

# Small carnivores in a logging concession in the Upper Baram, Sarawak, Borneo

John MATHAI, Jason HON, Ngumbang JUAT, Amanda PETER and Melvin GUMAL

## Abstract

Sarawak, Borneo, faces high levels of deforestation: logging, oil palm plantations, hunting and shifting cultivation pose major threats to its diverse fauna. Very little credible, accurate and up-to-date information exists regarding the small carnivores of Sarawak, even though many are considered threatened by the IUCN Red List. The first 54 months of a long-term wildlife monitoring programme in a logging concession in the Upper Baram of Sarawak found 14 of the 19 small carnivores expected there. Yellow-throated Marten *Martes flavigula*, Binturong *Arctictis binturong*, Masked Palm Civet *Paguma larvata*, Common Palm Civet *Paradoxurus hermaphroditus*, Banded Civet *Hemigalus derbyanus* and Short-tailed Mongoose *Herpestes brachyurus* seemed fairly widespread, and Hose's Civet *Diplogale hosei*, endemic to Borneo, was recorded often: the site may thus be a valuable one for further research into this little-known species. Main threats to small carnivores remain unclear, but they are not the primary quarry species of local hunters. Further camera-trapping of small carnivores supplemented with techniques to study the semi-arboreal and semi-aquatic species is urgently required to clarify their conservation status.

**Keywords:** activity patterns, camera-trapping, *Diplogale hosei*, Hose's Civet, logging

## Karnivora kecil di satu kawasan pembalakan di Ulu Baram, Sarawak, Borneo

### Abstrak

Sarawak, Borneo, sedang mengalami kadar kemusnahan hutan yang tinggi: pembalakan, perladangan kelapa sawit, pemburuan dan pertanian pindah randah merupakan ancaman utama kepada kepelbagaian faunanya. Sangat sedikit maklumat terkini yang tepat dan sahih wujud berkaitan karnivora kecil di Sarawak, walaupun kebanyakannya tergolong dalam "IUCN Red List". 54 bulan pertama dalam program kajian jangka panjang pemantauan hidupan liar di sebuah kawasan pembalakan di Ulu Baram, Sarawak, mendapati 14 spesis daripada 19 spesis karnivora kecil yang dijangkakan di situ, dengan kadar penemuan yang rendah berbanding hidupan liar yang lain. Yellow-throated Marten *Martes flavigula*, Binturong *Arctictis binturong*, Masked Palm Civet *Paguma larvata*, Common Palm Civet *Paradoxurus hermaphroditus*, Banded Civet *Hemigalus derbyanus* dan Short-tailed Mongoose *Herpestes brachyurus* nampaknya bertaburan meluas, dan Hose's Civet *Diplogale hosei*, endemik ke Borneo, nampaknya juga biasa ditemui: ini menunjukkan tempat ini suatu tempat kajian sangat bernilai untuk penyelidikan spesis yang sangat kurang kita ketahui ini. Ancaman utama kepada karnivora kecil di sini masih kita tidak pasti, tetapi spesis-spesis ini bukanlah tumpuan utama pemburu-pemburu tempatan. Kajian seterusnya menggunakan perangkap kamera, dan dibantu oleh teknik-teknik penyelidikan untuk spesis-spesis semi-arboreal dan semi-akuatik amatlah diperlukan segera untuk menentukan status pemuliharaannya.

**Kata kunci:** corak-corak aktiviti, perangkap kamera, Hose's Civet, *Diplogale hosei*, pembalakan

## Introduction

The Sundaic subregion of Southeast Asia, comprising the Thai-Malay peninsula, Borneo, Sumatra, Java and Bali, has very high mammal species richness and endemism (Corbet & Hill 1992). Borneo, approximately 746,337 km<sup>2</sup>, is among its biologically richest units, and a centre of distribution for many Indomalayan faunal genera (MacKinnon et al. 1996) with a high level of mammalian endemism (Payne et al. 1985).

Borneo currently suffers high levels of deforestation (Langner et al. 2007). In the state of Sarawak, forests outside protected areas are rapidly being degraded by timber extraction and converted to oil palm plantations and other land developments. Protected areas make up just 4% of Sarawak's land area whereas 35.2% are earmarked for logging activities (Sarawak Forest Department 1997), so it is critical to document status of mammals in forest remnants within logging concessions and in the modified habitats themselves, to determine conservation priorities and management

strategies.

Forest health can, in some circumstances, be ascertained by monitoring carnivores, but this requires sufficient data to be gathered with the resources available. Carnivores sit high in the food chain, and regulate populations of prey and other carnivores through predation and competition. Apart from diverse vertebrate and invertebrate prey, carnivores in Sarawak eat many fruits, and regularly pass intact seeds in their faeces, indicating their importance as seed dispersers (Wells et al. 2005). They thus have cascading effects on the entire forest trophic system and play a vital role in forest regeneration.

