

# Small Carnivores of the Lower Kinabatangan Wildlife Sanctuary, Sabah, Borneo, including a new locality for the Otter Civet *Cynogale bennettii*

Meaghan N. EVANS<sup>1,2</sup>, Stephen H. VICKERS<sup>2</sup>, Mohd Soffian ABU-BAKAR<sup>3</sup> & Benoit GOOSSENS<sup>1,2,3,4</sup>

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<sup>1</sup> Danau Girang Field Centre, c/o Sabah Wildlife Department, Wisma Muis, Block B, 5th Floor, 88100 Kota Kinabalu, Sabah, Malaysia.

<sup>2</sup> Organisms and Environment Division, Cardiff School of Biosciences, Cardiff University, Sir Martin Evans Building, Museum Avenue, Cardiff, CF10 3AX, UK.

<sup>3</sup> Sabah Wildlife Department, Wisma Muis, Block B, 5th Floor, 88100 Kota Kinabalu, Sabah, Malaysia.

<sup>4</sup> Sustainable Places Research Institute, Cardiff University, 33 Park Place, Cardiff CF10 3BA, UK..

## Correspondence:

Meaghan N. Evans  
harrismn24@gmail.com

## Associate editor:

Jan Schipper

## Abstract.

The tropical rainforest biodiversity of Sabah, Borneo is threatened by large-scale agricultural development, logging, and increasing hunting pressures. From 2010–2015, an extensive camera-trapping study in the Lower Kinabatangan Wildlife Sanctuary (LKWS) monitored wildlife utilisation of a lowland riparian forest corridor. This effort, culminating in nearly 600,000 images, was the longest running camera-trapping study in the Sanctuary, and documented 11 small carnivore species over 24,506 trap nights. The Malay Civet *Viverra zibellina* was the most frequently detected species, followed by the Malay Badger *Mydaus javanensis* and the Common Palm Civet *Paradoxurus hermaphroditus*. The survey also collected the first photographic record of an Otter Civet *Cynogale bennettii* in the LKWS, which represents a new locality for this little-known Southeast Asian species. Opportunistic sightings of five additional species, including the Endangered Flat-headed Cat *Prionailurus planiceps*, increased the total count of small carnivores persisting in the LKWS to 16. Given the highly degraded and fragmented status of the LKWS, this study highlights the importance of riparian lowland forest fragments in sustaining carnivore diversity, and also emphasizes the importance of continued, long-term monitoring efforts.

**Keywords:** Viverridae, Mustelidae, fragmented lowland rainforest, camera-trapping, Borneo, palm oil plantation

## Introduction

Habitat destruction and degradation by the anthropogenic conversion of natural ecosystems is currently the leading threat to global biodiversity (Schipper *et al.* 2008, Crooks *et al.* 2011). Agricultural development alone has resulted in the destruction of over 400 million hectares of tropical forests between 1995 and 2007, and currently threatens at least 40% of all terrestrial vertebrates (Visconti *et al.* 2011). With burgeoning human populations and rising global food demand, the maintenance of biodiversity in increasingly human-dominated landscapes will require specific knowledge of species' ecological responses to fragmented habitats.

The Southeast Asian island of Borneo is undergoing one of the highest rates of deforestation in the world, and is projected to lose an estimated 75% of its remaining native landscapes within the century if land conversion practices persist (Sodhi *et al.* 2004, Rautner *et al.* 2005). The main drivers of the forest loss and fragmentation are the expansions of agricultural oil palm (*Elaeis guineensis*) and logging industries, which are considered the greatest threats to Southeast Asian biodiversity (Wilcove & Koh 2010). Coincidentally, the region is identified as a global ‘biodiversity hotspot’ given the extraordinarily high numbers of endemic species paired with the highest global proportion of threatened species, excluding amphibians, of any region (Myers *et al.* 2000, Brooks *et al.* 2002, Sodhi *et al.* 2010).

