

Small carnivores of the Maliau Basin, Sabah, Borneo, including a new locality for Hose's Civet *Diplogale hosei*

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Abstract

The first camera-trapping study in the Maliau Basin Conservation Area of Malaysian Borneo, an area containing some of the last intact rainforest in Southeast Asia, detected 13 small mammalian carnivore species over 2,915 camera-trap-nights, including three newly recorded for the area: Banded Linsang *Prionodon linsang*, Masked Palm Civet *Paguma larvata* and Hose's Civet *Diplogale hosei*. Hose's Civet, endemic to Borneo, is one of the least known carnivore species in Southeast Asia and possibly the world. Maliau is only the fifth site where the species has been confirmed in Sabah. Camera-traps—deployed in three habitats: primary (unlogged) dipterocarp forest, logged dipterocarp forest and tropical heath (kerangas) forest—detected more small carnivore species in primary dipterocarp forest than in logged forest, despite similar sampling effort; data were too few to allow the estimation of meaningful habitat-specific detection probabilities. The Malay Civet *Viverra zibetha* was the small carnivore species detected most often overall, followed by Leopard Cat *Prionailurus bengalensis* and Banded Palm Civet *Hemigalus derbyanus*. We did not detect Malay Civet or Leopard Cat in logged forest, yet other studies suggest that they are common in disturbed areas. The paucity of records (only one) of the generally abundant Common Palm Civet *Paradoxurus hermaphroditus* is unusual. Ongoing monitoring at this and other sites across Borneo should help elucidate patterns of small carnivore distribution and richness with respect to natural and anthropogenic variation in forest characteristics.

Keywords: activity patterns, camera-trapping, dipterocarp forests, logging, tropical heath forest

Karnivor kecil di Lembangan Maliau, Sabah, Borneo, serta kawasan baru bagi Hose's Civet *Diplogale hosei*

Abstrak

Kami telah menjalankan kajian perangkap kamera yang pertama di Kawasan Konservasi Lembangan Maliau di Borneo, Malaysia, salah satu hutan hujan tropika yang belum terjejas di Asia Tenggara. Kami dapat mengesan 13 spesies karnivor mamalia kecil dalam 2,915 malam-perangkap kamera, termasuklah tiga rekod yang baru di kawasan ini, iaitu Banded Linsang *Prionodon linsang*, Masked Palm Civet *Paguma larvata* dan Hose's Civet *Diplogale hosei*. Hose's Civet ialah viverrida yang endemic di Borneo, ia merupakan satu karnivor yang paling kurang dikenali di Asia Tenggara biar pun di seluruh dunia. Lembangan Maliau merupakan lokasi yang ke-5 di mana spesies ini dijumpai/ disahkan di Sabah. Perangkap kamera telah diletakkan di tiga jenis habitat iaitu hutan dipterokarpa primer (tanpa pembalakan), hutan dipterokarpa sekunder dan hutan kerangas. Didapati lebih banyak spesies karnivora kecil dikesan di hutan dipterokarpa primer berbanding dengan hutan dipterokarpa sekunder dengan menggunakan kaedah persampelan yang sama. Data adalah tidak mencukupi untuk membuat angkaran kebarangkalian bagi pengesanan habitat khas. Pada keseluruhannya, Malay Civet *Viverra zibetha* ialah karnivora kecil yang paling kerap dikesan, diikuti oleh Leopard Cat *Prionailurus bengalensis* dan Banded Civet *Hemigalus derbyanus*. Kami tidak dapat kesan Malay Civet atau Leopard Cat di hutan sekunder, walaupun kajian lain mengatakan kedua-dua spesies ini adalah biasa dijumpai di kawasan terganggu. Jumlah rekod yang begitu jarang (hanya satu) bagi Common Palm Civet *Paradoxurus hermaphroditus* adalah luar biasa. Pemerhatian yang berterusan di kawasan ini dan lokasi yang lain di Borneo akan dapat menjelaskan corak taburan dan kekayaan bagi karnivora kecil di pelbagai jenis hutan sama ada semula jadi ataupun buatan manusia.