Borneo was identified as one of seven global priority areas in the 1989 IUCN/SSC Action plan for the conservation of mustelids and viverrids (Schreiber et al. 1989). It has more endemic carnivores than any other island except Madagascar (calculated from data in Meiri 2005): Bay Cat *Catopuma badia*, Hose's Civet *Diplogale hosei*, Bornean Ferret Badger *Melogale everetti*, and, if a valid species, which most recent authors (e.g. Corbett & Hill

1992, Patou *et al.* 2009) doubt, Hose's Mongoose *Herpestes hosei*. The term 'small carnivores' is used here for small-bodied members of the order Carnivora; that is, all Bornean species of that order excepting Sun Bear *Helarctos malayanus* and Sunda Clouded Leopard *Neofelis diardi*. In the Schedules of Totally Protected and Protected Species in Sarawak (under the Wild Life Protection Ordinance 1998), only the felids (excepting Leopard Cat *Prionailurus bengalensis*) are listed as Totally Protected, with special protection and severe punishment to offenders; all other small carnivores are listed as merely Protected, with limited protection and lenient punishment. In spite of the undoubted importance of Borneo to small carnivores, credible, accurate and up-to-date information about their distribution and ecology in Sarawak is scarce, with few systematic studies.

To understand status and ecology of wildlife in logging concessions in Sarawak, and evaluate conservation priorities and management recommendations, a long-term monitoring programme was launched by WCS Malaysia in 2004 in the Sela'an-Linau Forest Management Unit (FMU), the first of only two concessions in the state to be certified under the Malaysian Timber Certification Scheme. The main objective was to document the diversity and distribution of non-volant mammals, birds and bats within the FMU; small carnivores were simply part of the general remit, and reported here are records of them from the first 54 months. This FMU lies near the Kelabit Highlands that were, through the efforts of T. Harrison in the 1940s, among the historically best collected parts of Borneo. This collection (Davis 1958) recorded several small carnivores of particular interest through their endemism to Borneo and/or present global threat status, making a modern assessment of the area a high priority.

## Methods

### Study Area

The Sela'an-Linau FMU, of 55,949 ha, lies in the hinterland of northern Sarawak, north of the upper Baram River (Fig. 1). Samling Strategic Corporation (Samling) is the licensed concessionaire, under Timber Licence T/0412. In the FMU live many indigenous communities such as the Kayan, Kelabit, Kenyah and Penan, many of whom depend on forest for their livelihoods and on wildlife for their protein.

The Sela'an-Linau FMU is undulating in nature, with altitudes from 300 m above sea level (a.s.l.) in its south-west to about 2,000 m a.s.l. in the Tama Abu Range on its eastern edge. Much supports mixed dipterocarp forest (60%), with some montane forest on higher ground (4%) and tropical heath forest (*kerangas*) on infertile soils (21%). Old and current swidden (*temuda*) covers 15%. Enrichment planting with native timber species is occurring in some 3,000 ha that burnt during the 1997–1998 El Niño event. About half the forest was logged conventionally in the past, and since 2003 a reduced impact logging (RIL) is applied. The area receives high rainfall (3,400–5,900 mm annually) with no distinct wet or dry season. Temperatures in low-lying areas average around 26°C, falling to 14°C on summits.

Surveys were concentrated in 14 sites in the western, northern and central Sela'an-Linau FMU (Fig. 2). The survey areas were divided into sectors based on a variety of human uses, to allow investigation of occurrence patterns for regularly encountered species (Table 1; elaborated in Hon *et al.* 2009); however, no small carnivore was found frequently enough to allow an analysis of such spatial precision. Most of the survey efforts were

Fig. 1. The Sela'an-Linau Forest Management Unit (FMU) in Upper Baram.