In the face of these pressures, Borneo’s tropical forests continue to sustain a high diversity of carnivore species (Corbet & Hill 1992). Eight civet species (Viverridae), five cat species (Felidae), one linsang (Prionodontidae), one bear (Ursidae), two mongooses (Herpestidae) and seven confirmed mustelid species have been documented across the island (IUCN 2015). The ecological importance of small carnivore species is well known, with the guild acting as regulatory predators, seed dispersers, and model species for landscape-level conservation research (Colón 2002, Mudappa *et al.* 2007,; Nakashima *et al.* 2010). Borneo has therefore been highlighted as a critically important priority region for small carnivore conservation (Schreiber *et al.* 1989).

As is the case with many small carnivores, there exists a substantial paucity of information regarding even basic ecological parameters of Bornean species (Schipper *et al.* 2008). However, opportunistic sightings (Boonratana & Sharma 1997, Bennett 2014), a handful of targeted research projects (Colón 2002, Nakashima *et al.* 2013) and a growing number of systematic camera-trapping surveys (*e.g.*, Wells *et al.* 2004, Belden *et al.* 2007, Cheyne *et al.* 2010, Mathai *et al.* 2010, Wilting *et al.* 2010a, Brodie & Giordano 2011, Matsubayashi *et al.* 2011) have begun to fill in the information gaps concerning the guild. Attempts at modelling species distributions at a coarse geographic scale are developing (*e.g.* Jennings & Veron 2011, Cheyne *et al.* in prep, Samejima *et al.* in prep), but progress is slow and based on accurate species presence records, data that are still being accumulated in many regions.

Therefore, this study aimed to provide an inventory of the small carnivore species persisting in a highly fragmented lowland tropical forest in Sabah, Malaysian Borneo. Here, the results from both opportunistic sightings and the first systematic and longest-running camera trapping survey of the Lower Kinabatangan Wildlife Sanctuary in eastern Sabah are reported.

