait. Our results highlight the need of field studies tailored towards slow-flowing freshwater habitats with a high number of camera-trap nights (e.g. greater than 2000 nights), to better understand the flat-headed cat distribution, ecology, and conservation status.

Abstrak

Kucing Kepala Datar, *Prionailurus planiceps*, secara global terancam punah. Bertolak belakang dengan banyaknya studi menggunakan Kamera-jebak di Asia Tenggara, hanya sedikit studi yang berhasil mendeteksi keberadaan Kucing Kepala Datar tersebut. Selain itu, informasi dari deteksi-deteksi sebelumnya tetap simpang siur. Kami menggabungkan metode studi literatur dan studi lapangan untuk (1) mengumpulkan informasi yang tersedia tentang deteksi Kamera-Jebak dari Kucing Kepala Datar sebelumnya, (2) mencoba memantau kembali Kucing Kepala Datar di Suaka Margasatwa Pasoh, Malaysia, yang sebelumnya pernah terpantau pada tahun 2013, dan (3) membandingkan tiga macam komposisi program kamera-jebak yang berbeda. Studi literatur kami berhasil mengumpulkan sampel sebanyak 105.866 malam kamera-jebak , dan 46 deteksi Kucing Kepala Datar dari 6 area yang berbeda di Borneo (Kalimantan), Sumatra, dan Semenanjung Malaysia; tapi tidak sama sekali dari Thailand dan Myanmar. Pendeteksian kembali lebih dari dua kali Kucing Kepala Datar hanya terdapat di 50% dari semua area. Kami tidak menemukan studi Kamera-jebak sebelumnya yang secara eksplisit mencoba untuk memantau Kucing Kepala Datar. Upaya studi Kamera-jebak kami di Suaka Margasatwa Pasoh gagal menghasilkan pendeteksian ulang Kucing Kepala Datar, bahkan ketika menggunakan makanan ikan sebagai umpan. Temuan kami menyorot perlunya studi lapangan yang disesuaikan khusus untuk habitat perairan tawar arus lambat dengan jumlah malam kamera-jebak yang banyak (mis. lebih dari 2.000 malam) untuk lebih mengerti penyebaran, ekologi, serta status konservasi Kucing Kepala Datar.

Keywords: *camera-trapping, camera-trap placement, Pasoh Forest Reserve, Prionailurus planiceps, sampling effort*

Introduction

The flat-headed cat (FHC) *Prionailurus planiceps* is a globally endangered species (IUCN, 2015). Its geographic range includes Borneo, Sumatra, Peninsular Malaysia, Thailand, and perhaps southern Myanmar (IUCN, 2015; Lydekker, 1895; Nowell & Jackson, 1996; Sunquist & Sunquist,

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2009; Wilting et al., 2010a). The details of its distribution, as well as our knowledge about the FHC's ecology and behaviour, remain highly speculative due to low detection rate in field studies and ongoing range contraction due to habitat loss (Wilting et al., 2010a; Miettinen et al., 2011).

Wilting et al. (2010a) compiled the available information on the detections of FHC to model the species' distribution and concluded that most of the detections occurred within 5 km from large rivers and lakes and at elevations lower than 200 m above sea level (asl). This link to semi-aquatic environments is in line with some of the FHC anatomical traits, such as the slight webbing between its toes and dental structure, which suggest an adaptation to aquatic environments and at least a partially piscivorous diet (Muul & Lim, 1970). Southeast Asian wetlands, peat swamps, and other fresh-water environments are likely to be under-represented in camera-trap studies, which might explain the low rate of detection of FHC in camera-trap studies in the region.

The low detection rate of FHC is probably related to (1) very small population sizes and (2) the lack of studies specifically designed to target the species. Although the number of camera-trap studies in Southeast Asia has increased considerably in the past few years (e.g. Azlan & Sharma, 2006; Hedges et al., 2015a; Linkie et al., 2008, 2013; Rayan & Linkie, 2015; Rayan & Shariff, 2009), few of these studies have spatial overlap with the FHC geographic and ecological range. Camera-trap surveys of big cats have recorded other small cats very frequently; thus size is unlikely the main reason behind the rarity of FHC records from big-cat camera-trapping (Duckworth et al., 2014).

