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Short communication

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

Seth Timothy Wong[a,*], Jerrold L. Belant[a], Rahel Sollmann[b], Azlan Mohamed[c], Jürgen Niedballa[c], John Mathai[c], Erik Meijaard[d], Garrett M. Street[e], Johnny Kissing[f], Sam Mannan[f], Andreas Wilting[c]

[a] *Carnivore Ecology Laboratory, Forest and Wildlife Research Center, Mississippi State University, Mississippi State, 39759 MS, USA*
[b] *Department of Wildlife, Fish and Conservation Biology, University of California Davis, Davis, 95616 CA, USA*
[c] *Leibniz Institute for Zoo and Wildlife Research, Alfred-Kowalke-Str. 17, 10315 Berlin, Germany*
[d] *Borneo Futures, Ciputat, Jakarta, 15412, Indonesia*
[e] *Department of Wildlife, Fisheries, and Aquaculture, Mississippi State University, Mississippi State, 39759 MS, USA*
[f] *Sabah Forestry Department, Locked Bag 68, 90009 Sandakan, Sabah, Malaysia*

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## 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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* Corresponding author.
*E-mail address:* seth.timothy.wong@gmail.com (S.T. Wong).

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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

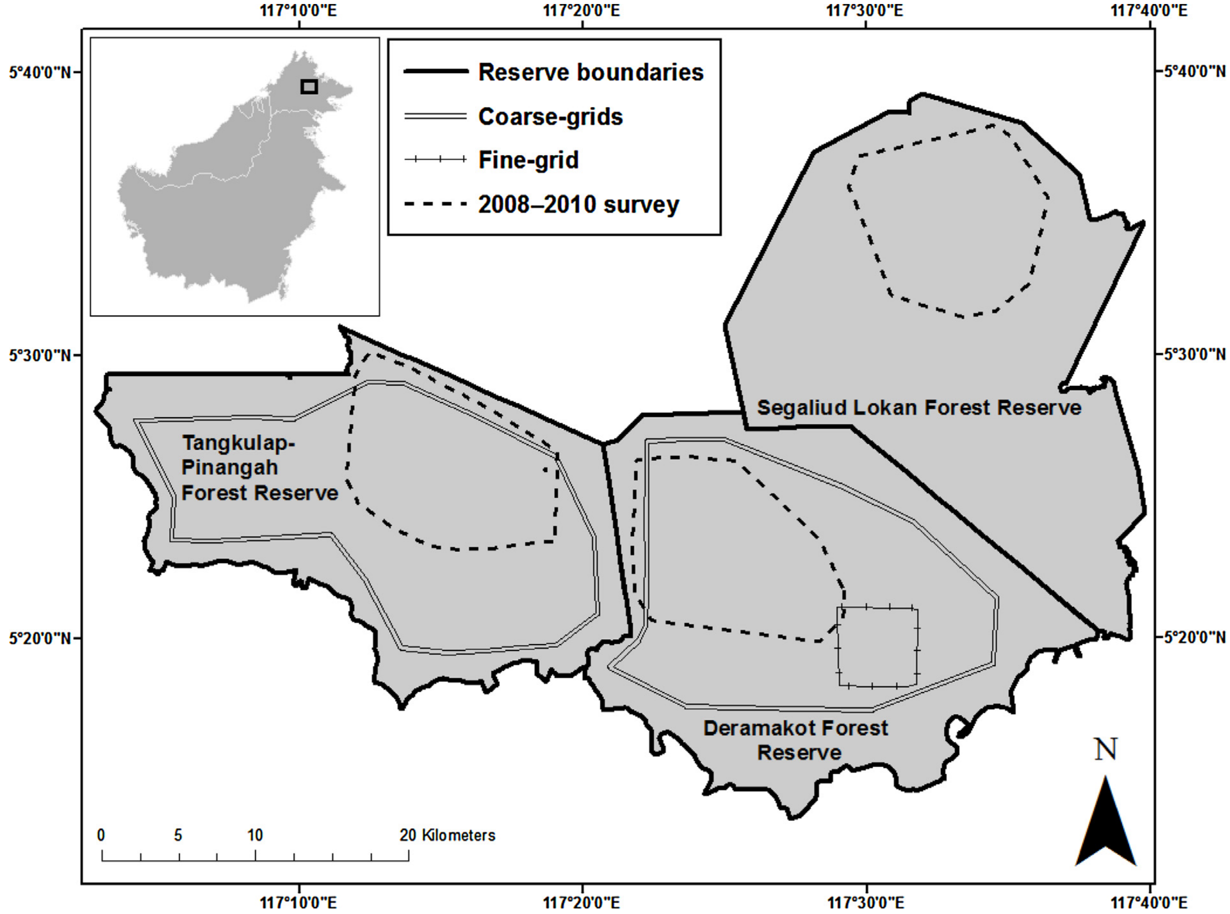

**Fig. 1.** Location of three forest reserves on Borneo (black square; inset) and the areas sampled to estimate Sunda stink-badger occupancy during the coarse-grid surveys (September–December 2014 in Deramakot Forest Reserve; July–October 2015 in Tangkulap-Pinangah Forest Reserve), fine-grid survey (January–May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

