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Habitat use of Bornean Ferret Badger *Melogale everetti* in Sabah, Malaysian Borneo

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Abstract.

Bornean Ferret Badger *Melogale everetti* is endemic to the uplands of the Mount Kinabalu and the Crocker Range, Sabah, north Borneo; it is currently categorized as Endangered on The IUCN Red List of Threatened Species. No systematic survey has been conducted and its ecology is largely unknown. To better understand the ecology of Bornean Ferret Badger and the influences of human impacts on the species, a targeted camera-trap survey was conducted. Camera-traps were set up in an area between Crocker Range Park and Tenompok Forest Reserve, along a ridge connecting Mount Kinabalu with the Crocker Range. This area is inhabited by local people and includes old-growth forests, secondary forests and slash-and-burn fields. A total of 112 images of Bornean Ferret Badger were obtained from old-growth forests and from slash-and-burn fields, but none from secondary forests. The encounter rate for this species was not significantly different between old-growth forests and slash-and-burn fields and highest among the 10 wild carnivores recorded in the survey area. The elevation range of the camera-trap records was 990–1440 m. These findings indicate that the habitat of Bornean Ferret Badger in this landscape includes slash-and-burn fields and old-growth forests. However, its population trends must be carefully monitored; the camera-traps often detected Domestic Dogs *Canis familiaris*, which could be a major threat to this species, both within and outside the protected area.

Keywords: Bornean Ferret Badger, camera-trap, Crocker Range Park, Kinabalu Park, slash-and-burn field.

Introduction

Bornean Ferret Badger *Melogale everetti* is one of the least known small carnivores in the world. All that is known for certainty is that it is endemic to the island of Borneo and that it has an extremely restricted distribution range within the island. Reliable records after the 1970s are limited to the uplands and highlands around Mount Kinabalu (Payne *et al.* 1985, Dinets 2003) and Crocker Range Park (Wong *et al.* 2011) in northern Borneo. The species' distribution range is estimated to be around 4,200 km² (Wilting *et al.* 2015).

Reflecting this extremely restricted distribution range, Bornean Ferret Badger is currently classified as Endangered in The IUCN Red List of Threatened Species (Wilting *et al.* 2015). However, its actual population status and major threats have not been systematically evaluated so far.

Although Bornean Ferret Badger could be threatened by multiple factors, including climate change and hunting, one of the main threats could be habitat degradation (Struebig *et al.* 2015). The montane forest within Kinabalu Park and Crocker Range Park is relatively well-protected from human activities, however, the habitat outside the parks has been converted into slash-and-burn agriculture by local people. Given that this species might occur at low densities even within protected areas (Wilting *et al.* 2015) and thus total population size within the parks could be small, the species' population viability may be largely dependent on habitat suitability outside the parks. Furthermore, the montane forest of Kinabalu Park and Crocker Range Park is not continuous and is separated by unprotected and highly human-impacted habitats. Therefore, if Bornean Ferret Badger is vulnerable to habitat conversion, population exchange and gene flow between the two parks are unlikely to take place; these might be critical to population viability. Here we present a systematic survey for Bornean Ferret Badger in order to assess its habitat use and potential threats in the area.

Materials and methods

Survey area

The survey area (5°56'N, 116°28'E) is located on a ridge between Tenompok Forest Reserve (19 km²) and Crocker Range Park (1,400 km²; Figure 1). Most of the forests in Tenompok Forest Reserve and Crocker Range Park are strictly protected old-growth forests. The area between the forest reserve and the park has been allocated to local people and consists of secondary forests and slash-and-burn fields. The area consists of a mixture of old-growth forests inside the forest reserve and the park, and secondary forests and slash-and-burn fields outside. The altitude of this area ranges from about 900–1400 m asl. The average annual rainfall is 2000–2500 mm (Fujiki *et al.* 2017).