## Materials and methods

### *Study areas*

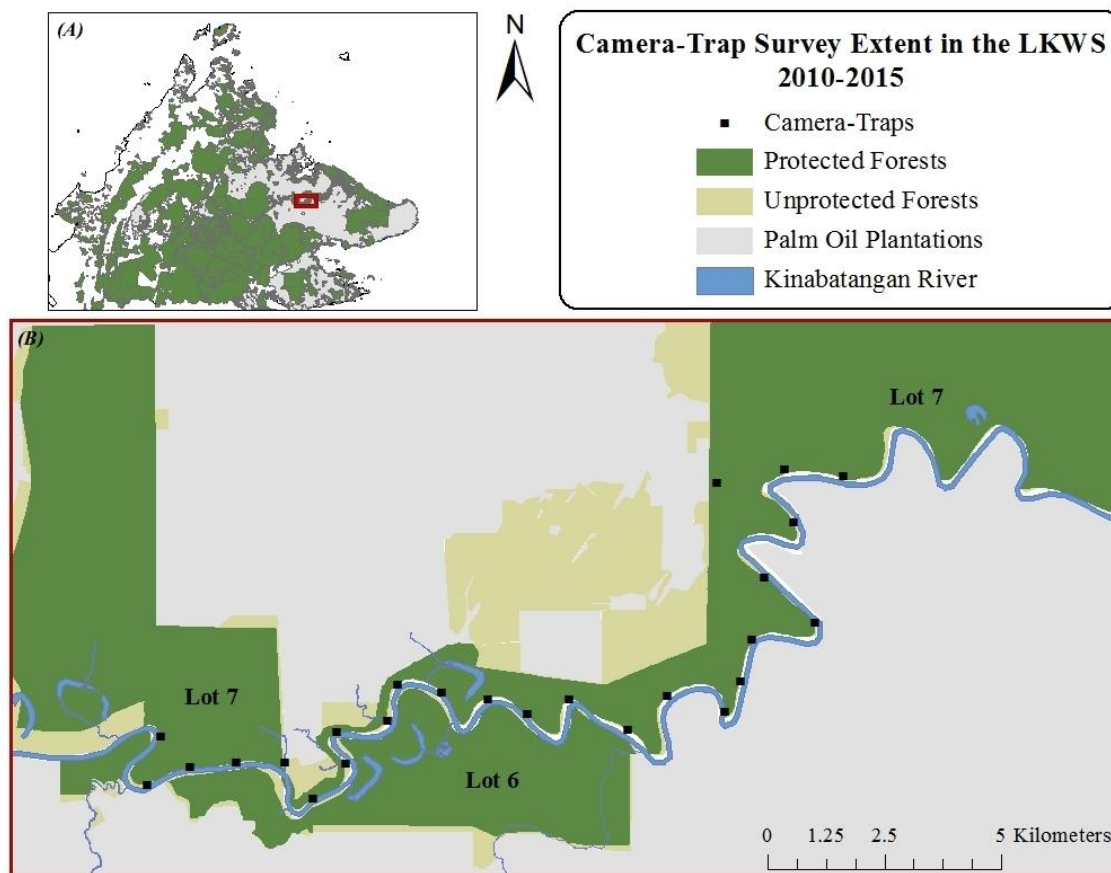
The study was conducted within the Lower Kinabatangan Floodplain (approximate range 5°18'N to 5°24'N and 117°54'E to 118°33'E) in eastern Sabah, Malaysian Borneo. The Kinabatangan River is the longest river in Borneo and sustains some of the richest fisheries in the state (Hai *et al.* 2001, Röper *et al.* 2014). The climate of the area is considered humid tropical, with temperatures ranging from 21°–34° C (Ancrenaz *et al.* 2004). Mean annual rainfall measures 3,000 mm, with wetter months occurring between October–May (Estes *et al.* 2012). The floodplain is subject to intermittent flooding events of varying severity and occasional drought (Estes *et al.* 2012). Nearly 50% of the floodplain has been converted to oil palm plantations, and patches of both private and protected secondary riverine forest persist within the agricultural matrix (Abram *et al.* 2014).

The camera-trapping survey occurred in the riparian lowland forests of the Lower Kinabatangan Wildlife Sanctuary (LKWS), a 279 km<sup>2</sup> area of degraded habitat flanking the Kinabatangan River surrounded by large oil palm plantation estates. Comprised of 10 lots of varying degrees of disturbance history and isolation, the sanctuary is connected to seven additional fragments of Virgin Forest Reserves, managed by the Sabah Forestry Department, increasing the size of protected area to 450 km<sup>2</sup> (Ancrenaz *et al.* 2004, Goossens *et al.* 2005). The sanctuary contains a mixture of dry lowland, semi-inundated, and swamp forests interspersed with small grasslands (Abram *et al.* 2014). Despite the extensive anthropogenic habitat fragmentation, the LKWS supports many endemic Bornean species (Goossens *et al.* 2005, Sha *et al.* 2008, Goossens *et al.* 2016), and serves as the sole forest corridor bridging the coastal mangroves to the east and the large continuous tracts of rainforest in central Sabah.

### *Camera-trapping*

Camera traps were deployed within the LKWS from 12 November 2010 through 9 May 2015. Active camera trap sites varied from nine to 25 stations throughout this period due to logistical constraints (*i.e.*, wildlife damage, theft, battery failure). Sites were stationed at least 1 km apart within the thin (~100–1200 m) forest corridor of the LKWS Lots 5 and 7, forest blocks on the north bank of the river (Figure 1). At each site, one or two Reconyx HyperFire Professional Infrared (IR) passive camera traps (Model HC500 or PC800, Reconyx, Holmen, USA) were deployed and protected by armour casing. Traps were tree-mounted and set 0.5 m from the forest floor on naturally occurring riverine trails. Once cameras detected a moving heat source, a series of three photos at 1-second intervals were recorded. In lowlight conditions, an IR flash was triggered to illuminate the subject while minimizing animal disturbance. When two cameras were mounted at a site, units were placed facing each other but slightly offset to avoid night-time image washout from the

opposing camera's IR flash. Sites were checked biweekly or monthly, based on battery performance, and riverine trails were cleared of excess foliage to reduce camera misfires.