**Table 1**
Mean, standard deviation (SD), and range of values for habitat covariates collected during 2008–2010 and 2014–2015 from three study designs conducted in three forest reserves: Deramakot, Tangkulap-Pinangah, and Segaliud Lokan; Sabah, Malaysian Borneo.

| Covariate[a] | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|
| Coarse-grid survey (2014–2015) | | | | |
| Canopy cover | 0.788 | 0.186 | 0.159 | 0.950 |
| Lateral obstruction | 0.525 | 0.159 | 0.180 | 0.878 |
| Forest score | 2.3 | 0.4 | 0.9 | 3.0 |
| Distance to plantation | 6.35 | 3.98 | 0.01 | 15.79 |
| Distance to water | 0.77 | 0.69 | 0.02 | 3.11 |
| Distance to bare earth | 0.23 | 0.24 | 0.00 | 1.19 |
| Distance to shrub | 0.03 | 0.04 | 0.00 | 0.20 |
| Fine-grid survey (2015) | | | | |
| Average earthworm abundance | 2.4 | 1.6 | 0.0 | 8.7 |
| Leaf litter cover | 2.4 | 0.8 | 0.9 | 4.0 |
| Canopy cover | 0.820 | 0.137 | 0.378 | 0.924 |
| Lateral obstruction | 0.493 | 0.163 | 0.120 | 0.865 |
| Forest score | 2.3 | 0.3 | 1.4 | 3.0 |
| 2008–2010 Survey | | | | |
| Forest score | 1.8 | 0.5 | 0.4 | 2.8 |
| Distance to plantation | 5.65 | 3.24 | 0.06 | 13.53 |
| Distance to water | 0.47 | 0.44 | 0.00 | 2.21 |
| Distance to bare earth | 0.08 | 0.14 | 0.00 | 0.69 |
| Distance to shrub | 0.01 | 0.01 | 0.00 | 0.05 |

[a] Canopy cover and lateral obstruction are represented as proportion of vegetation coverage at each station. Distances are in km. Leaf litter cover is average of 9 categorical values from 0 to 4, with 0 representing no leaf litter, 1 representing 0–25% cover, 2 representing 26–50% cover, 3 representing 51–75% cover, and 4 representing 76–100% cover.

trail about 5 m apart. We programed cameras to take 3 consecutive images during each detection, with camera options set to “no delay” between detections. We cleared vegetation to reduce false triggering of cameras. We checked cameras after 30 days to download images and replace batteries, then retrieved cameras after $\geq$60 days of operation.

During January–May 2015, we sampled 49 km$^2$ of DFR intensively through a clustered camera design (fine-grid survey). We established 64 stations in 16 clusters with each cluster containing 4 stations set in a $2 \times 2$ array with 500 m between stations. The 16 clusters were set in a $4 \times 4$ array with 1.5 km between edges of clusters. Similar to the course-grid study, at each station, we placed 2 cameras <5 m apart and at opposite sides of a feature (i.e. logging road or animal trail). Cameras were checked after 30 days and retrieved after $\geq$60 days of operation.

Additionally, we incorporated records of Sunda stink-badger collected during 2008–2010 (see Mohamed et al., 2013; Sollmann et al., 2017). The study comprised 47, 64, and 55 camera stations across 123 km$^2$, 122 km$^2$, and 114 km$^2$ of DFR, TPFR, and SLFR, respectively (Fig. 1). Camera stations were set at 1.4-km intervals with 2 cameras at each station facing each other along logging roads or animal trails. Cameras were operational for 42 (DFR and TPFR) or 47 (SLFR) consecutive days before collection.

At each station during our coarse- and fine-grid surveys, we estimated canopy cover and lateral obstruction from understory vegetation (Table 1). We established a $20 \times 20$ m plot using two 20-m ropes oriented along the cardinal directions and centered at the midpoint between the two cameras. Canopy cover data was obtained from images taken using a hand-held GPS (Garmin GPSmap 62sc, Garmin ltd, Canton of Schaffhausen, Switzerland) at the center of the plot and 10 m in each cardinal direction. We converted images to black and white, where vegetation was represented with black pixels and sky was represented as white pixels. We used the GNU Image Manipulation Program (GIMP, GIMP team, 2014) to estimate percentage canopy cover based on the ratio of black to total pixels and estimated mean percentage canopy cover of the 5 images taken at each station. To quantify lateral obstruction, we took images of understory vegetation from each plot center against an orange $1.5 \times 1$ m tarpaulin held at ground level and 10 m from the plot center in each cardinal direction. We edited images using GIMP software to crop images so only the area of the tarpaulin was represented. We converted images to black and white, where vegetation was represented as black pixels and the tarpaulin as white pixels. We divided the number of black pixels by total pixels to estimate the percentage lateral obstruction in each image, and averaged values from the 4 images at each station to estimate the mean percentage lateral obstruction from understory vegetation.