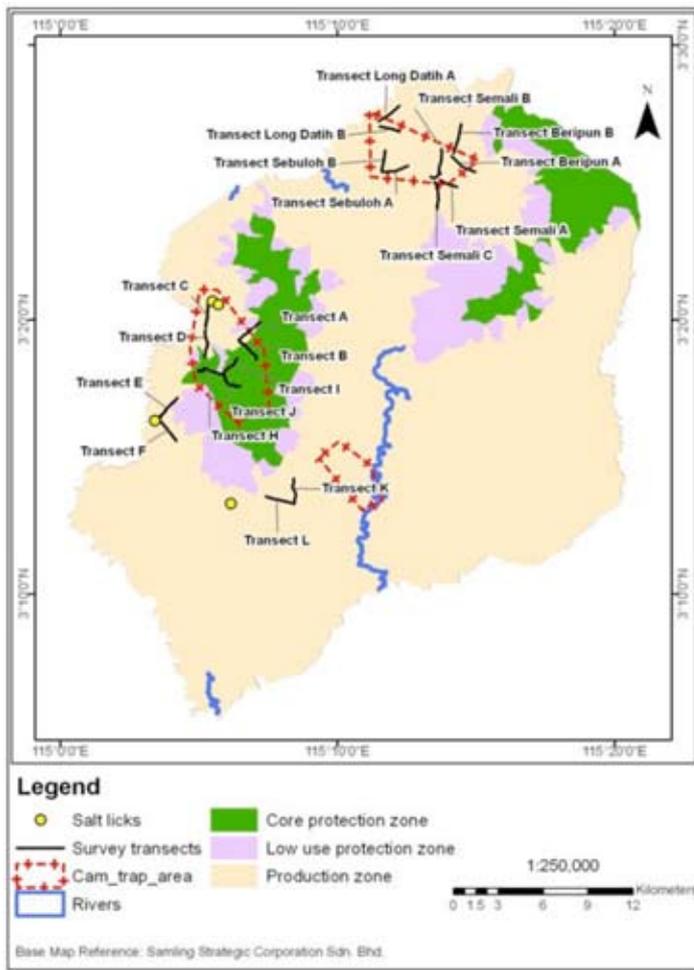


Fig. 2. Location of line transects used for wildlife surveys and focal areas of camera-trapping in the Sela'an-Linau FMU.

performed in the Protected Zone (PZ), an area which is set aside for conservation, with no timber harvesting planned in the FMU's current Forest Management Plan. The PZ is not gazetted under the state government and hence, has no legal protection. The PZ covers roughly 15,000 ha, comprising a fairly contiguous block of about 8,000 ha and clusters of smaller, oddly shaped patches. It is mainly montane and submontane forest, ranging from 900 m to almost 2,000 m a.s.l.

#### Methodology

Fieldwork spanned March 2004 to September 2008, using multiple methods. Three recorded small carnivores: line transects (diurnal direct observation), sign surveys, and camera-trapping. The survey walked 789 $\frac{1}{8}$  km of line transects, 277 $\frac{1}{2}$  km during sign surveys, and camera-trapped for 5,252 trap-nights.

Camera-trapping occurred from January 2005 to September 2008, using 40 Camtrakker™ units. In 2008, two LeafRiver digital units were acquired. By the end of survey, all 42 cameras were out of commission, mainly through high humidity. Cameras were set at salt licks, at Great Argus *Argusianus argus* dancing grounds, and along ridges near the transect lines. Some were placed far from transect lines. Cameras were placed typically at heights of 20–30 cm above ground level, at a distance 1–1 $\frac{1}{2}$  m from the animal trail. All cameras were set to run 24 hours a day. Initially, baits of sardines and dead chicken, and lures consisting of commercially available essences of banana, pandan and yam were trialled.

This was abandoned because ants and rats quickly consumed baits and the heavy rains in the study area soon washed away all traces of the lures. Because many cameras malfunctioned, it was not possible to determine whether the baits/lures increased encounter rate of animals. Independent observations were taken as consecutive images of conspecifics at the same camera location separated by at least half an hour (O'Brien *et al.* 2003). This did not pose much of a problem: most such images were separated by at least 2 hours, with Malay Civet and Masked Palm Civet the species most often providing repeat photographs within half an hour. The 24 hours of the day were divided into 01h01–04h00 = Late night; 04h01–07h00 = Dawn; 07h01–10h00 = Morning; 10h01–17h00 = Day; 17h01–19h00 = Dusk; 19h01–23h00 = Early night; 23h01–01h00 = Midnight.

Line transects undertaken separately for direct sighting and for sign surveys were the major general survey methods (Hon *et al.* 2009) but both yielded too few small carnivore records for species-level analysis. Latrines, with multiple piles of faeces of different ages, were reported by local people to be only from Malay Civet. If true, it would enable effective detection and visual identification of Malay Civet through signs. These records, those from reconnaissances, and incidental records were all used in the preparation of the present text.

## Results

In total, 16 carnivore species were recorded: 14 small carnivores, Sun Bear and Sunda Clouded Leopard (Table 2). Of the small carnivores, four are listed as Vulnerable under the *IUCN Red List of Threatened Species* and one as Data Deficient (IUCN 2009). Otters could not be identified to species; the species present is/are Endangered, Vulnerable and/or Near-Threatened. Both large carnivores are Vulnerable. The Protected Zone recorded nine of the 14 small carnivore species found (64.3%). Survey effort and type varied too much from site to site for comparisons between them of their small carnivore records to be meaningful (Table 1).