The old-growth forest (elevation range during this survey was approximately 1210–1440 m asl) within Tenompok Forest Reserve and Crocker Range Park, consists of lower montane vegetation dominated by Fagaceae. The maximum tree height was about 30 m. Tenompok Forest Reserve and Crocker Range Park were established in 1984. The old-growth forests in this survey area have been preserved for more than 30 years. Secondary forests (1140–1260 m asl), mostly in the form of recent regrowth, occur along the ridge top with estimated ages of 10–30 years since the last burning by local communities. Secondary forests here are characterized by the dominance of Macaranga trees with a maximum tree height of about 10–20 m. It appears that the secondary forests have been maintained for 10–30 years

because local people rarely convert these to slash-and-burn field due to the remoteness from their communities, which are 1 to 2 km away. The slash-and-burn fields (960–1270 m asl) consists of a mixture of farmlands (*i.e.*, rice fields, small plantations of rubber trees or coffee trees) and abandoned fields that were burnt 1–15 years prior to this camera-trap survey. Grassland or short pioneer shrubs occur in the abandoned fields and include the genera *Eupatorium*, *Thysanolaena*, *Imperata*, *Melastoma* and *Clethra*. See Fujiki *et al.* (2017) for further details of the survey area.

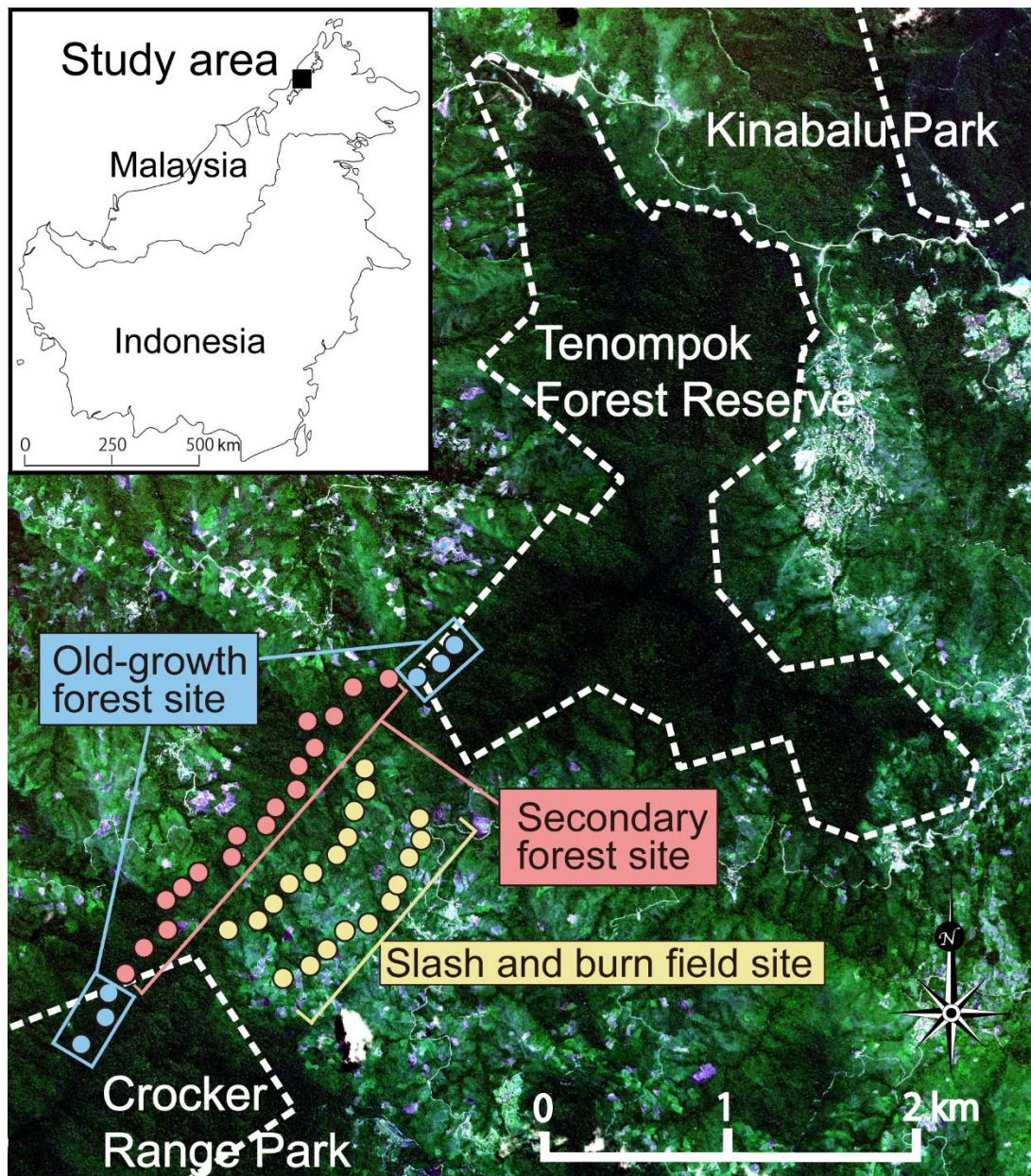


Figure 1. A satellite image of the study sites located between Crocker Range Park and Tenompok Forest Reserve in Sabah, Malaysia (Borneo). Dotted lines are the boundary of the forest reserve or the park and points are the locations of the camera-traps.

Methods

Three parallel transect lines were set up between Crocker Range Park and Tenompok Forest Reserve along the ridge (Figure 1). The longest line was located along the ridge top connecting Crocker Range Park with Tenompok Forest Reserve. This line crossed old-growth forests and secondary forests. In total, 23 camera-traps (Bushnell Trophy Cam) were set along this line (6 camera-traps in old-growth forests, and 17 camera-traps in secondary forests). Each camera was set 50 m downward on either slope from the top of the ridge, and subsequently shifted to the other slope side across the ridge twice to reduce the bias of camera-trap positions. The other two transect lines were located in slash-and-burn fields downslope of the ridge and ten cameras were set along each transect line (*i.e.*, 20 camera-traps in the slash-and-burn fields); there was some overlap in altitudinal range between these transects. All camera-traps on each transect line were set at 250 m intervals. The survey lasted for two years from February/March 2013 to February 2015 on the longest line, and for about 6 months from September 2014 to February 2015 on the two lines in the slash-and-burn fields.