Kata kunci: Corak aktiviti (pergerakan), perangkap kamera, kadar pengesanan, pembalakan, kerangas

Introduction

Borneo has some of the last remaining large contiguous tracts of rainforest in Southeast Asia (Sanderson *et al.* 2002, Bradshaw *et al.* 2009). The largest island in the Sunda archipelago, Borneo was historically covered predominantly by tropical rainforest (Ashton 2010) and supported high biodiversity (e.g. Corbet & Hill 1992, Ashton 2010), with many species endemic to the island. The remaining forest cover, however, remains under continued threat; with approximately 1.7% of its forests converted annually, Borneo has one of the highest deforestation rates in the world (Koh 2007, Langer *et al.* 2007), most of which is driven by international logging interests and the commercial harvesting of exotic tree products

such as palm oil (Laurance 2007). Those forests not converted outright may be seriously degraded by other activities such as selective logging (Poffenberger 2009). Although approximately 9% of Borneo is afforded some level of protected status (IUCN categories I–IV, as defined in IUCN 1994), these protected areas are becoming increasingly isolated from each other as the forests in between are lost or degraded (Curran *et al.* 2004). Furthermore, wildlife in protected areas is still susceptible to internal threats such as mining (Hazebroek *et al.* 2004), illegal logging (Curran *et al.* 2004) and hunting (Milner-Gulland *et al.* 2003).

Borneo contains high carnivore species richness (Corbet & Hill 1992) and endemism (Schreiber *et al.* 1989). Despite this, little is known about how carnivore populations and communities

vary spatially across the island, particularly with respect to forest type and habitat characteristics. Systematic and opportunistic camera-trapping surveys have provided important information on small carnivores at a few sites such as the Sabangau peat forest in Central Kalimantan (Cheyne *et al.* 2010), Mount Kinabalu (Wells *et al.* 2005) and Deramakot Forest Reserve (Wilting *et al.* 2010a) in Sabah, and the upper Baram watershed of Sarawak (Mathai *et al.* 2010) and there remains a pressing need for similar profiles at other localities. In some instances, these photographic surveys represent the only known information on the occurrence of particular mammal species in a given area.

However, there is little published information on small carnivore communities in the few remaining forests of Borneo that have not been logged historically and that have lost no known native Holocene vertebrates. This lack of baseline data from undisturbed sites makes it difficult to assess the impact of human activities such as logging (Wells *et al.* 2005) and hunting (Milner-Gulland *et al.* 2003) on rainforest vertebrates such as carnivores. Without knowing how habitat differences naturally influence mammal community composition, it is difficult to discern the impact of human-induced landscape changes on these communities.

Moreover, nearly nothing is known of the ecology or natural history of several small carnivore species on Borneo. Among these is the Hose's Civet *Diplogale hosei*, a 'Vulnerable' viverrid (Schipper *et al.* 2008) endemic to the island. First collected on Mount Dulit in northern Sarawak in 1891, as of 2004 the animal had been collected or observed at only seven sites in Sarawak, four in Sabah and two in Brunei, with only 17 known museum specimens, all collected before 1983 (Van Rompaey & Azlan 2004). Hose's Civet has been observed from 450 to 1,700 m in elevation and is thought to be a mainly ground-dwelling species of lower montane regions in northeast Borneo (Payne *et al.* 1985, Van Rompaey & Azlan 2004). Although it is perhaps not abundant anywhere (Van Rompaey & Azlan 2004), Hose's Civet may be comparatively locally common in the Kelabit Highlands (Davis 1958) and the nearby upper Baram watershed (Mathai *et al.* 2010). Although they listed its ecology and habitat as "unknown", Payne *et al.* (1985: 286) speculated that Hose's Civet could be specialised for foraging among mossy streams and boulders, based on the presence of hair between its footpads and long whiskers on its face. Davis (1958) speculated that it primarily consumes arthropods.

Here we report on the first camera-trapping study of the Maliau Basin in Sabah, with special reference to small carnivore richness, detection rates, and activity patterns. We sampled three habitats: primary mixed dipterocarp forest, logged mixed dipterocarp forest, and primary tropical heath forest (known locally by the Iban name of 'kerangas'). Kerangas forests occur on sandy, nutrient-poor soil and are drained by dark, tannin-rich streams; average canopy height is lower and average tree trunk diameter is smaller than in other forest types. Because of their reduced productivity, kerangas forests are thought to be depauperate in many vertebrate taxa (Janzen 1974, Struebig *et al.* 2006), but little is known about which small carnivore species use these habitats. The study's primary goals are to assess the distribution, richness, habitat usage and response to anthropogenic impacts of mammals. The data presented here are from the first five months of camera-trapping in the Maliau Basin, and should be viewed as a preliminary assessment of the small carnivore community in the area.