#### Malay Weasel *Mustela nudipes*

Malay Weasel was encountered twice, on the ground, by line transect surveys (Table 3). It was never camera-trapped, reflecting a great rarity of such photographs from across its range, for as yet unknown reasons (Duckworth *et al.* 2006).

#### Yellow-throated Marten *Martes flavigula*

Martens were found under a wide range of disturbances including logging activities, shifting cultivation and hunting pressure. As in India (Choudhury 1997) and Myanmar (Than Zaw *et al.* 2008), it occupied a wide elevation range. It was found twice in the middle canopy of trees, and thrice on the ground, in the morning and dusk, reflecting its mainly diurnal nature (Grassman *et al.* 2005, Than Zaw *et al.* 2008). Animals were detected as singletons, duos or trios, as elsewhere (Parr & Duckworth 2007). Line transects recorded more encounters than did camera-traps.

#### Otters

Otters were found only thrice, through tracks not identified to species. Very little is known about the different species of otters in Sarawak. Oriental Small-clawed Otter *Aonyx cinereus* may be the widest-ranging otter in the state (Payne *et al.* 1985) and is

Table 1. Survey sites, their relative levels of disturbance and survey techniques employed.

Site	Logging regime	Hunting pressure	Elevation	Proximity to logging roads	Proximity to slash and burn fields and settlements	Degree of contiguous forest	Line transect (km)	Sign survey (km)	Camera-trap (trap-nights)	
Coupe 1 Block 8 (A and B)	Logged <5 years ago by RIL	Before logging	M	M	M	M	H	73.8	40	Not conducted
	After logging		M	M	M	M	M	76.425	34.025	Not conducted
Coupe 1 Block 4 (C and D)	Logged 5–10 years ago by RIL		H	L	H	H	L	138.575	74.275	All spoilt
Coupe 1 Blocks 5, 6 and 11	Logged <10 years ago by RIL		H	L/M	H	H	L	Not conducted	Not conducted	461
Coupe 9 Block 14 (E and F)	Logged > 15 years ago by CL, then subject to silviculture treatment		H	L	M	M	M	79.425	42.675	All spoilt
Protected Zone (H, I and J)	Not to be logged		L	H	L	M	H	94.45	48.55	1,280
Coupe 5 (K and L)	Logged >15 years ago by CL, subsequently***		H	L	H	H	L	16.0	8.0	All spoilt
Selungo	Unlogged; surrounded by burnt areas		H	L	M	H	M	Not conducted	Not conducted	641
Sebuloh	Unlogged		H	M	L	H	M	88.75	8.0	Not conducted
Beripun	Unlogged		L	M	L	L	H	56.0	4.0	546
Semali	Unlogged,		L	H	L	L	H	85.5	9.75	1,199
Long Lellang*	Unlogged		H	L	H	H	L	2.85	1.225	312
Long Sabai**	Unlogged		M	M	L	M	M	Not conducted	Not conducted	469
Selunok	Unlogged		M	M	L	M	H	Not conducted	Not conducted	344
Long Datih	Unlogged		H	L	L	M	M	39.6	7.0	Not conducted

Relative levels (L=low, M=medium, H=high) of hunting pressure, proximity to logging roads, proximity to slash and burn fields + settlements and forest contiguity were assessed qualitatively through the surveyors' observations. Elevation: low = average elevation <600 m above sea level; medium = average elevation 600–900 m a.s.l.; high = average elevation >900 m a.s.l.

CL = Conventional Logging; RIL = Reduced Impact Logging.

\*Kelabit settlement; \*\*Penan settlement; \*\*\* subsequently burnt during El Niño fires 10 years ago; now subject to reforestation and shifting cultivation

known from the Kelabit Highlands, as is Hairy-nosed Otter *Lutra sumatrana* (Davis 1958). Although Smooth-coated Otter *Lutrogale perspicillata* is widely distributed on Borneo, it has so far not been recorded in these highlands. Otter signs were found only in unlogged sites within the Sela'an-Linau FMU, but further survey is needed to determine whether this reflects chance or a genuine pattern of habitat use.

#### Banded Linsang *Prionodon linsang*

A single linsang was camera-trapped on the ground, off an animal track, at 00h34 on 18 May 2005 in the Protected Zone at 1,083 m (3°17'32"N, 115°06'15"E).

