CARNIVORE RECORDS, INCLUDING UPDATED RECORDS OF THE ENDEMIC HOSE'S CIVET *DIPLOGALE HOSEI*, FROM A LOGGING CONCESSION IN THE UPPER BARAM, SARAWAK

by

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Abstract

There is very little credible, accurate and up-to-date information regarding the carnivores of Sarawak, 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 17 of the 21 carnivores expected there. Sun Bear *Helarctos malayanus*, 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 valuable for further research into this little-known species. Main threats to carnivores remain unclear, but they are not the primary quarry species of local hunters. Further camera-trapping of 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

INTRODUCTION

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) and 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.* According to 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 provided and severe punishment to offenders; all other carnivores are listed as merely Protected, with limited protection and lenient punishment to offenders. Despite the undoubted importance of Borneo to carnivores and small carnivores in particular, credible, accurate and up-to-date information about their distribution and ecology in Sarawak is scarce, with few systematic studies being undertaken.

Carnivores can be good indicators of forest health, provided sufficient data can 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. However, due to their spatial requirements, carnivores are among the first to suffer due to alterations in their habitat caused by human exploitation – in Sarawak, this is caused mainly by logging and more recently and worryingly, conversion to monoculture plantations.

It is increasingly being recognised that wildlife can benefit from forests that are managed sustainably for timber extraction (e.g. Meijaard & Sheil, 2007). In Sarawak, where protected areas make up just 4% of the total land area whereas 35.2% are earmarked for logging activities (Sarawak Forest Department 1997), logging concessions have become areas of key conservation importance as protected areas are simply too small and too isolated to protect rare and/or threatened species – this is especially true for the more wide ranging carnivores such as Sunda Clouded Leopard *Neofelis diardi.*

However, little is known about how different forest management approaches affect specific wildlife.

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 the Wildlife Conservation Society (WCS) Malaysia Program 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 (MTCS). The Sela'an-Linau FMU was awarded voluntary certification under the MTCS in 2004 but this certification was lost in 2009, mainly due to unsettled issues with native communities. The main objective of the monitoring programme was to document the diversity and distribution of non-volant mammals, birds and bats within the FMU; carnivores were simply part of the general remit. Many of these records have been published in Mathai *et al.* (2010) – this paper includes detailed species accounts of the large carnivores, and additional small carnivore records, particularly two more records of the endemic Hose's Civet and a new record, the Small-toothed Palm Civet *Arctogalidia trivirgata.*

METHODS

Study Area

The Sela'an-Linau FMU, covering an area 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 the forest for their livelihoods and on wildlife for their protein.

The Sela'an-Linau FMU is undulating in nature, with altitudes ranging 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 (60%) supports mixed dipterocarp forest, with some montane forest