Much of the camera-trapping in Southeast Asia is based on trapping stations set up in systematic grids with either one or two camera-traps per station (Azlan & Sharma, 2006; Hedges et al., 2015a; Linkie et al., 2008, 2013; Rayan & Linkie, 2015; Rayan & Shariff, 2009). This study design provides mathematical unbiased detection rates used to calculate a species occupancy patterns and/or density in a landscape, but it might not be the best approach to maximize the chance of detecting very elusive species. To maximize the detectability of FHC in a landscape the study should include: (a) increasing the number of camera-trap placements in habitats that are considered suitable for the species, rather than based on percentage-wise number of cameras per unit area, irrespective of systematic grid arrangement, (b) an increase in the number of camera-traps per station to increment the coverage of the sampling station, (c) the use of bait to attract the species, and (d) placement of a camera-traps specifically targeting FHC (e.g. at 10-20 cm above the ground).

In 2013, we detected the presence of FHC in Pasoh Forest Reserve (hereafter 'Pasoh'), Peninsular Malaysia (Wadey et al., 2014). The FHC had already been documented in Pasoh in the 1960s, based on accounts from the indigenous community (Kemper, 1988), but subsequent studies failed to detect the species in Pasoh (e.g. Ickes & Thomas, 2003; de Koning, 2013; Lim et al., 2003; Numata et al., 2005; Rooduijn, 2015). Our recent detection of FHC in Pasoh poses an important opportunity to learn more about the species distribution and ecology. Here we present the first camera-trap study specifically designed to detect the presence of FHC, with the objectives to (1) compile publicly available (either published and or available through open source repositories) information on camera-trap detections of FHC, (2) attempt to re-detect the FHC in Pasoh, and (3) compare three types of camera-trap approaches to detect FHC and similar species.

Methods

Review of previous FHC camera-trap detections

We compiled camera-trap detections of FHC from published literature and available open source online data repositories. We searched for multiple camera-trap studies in the same study site, even if they did not report detecting FHC and recorded studies where re-detection had occurred. The standard of reporting camera-trap effort varied between publications and, in some cases, we contacted the authors to obtain additional information. In cases in which the same camera-trap data was published in multiple papers, we did not accumulate the FHC detections. From all sources we compiled information of: study site, studies' target species, total camera-trap nights, and number of FHC detections.

Study area

Pasoh, located 70 km southeast from Kuala Lumpur (2°98'N 102°31'E), is an elongated 'forest island' of approximately 135 km^2 surrounded by oil palm and rubber plantations. Most of Pasoh consists of secondary hill dipterocarp forest regenerating from timber extraction in the 1950s and is still subject to selective logging (Manokaran & Swaine, 1994; Fletcher et al., 2012). The southern part of Pasoh harbours the last large patch of primary lowland dipterocarp forest, which covers an area of approximately 25 km^2 (Fig. 1). Pasoh contains no major rivers or lakes. Since 2011, Pasoh has been a focus of the Tropical Ecology Assessment Monitoring network (TEAM), which has conducted annual camera-trap surveys (TEAM Network, 2015).

Camera-trap sampling area

Since so little is known about FHC behavioural ecology, we assumed that FHC prefer gentle terrain