Cameras were set to record 10 second video. Although video recordings of nocturnal animals were monochrome, it was not difficult to recognize Bornean Ferret Badgers from the other carnivores. Bornean Ferret Badger has a white line on the back from head to forelimb and between eyes, and the ears and lower cheek are white (Payne *et al.* 1985). Also, the length of its tail is about half of its head and body length (Figure 2). The tail's length and club-like shape are distinctive from the other animals that have similar body sizes in Borneo (Payne *et al.* 1985). A video recording was considered as evidence of a single visit by a given species, provided that the recording was obtained at a time interval of 30 minutes or greater after the previous recording of the same species. The number of notionally independent video records per 100 camera-trap-days for each camera-trap was defined as the encounter rate. Camera-traps in each habitat type (*i.e.*, the old-growth forest, the secondary forest and the slash-and-burn fields) were treated as replicates. Mean \pm SD encounter rates was calculated for each habitat category. A Kruskal–Wallis test and Steel–Dwass test for multiple comparison were used to test for statistically significant differences in encounter rates between the old-growth forest, the secondary forest, and the slash-and-burn fields.

Results

A total of 112 video recordings of Bornean Ferret Badgers were obtained, all at night (Figure 3). The encounter rate of Bornean Ferret Badger in the old-growth forest was 2.20 ± 3.89 (mean \pm SD). In 3,292 camera-trap-days it was detected at three out of the six camera-trap stations set in the old-growth forest at an elevation range of 1380–1440 m asl. In the secondary forest, no images of Bornean Ferret Badger were obtained despite 12,126 camera-trap-days spread across 17 stations. The encounter rate of Bornean Ferret Badger in slash-and-burn fields was 1.28 ± 1.91 (mean \pm SD). In 3,242 camera-trap-days, it was detected at

9 out of the 20 camera-trap stations set in the slash-and-burn fields, at an elevation range of 990–1270 m asl. There was no significant difference in encounter rates between the old-growth forest and the slash-and-burn fields ($p > 0.05$, Steel–Dwass test). The encounter rate in the secondary forest was significantly lower than that of the old-growth forest or the slash-and-burn field ($p < 0.05$, Steel–Dwass test; Figure 4). In total 10 wild carnivore species and one domestic carnivore species, Domestic Dog *Canis familiaris*, were filmed (Table 1). The encounter rate of Bornean Ferret Badger was the highest among the carnivores both in the old-growth forest and in the slash-and-burn fields.



Figure 2. An example of a Bornean Ferret Badger captured by a camera-trap. This species has a white line on its back from head to forelimb. Its ears are white, and the length of its tail is about a half of its head and body length.