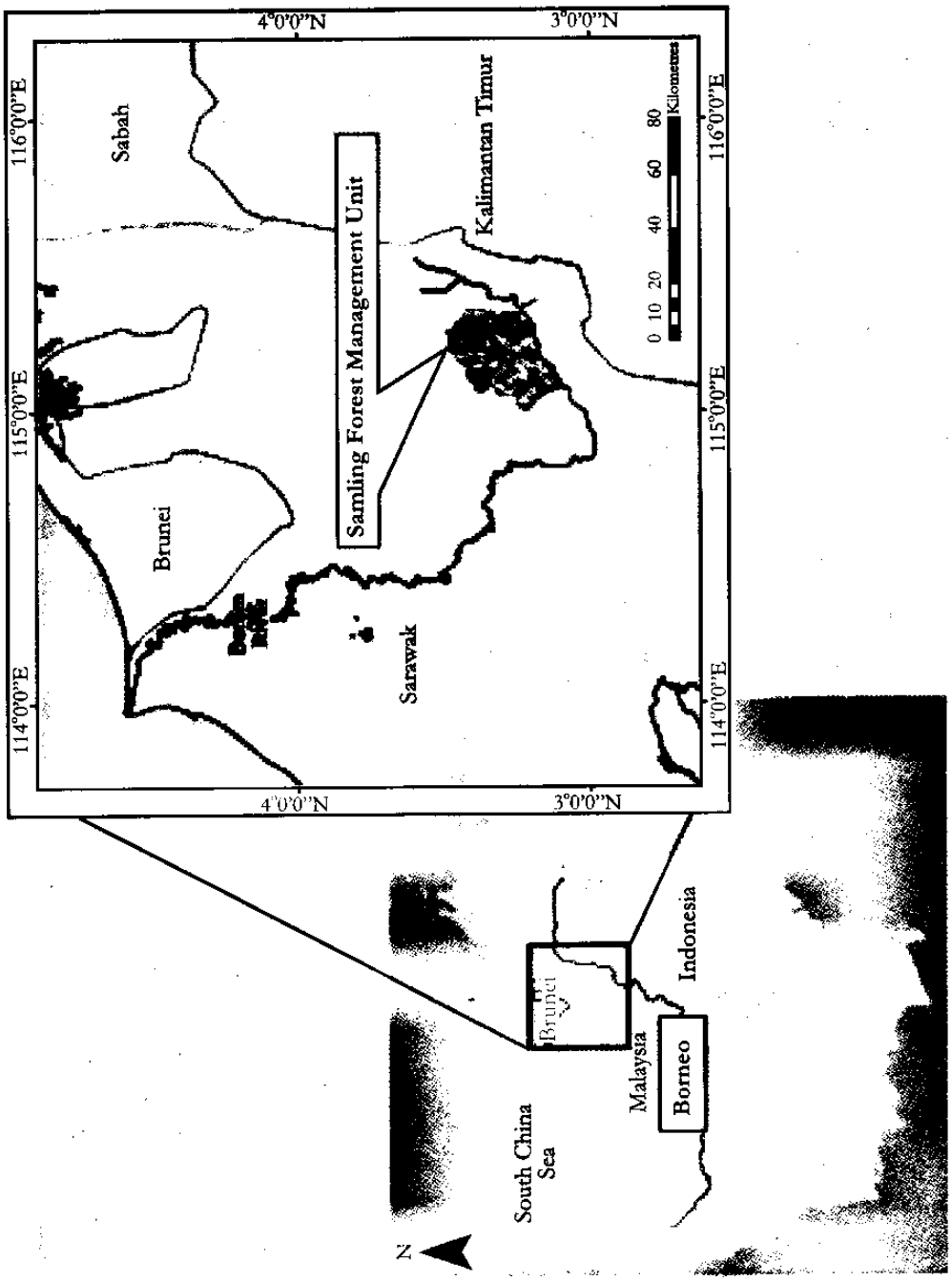

Fig. 1: The Sela'an-Linau Forest Management Unit (FMU) in Upper Baram (Mathai *et al.*, 2010)

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 being conducted 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 portions of the 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)); no carnivore was found frequently enough to allow an analysis of such spatial precision. Most of the survey effort was conducted 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

Field work spanned from March 2004 to September 2008, using multiple methods. Three recorded carnivores: line transects (diurnal direct observation), sign surveys, and camera-trapping. Line transects were walked for a total distance of 789 km, sign surveys were conducted for 277½ km and camera-trapping was conducted for 5,252 trap-nights.

Camera-trapping occurred from January 2005 to September 2008, using 40 Camtrakker™ units; before this, from June till December 2004, five cameras were experimented with to study optimum