Methods

Study site

The Maliau Basin Conservation Area (centred on 4°49'N, 116°54'E; 588 km²; Fig. 1) contains some of the last floristically and faunally intact forest in all Southeast Asia. The protected area spans the basin itself and a surrounding buffer zone; it was nominated as a World Heritage Site in 2003. It is possible that the interior of the Maliau Basin itself (about 400 km²) was never occupied by humanity: there are few records of people in the area before the 1980s (Hazebroek *et al.* 2004). The basin consists of lowland and hill rainforest surrounded by a circle of sedimentary mountains up to 1,700 m altitude. Estimated annual precipitation in the region is approximately 3,800 mm (Mykura 1989). The area is drained by many streams that converge into the Maliau river. The rim and interior of the basin contain a mixture of primary dipterocarp forest and kerangas forest. The surrounding mountains contain highland kerangas and casuarina forests. The 'southern plateau', a topographically undulating area on the southern rim of the basin, contains mid-elevation (about 1,000–1,200 m) kerangas forest with thick moss and abundant carnivorous pitcher plants *Nepenthes*. Outside the basin itself, but still within the Conservation Area, are large tracts of dipterocarp forest selectively logged in the early-mid 1990s (H. Tangki verbally 2011). The logged forests seen during the present survey have much reduced forest canopy cover, a thick understorey of grasses, forbs and ferns, and abundant herbaceous vines covering many of the trees.

Initial observational surveys of fauna within the basin recorded a high richness of vertebrate species (Hazebroek *et al.* 2004). These surveys were conducted by zoologists and ecologists affiliated with the Universiti Malaysia Sabah (UMS) in Kota Kinabalu. However, the methods for species identification on these surveys have not been clearly specified, so their species lists

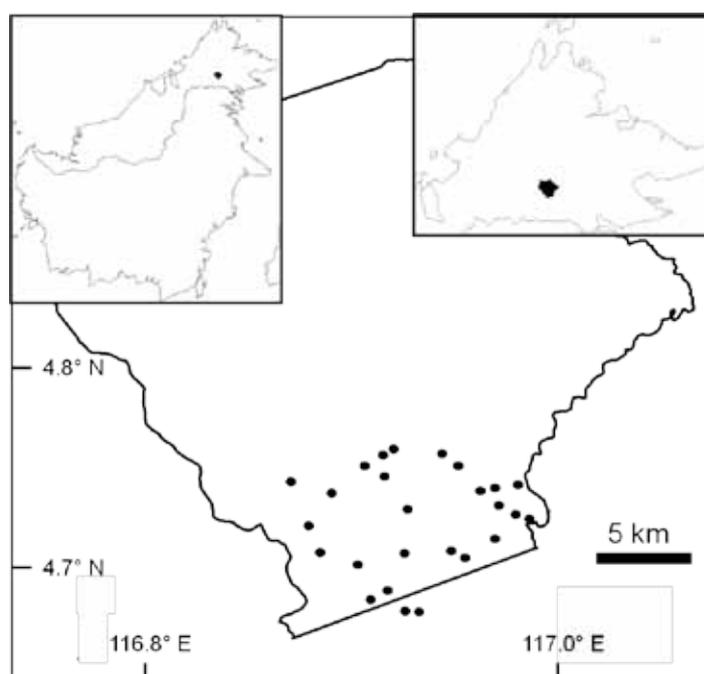


Fig. 1. The Maliau Basin Conservation Area study area, showing camera station locations (dots), location of the area within Sabah (upper right insert), and location of the area within Borneo (upper left insert).

must be viewed as preliminary. Maliau Basin is one of the last three places in Malaysian Borneo (the others being Danum Valley Conservation Area and Tabin Wildlife Reserve; A. Hearn and J. Ross *in litt.* 2011) that still have Asian Elephant *Elephas maximus*, Banteng *Bos javanicus*, Bornean Orang-utan *Pongo pygmaeus*, and recent (< 10 year old) records of Sumatran Rhinoceros *Dicerorhinus sumatrensis*.