**Figure 1.** Map of camera-trap survey stations within Lots 5 and 7 in the Lower Kinabatangan Wildlife Sanctuary from 2010—2015.

### *Data handling*

Once SD cards were collected, metadata were extracted from the images using ExifTool 9.6.8.0. Each photo was individually examined for the presence of an animal and, if a confident identification could be recorded, was classified based on the species present. If no positive identification could be made, the photo was excluded from future analyses. Each burst of three images was considered a single capture. Captures were then further grouped into unique events, whereby photos of the same species >30 minutes apart were classified as independent events, per Yasuda & Tsuyuki (2012), in order to avoid pseudoreplication. Survey effort was quantified by calculating total potential camera-trap nights (active calendar nights x number of active camera-traps).

## Results

Throughout the 48 non-consecutive month survey, camera-traps accumulated 24,506 total potential trap nights and captured a total of 596,240 images. Of these, 419,528 photos recorded the presence of wildlife, with the remaining images consisting of humans or false trigger events. Species could not be identified in 1,254 images, and as such, were excluded from analyses.

Overall, 13 species of Bornean Carnivora were detected in 21,715 images across 2,327 unique events. This count includes multiple captures of the Sunda Clouded Leopard *Neofelis diardi* and the Malayan Sun Bear *Helarctos malayanus*, which, per Mathai *et al.* (2011), are excluded from these results. After the removal of these species, 11 small carnivore species were detected in 2,030 unique capture events throughout the survey (Table 1). Small carnivores detected on the camera traps comprised of five Viverridae species, one Prionodontidae species, three Mustelidae species, one Felidae species, and either one or two Herpestidae species. In most cases, low photo quality made distinguishing between the Bornean mongooses (Collared Mongoose *Herpestes semitorquatus* and the Short-tailed Mongoose *Herpestes brachyurus*) difficult, and as such we did not differentiate between the two in this survey.

**Table 1.** Small carnivore results from November 2010—May 2015 camera-trapping survey within Lots 5 and 7 of the Lower Kinabatangan Wildlife Sanctuary.

Species	Scientific name	No. of Capture events	No. of camera-trap stations detected	No. of trap nights until first detection	2015 IUCN Red List Status
Malay Civet	<i>Viverra zangalunga</i>	1,108	24	21	Least Concern
Common Palm Civet	<i>Paradoxurus hermaphroditus</i>	179	20	21	Least Concern
Banded Palm Civet	<i>Hemigalus derbyanus</i>	62	12	208	Vulnerable
Otter Civet	<i>Cynogale bennettii</i>	1	1	208	Endangered
Binturong	<i>Arctictis binturong</i>	2	1	19,321	Vulnerable
Banded Linsang	<i>Prionodon linsang</i>	1	1	12,211	Least Concern
Malay Badger	<i>Mydaus javanensis</i>	470	18	188	Least Concern
Smooth-coated Otter	<i>Lutrogale perspicillata</i>	140	12	166	Vulnerable
Yellow-throated Marten	<i>Martes flavigula</i>	11	6	565	Least Concern
Mongoose sp.	<i>Herpestes</i> sp.	28	11	628	Least Concern
Leopard Cat	<i>Prionailurus bengalensis</i>	28	11	48	Least Concern

The greatest abundance of captures occurred for Malay Civets, followed by the Malay Badger and the Common Palm Civet, all of which were documented across the greatest number of camera-trap stations. Only a handful of unique capture events were recorded for the Binturong, Banded Linsang and Otter Civet, and each were documented at one station only. Seven of these photo-captured species are listed as Least Concern, three as Vulnerable, and one as Endangered on the IUCN Red List (IUCN 2015).