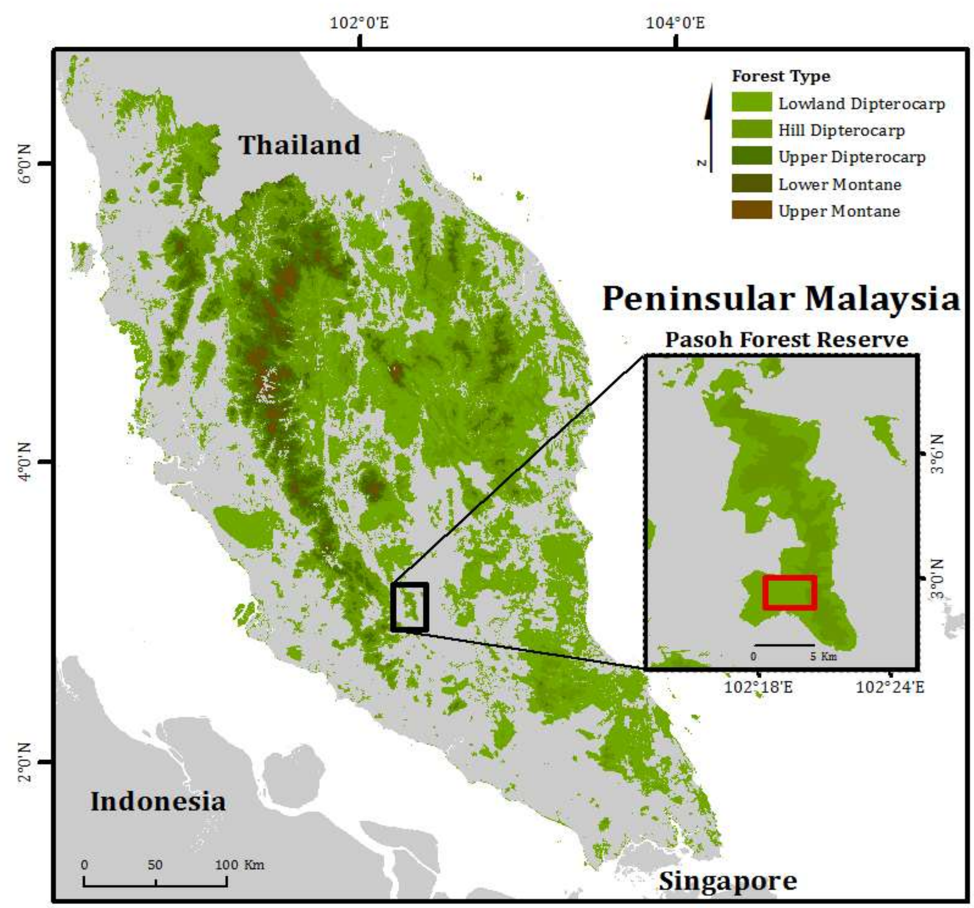

Figure 1. Map of Pasoh Forest Reserve in relation to Peninsular Malaysia. FHC camera trapping was conducted in the southern lowland extent of the reserve (red box). Remaining lowland forest outside the study area is under high encroachment pressure.

with slow-flowing streams and tidal areas that usually correlate with lower altitudes (e.g. below 200m asl (Wilting et al., 2010a). Moreover, we assumed that the FHCs are territorial and that, given their small body size, these territories are relatively small as well (Lindstedt et al., 1986). This means that FHC should be easier to detect near a location of a recent detection. Following this rationale, we selected Pasoh's southern area of lowland tropical forest (Fig. 1) as our sampling area. This area contains the only previous FHC camera-trap detection in Pasoh (Wadey et al., 2014), elevation is below 200m asl, with slow moving streams, and is waterlogged several months of the year by monsoonal rains.

Camera-trap sampling designs

Between July 2014 and January 2015, we attempted to re-detect the presence of FHC in Pasoh near the original detection, where the habitat was either swampy or contained water pooling or slow-flowing streams. This study was independent from the annual TEAM Network (2015) survey. We deployed camera-traps following three different approaches: (1) a standard systematic design with 16 single-camera stations (Fig. 2a); (2) a targeted clustered design with 4 stations, each consisting of four cameras – one in the centre and three cameras surrounding the one in the centre (Fig. 2b); and (3) a baited clustered design with 16 stations and four cameras per station – one in the centre and three additional cameras around it (Fig. 2c). In the baited clustered design, we used one application (200g) of edible fish-bait placed in several clumps and/or smeared on fallen trees, saplings, or tree roots within 5m of 14 camera-trap stations. To reduce the chance of our trapping grid containing holes larger than a FHC home-range, we used the home-range of leopard cats *Prionailurus bengalensis*, a similar sized felid, to gauge our camera-trap spacing. Leopard-cat home-ranges have been reported to range between 2 and 5km^2 (Grassman, 2000; Rajaratnam et al., 2007). In all cases, the inter-station spacing was 700m and intra-stations spacing was 50m. Camera-trap height was standardized across all sites at 10cm from ground level (Wadey et al., 2014). Each camera-trap arrangement had an equal cumulative number of station-nights deployed, but the number of camera-trap-nights differed (Tab.1). To compare the different camera placement designs, we used an index based on the number of species (either vertebrate or carnivores) detected per sampling effort, either per station-night or camera-trap-night.