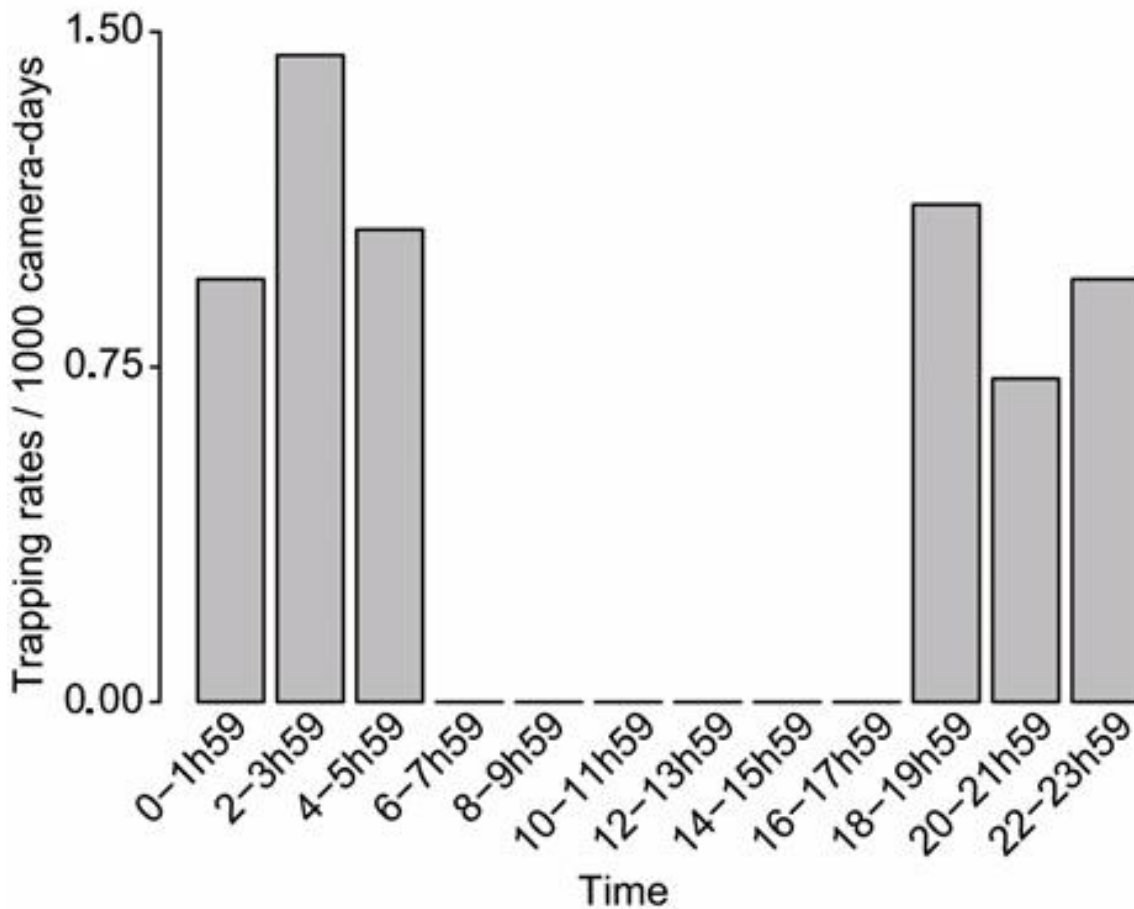


Figure 3. Patterns of the detection of Bornean Ferret Badger (112 records) in 17,962 camera-trap-days with all cameras combined.

Table 1. Carnivore species recorded by camera-traps and mean +/-SD of their encounter rates (number of notionally independent records per 100 camera-trap-days) in each habitat type in the survey area