Of special note, the first reported camera-trap image of the Endangered Otter Civet in the LKWS was taken on 27 November 2010 at 04h58 (5°25'N, 118° 04'E; Figure 2).

The camera-trap station was located in Lot 5 of the LKWS approximately 50 m from the riverbank and 530 m from the nearest oil palm plantation.



**Figure 2.** Camera-trap photo of an Otter Civet *Cynogale bennettii* within Lot 5 of the Lower Kinabatangan Wildlife Sanctuary (DGFC/SWD).

### *Opportunistic Sightings*

Additionally, five small carnivore species were opportunistically sighted but not recorded on camera-traps, raising the total number of documented species to 16. Multiple records of the Small-toothed Palm Civet *Arctogalidia trivirgata* were reported throughout the LKWS (Figure 3A). The Malay Weasel *Mustela nudipes* was documented in several unique events within Lot 6 of the LKWS. The Endangered Flat-headed Cat *Prionailurus planiceps* was sighted and photographed by researchers along both sides of the riverbanks on multiple occasions (Figure 3B). The Asian Small-clawed Otter *Aonyx cinereus* was documented on a separate research camera-trap in the study area, and signs of the species have been recorded along the oxbow lakes in the LKWS (Evans unpublished data). A single non-related camera-trap recorded the presence of a Marbled Cat *Pardofelis marmorata* at the eastern edge of this study's survey extent. Lastly, in addition to the camera-trap photo of the Otter Civet, opportunistic sightings were made within Lot 6 of the LKWS in three separate occurrences. In the early evening of 25 July 2013, a solitary individual was documented close to an oxbow lake in close proximity to Danau Girang Field Centre (~5°24'N, 118°02'E). In mid-August 2013, an individual was seen crossing the concrete main path of the Field Centre (~5°25'N, 118°02'E). Lastly, on 8 February 2015, several research assistants observed an adult Otter Civet accompanied by two offspring once again crossing the concrete path, confirming the presence of a breeding unit of *C. bennettii* in the area.



**Figure 3.** Photos of (A) a Small-toothed Palm Civet *Arctogalidia trivirgata* and (B) Flat-headed Cat *Prionailurus planiceps* imaged within Lot 6 of the Lower Kinabatangan Wildlife Sanctuary by researcher S. H. Vickers on 7 June 2015 at 20h12 and 6 May 2015, 21h47.

## Discussion

The results from this long-term monitoring survey of small carnivores within a degraded and fragmented riverine habitat demonstrate the importance of the Lower Kinabatangan Wildlife Sanctuary for small carnivore persistence. Overall, the sanctuary appears to support species diversity comparable to less disturbed forests throughout Borneo, with generalist species such as the Malay Civet and the Common Palm Civet documented routinely (e.g. Belden *et al.* 2007, Wilting *et al.* 2010a, Brodie & Giordani 2011, Mathai *et al.* 2010, Matsubayashi *et al.* 2011). Species with low capture rates are those species displaying behavioural traits nonconductive to capture by trail-based camera-traps, such as the arboreal Binturong (Wilting *et al.* 2010a) or the dense understory-preferring Banded Linsang (Cheyne *et al.* 2010). It is of interest, however, to note the relatively low number of photographic capture events of Leopard Cats, given that many authors suggest the species may thrive in disturbed areas, especially in regions containing oil palm plantations (Azlan & Sharma 2006, Rajaratnam *et al.* 2007, Jennings *et al.* 2015).