#### Malay Civet *Viverra zibellina*

This civet was the most frequently found small carnivore, photographed twelve times and detected by its apparent signs nine times, in three sites at medium to low elevation, with various levels of hunting pressure and disturbance from shifting cultivation and logging activities, in fairly contiguous forest. Images were at early night, midnight, late night, dusk, and, mostly, dawn, suggesting a more crepuscular nature with some nocturnal activity,

as found by Colón (2002) and Jennings *et al.* (2006). All images were of singletons, except one adult with an infant on 25 December 2005 at 18h26, in low elevation forest, close to old slash and burn fields (03°14'58"N, 115°10'20"E; altitude 530 m).

#### Common Palm Civet *Paradoxurus hermaphroditus*

This civet was detected thrice, always singly, this low detection no doubt reflecting its partly arboreal and nocturnal nature (Payne *et al.* 1985). Records came from lower elevation forest with high hunting pressure, rather close to logging roads and slash and burn fields. The sighting was in the morning in treetops; camera-trap images were at midnight and late night, in line with past information that this species is overwhelmingly nocturnal with occasional daylight activity.

#### Masked Palm Civet *Paguma larvata*

This civet was found once by line transects and six times by camera-traps. The single sighting was of a duo at about 11h00 on 14 May 2008, at altitude of about 690 m: the lowest encounter. Camera-trap images were all of singletons, at early night, midnight and late night, suggesting the species is nocturnal with occasional day-

Table 2. Carnivores detected by all survey methods at all sites.

Species	Sites with corresponding number of independent observations at each site															Total no. of sites detected	IUCN Red List Status
	Coupe 1 Block 8		Coupe 1 Block 4	Coupe 1 Blocks 5, 6, 11	Coupe 9 Block 14	Protected Zone	Coupe 5	Selungoh	Sebuloh	Beripun	Semali	Long Lellang	Long Sabai	Selunok	Long Datih		
Before logging	After logging																
Malay Weasel	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	2	LC
Yellow-throated Marten	1	0	1	0	0	1	0	0	0	1	1	0	0	0	0	5	LC
Otter (Lutrinae)	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	3	**
Banded Linsang	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	LC
Malay Civet	8	1	0	0	0	0	0	12	0	1	0	0	0	0	0	3	LC
Common Palm Civet	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	2	LC
Masked Palm Civet	0	0	0	0	0	4	0	1	2	0	0	0	0	0	0	3	LC
Binturong	1	0	0	0	1	2	0	3	0	0	0	0	0	0	0	4	VU
Hose's Civet	0	0	0	0	0	9	0	0	0	0	2	1	0	0	0	3	VU
Banded Civet	0	0	0	0	0	3	0	2	0	0	1	0	0	0	0	3	VU
Collared Mongoose	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	DD
Short-tailed Mongoose	0	0	1	0	0	1	0	2	0	0	0	0	0	0	0	3	LC
Marbled Cat	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	VU
Leopard Cat	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	LC
Total number of species detected at each site	3 *m	1	2 *c	0	2 *m	9	0	7	3	3	4 *c	1	0	0	1		
Sun Bear	10	4	4	0	2	15	0	5	5	4	5	1	*	*	1	12	VU
Sunda Clouded Leopard	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	VU

'Independent observations' are defined in the text. Total number of sites where each species was detected and total number of small carnivores detected at each site is given, with corresponding IUCN Red list status (LC=Least concern, DD=Data deficient, VU=Vulnerable, EN=Endangered). Legal protection status in Sarawak is discussed in the text.

\* Signs recorded incidentally at these sites, but not during formal transects.\*\*All possible species are at least Near-Threatened (see text).\*c Tracks of unidentified civets were recorded at these sites.\*m Tracks of unidentified mongooses were recorded at these sites.

light activity, in line with previous studies (e.g. Than Zaw *et al.* 2008). This civet's semi-arboreal nature (Than Zaw *et al.* 2008) may have contributed to the relatively few photographs.

#### Binturong *Arctictis binturong*

Binturongs were detected four times by camera-trap and thrice by line transects. Direct sightings were all in trees whereas camera-trap images were on the ground, suggesting that though this species may be generally arboreal, it may have to descend to the ground frequently when moving between trees, due to its heavy build (Than Zaw *et al.* 2008). It was encountered fairly close to slash and burn fields and in forests with elevation and hunting pressure ranging from low to high. This suggests that in this

concession, hunting may not be a serious threat for this species. Records were consistently in forests with medium to high contiguity, and not near logging roads; the sole logged site with a record had been logged more than 15 years ago. Direct sightings were all by morning, whereas camera-trap images were from morning, early night, midnight and late night, corroborating reports that Binturongs are regularly active by day (Nettelbeck 1997), and contrary to statements they are mostly nocturnal (e.g. Rozhnov 1994). Ground-level camera-trapping is an excellent tool for determining activity patterns of ground-dwelling species, but for those largely arboreal, its results need triangulation with methods able to detect the species at all heights in the habitat, in case visits to the ground are not spread randomly through the animal's activity cycle. This

Table 3. Sightings of Malay Weasel *Mustela nudipes*.