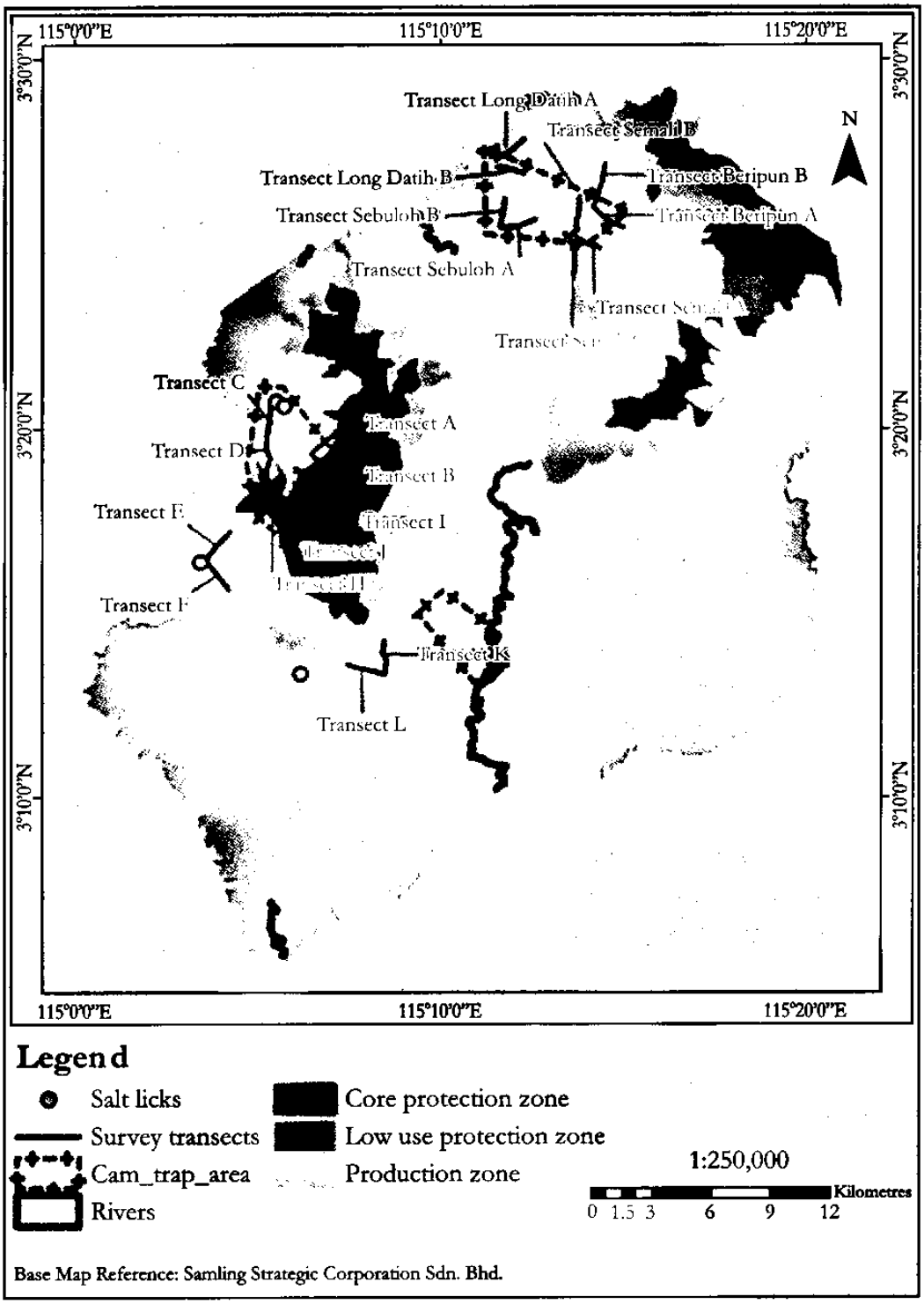

Fig. 2: Location of line transects used for wildlife surveys and focal areas of camera-trapping in the Sela'an-Linau FMU (Mathai *et al.*, 2010).

Table 1: Survey sites, their relative levels of disturbance and survey techniques employed (Mathai *et al.* 2010).

Site	Logging Regime		Hunting Presure	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

Table 1: (cont.)

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

placement, heights and angles. As this was just an experimental period, documentation was minimum and hence, survey effort from this period could not be calculated and is not presented here. Moreover, the main site where this experimentation was carried out, Murud Kecil, is not included in the 14 sites mentioned above where surveys were concentrated with the intention of investigating occurrence patterns as listed in Table 1. Murud Kecil is high elevation forest, far from logging roads, with medium levels of forest contiguity and hunting pressure, though not far from slash and burn fields.