Results

Review of previous FHC camera-trap detections

The literature review yielded a total sampling

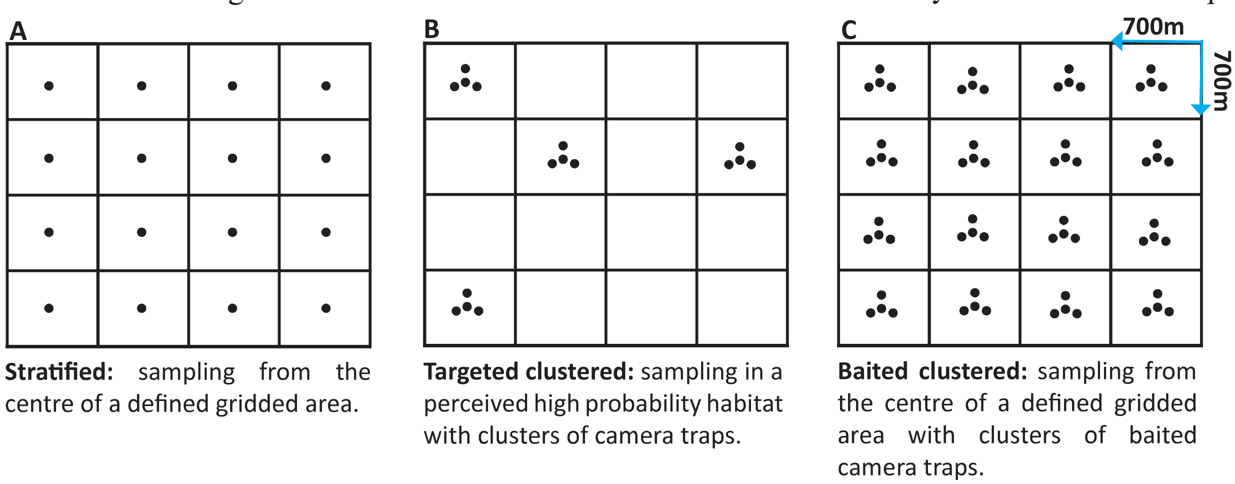

Figure 2. Different camera-trap designs used in the study. Black dots are individual cameras with 700-meter spacing between grids. Spacing of camera-traps within clustered designs were set at 50 meters. We define a 'cluster' as multiple camera-traps within close range i.e. 50 meters.

effort of 105,866 camera-trap nights and 46 FHC detections that translates into one detection per 2,301 camera-trap-nights for areas with at least one FHC camera-trap detection. We found 15 publications reporting camera-trap detections of FHC in six different areas of Borneo, Sumatra, and Peninsular Malaysia (Adul et al., 2015; Bernard et al., 2012; Cheyne et al., 2009a, 2009b, 2013; Cheyne & Macdonald, 2011; Gardner et al., 2014; Matsubayashi et al., 2006; Mohamed et al., 2009, 2013; Ross et al., 2013; Samejima et al., 2012; Soemarsono, 1996; Wadey et al., 2014; Wilting et al., 2010a; Yasuda et al., 2007; Tab.2). We found no published study on FHC camera-trap detections from Thailand and Myanmar and no published camera-trap study that explicitly targeted the FHC. From the 15 studies in our sample, four targeted mammal communities (Matsubayashi et al., 2006; Samejima et al., 2012; Wadey et al., 2014; Yasuda et al., 2007); three targeted carnivore communities (Matsubayashi et al., 2006; Mohamed et al., 2009, 2013; Wilting et al., 2010b); seven targeted felid communities (Adul et al., 2015; Bernard et al., 2012; Cheyne et al., 2009a, 2009b, 2013; Cheyne & Macdonald, 2011; Ross et al., 2013); one targeted banteng (*Bos javanicus*; Gardner et al., 2014); and one targeted tiger (*Panthera tigris*; Soemarsono, 1996). We found only one open source database for camera-trapping in FHC geographic range (TEAM Network, 2015) and one publication that repeated a camera-trap study at a detection site, though it did not re-detect FHC (Bernard et al., 2012; Tab.2). Most of the detections (96%, *N*=46) occurred in Borneo. The median number of FHC detections per study was 1.0, ranging from 0-30 (Tab.2). Re-detecting FHC more than twice only occurred in 50% of areas (Tab.2). A single study in Sabangau, Kalimantan, accounted for 33% of the camera-trap-nights and 65% of the FHC detections (Adul et al., 2015; Tab.2). Excluding Adul et al. (2015), the