Site	Lat (N)	Long (E)	Altitude (m)	Date	Time	N° animals
Sebuloh	3°25.824'	115°10.533'	673	30 Oct 2004	10h07	2
Coupe 9 Block 14	3°16.512'	115°03.634'	*	23 Sept 2006	07h17	1

\* unknown precisely; low or medium elevation

Table 4. Camera-trap encounters of Hose's Civet *Diplogale hosei* and Collared Mongoose *Herpestes semitorquatus*.

Species	Site	Lat (N)	Long (E)	Altitude (m)	Date	Time	Other notes
Hose's Civet	Semali	3°25.302'	115°13.602'	945	6 Sept 2005	22h59	
	Semali	3°25.302'	115°13.602'	945	26 Sept 2005	23h10	
	Long Lellang	3°25.807'	115°08.094'	731	3 Nov 2005	18h33	
	PZ	3°17.538'	115°06.308'	1,062	6 July 2005	19h40	Animal track off Trail H
	PZ	3°17.538'	115°06.308'	1,062	17 April 2005	22h22	Animal track off Trail H
	PZ	3°18.201'	115°05.194'	960	23 May 2005	02h34	Animal track on ridge off Trail J
	PZ	3°17.963'	115°05.243'	969	20 Nov 2005	19h17	Animal track on ridge
	PZ	3°17.963'	115°05.243'	969	22 Nov 2005	19h06	Animal track on ridge
	PZ	3°17.963'	115°05.243'	969	1 Dec 2005	05h04	Animal track on ridge
	PZ	3°17.526'	115°06.252'	1,083	20 April 2005	22h53	Animal track near ridge, off Trail H
	PZ	3°17.551'	115°07.025'	>1,000	29 Sept 2005	00h46	Animal track on ridge in mossy forest; little undergrowth
	PZ	3°17.551'	115°07.025'	>1,000	4 Oct 2005	01h34	Animal track on ridge in mossy forest; little undergrowth
Collared Mongoose	Selungo	3°13.430'	115°10.859'	356	12 May 2005	unknown	
	Selungo	3°14.325'	115°10.724'	300	12 May 2005	16h47	

remains unknown in the case of Binturongs.

#### Hose's Civet *Diplogale hosei*

Hose's Civet was detected in three sites, only by camera-traps. The number of individuals involved is unknown. Being a plain-coated species, identification of Hose's Civet photographs to individual is more challenging than with patterned species. The 12 images were spread across the night (Table 4, Fig. 3), suggesting the species is crepuscular and nocturnal. All images were from unlogged forests, all but one from montane forests with low hunting pressure, far from logging roads; these forests had high contiguity and were not close to slash and burn fields. One image, however, came from low elevation forests (the camera site itself was at 731 m a.s.l.), with high hunting pressure, near logging roads (but not with logging activities per se), and fragmented by slash and burn fields. Whether this is a dispersing animal or whether Hose's Civet can subsist in these more encroached areas, is unclear.

The Sela'an-Linau FMU may be the only place where camera-trapping found this little-known species regularly, let alone



Fig. 3. Hose's Civet *Diplogale hosei* Sela'an-Linau Forest Management Unit, upper Baram, Sarawak. Photo: WCS Malaysia

as one of the two most commonly trapped small carnivores (Van Rompaey & Azlan 2004, J. W. Duckworth verbally 2009). Moreover, the area providing the biggest series of collected specimens was the nearby Kelabit Highlands (Davis 1958): perhaps this part of Sarawak is the species's prime habitat. The conservation needs of Hose's Civet are entirely unknown (Van Rompaey & Azlan 2004, Yasuma 2004). Outside Sarawak, this species has been recorded only in Sabah (e.g. Wells *et al.* 2005) and Brunei (e.g. Yasuma 2004).

#### Banded Civet *Hemigalus derbyanus*

This civet was recorded seven times, six as singletons by camera-traps. Its higher photograph rate than palm civets may reflect a more ground-dwelling nature. All images were at midnight or late night, corroborating its exclusively nocturnal nature (Davis 1962). Coat colour varies much in northern Borneo (Davis 1962). All images were of buffy-grey animals with black bars across back and face, and this may be the predominant colour form over Sarawak (examination of about 15 skins in Sarawak Museum in 2009). A local hunter killed a rich reddish brown animal (as shown in Payne *et al.* 1985) in early 2004 in Sebuloh, an unlogged area at medium elevation, close to slash and burn fields, indicating that this colour form also inhabits the area.