English name	Scientific name	Old-growth*		Secondary**		Slash and burn***		Elevation (m)	
		No. [‡]	Frequency	No.	Frequency	No.	Frequency	Min	Max
Bornean Ferret Badger	<i>Melogale everetti</i>	67	2.20 ±3.89	0	0	45	1.28 ±1.91	986	1258
Banded Linsang	<i>Prionodon linsang</i>	18	0.60 ±1.12	51	0.35 ±0.96	9	0.27 ±0.59	988	1438
Binturong	<i>Arctictis binturong</i>	0	0	1	0.01 ±0.05	0	0	1339	1339
Collared Mongoose	<i>Herpestes semitorquatus</i>	0	0	4	0.02 ±0.12	0	0	1194	1385
Hose's Civet	<i>Diplogale hosei</i>	0	0	1	0.01 ±0.05	0	0	1355	1355
Leopard Cat	<i>Prionailurus bengalensis</i>	1	0.03 ±0.11	15	0.09 ±0.32	0	0	1194	1355
Malay Weasel	<i>Mustela nudipes</i>	3	0.11 ±0.26	9	0.06 ±0.18	3	0.09 ±0.29	988	1437
Marbled Cat	<i>Pardofelis marmorata</i>	1	0.03 ±0.12	0	0	0	0	1437	1437
Masked Palm Civet	<i>Paguma larvata</i>	14	0.42 ±0.50	54	0.34 ±1.07	9	0.27 ±0.58	988	1437
Yellow-throated Marten	<i>Martes flavigula</i>	6	0.17 ±0.38	15	0.09 ±0.26	5	0.15 ±0.32	1060	1361
Domestic dog	<i>Canis familiaris</i>	2	0.08 ±0.24	21	0.15 ±0.39	32	0.97 ±3.55	988	1355

*3,292 camera-days, **12,126 camera-days, ***3,242 camera-days, ‡ Number of detections.