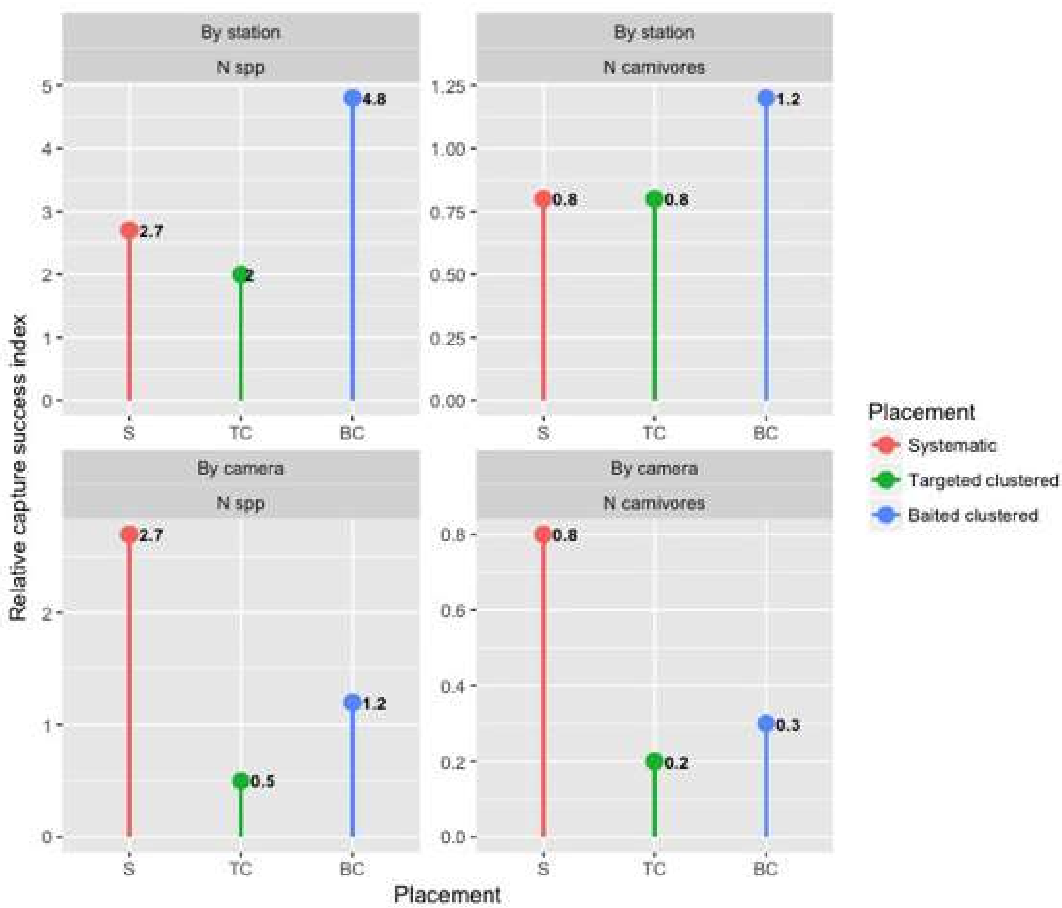

Figure 3. Comparison of relative capture success index of camera-trapping placement methods used in this study. The relative capture success index was calculated as the number of vertebrate species ("N spp") or the number of carnivore species ("N carnivores) detected multiplied by 100 and then divided either by station • day ("By station") or by camera • day ("By camera").

Table 1. Summary of the different camera-trap placement approaches used in this study. Approach = type of camera trap placement; S = systematic, TC = targeted clustered, BC = baited clustered; N days = length (in days) a particular placement type was used; Cam spac = distance in kilometres between camera-trap stations; N sta = number of camera trap stations used in each placement type; Sta size = number of camera traps used in the station; N cams = total number of camera traps used for each placement type; Sta x day = sampling effort measured in the cumulative number of station-nights deployed; Cam x day = sampling effort measured in the cumulative number camera trap-nights deployed; Bait = whether bait was used in each placement type; N = no bait; Y = bait was used; N spp = total number of vertebrate species detected in each placement type; N carn = total number of carnivore species detected.

Approach	Period	Year	*N* days	Cam spac	N sta	Sta size	*N* cams	Sta x day	Cam x day	*N* spp	*N* carn	Bait
S	Jul	2014	30	0.7	16	1	16	480	480	12	4	N
TC	Aug-Nov	2014	120	0.7	4	4	16	480	1,920	9	3	N
BC	Dec-Jan	2014-2015	30	0.7	16	4	64	480	1,920	23	6	Y

detection rate of FHC is one per 4,421 camera-trap nights, with a total of 70,737 camera-trap nights and only 16 camera-trap detections.

FHC in Pasoh

This study failed to re-detect the presence of FHC in Pasoh. A total of 1,440 station-nights and 4,320 camera-trap-nights resulted in the detection of 30 vertebrate species, including 22 mammals, 7 birds, and 1 reptile species (Tab.1; Tab.4). Among the mammals, we detected nine different carnivore species, including three felids (Tab.3), but no FHC.