In 2008, two LeafRiver digital units were acquired. By the end of survey, all 42 cameras were out of commission, mainly due to 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 at heights of 20 – 30 cm above ground level, at a distance between 1 – 1.5 m from the animal trail. All cameras were set to run for 24 hours a day. Initially, baits consisting of sardines and dead chicken as well as lures consisting of commercially available essences of banana, pandan and yam were trialled. This was abandoned, as baits were quickly consumed by ants and rats and the heavy rains in the study area almost immediately washed away all traces of the lures. Also, as many cameras malfunctioned, it was not possible to determine whether the baits/lures increased the encounter rate of animals in any way.

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 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 sign surveys were the major general survey methods but both yielded too few carnivore records for species-level analysis. Direct diurnal observations were conducted along the 2 km long line transects from 0700 to 1100 hrs whereby all animals observed from the transect, as well as their perpendicular distance from the transect, measured using a rangefinder, were recorded; for sign surveys, signs visible from the transect such as tracks, scratches on tree or ground, bite marks and faeces, were recorded (both elaborated in Hon *et al.,* 2009). Latrines, with multiple piles of faeces of different ages, were reported by local people to be only from Malay Civet. If true, this would enable effective detection and visual identification of Malay Civet through signs. A single observation (or sign) for each species per transect per day was taken as an independent observation. These records, those from reconnaissances, incidental records and records from the 6-month experimentation period with camera traps were all used in the preparation of the present text.

RESULTS

Seventeen carnivore species were recorded: 15 small carnivores and two large, Sun Bear *Helarctos malayanus* and Sunda Clouded Leopard *Neofelis diardi* (Table 2) (previously recorded as 16 carnivores and 14 small carnivores in Mathai *et al.,* 2010). Of the small carnivores, four are listed as Vulnerable under the *IUCN Red List of Threatened Species* and one as Data Deficient (IUCN 2010). 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 11 of the 17 carnivore species found (65%). However, survey effort and type varied too much from site to site for comparisons between them of their carnivore records to be meaningful (Table 1).

Table 2: Carnivores detected by all survey methods at all sites. Note: the Murud Kecil site is also reported here, though in a separate column from the other 14 sites, as it was not one of the sites where surveys were concentrated, rather, it was a site where cameras were simply experimented with, as explained in the text. Table updated from Mathai *et al.*, 2010.

Species	Sites with corresponding number of independent observations at each site															Murud Kecil (experimental phase with cameras)	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 Sabal	Selunok	Long Datih			
	Before logging	After logging																
Malay Weasel *Mustela nudipes*	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2	LC
Yellow-throated Marten *Martes flavigula*	1	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	5	LC
Otter (Lutrinae)	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	3	**
Banded Linsang *Prionodon linsang*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	LC
Malay Civet *Viverra tangalunga*	8	1	0	0	0	0	0	12	1	1	0	0	0	0	0	0	4	LC
Small-toothed Palm Civet *Arctogalidia trivirgata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	LC
Common Palm Civet *Paradoxurus hermaphroditus*	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	2	LC
Masked Palm Civet *Paguma larvata*	0	0	0	0	0	4	0	1	2	0	0	0	0	0	0	2	4	VU
Binturong *Arctictis binturong*	1	0	0	0	1	2	0	3	0	0	0	0	0	0	0	0	4	VU

Hose's Civet *Diplogale hosei*	0	0	0	0	0	9	0	0	0	0	2	1	0	0	0	2	4	VU
Banded Civet *Hemigalus derbyanus*	0	0	0	0	0	3	0	2	0	0	1	0	0	0	0	0	3	VU
Collared Mongoose *Herpestes semitorquatus*	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	DD
Short-tailed Mongoose *Herpestes brachyurus*	0	0	1	0	0	1	0	2	0	0	0	0	0	0	0	0	3	LC
Marbled Cat *Pardofelis marmorata*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	VU
Leopard Cat *Prionailurus bengalensis*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	LC
Sunda Clouded Leopard *Neofelis diardi*	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	VU
Sun Bear *Helarctos malayanus*	10	4	4	0	2	17	0	6	5	4	5	1	*	*	1	*	13	VU
Total number of species detected at each site	4*m	2	3*c	0	3*m	11	0	8	5	4	5*c	2	1	1	2	4		

'Independent observations' are defined in the text. Total number of sites where each species was detected and total number of 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.