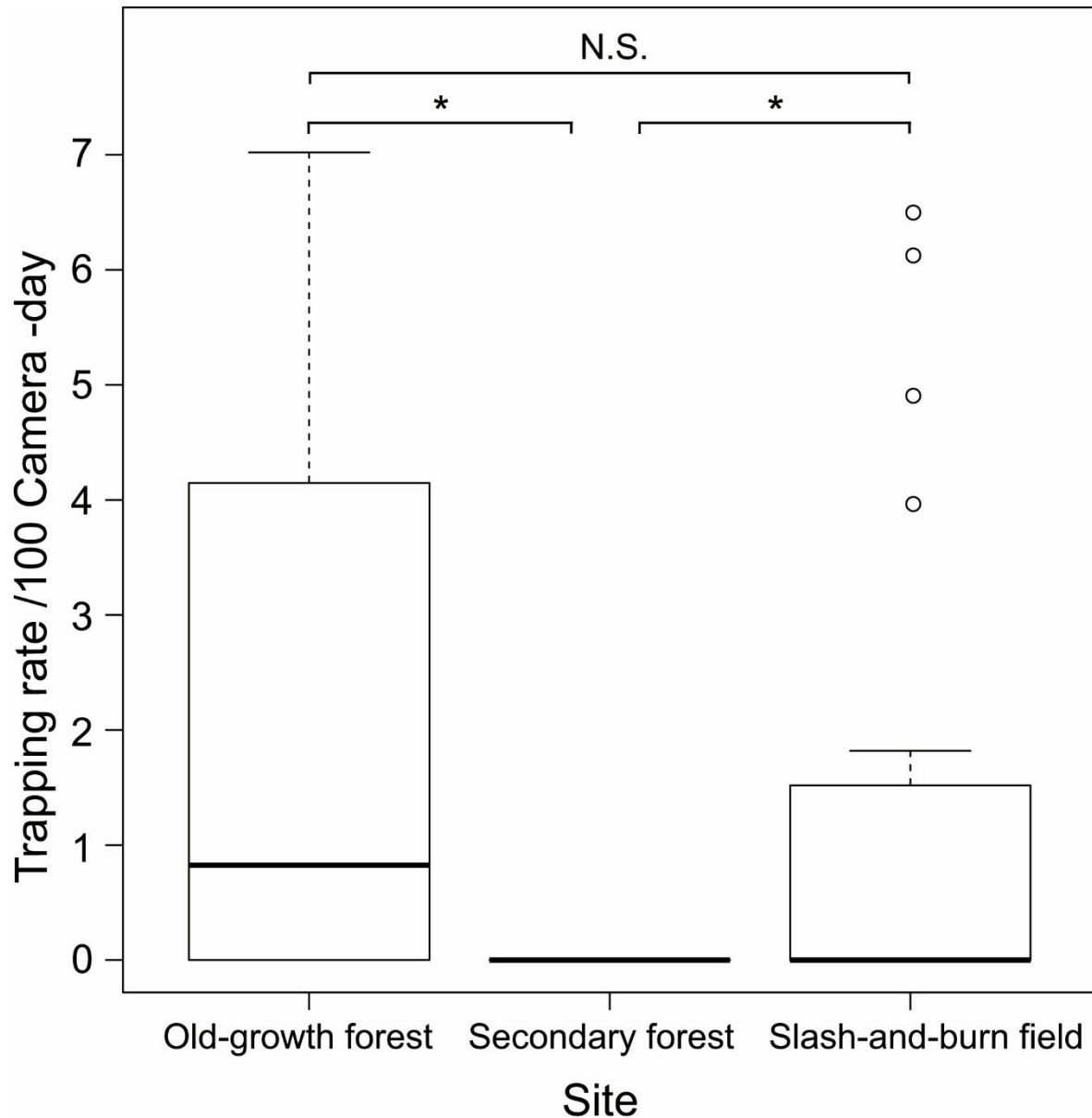


Figure 4. Boxplot indicating camera-trap encounter rates of Bornean Ferret Badger in each of the tree land categories. (* $p < 0.001$, Steel–Dwass test)

Discussion

In this survey, Bornean Ferret Badger inhabits old-growth forest and the slash-and-burn fields. Surprisingly, the encounter rates of Bornean Ferret Badgers were significantly higher in the old-growth forest and in the slash-and-burn field than in the secondary forest, though most records of Bornean Ferret Badger are from protected forests (Wilting *et al.* 2016). In both the old-growth forest and the slash-and-burn fields, the encounter rates of Bornean Ferret Badger were highest among the 10 wild carnivores recorded in the study site. The slash-and-burn fields had many holes (width about 8 cm, height about 10–13 cm, depth about 10 cm), which may have been foraging digs by Bornean Ferret Badgers.

The relationship between camera-trap encounter rates and the abundance of animals on the ground cannot be determined, but it is clear that this species uses both habitats regularly and may be among the most numerous small carnivore species in each. The only previous camera-trap survey in Crocker Range Park camera-trapped Bornean Ferret Badger less frequently than many other small carnivores (A.J. Hearn and J. Ross pers. comms. in Wilting *et al.* 2015). Thus, the population of Bornean Ferret Badgers may be greatly different between areas, although these divergent results might also reflect differences in camera-trapping style.

The absence of Bornean Ferret Badger camera-trap records in the secondary forest is surprising. Soil condition in the secondary forest was different from those of the old-growth forest and the slash-and-burn field. Given that Bornean Ferret Badger depends on ground-dwelling insects and earthworms (Payne *et al.* 1985), it is likely that soil condition directly influences the abundance of food resources and foraging efficiency. The species' abundance may depend on the physical soil condition such as soil moisture, rather than forest structure.

Bornean Ferret Badger was recorded only during night, which suggests that it is strictly nocturnal. This nocturnal habit might partly explain why this species was considered scarce in earlier assessments (Wilting *et al.* 2015). A similar case was reported in an African rainforest. Black-footed Mongoose *Bdeogale nigripes* was thought to be very rare and assumed to be a forest dweller: however, recent camera-trapping studies have shown that it is relatively common even within disturbed habitats (Bahaa-el-din *et al.* 2013). The range of habitats that Bornean Ferret Badger uses and its population size could have been underestimated due to the difficulties in detecting this species.

The abundance of Bornean Ferret Badger in slash-and-burn fields might suggest that it is relatively tolerant to habitat disturbances and degradation. Whether this species can thrive in isolated slash-and-burn fields not surrounded by old-growth forests is not known. Even if the species can persist in non-forested landscapes, its population trends must be monitored carefully. Domestic Dogs were camera-trapped often both within and outside protected areas. Domestic Dogs can be a major threat to wildlife (Imazato 2012), so it is critical to determine the effects of predation by dogs on Bornean Ferret Badger populations; disease risks such as rabies and canine distemper might be another threat. The apparent use of slash-and-burn fields does not necessarily mean that the Bornean Ferret Badger can thrive in intensive agriculture, which is widely spreading in the upland areas around the Kinabalu Park; intensive agriculture might be a serious threat to the Bornean Ferret Badger. Further research on this species' tolerance to human impacts and threats such as Domestic Dogs is warranted.

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