Comparison of camera-trap placement designs

The clustered design baited with fish recorded the highest number of both of vertebrate and carnivore species per station-night (Tab.1; Fig. 3). The systematic approach, however, detected the highest number of vertebrate and carnivore species per camera-trap night (Tab.1; Fig.3). Nine vertebrate species were detected exclusively with the fish-baited clustered approach (Tab.4), including six out of the seven bird species (Tab.4).

Discussion

Review of previous FHC camera-trap detections

This is the first camera-trap study that explicitly targeted the FHC. All previously published camera-trap information about FHCs comes from general studies targeting communities or from studies designed for other individual species (Adul et al., 2015; Bernard et al., 2012; Cheyne et al., 2009a, 2009b, 2013; Cheyne & Macdonald, 2011; Gardner et al., 2014; Matsubayashi et al., 2006; Mohamed et al., 2009, 2013; Ross et al., 2013; Samejima et al., 2012; Soemarsono, 1996; Wadey et al., 2014; Wilting et al., 2010b; Yasuda et al., 2007). This lack of specifically designed studies is concerning given that the FHC has been listed as Endangered in IUCN's Red List since 2008 (IUCN, 2015).

In spite of the intensive camera-trapping efforts across its distribution range (Linkie et al., 2013), 96% (N=46) of the published photo captures come from just four sites in Borneo (Sabangau, Dermakot, Tasik Merimbun, and Tabin; Tab.2), where the FHC has been detected repeatedly (range = 4-30 camera-trap detections per site). Outside Borneo, we only found single camera-trap detections in Way Kambas (Sumatra) and Pasoh (Peninsular Malaysia), and no camera-trap detection in Thailand and Myanmar. There might be other sites where the FHC has been photo captured, but the results have not been made publicly available. Our results highlight the need to make such relevant information publicly available, either through publications (preferably open access) or through online data repositories (e.g. TEAM Network, 2015).

Our review also revealed the high sampling efforts required to detect the FHC in community-level camera-trap studies. In Sabangau – where 65% of the 46 published records took place – the detection rate remains low, with one per 1,171 camera-trap nights (Adul et al., 2015; Cheyne et al., 2009a, 2009b, 2013; Cheyne & Macdonald, 2011). Wearn et al. (2013) estimated that 10,970 camera-trap nights are needed to obtain a FHC probability of detection equal 1.0 in Kalabakan Forest Reserve in Sabah, Boreno. This highlights the difficulty to detect the species. The lack of FHC detection in studies with small sampling efforts should therefore be interpreted with additional caution.

In this review we focused on camera-trap detections. We acknowledge that FHCs have been detected in other ways, such as direct sightings, road kills, and individuals being surrendered to the authorities (Bezuijien, 2000; Meijard et al., 2005; Oswald & Mohamed, 2013).

Failure to re-detect FHC in Pasoh

We failed to re-detect FHC in Pasoh. Considering our previous detection of the species (Wadey et al., 2014), the FHC-specific design of our camera-trap placing and the sampling effort (4,320 camera-trap night) in a relatively small area, we expected to re-detect it.

We assume that FHCs are still present in Pasoh because wild felids usually live several years (Lydekker, 1895; Sunquist & Sunquist, 2009) and the area has neither been subject to drastic habitat changes, nor has there been any reports of hunting that could decimate the population. However, hunting for the pet-trade could still have played a role in decimating an already small population of FHC. Our lack of detection might be because we were looking in the wrong place, e.g. (1) FHCs might not be territorial and hence the information on the previous detection did not increase our chance of re-detecting it; (2) the home range of FHC might be very large or have unusual shapes (e.g. following rivers); (3) our general assumptions about FHC habitat preferences (lowland, near water) might be wrong; or (4) the population size is extremely low.

The results of both our review and fieldwork bring up the question of why are FHCs so difficult to detect? Is it because researchers are not looking at the right place (e.g. peatswamp forests, mangroves and wetlands); is it because we are not looking in the right way (e.g. detections as by-catch from studies of larger mammals); or is it just that FHCs actually occur at very low densities? And, if the later is true, are these low densities natural and associated with high specialization to resource-poor habitats (Kennedy et al., 2011) or the result of recent human activities (e.g. habitat loss or human-triggered trophic cascades (Andren, 1994; Crooks & Soulé, 1999)?