Malay Weasel *Mustela nudipes*

Malay Weasel was encountered twice, on the ground, by line transect surveys. 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). Details of sightings are given in Mathai *et al.* (2010).

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 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 1,100 m.

Malay Civet *Viverra tangalunga*

This was the most frequently found small carnivore, photographed thirteen times (previously reported as twelve times in Mathai *et al.,* 2010 – here, we include a single photo from the experimentation phase with cameras, at Sebuloh) and detected by its apparent signs nine times, in four 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.

Small-toothed Palm Civet *Arctogalidia trivirgata*

A single Small-toothed Palm Civet was camera-trapped on a fallen trunk, at 22h34 on 15 June 2004 along the slopes of Murud Kecil. This image was one of those taken during the experimentation phase with cameras.

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 eight times by camera-traps (previously recorded as six times by line transects in Mathai *et al.* (2010) – here we include two images from the

experimentation phase with cameras at Murud Kecil). It was detected from four sites, including Murud Kecil. The single sighting was of a duo at about 11h00 on 14 May 2008, at altitude about 690 m: the lowest encounter. Camera-trap images were all of singles, at early night, midnight and late night, suggesting the species is nocturnal with occasional daylight activity, in line with previous studies (e.g. Than Zaw *et al.,* 2008).

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 remains unknown in the case of Binturongs.

Hose's Civet *Diplogale hosei*

Hose's Civet was detected in four sites (including Murud Kecil), 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. Its higher photograph rate than palm civets may reflect a more ground-dwelling nature. The 14 images (previously published as 12 images from three sites in Mathai *et al.,* 2010) were spread across the night (Table 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 as the most commonly trapped small carnivore (Van Rompaey & Azlan, 2004; J. W. Duckworth, *pers. comm.* 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 prime habitat of the species. 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 six times, always 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

Table 3: Camera-trap encounters of Hose's Civet *Diplogale hosei* from the Selaan-Linau FMU, Upper Baram, updated from Mathai *et al.*, 2010.

Site	Lat (N)	Long (E)	Alt/m	Date	Time	Other Notes
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′	1062	6 July 2005	19h40	Animal track off Trail H
PZ	3°17.538′	115°06.308′	1062	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′	1083	20 April 2005	22h53	Animal track near ridge, off Trail H
PZ	3°17.551′	115°07.025′	more than 1000	29 Sept 2005	00h46	Animal track on ridge in mossy forest; little under-growth
PZ	3°17.551′	115°07.025′	more than 1000	4 Oct 2005	01h34	Animal track on ridge in mossy forest; little under-growth
Previously unpublished records						
Murud Kecil	3°23.612′	115°07.869′	1150	10 July 2004	20h39	Animal track on ridge
Murud Kecil	3°23.612′	115°07.869′	1150	22 Aug 2004	03h45	Animal track on ridge

(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 variety 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.

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. Details of these encounters are given in Mathai *et al.,* (2010).

Short-tailed Mongoose *Herpestes brachyurus*

This mongoose was encountered in three sites, twice each by camera-trap and line transects. Sites, which were 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 at an altitude of 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.

Sunda Clouded Leopard *Neofelis diardi*

Sunda Clouded Leopard was detected three times, always by camera trap, at the same location in the Protected Zone: on an animal track on a ridge at an altitude of 960 m. From visual observations of coat markings, all three images were of the same individual, an adult male. Images were at late night, dawn and morning (Table 4).

Table 4: Camera trap encounters of the Sunda Clouded Leopard *Neofelis diardi* from the Sela'an-Linau FMU, Upper Baram.The Bornean and Sumatran

Site	Lat (N)	Long (E)	Alt/m	Date	Time	Other Notes
PZ	3°18.201′	115°05.194′	960	3 May 2005	07h26	Animal track on ridge off Trail J
				5 Aug 2005	01h51	
				6 Sept 2005	05h36	

Clouded Leopard (Sunda Clouded Leopard) have recently been reclassified as a separate species *Neofelis diardi*, distinct from its continental relative *Neofelis nebulosa*, based on significant genetic and morphological differences between the two species (Buckley-Beason *et al.*, 2006; Kitchener *et al.*, 2006). This reclassification puts the Sunda Clouded Leopard at an even greater threat level, and increases the importance of research on the species.