The previous UMS surveys in Maliau Basin reported the following small carnivores: Yellow-throated Marten *Martes flavigula*, Malay Weasel *Mustela nudipes*, Sunda Stink-badger *Mydaus javanicus*, Smooth-coated Otter *Lutrogale perspicillata*, Oriental Small-clawed Otter *Aonyx cinereus*, Malay Civet *Viverra zangalla*, Binturong *Arctictis binturong*, Small-toothed Palm Civet *Arctogalidia trivirgata*, Common Palm Civet *Paradoxurus hermaphroditus*, Banded Palm Civet *Hemigalus derbyanus*, Collared Mongoose *Herpestes semitorquatus*, Short-tailed Mongoose *H. brachyurus*, Marbled Cat *Pardofelis marmorata*, Flat-headed Cat *Prionailurus planiceps* and Leopard Cat *P. bengalensis* (Hazebroek *et al.* 2004). As noted, these records should be viewed as preliminary. In addition, the expeditions reported an “unconfirmed” record of Bay Cat *Pardofelis badia* (Hazebroek *et al.* 2004: 191). Following Mathai *et al.* (2010), term ‘small carnivores’ includes all Bornean Carnivora except the Sunda Clouded Leopard *Neofelis diardi* and Sun Bear *Helarctos malayanus*.

Field methods and data analysis

We established 26 camera-trap stations in the Maliau Basin Conservation Area in January 2010. These stations included areas in logged forest outside the basin (but still inside or immediately adjacent to the Conservation Area; 11 sites), in adjacent primary dipterocarp forest on the south-facing flank of the southern rim of the basin (i.e. outside the basin itself), inside the basin and near the rim (12 primary dipterocarp sites total), and in kerangas forest on the southern plateau (three sites; Fig. 1). Stations were generally positioned 1–2 km apart and were set up over potential travel routes for carnivores such as wildlife trails (particularly along ridge tops), human footpaths, abandoned logging roads and streambeds. Stations spanned a recorded elevational gradient of 901 m across all habitat types (Table 1).

Each station had two Reconyx™ RM45 digital camera-traps facing each other on opposite sides of the trail, path, or streambed, attached to tree trunks an average of ~80 cm above the ground, but angled slightly downward. Cameras were powered by six 3000mAh NiMH C-cell batteries. Camera trigger sensitivity was set to ‘high’ and each unit was set to take three photographs in rapid-fire succession upon being triggered. Cameras were set to trigger through the 24-hour cycle; no baits or lures were used. All units held 1–2 GB memory cards capable of storing 7,000–15,000 images per card. All memory cards were retrieved from camera units in May 2010.

Separate detections of a given species at a particular site were photographs that occurred >1 hour apart; the 1 hour threshold is arbitrary. We present two crude indicators of species occurrence: (1) species- and habitat-specific detection rates as the number of detections per 100 trap-nights, and (2) the number of camera-trap stations at which each species was recorded. Camera-trap-nights are defined as the product of the total number of camera-trap stations operating over a given area, and the total number of nights over which they were operating. The preliminary analyses here do not attempt to estimate or correct for detection probability.

Table 1. Characteristics of the camera-trap stations, Maliau Basin, Sabah, Malaysia.

Station	Forest type (elevation in m)	Number of trap-nights
01	Primary dipterocarp (340)	126
02	Logged dipterocarp (290)	128
03	Logged dipterocarp (300)	95
04	Logged dipterocarp (230)	98
05	Primary dipterocarp (210)	(destroyed by flood)
06	Primary dipterocarp (540)	126
07	Primary dipterocarp (400)	126
08	Logged dipterocarp (590)	89
09	Logged dipterocarp (610)	124
10	Logged dipterocarp (420)	119
11	Logged dipterocarp (350)	126
12	Logged dipterocarp (240)	81
13	Primary dipterocarp (590)	126
14	Kerangas (1030)	126
15	Kerangas (1080)	125
16	Kerangas (1060)	125
17	Primary dipterocarp* (1120)	125
18	Logged dipterocarp (280)	107
19	Logged dipterocarp (360)	101
20	Primary dipterocarp (620)	124
21	Primary dipterocarp (900)	124
22	Primary dipterocarp (730)	125
23	Primary dipterocarp (890)	123
24	Primary dipterocarp (780)	123
25	Primary dipterocarp (870)	123
26	Logged dipterocarp (290)	100

*Very near ecotone with kerangas forest.

Elevation was measured with a barometric altimeter built into a Garmin GPSMAP® 60CSx.

In several instances (see below) we sought independent verification of the identification of animals in photographs.