Notes on the different camera-trap approaches

We used several camera-trap approaches in a rather *ad hoc* manner. Our study design only allows for limited comparisons, because more than one factor changes between the different approaches (e.g. besides having bait, the baited clustered placement differs from the other placements in the number of cameras used per station. Nevertheless, some general patterns emerge about the different approaches. For example: (1) the standard systematic approach (1-2 cameras per station) is the most cost-effective approach when the amount of camera-traps available is limited, both for carnivores and for the rest of the terrestrial mammal community; (2) the use of the edible fish-bait increased the number of species detected, suggesting that it is a good approach to confirm presence of a species.

Adding food bait to camera-traps, however, can lead to biased population estimates (du Preez et al., 2014; Karanth et al., 2011). Bait, however, increases the detection probability of certain species (Nichols & Karanth, 2002) and can be very effective to detect rare or "elusive species". Scented and audio lures present opportunities (Hedges et al., 2015b) that remain largely unexplored for felids, including FHC (J. Sanderson pers. comm.). Even though we did not detect the FHC in this study, we recommend further exploring the use of baits with camera-trapping to detect FHC and other illusive species.

Implications for conservation

This study shows that, even in places where FHCs are assumed to occur or have been recently detected, they remain difficult to re-detect. In parts of their predicted distribution, there is little recent evidence of actual presence. The species conservation status

Table 2. Results table of camera-trap detections on FHC from literature and open source repositories.

Study area	Survey year	Study target	Trap nights	Detections	Publications & open source repositories
Deramakot, Sabah	2003-05	Mammal Community	981	2	Yasuda et al. 2007; Matsubayashi et al. 2006
Deramakot, Sabah	2008-09	Mammal Community	1,916	4	Mohamed et al. 2009; Wilting et al. 2010b; Mohamed et al. 2013
Deramakot, Sabah	2008-09	Mammal Community	15,400	1	Samejima et al. 2012
Pasoh, N. Sembilan	2002-03	Mammal Community	3,659	0	Yasuda et al. 2007
Pasoh, N. Sembilan	2011	Mammal Community	900	0	TEAM Network, 2015
Pasoh, N. Sembilan	2012	Mammal Community	900	0	TEAM Network, 2015
Pasoh, N. Sembilan	2013	Mammal Community	3,600	1	Wadey et al. 2014 TEAM Network, 2015
Pasoh, N. Sembilan	2014	Mammal Community	1,800	0	TEAM Network, 2015
Pasoh, N. Sembilan	2015	Mammal Community	1,800	0	TEAM Network, 2015
Pasoh, N. Sembilan	2015	FHC	4,320	0	Wadey et al. [current study]
Sabangau, Kalimantan	2008-12	Felid Community	35,129	30	Cheyne et al. 2009a; Cheyne et al. 2009b; Cheyne & Macdonald, 2011; Cheyne et al. 2013; Adul et al. 2015
Tabin, Sabah	2002	Mammal Community	574	2	Yasuda et al. 2007
Tabin, Sabah	2009-10	Felid Community	3,733	0	Bernard et al. 2012
Tabin, Sabah	2009-10	Felid Community	6,172	1	Ross et al. 2013
Tabin, Sabah	2011-12	Banteng	10,248	1	Gardner et al. 2014
Tasek Merimbun, Brunei	2001-03	Mammal Community	334	4	Yasuda et al. 2007
Way Kambas, Lampung	1996	Tiger	N/A	1	Soemarsono, 1996
		Total	**105,866**	**46**	**18**

Table 3. Carnivore species detected in Pasoh using different camera-trap placement approaches: S = systematic, TC = targeted clustered, BC = baited clustered; IUCN status: LC = Least Concern, NT = Near Threatened, VU = Vulnerable. Baited clustered (BC) used fish-bait. Body mass details (Francis, 2008). ✔ = detected.

Family	Scientific name	Common name (IUCN)	IUCN status	Body mass (kg)	S	TC	BC
Prionodontidae	*Prionodon linsang*	banded linsang	LC	0.6-0.8	✔		
Herpestidae	*Herpestes brachyurus*	short-tailed mongoose	LC	1-2		✔	✔
Viverridae	*Hemigalus derbyanus*	banded civet	VU	1-3			✔
	Paradoxurus hermaphroditus	Asian palm civet	LC	2-3		✔	✔
	Viverra tangalunga	Malay civet	LC	4-5	✔		✔
Mustelidae	*Martes flavigula*	yellow-throated marten	LC	1.3-3	✔		
Felidae	*Prionailurus bengalensis*	leopard cat	LC	3-5		✔	✔
	Pardofelis marmorata	marble cat	VU	2-4			✔
	Panthera pardus	leopard	NT	45-65	✔		
Total		**(9 spp)**			**4**	**3**	**6**

Table 4. Species detected in Pasoh using different camera-trap placement approaches: S = systematic, TC = targeted clustered, BC = baited clustered. IUCN status: LC = Least Concern, NT = Near Threatened, VU = Vulnerable. Baited clustered (BC) used fish-bait. ✔ = detected.