Sun Bear *Helarctos malayanus*

The Sun Bear was the most frequently found carnivore, both in terms of numbers of observations and sites encountered – its identification by sign much increased recording efficiency. Sun Bears

were found under a wide range of disturbances including logging activities, shifting cultivation and hunting pressure, corroborating reports that Sun Bears are widespread opportunists (Fredriksson, 2005), found in logged forest (Wong *et al.,* 2004) and planted forest (Giman *et al.,* 2007), and contrary to statements they are found only in primary forest (e.g. Wilson & Johns, 1982). It occupied a wide elevation range, and was detected in 13 sites. It was detected four times by line transects, photographed 10 times (previously recorded as seven in Mathai *et al.,* 2010) and detected by sign 45 times. Direct observations consisted of three visual encounters and one by vocalisation (roars); three of these were of singletons during the day and one, a visual observation of two adults and a young, in high elevation forest with high contiguity and low hunting pressure, was recorded in the morning on 18th January 2005 at 09h00. Camera trap images were by morning, day, dusk, early night, midnight, and late night corroborating reports that Sun Bears are regularly active by day (Wong *et al.,* 2004). All images were of singletons, except one of a duo taken on 20th June 2005 at 01h30, in low elevation forest with high hunting pressure, close to slash and burn fields, on an animal track in the burnt area.

CONCLUDING DISCUSSION

Table 5: Number of independent observations of each carnivore species using each method. Records from the experimentation period with cameras (June 2004 – Dec 2004) are included. Table updated from Mathai *et al.* (2010).

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	13	22
Small-toothed Palm Civet	0	0	1	1
Common Palm Civet	1	0	2	3
Masked Palm Civet	1	0	8	9
Binturong	3	0	4	7
Hose's Civet	0	0	14	14
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				
Sunda Clouded Leopard	0	0	3	3
Sun Bear	4	45	10	59

Survey effort is quantified in the text.

Camera-trapping was the best survey method for carnivores (Table 4): of 17 species recorded, 15 were detected by camera-traps (88%), 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 actual 14 sites surveyed (Table 2). This is, however, to be expected: it and Malay Civet are the only species identifiable by signs, much increasing recording efficiency. Small carnivores were mostly sparsely recorded. Yellow-throated Marten was the most widely encountered, at five sites, 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, may be more restricted in range. Malay Civet may occur mainly below 900 m a.s.l. and Hose's Civet may be more common between 600 and 1,500 m a.s.l. Banded Linsang, Small-toothed Palm Civet, Collared Mongoose, Marbled Cat, Leopard Cat and Clouded Leopard were detected in just one site each. 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 14 for any carnivore (Hose's Civet). Line transects gave 140 independent muntjac observations, compared with four for Yellow-throated Marten and Short-tailed Mongoose, the most recorded carnivores. Sign surveys gave 163 independent muntjac observations: this was comparative only to Sun Bear (45 observations) whereas

for small carnivores, the maximum was just nine (Malay Civet).

At least 21 species of carnivore are expected in the Upper Baram region, of which 17 were found in the Sela'an-Linau FMU during 54 months of line transects, sign surveys and camera-trapping. These 17 include six species listed as Vulnerable by the *IUCN Red List of Threatened Species* (IUCN 2010): Hose's Civet (endemic to Borneo), Binturong, Banded Civet, Marbled Cat, Sun Bear and Clouded Leopard. 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 three more species of carnivore plausibly in the Upper Baram were not found by this survey. Local hunters' reports suggest 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 Harrisson (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 carnivores in the FMU remain unclear. They are not actively sought by local hunters, 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. All these are hunted as sources of protein. At least Sun Bear, Binturong and other palm civets are taken as encountered, but hunters do not set out to hunt them. In the case of Sun Bear,

however, there is the added pressure of the value placed on their gall bladder, purportedly of medicinal value, thereby increasing hunting pressure on them (Hon *et al.,* 2009). Local hunters usually use home-made guns, spears and blowpipes, and hunt both by day and night. Snares are often used – these are intended for pheasants, rodents and mouse deer *Tragulus*, though often, civets, particularly Malay Civet, fall victim. Snares may potentially be a threat to the other more ground dwelling civets such as Hose's Civet and Banded Civet.