Results

From January to May 2010 we accumulated 2,915 trap-nights across our entire study region: 1,371 trap-nights (at 11 sites) in primary dipterocarp forest, 1,168 trap-nights (11 sites) in logged dipterocarp forest, and 376 trap-nights (three sites) in kerangas forest. At one camera station (in primary dipterocarp forest), both cameras were destroyed by flooding. Cameras at several other stations had batteries fail before May 2010, although no station had fewer than 81 trap nights (Table 1). This sampling effort obtained 88 detections of small carnivores in the MBCA (Table 2). Station 17, at 1,115 m elevation in primary dipterocarp forest but near an ecotone with kerangas forest, recorded the highest number of species (seven). The small carnivore species with the highest independent detections were the Malay Civet, Leopard Cat, Banded Palm Civet and mongooses *Herpestes* (Table 1; Fig. 2). Detections of both Collared Mongoose *H. semitorquatus* and Short-tailed Mongoose *H. brachyurus* were confirmed from some photos, but in some photos it was impossible to distinguish between the two.

The Malay Civet, Leopard Cat and Banded Palm Civet appeared to be predominantly nocturnal and crepuscular, while

Table 2. Number of small carnivore detections >1 hour apart at different camera-trap stations. Station characteristics are given in Table 1. Scientific names for species are given in the main text. We did not distinguish between the two species of mongoose (*Herpestes collaris* and *H. semitorquatus*).

Species/Station	01	02	03	04	06	14	17	18	19	20	21	22	23	24	25	26
Leopard Cat						1						1	6	1	11	
Flat-headed Cat														1		
Marbled Cat							1			1		1				
Banded Linsang						1	2									
Binturong								1								1*
Malay Civet							2			1	1		14	5	3	
Common Palm Civet		1														
Masked Palm Civet							1							1		
Banded Palm Civet	4			1			1	1	2		1	1	1	5		1
Hose's Civet							3									
Mongoose			1	1	1		3		1		1	1				
Yellow-throated Marten		1														

*Photographic sequence contained three individuals, an adult and two young.

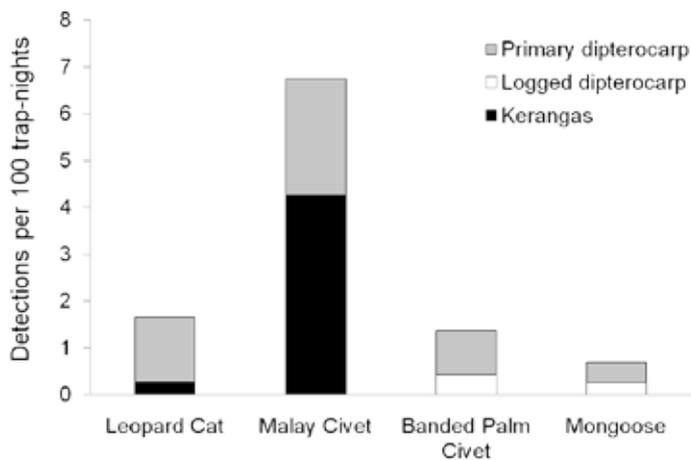


Fig. 2. Number of detections >1 hour apart for the four most commonly detected small carnivores. We did not distinguish the two species of mongoose (*Herpestes collaris* and *H. semitorquatus*).

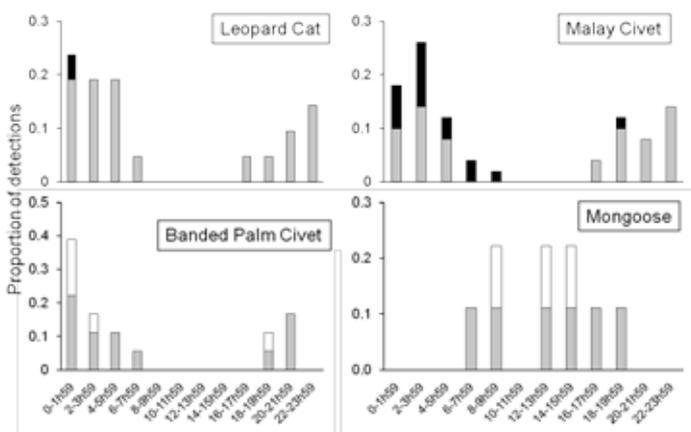


Fig. 3. Detection times of the four most commonly detected small carnivores in primary dipterocarp forest (grey bars), logged dipterocarp forest (white bars) and kerangas forest (black bars). We did not distinguish the two species of mongoose (*Herpestes collaris* and *H. semitorquatus*). Typical sunrise and sunset times were 6h20 and 18h20, respectively.