Group	Family	Scientific Name	Common Name (IUCN)	IUCN Status	S	TC	BC	BC
Reptiles	Varanidae	*Varanus salvator*	Monitor lizard	LC			✔	
Birds	Bucerotidae	*Anthracoceros albirostris*	Oriental pied hornbill	LC			✔	
	Columbidae	*Chalcophaps indica*	Emerald dove	LC			✔	
	Eupetidae	*Eupetes macrocerus*	Rail-babbler	NT			✔	
	Phasianidae	*Gallus gallus*	Red jungle-fowl	LC	✔		✔	
	Phasianidae	*Lophura ignita*	Crested fireback	NT			✔	
	Pellorneidae	*Pellorneum capistratum*	Black-capped babbler	LC			✔	
	Accipitridae	*Spilornis cheela*	Crested serpent eagle	LC			✔	
Tree-shrews	Tupaiidae	*Tupaia glis*	Common tree-shrew	LC	✔	✔	✔	
Rodents	Hystricidae	*Atherurus macrourus*	Brush-tail porcupine	LC			✔	
	Hystricidae	*Hystrix brachyura*	Malay Porcupine	LC		✔	✔	✔
	Sciuridae	*Lariscus insignis*	Three-striped ground squirrel	LC		✔	✔	
	Muridae	*Leopoldamys sabanus*	Long-tailed giant rat	LC	✔		✔	✔
Herbivores	Tragulidae	*Tragulus kanchil*	Lesser mouse-deer	LC	✔		✔	✔
	Cervidae	*Muntiacus muntjak*	Barking deer	LC	✔			
	Cervidae	*Rusa unicolor*	Samba deer	VU	✔			
	Tapiridae	*Tapirus indicus*	Malay tapir	EN	✔			✔
Pigs	Suidae	*Sus scrofa*	Wild boar	LC	✔	✔	✔	✔
Primates		*Macaca fascicularis*	Long-tailed macaque	LC			✔	✔
		Macaca nemestrina	Southern pig-tailed macaque	VU	✔	✔	✔	✔
Carnivores	Herpestidae	*Herpestes brachyurus*	Short-tailed Mongoose	LC		✔	✔	
	Prionodontidae	*Prionodon linsang*	Banded Linsang	LC	✔			
	Viverridae	*Hemigalus derbyanus*	Banded Civet	VU			✔	
	Viverridae	*P. hermaphroditus*	Asian Palm Civet	LC		✔	✔	✔
		Viverra megaspila	Large Spotted Civet	VU		✔		
		Viverra tangalunga	Malay Civet	LC	✔		✔	
	Mustelidae	*Martes flavigula*	Yellow-throated Marten	LC	✔			
	Felidae	*Prionailurus bengalensis*	Leopard Cat	LC		✔	✔	
		Pardofelis marmorata	Marble Cat	VU			✔	
		Panthera pardus	Leopard	NT	✔			
		Total	**30**		**13**	**10**	**23**	**8**

requires attention – its situation might be worse than generally assumed and warrants careful review and possibly reassessment. For example, its presence in southern Myanmar and Thailand, remains anecdotal (Zaw et al., 2014; Tantipisanuh et al., 2014). Ascertaining the real status of the species will require studies specifically designed to target FHC at suitable sites (e.g. Sabangau, Tasik Merimbun, or Deramakot) and particularly concerning the species' population ecology, distribution pattern and behaviour. We encourage funding bodies to give high priority to this little known felid that probably plays important ecosystem functions as a highly specialized predator in Southeast Asian peatswamp forests and wetlands. The Roundtable Sustainable Palm Oil (RSPO)'s remediation and compensation procedures could offer additional opportunities to restore FHC habitat (RSPO, 2014).

Overall, the FHC is a highly endangered species living in also highly threatened habitats, such as Southeast Asian peatswamp forests (IUCN, 2015; Wilting et al, 2010a). We see potential here to use conservation marketing (Wright et al., 2015) to brand FHC as the ghost cats of Southeast Asia, i.e. as a flagship species for the conservation of Southeast Asian peatswamp forests and wetlands.

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