More camera-trapping is required to clarify this civet's status, particularly its use of disturbed habitats. Its IUCN Red Listing as Vulnerable is based on declines inferred from habitat change; there seems to remain no empirical study of its adaptability to encroachment and change in land-use patterns.

#### Collared Mongoose *Herpestes semitorquatus*

Collared Mongoose was camera-trapped at only one site; one image came from an animal track near a logging road in secondary forest (dense undergrowth), surrounded by burnt area, with the other from an animal track in a burnt area (Table 4).

#### Short-tailed Mongoose *Herpestes brachyurus*

This mongoose was encountered in three sites, twice each by camera-trap and line transects. Sites, always fairly close to slash

and burn fields, varied in hunting pressure, elevation, proximity to logging roads and forest contiguity. It may be a widespread opportunist, tolerant of disturbance. All records were of singletons on the ground. Sightings were in the morning, photographs in the morning and by day, indicating at least mainly diurnal activity.

#### Marbled Cat *Pardofelis marmorata*

A Marbled Cat was camera-trapped on an animal track in the Protected Zone (3°17'32"N, 115°06'18"E, altitude 1,062 m), on the ground, at 05h49 on 22 April 2005.

#### Leopard Cat *Prionailurus bengalensis*

A Leopard Cat was camera-trapped in the Protected Zone in the early night.

## Concluding discussion

Camera-trapping was the best survey method for small carnivores (Table 5): of 14 species recorded, 12 were detected by camera-traps, only six by line transects, and, given ambiguous species identification, sign surveys were useful only for Malay Civet, Sun Bear and otters. Sun Bear was the most widely found carnivore, in 12 of the 14 sites (Table 2). This is, however, to be expected: Sun Bear and Malay Civet are the only species identifiable by signs, increasing recording efficiency. Small carnivores were mostly sparsely recorded. Yellow-throated Marten was the most widely encountered, at five sites (35.7%), perhaps reflecting its position as one of the few carnivores recorded during line transects, rather than it genuinely being more widespread than all other species. Binturong, Masked Palm Civet, Common Palm Civet, Banded Civet and Short-tailed Mongoose are also probably widespread within the FMU. Hose's Civet and Malay Civet, though two of the most commonly found small carnivores, were found at few sites. Malay Civet may occur mainly below 900 m a.s.l. and Hose's Civ-

Table 5. Number of independent observations of each carnivore species using each method.

Species	Number of independent observations			
	Line transect	Sign survey	Camera-trap	Total
Malay Weasel	2	0	0	2
Yellow-throated Marten	4	0	1	5
Otter	0	3	0	3
Banded Linsang	0	0	1	1
Malay Civet	0	9	12	21
Common Palm Civet	1	0	2	3
Masked Palm Civet	1	0	6	7
Binturong	3	0	4	7
Hose's Civet	0	0	12	12
Banded Civet	0	0	6	6
Collared Mongoose	0	0	2	2
Short-tailed Mongoose	2	0	2	4
Marbled Cat	0	0	1	1
Leopard Cat	0	0	1	1
Large carnivores				
Sun Bear	4	45	7	56
Sunda Clouded Leopard	0	0	3	3

Survey effort is quantified in the text; 'total' refers here only to records by these three survey methods.

et may be more common between 600 to 1,300 m a.s.l. Banded Linsang, Marbled Cat and Leopard Cat were detected in just one site each (7.1%). All these patterns, however, require verification through more records.

Comparison with results for muntjac *Muntiacus* spp. over the same period, using the same criteria for independent observations, highlights the effort needed for small carnivore records, and how comparisons between species might well just reflect differences in survey methodology effectiveness. At least 170 independent images of muntjac were obtained (a conservative estimate: some images could not be identified precisely, and many lacked the time print, hindering tallying of independent images) compared with the peak of 12 for any small carnivore (both Hose's Civet and Malay Civet). Line transects gave 140 independent muntjac observations, compared with four each for Yellow-throated Marten and Short-tailed Mongoose, the most recorded small carnivores. Sign surveys gave 163 independent muntjac observations, compared with the maximum of nine for any small carnivore (Malay Civet).

At least 19 species of small carnivore are expected in the Upper Baram region, of which 14 were found in the Sela'an-Linua FMU during 54 months of line transects, sign surveys and camera-trapping. These 14 include four species listed as Vulnerable by the IUCN Red List of Threatened Species (IUCN 2009): Hose's Civet (endemic to Borneo), Binturong, Banded Civet and Marbled Cat. Otters were not identified to species, but are also red-listed. One species, Collared Mongoose is Data Deficient on the Red List.

