Mammalian Biology 88 (2018) 75–80

Contents lists available at ScienceDirect

Mammalian Biology

journal homepage: www.elsevier.com/locate/mambio

Short communication

Habitat associations of the Sunda stink-badger *Mydaus javanensis* in three forest reserves in Sabah, Malaysian Borneo

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ARTICLE INFO

Article history:
Received 11 May 2017
Accepted 27 November 2017
Handled by Mauro Lucherini
Available online 28 November 2017

Keywords:
Sunda stink-badger
Occupancy
Logging concession
Borneo
Disturbance

ABSTRACT

The Sunda stink-badger *Mydaus javanensis* is one of the most frequently recorded carnivore species in portions of Sabah, Malaysian Borneo. However, its current distribution on Borneo is patchy, with recent records lacking from areas where the species was previously considered common. We assessed the hypothesis that occurrence of Sunda stink-badgers is restricted to areas of high earthworm density. We also assessed the influence of forest disturbance on occurrence, as the species is thought to be disturbance-tolerant. We compiled camera-trap data from three commercial forest reserves in central Sabah collected during 2008–2010 and 2014–2015. We used single season occupancy modeling to estimate probability of occupancy and detection. We obtained 323 detections of Sunda stink-badger over 19,875 trap-nights. We found no fine-scale association between occurrence and earthworm abundance, suggesting that Sunda stink-badgers have broader diets than currently assumed, or that earthworm density potentially influences their occurrence at larger scales. The influence of forest disturbance on occurrence was mixed; although our results suggested that Sunda stink-badgers might have a higher probability of occupancy in more disturbed forests, it is possible that a disturbance threshold exists where extreme forest conversion (e.g., oil palm plantations, human settlements) results in lower occupancy. We did not find strong associations with proximity to water, oil palm plantation, bare earth, or shrub landcovers, suggesting that Sunda stink-badgers are not affected by edge effects or the proximity of disturbed areas. Despite our large dataset across three forest reserves, this study is only a first step in understanding the current irregular distribution of Sunda stink-badgers on Borneo. Further studies across a larger gradient of habitat disturbance are needed to determine potential habitat disturbance thresholds, which will aid in management of this species as the landscape on Borneo continues to undergo anthropogenic change.

The Sunda stink-badger, *Mydaus javanensis*, is one of only two species from the family Mephitidae occurring outside of the Americas. This species occurs on the islands of Sumatra, Borneo, Java, and the Natuna Islands, and has been recorded within diverse habitats including primary, secondary and disturbed forests; open areas adjacent to forests; and oil palm plantations (Samejima et al., 2016; Wilting et al., 2015). On Borneo, this species appears largely restricted to the Malaysian state of Sabah where it is often among the most frequently recorded carnivore species in camera-trap studies (Samejima et al., 2016; Vickers et al., 2017). There are occasional sightings of Sunda stink-badger in the Malaysian state of Sarawak and the Indonesian state of Kalimantan where the species was last recorded in the early 20th century (Wilting et al., 2015).

It is unknown why Sunda stink-badger distribution on Borneo is patchy (Payne et al., 1985; Wilting et al., 2015), especially in Kalimantan. The apparent recent absence in Kalimantan may be due to the species being hunted (Bock, 1882; Puri, 1997; Samejima et al., 2016). Soil type could be an important habitat factor as Sunda stink-badger occurrence may be linked to earthworm density and soil

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https://doi.org/10.1016/j.mambio.2017.11.010
1616-5047/

characteristics (Wilting et al., 2015), though the species' diet also includes bird eggs, carrion, insects, and plants (Long and Killingley, 1983; Neal and Cheeseman, 1996; Payne and Francis, 1985). Sunda stink-badger occurrence could also be influenced by forest disturbance; though this species has been recorded in non-forest habitat such as oil palm plantations, this species might depend on forest cover for survival (Samejima et al., 2016).

We investigated environmental and anthropogenic factors that might influence occurrence of Sunda stink-badgers using camera-trapping data and occupancy modeling. In particular, we assessed the hypothesis that Sunda stink-badger occurrence is positively associated with earthworm abundance. Additionally, we assessed the influence of forest disturbance on Sunda stink-badger occurrence, as the species is currently considered disturbance-tolerant (Samejima et al., 2016), suggesting at least limited use of disturbed forest.

We used camera-trap survey data from three forest sites: Deramakot Forest Reserve (DFR; 5°14–28′N, 117°19–36′E), Tangkulap-Pinangah Forest Reserve (TPFR); 5°17–30′N, 117°11–21′E; Fig. 1) and Segaliud Lokan Forest Reserve (SLFR; 5°20–27′N, 117°23–39′E). Currently, DFR (550 km^2) and SLFR (572 km^2) are designated as Class II Production Forest (primarily intended for commercial timber production) under the Sabah Forest Enactment (Forest Enactment, 1968; Kitayama 2013) while TPFR (501 km^2) was reclassified in 2015 from Class II to Class I Protection Forest (area managed for biodiversity conservation and enhancement of ecosystem functions). Both DFR and TPFR are certified by the Forest Stewardship Council (FSC; Forest Stewardship Council, 1996) and are currently managed by the Sabah Forestry Department. Since 1995, DFR has experienced reduced-impact logging (RIL) strategies whereby placement of logging roads and skid trails and harvesting methods are conducted to reduce forest disturbance. Approximately 3% of the reserve (16.5 km^2) is logged each year with a 40-year rotation (Kitayama, 2013). Before 2001, TPFR was harvested using conventional selective logging techniques, but logging has ceased to allow forest regeneration. Similarly, SLFR, which has been privately managed by KTS Plantation Sdn Bhd. since 1994, was logged through conventional logging practices. Approximately 374 km^2 of SLFR was previously clear-cut and transformed into industrial tree plantations. Since 1998, SLFR has implemented RIL practices with 25 km^2 logged annually with a 20-year rotation. Overall, there is a gradient in forest disturbance from DFR (lowest) to TPFR to SLFR (highest) due to past logging histories (Sollmann et al., 2017). Though hunting is prohibited in all forest reserves (Mohamed et al., 2013), we found some evidence of hunting activities (i.e. bullet cartridges, illegal camp sites, and photos of hunters from remote cameras). Low incidence of such records prevented us from quantifying hunting levels but indicates that hunting activity was generally low within our study sites.