Fig. 4. Hose's Civet *Diplogale hosei*, in primary mixed dipterocarp near an ecotone with kerangas forest; 20h41 on 26 April 2010; elevation = 1,115 m.

mongoose were more diurnal (Fig. 3). We lacked the statistical power to assess whether activity patterns differed significantly among forest types. Hose's Civet was detected on three occasions (at 03h58, 19h41 and 20h41) at the same site (station 17) near the primary dipterocarp–kerangas ecotone (Fig. 4). Hose's Civet identifications were confirmed independently by Siew Te Wong, Joanna Ross, Andrew Hearn and Ch'ien Lee. The one Flat-headed Cat identification was confirmed by Jim Sanderson. Mongoose identification was assisted by Will Duckworth, Mohamed Azlan and Andreas Wilting.

Discussion

We are actively studying the mammal communities of the Maliau Basin, and report here the first assessments of small carnivore richness, habitat use, and activity patterns in the area. Since the Maliau Basin has some of the last floristically and faunally near-intact (i.e. unlogged and only lightly hunted) rainforest in all Southeast Asia, these data could provide useful baseline information with which to compare other sites.

The different forest types seem, based on the preliminary results here, likely to hold somewhat different small carnivore

representation. We detected more species in primary dipterocarp forest than logged dipterocarp forest, despite having only a slightly higher trapping effort in the former. Explicit correction for potential differences in detectability between habitats is planned for subsequent analyses. We did not detect Leopard Cat or Malay Civet in the logged forest, despite evidence from other sites that they are common in disturbed habitat (e.g. Lim 1999, Colón 2002, Azlan & Sharma 2006). Our ongoing research should eventually allow us to assess quantitatively the impacts on small carnivores as additional records increase sample sizes for statistical analysis.

Several records could help illuminate the natural history of little-known Bornean small carnivores. The sole Flat-headed Cat record (at 17h42) was from 782 m, whereas most records for this species come from below 100 m (Wilting *et al.* 2010b). Banded Palm Civet was detected much more often than Common Palm Civet (the latter only once; 20h57), contrasting with other sites (e.g. Wilting *et al.* 2010a).

Some other preliminary results corroborate previous studies (e.g. Mathai *et al.* 2010, Wilting *et al.* 2010a) that demonstrate a relative paucity of Malay Weasel, Banded Linsang, and Binturong records from camera-trapping. We detected Banded Linsang (03h51, 04h11 and 18h58) and Binturong (11h52 and 23h19) at only two sites each, although one photographic sequence of Binturong (station 26 in secondary forest) included three individuals: an adult and two young coming down to a small stream to drink.

One site (station 17) stood out as particularly rich in small carnivore species with seven species detected. It was in primary dipterocarp but very near the expansive kerangas forest on the Southern Plateau. Habitat heterogeneity near this boundary may at least be partially responsible for the high species richness observed. Also, this station was very near the southern rim of the basin, and animal movement may have been constrained by adjacent steep topography. This was also the highest camera-trap location (1,115 m); mid-elevation peaks in species richness have been observed in a variety of taxa, for example birds (McCain 2009), plants (Bachman *et al.* 2004, Grytnes & Beaman 2006), herpetofauna (Fu *et al.* 2006, McCain 2010) and small mammals (Rowe & Lidgard 2009).

With these additional species records presented here, few Bornean carnivores remain to be found in the Maliau Basin. Assuming that the UMS survey records, including the unconfirmed report of a Bay Cat, are valid, the only Bornean carnivores still unrecorded from the basin are the Otter Civet *Cynogale bennettii*, Bornean Ferret Badger *Melogale everetti* and Hairy-nosed Otter *Lutra sumatrana*. Other potentially unconfirmed species include the Eurasian Otter *Lutra lutra*, if it even occurs in Borneo (which is considered unlikely; Sivasothi & Nor 1994) and Hose's Mongoose *Herpestes hosei*, only doubtfully a distinct species, (see Corbet & Hill 1992, Patou *et al.* 2009). This high species richness of small carnivore species in the Maliau Basin of northern Borneo highlights the importance of this site, as well as other little-disturbed rainforest ecosystems, for rainforest mammal conservation.

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