The otter species present in the FMU remain unclear; Davis (1958) recorded two in the nearby Kelabit Highlands (see above). At least four more species of small carnivore plausibly in the Upper Baram were not found by this survey. Small-toothed Palm Civet *Arctogalidia trivirgata* (IUCN Least Concern) was recorded in the Kelabit Highlands by Davis (1958) and reported by local people in the FMU. It is strongly nocturnal and arboreal (Payne *et al.* 1985), and no survey methods suitable to find it were used (see Wilting *et al.* 2010). Local hunters' reports suggested that two IUCN Endangered species, Bay Cat, endemic to Borneo and one of the rarest cats in the world (Mohd-Azlan & Sanderson 2007), and Otter Civet *Cynogale bennettii*, previously seen in the Kelabit Highlands by Harrison (Medway 1977), occurred in the FMU. Reports dated from before logging operations were wide scale. Another species, the Sunda Stink-badger (Malay Badger) *Mydaus javanensis* (IUCN Least Concern), has been collected several times in the Kelabit Highlands (Davis 1958). This highly distinctive species seemed unknown to local people, so it may have never inhabited the FMU.

The main threats to small carnivores in the FMU remain unclear. Local hunters do not actively seek them, and some species were found in areas of high hunting pressure. Hunting in the FMU usually (but not always) involves dogs, which accompany local hunters in their search for ungulates, especially Bearded Pig *Sus barbatus*, muntjacs and Sambar *Cervus unicolor*. Primates, especially macaques *Macaca* and langurs *Presbytis*, and rodents are hunted to a lesser extent. At least Sun Bear, Binturong and other palm civets are taken as encountered, but hunters do not set out to hunt them. Local hunters usually use home-made guns, spears and blowpipes, and hunt both by day and night. Snares are much used, targeting pheasants, rodents and chevrotains (mousedeer) *Tragulus*, although often, civets, particularly Malay Civet, fall victim.

Many small carnivores were found in areas affected by

logging, but the latter may constrain Binturong range. Otters in mainland South-east Asia are in heavy decline, through greatly increased trade-driven hunting (e.g. Than Zaw *et al.* 2008), but this seems not to occur in Sarawak. Instead, here, shrinking habitat, pollution and siltation of rivers, the use of chemicals and explosives/electricity when fishing, resulting in severe depletion of the prey base of otters, may be problematic (see SAMD 2006). Shifting cultivation might be a threat to small carnivores mainly through the temporary loss of the areas under cultivation at any given time: most species were found near slash and burn fields. However, the ability for populations to persist in such landscapes with extensive conversions may differ greatly from the ability of individuals resident in adjacent tall forest to use small degraded patches.

Urgently required now are studies specifically of small carnivores to determine distribution and conservation status within the Sela'an-Linau FMU. Encounter rates are very low and many species nocturnal and crepuscular: line transects yield few data. Sign surveys are useful only for few species. Night-spotting may be an option, but there are no roads in unlogged areas and uneven terrain makes passage on foot noisy. Moreover, it is risky to the surveyors: hunters regularly use firearms at night in the FMU. Camera-traps seem best to study these animals, except those species mostly arboreal. Modifications to the selection of sites for camera-traps so far used here could include aiming cameras towards fallen trees, and, in particular, using odours/scents in canisters resistant to rain (see Gimán *et al.* 2007). Otters may require camera placement nearer rivers and streams, which would also allow consideration of Otter Civet status. Knowledge of local guides is invaluable in selecting sites: that the Selungoh site yielded many species and records in part reflects that the main guide was from this area. Wider use in camera-trapping surveys of hunters knowledgeable of each site could boost small carnivore encounter rates. It is also suggested that a record be kept of animals hunted by local hunters, with detailed description of where they were hunted.

In conservation terms, Hose's Civet stands out from the other species recorded, because it has a much smaller known range, and no protected area is known to hold a large population. Fuller survey of montane northern Borneo to allow an assessment of overall status is imperative. For detailed research on Hose's Civet conservation needs, Sela'an-Linau FMU may be invaluable, because the species seems to be common there. Thus far, nobody has attempted any autecological research on it because no suitable site was previously known. Currently, the basic factors likely to determine its long-term future, such as population densities, dependency level on old-growth forest (if any), ranging and dispersal patterns, and others, are entirely unknown. Specific conservation measures (if indeed any are needed) are thus presently impossible. Its naturally highly localised distribution (i.e. one not bounded by coasts or other physical barriers) implies it is a habitat specialist that perhaps may be under great threat. Thus, such research is urgent.

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**Wildlife Conservation Society Malaysia Program, 7  
Jalan Ridgeway, 93200 Kuching, Sarawak, Malaysia  
Emails: greensmoke72@yahoo.com (John Mathai),  
ngumbangjuat@yahoo.com (Ngumbang Juat)**

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