Many carnivores were found in areas affected by logging, but the latter may constrain Binturong, Hose's Civet and Clouded Leopard range. Otters in mainland South-east Asia are in heavy decline, through greatly increased trade-driven hunting (e.g. Than Zaw *et al.,* 2008), though 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 a problem (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, however, 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.

What are urgently required now are studies focussing on carnivores to determine distribution and conservation status within the Sela'an-Linau FMU. Encounter rates are very low and many species nocturnal and crepuscular: hence, 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 as 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 Giman *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 reflect 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.

In conservation terms, Hose's Civet stands out from the other species recorded as 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, the 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 which perhaps may be under great threat. Thus, such research is urgent.

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REFERENCES

Buckley-Beason, V.A., Johnson, W.E., Nash, W.G., Stanyon, R., Menninger, J.C., Driscoll, C.A., Howard, J.G., Bush, M., Page, J.E., Roelke, M.E., Stone, G., Martelli, P.P., Wen, C., Ling, L., Duraisingam, R.K., Lam, P.V. & O'Brien, S.J.

2006 Molecular evidence of species-level distinctions in clouded leopards. *Current Biology* 16: 2371–2376.

Choudhury, A.U.

1997 Small carnivores (mustelids, viverrids, herpestids and one ailurid) in Arunachal Pradesh, India. *Small Carnivore Conservation* 17: 7–9.

Colón, C.P.

2002 Ranging behaviour and activity of the Malay Civet (*Viverra tangalunga*) in a logged and unlogged forest in Danum Valley, East Malaysia. *Journal of Zoology, London* 257: 473–485.

Corbet, G.B. & Hill, J.E.

1992 *Mammals of the Indomalayan region: a systematic review.* Natural History Museum Publications and Oxford University Press, London and Oxford, U.K.

Davis, D.D.

1958 Mammals of the Kelabit plateau, northern Sarawak. *Fieldiana, Zoology* 39: 119–147.

1962 Mammals of the lowland rainforest of North Borneo. *Bulletin of the National Museum of Singapore* 31: 1–129.

Duckworth, J.W., Lee, B.P. Y.-H., Meijaard, E. & Meiri, S.

2006 The Malay Weasel *Mustela nudipes*: distribution, natural history and a global conservation status review. *Small Carnivore Conservation* 34 & 35: 2–21.

Fredriksson, G.
2005 Human – sun bear conflicts in East Kalimantan, Indonesian Borneo. *Ursus* 16(1): 130–137.

Giman, B., Stuebing, R., Megum, N., McShea, W.J. & Stewart, C.M.
2007 A camera trapping inventory for mammals in a mixed use planted forest in Sarawak. *Raffles Bulletin of Zoology* 55: 209–215.

Grassman, L.I., Jr., Tewes, M.E. & Silvy, N.J.
2005 Ranging, habitat use and activity patterns of Binturong *Arctictis binturong* and Yellow-throated Marten *Martes flavigula* in north-central Thailand. *Wildlife Biology* 11: 49–57.

Hon, J., Mathai, J., Juat, N., Peter, A. & Gumal, M.
2009 *A wildlife survey of the Sela'an-Linau Forest Management Unit, with conservation implications and management recommendations.* Wildlife Conservation Society Malaysia, Kuching, Sarawak, Malaysia.

IUCN
2010 *IUCN Red List of Threatened Species.* Version 2010. <www.iucnredlist.org>. Downloaded on 3 November 2010.

Jennings, A.P., Seymour, A.S. & Dunstone, N.
2006 Ranging behaviour, spatial organization and activity of the Malay Civet (*Viverra tangalunga*) on Buton island, Sulawesi. *Journal of Zoology, London* 268: 63–71.

Kitchener, A.C., Beaumont, M.A. & Richardson, D.
2006 Geographical variation in the clouded leopard *Neofelis nebulosa*, reveals two species. *Current Biology* 16: 2377–2383.