The importance of supporting camera-trapping surveys with researcher presence within a study area is highlighted by the results of this survey, as five additional species would have been otherwise undocumented. The Small-toothed Palm Civet is highly arboreal, making terrestrial detection improbable (Walston & Duckworth 2003), while Asian Small-clawed Otters and Flat-headed Cats reside in close proximity to shallow pools and tributaries, areas not targeted by this survey (Wilting *et al.* 2010b, Hussain *et al.* 2011). It has been suggested that historically low photographic detection rates of Malay Weasels might be attributable to a behavioural preference of hunting in dense undergrowth (Duckworth *et al.* 2006, Ross *et al.* 2013). When attempting to document the carnivore species within an area, species' specific behavioural ecology should be taken into consideration during survey design and planning (Sunarto *et al.* 2013).

Of the remaining Bornean Carnivora species, five species were neither photographed nor observed throughout the five-year monitoring survey of the LKWS. Neither the Masked Palm Civet *Paguma larvata* nor the Hose's Civet *Diplogale hosei* were detected, results not entirely surprising, as it has been suggested these species do not occur in lowland forests (Wilting *et al.* 2010a, Matsubayashi *et al.* 2011). Neither the Hairy-nosed Otter *Lutra sumatrana* nor the Bay Cat *Catopuma badia* were detected in the lower floodplains, despite both being documented in Deramakot Forest Reserve within the Kinabatangan, approximately 75 km upriver from the current survey site (Mohamed *et al.* 2009, Wilting *et al.* 2010a). Finally, despite apparent observations of the Bornean Ferret Badger *Melogale everetti* approximately 45 km downriver from this study area in the early 1990's (Boonratana 2010), this survey did not detect the species during over four years of monitoring.

This study confirms a new locality for the Endangered Otter Civet, an elusive and significantly understudied Southeast Asian civet species (Veron *et al.* 2006). This nocturnal animal is believed to reside in swampy areas and lowland primary forest streams, although some observations have been made in secondary forests (Heydon & Ghaffar 1997, Veron *et al.* 2006, Cheyne *et al.* in prep). However, this documentation of *C. bennettii* in a significantly degraded and fragmented environment suggests that the species may persist in a broader range of habitats than originally believed. Alternatively, the presence of a breeding unit could suggest the LKWS forest patches are of sufficient ecological health to act as species reservoirs, offsetting the immediate detriments to species residing in close proximity to oil palm plantations. These preliminary records demand more targeted research efforts to determine the population status of *C. bennettii* within the floodplain. Regardless, the confirmed presence of this incredibly rare species in the LKWS strikes a strong case for the importance of these forest lots, and should play a substantial role in spearheading the extension of legal protective measures to the 30,173 ha of unprotected forests persisting within the floodplain (Abram *et al.* 2014).

Although these preliminary results demonstrating the presence of both common and rare small carnivores in the LKWS are undoubtedly positive, this inventory itself should be taken with caution, as several of these occurrences were marked by a single photo across over four years of continuous monitoring. Species residing in fragmented habitats are faced with a multitude of threats and survival pressures (Laurance 2008, Gerber *et al.* 2012), such that it is possible the LKWS small carnivore guild is not yet at equilibrium. Specifically, the authors would like to emphasize the threat of increased illegal hunting activities, which are exacerbated in habitat fragments due to the relative ease of accessing the forest (Cullen *et al.* 2000, Milner-Gulland *et al.* 2003). Throughout this survey period, multiple photos documented illegal encroachment and evidence of hunting within the LKWS. In order to preserve the tenuously rich biodiversity persisting in the protected regions, significant effort must be invested to curb these illegal activities (Shepherd & Shepherd 2010). In face



of these threats, more detailed and rigorous population and density estimates for the small carnivores from this region are required, which will, in turn, provide researchers a greater understanding of the conservation importance of degraded and fragmented riverine habitats. It is suggested that research efforts pair survey transects with both trail-based and arboreal camera trapping efforts, as by Oliveira-Santos *et al.* (2008), to maximize the probability of cataloguing all potential small carnivore species, regardless of behavioural traits. As the agricultural sector continues to expand and pristine rainforests are encroached upon all over the globe, it will be critical for the conservation community to understand the mechanisms by which forest fragments may benefit biodiversity.

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