We surveyed within DFR during September–December 2014, establishing 63 stations at 2.5-km intervals (coarse-grid survey; Fig. 1). During July–October 2015, we replicated the same survey design in TPFR, establishing 64 stations at 2.5-km intervals. At each station during the coarse-grid survey, we set two infrared motion detection cameras (Reconyx PC850 HyperfireWhiteflash LED, Reconyx, Wisconsin, USA), each on a logging road or animal

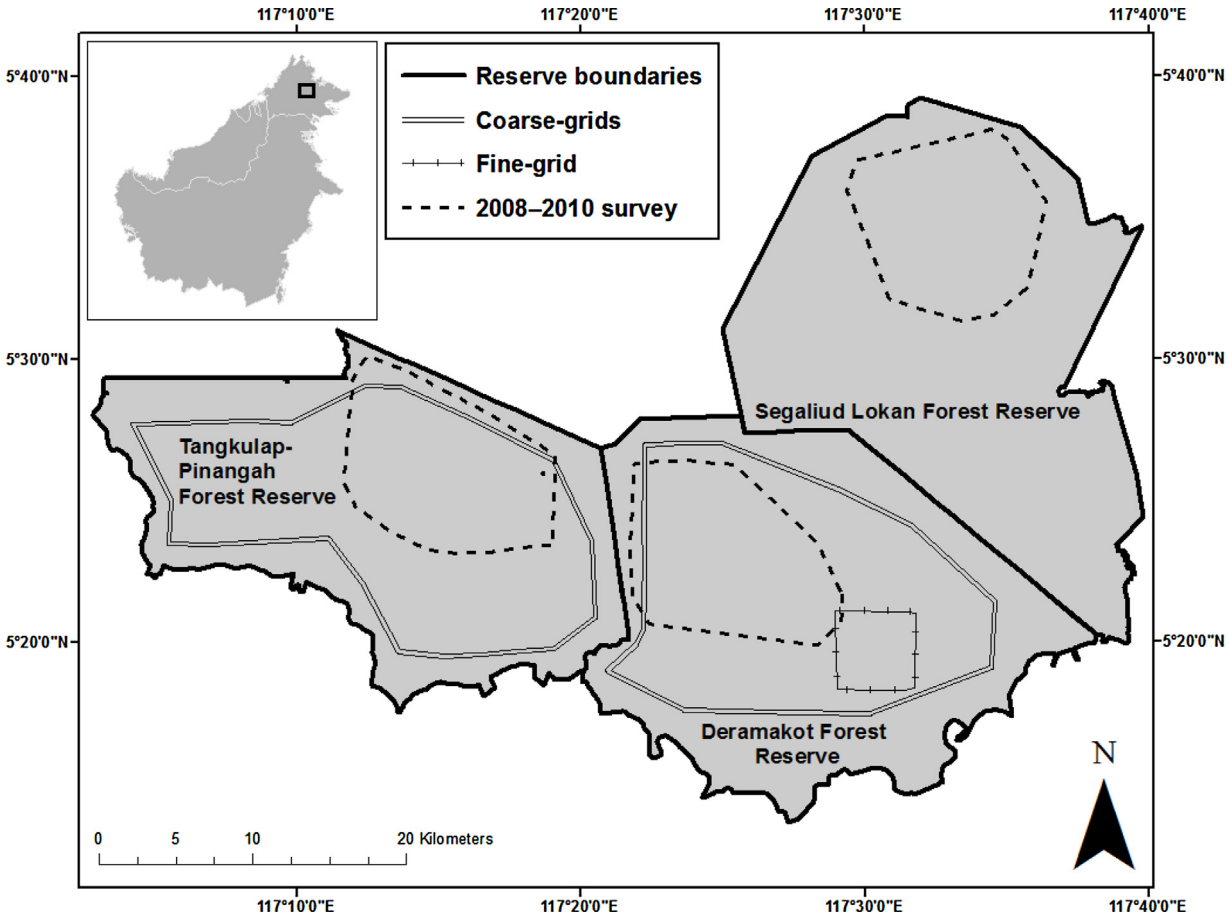

Fig. 1. Location of three forest reserves on Borneo (black square; inset) and the areas sampled to estimate Sunda stink-badger occupancy during the coarse-grid surveys (September–December 2014 in Deramakot Forest Reserve; July–October 2015 in Tangkulap-Pinangah Forest Reserve), fine-grid survey (January–May 2015), and an earlier survey during 2008–2010.