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.

Medway, Lord
1977 Mammals of Borneo: field keys and annotated checklist. *Monographs of the Malaysian Branch of the Royal Asiatic Society* 7: i–xii, 1–172.

Meijaard, E. & Sheil, D.
2007 Wildlife Conservation in Bornean Timber Concessions. In Petrus Gunarso, Titiek Setyawati, Terry Sunderland & Charlie

Shackleton (Eds.) *Managing Forest Resources in a Decentralized Environment: Lessons learnt from the Malinau Research Forest, East Kalimantan, Indonesia.* Technical Report for ITTO PD39/00 Rev. 3(F). Centre for International Forestry Research (CIFOR), Indonesia.

Meiri, S.
2005 Small carnivores on small islands. New data based on old skulls. *Small Carnivore Conservation* 33: 21–23.

Mohd-Azlan, J. & Sanderson, J.
2007 Geographic distribution and conservation status of the Bay Cat *Catopuma badia*, a Borneo endemic. *Oryx* 41: 394–397.

Nettelbeck, A.R.
1997 Sightings of Binturongs in the Khao Yai National Park, Thailand. *Small Carnivore Conservation* 16: 22–24.

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.

Parr, J.W.K. & Duckworth, J.W.
2007 Notes on diet, habituation and sociality of Yellow-throated Martens *Martes flavigula. Small Carnivore Conservation* 36: 27–29.

Patou, M.-L., Mclenachan, P.A., Morley, C.G., Couloux, A., Jennings, A.P. & Veron, G.
2009 Molecular phylogeny of the Herpestidae (Mammalia, Carnivora) with special emphasis on the Asian *Herpestes. Molecular Phylogenetics and Evolution* 53: 69–80.

Payne, J., Francis, C.M. & Phillips, K.
1985 *A field guide to the mammals of Borneo.* The Sabah Society with World Wildlife Fund Malaysia, Kota Kinabalu and Kuala Lumpur, Malaysia.

Rozhnov, V.V.
1994 Notes on the behaviour and ecology of the Binturong (*Arctictis binturong*) in Vietnam. *Small Carnivore Conservation* 10: 4–5.

Sarawak Forest Department
1997 *Forest Department Sarawak annual report 1997.* SFD, Kuching, Sarawak, Malaysia.

[SAMD] Southeast Asian Mammal Databank
2006 *Southeast Asian Mammal Databank.* IUCN/La Sapienza University, Rome, Italy.

Schreiber, A., Wirth, R., Riffel, M., & Van Rompaey, H.
1989 *Weasels, civets, mongooses, and their relatives: an action plan for the conservation of mustelids and viverrids.* IUCN, Gland, Switzerland.

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

Van Rompaey, H. & Azlan J.M.
2004 Hose's Civet, *Diplogale hosei. Small Carnivore Conservation* 30: 18–19.

Wells, K., Bium, A. & Gabin, M.
2005 Viverrid and herpestid observations by camera and small cage trapping in the lowland rainforests on Borneo including a record of the Hose's Civet, *Diplogale hosei. Small Carnivore Conservation* 32: 12–14.

Wild Life Protection Ordinance
1998 *Sarawak Wild Life Protection Ordinance 1998.* SFD, Kuching, Sarawak, Malaysia.

Wilson, W.L. & Johns, A.D.
1982 Diversity and abundance of selected animal species in undisturbed forest, selective logged forest and plantation in East Kalimantan, Indonesia. *Biological Conservation* 24: 205–218.

Wilting, A., Samejima, H. & Mohamed, A.
2010 Diversity of Bornean viverrids and other small carnivores in Deramakot Forest Reserve, Sabah, Malaysia. *Small Carnivore Conservation* 42.

Wong, S.T., Servheen, C.W. & Ambu, L.
2004 Home range, movement and activity patterns, and bedding sites of Malayan sun bears *Helarctos malayanus* in the Rainforest of Borneo. *Biological Conservation* 119: 169–181.

Yasuma, S.
2004 Observations of a live Hose's Civet *Diplogale hosei*. *Small Carnivore Conservation* 31: 3–5.