For the fine-grid survey, we also estimated leaf litter cover and earthworm abundance at each station. We measured leaf litter cover in nine $1 \times 1$ m subplots located at the center, 10 m in the cardinal directions, and 14.14 m in the ordinal directions of the plot. We assigned each subplot a value from 0 to 4, with 0 representing no leaf litter, 1 representing 0–25% cover, 2 representing 26–50% cover, 3 representing 51–75% cover, and 4 representing 76–100% cover. We estimated relative leaf litter cover at each station by taking an average of the 9 subplot values. We estimated worm abundance by counting worms in three $25 \times 25 \times 10$ cm excavated samples of soil (Fragoso and Lavelle 1992; Rickart et al., 1991). Samples were located 5 m from plot center at 0, 120, and 240°.

Using a landcover map derived from RapidEye 5 m resolution satellite imagery (RapidEye, 2011) of the three forest reserves acquired during 2011 and 2012 (see Niedballa et al., 2015), we calculated 5 covariates for all surveys: distance from each station to the nearest oil palm plantation, water, bare ground, and shrub land cover and forest score, a weighted mean of land cover percentages within a 50-m radius of each station. Distance to water provided an indication of accessibility to a water source, a basic resource for animals. Distance to oil palm, bare ground, and shrub were used as indices of potential edge effects and served as proxies for coarse-scale forest disturbance. Forest score was calculated to quantify the degree of forest disturbance at each station (Niedballa et al., 2015). We assigned an integer value to each land cover pixel to rank forest disturbance: bare areas, grassland, oil palm plantations and water were assigned 0; shrub was assigned 1; secondary and degraded forest 2; and dense and primary forest 3. An average of pixel values produced a forest score from 0 to 3, with lower numbers indicating higher forest disturbance. Since stations were closer together in the fine-grid survey, there was little variation in distance to nearest land-cover type (i.e., land cover is locally autocorrelated). Therefore, distance measures in the fine-grid survey were excluded from the modeling process.

To investigate Sunda stink-badger habitat associations, we used likelihood-based occupancy modeling (MacKenzie et al., 2006). We used package camtrapR version 0.99.5 (Niedballa et al., 2016) in Program R version 3.2.2 (R Core Team, 2015) to organize and extract metadata from camera images and create species detection/non-detection matrices for Sunda stink-badger records across all stations. We considered each pair of camera traps as a single station which we considered operational if at least one of the two cameras was functioning. All missing data caused by trap malfunction was accounted for in the occupancy analysis. We considered 5 days as a sample occasion and used only full 5-day occasions in detection matrices.

We implemented single season occupancy models in program R using the package unmarked version 0.11–0 (Fiske and Chandler, 2011). Due to differences in study design and timing of data collection, we analyzed the coarse-grid, fine-grid, and 2008–2010 surveys separately. To avoid over-parameterizing models and increasing uncertainty in estimates, we conducted a 2-stage modeling process. We first determined the most suitable model for detection probability using single covariate models for differences in camera placement (i.e. logging road or animal trail) and differences in site surveyed while holding occupancy probability constant across camera-trap stations. Covariates were included in the final detection model only if they were the best supported model based on model ranking using Akaike's Information Criterion ($\Delta$AIC = 0, where all models with $\Delta$AIC < 2 are considered equally supported; Burnham and Anderson, 2002) and 95% confidence intervals (CI) of coefficient estimates did not include 0. Conditional on the selected detection model, we tested covariates for occupancy probability in the same manner. We estimated average detection and occupancy probability for each survey based on the best supported model. Particularly, we used the fine-grid survey to investigate worm abundance effects on occupancy, while we used distance to nearest land-cover type only in the coarse-grid and 2008–2010 survey models for occupancy probability.

During the coarse-grid surveys, we obtained 36 detections (29 in DFR and 7 in TPFR) of Sunda stink-badger over 8415 trap-nights. Sunda stink-badger detection was lower in TPFR than in DFR; using this detection model, distance to water was the best supported model for probability of occupancy though the 95% CI of the coefficient included 0 (Table 2). Detection probability (mean ± standard error [SE]) for the coarse-grid survey was 0.110 ± 0.025 in DFR and 0.020 ± 0.011 in TPFR with an average occupancy probability of 0.317 ± 0.071.

During the fine-grid survey (DFR only), we obtained 71 Sunda stink-badger detections across 37 sites over 3925 trap-nights. Sunda stink-badger detection was not affected by camera placement as 95% CI of the coefficient included 0 and the best supported model was the null model, therefore, detection was held constant. For occupancy in the fine-grid, neither earthworm abundance nor other habitat covariates had significant effects on Sunda stink-badger occurrence as 95% CI for all coefficients included 0. The null model along with canopy cover and leaf litter cover models were equally supported (i.e., $\Delta$AIC < 2). Based on the null model, detection probability was 0.125 ± 0.018 with an average occupancy probability of 0.717 ± 0.088 for the fine-grid survey.

From the 2008–2010 survey, we obtained 216 detections (49 in DFR, 78 in TPFR, and 89 in SLFR) over 7535 trap-nights. Neither camera placement nor site significantly influenced detection probability (i.e. 95% CI included 0 and null model was best supported model). With detection probability held constant, forest score was the best supported model (95% CI: −2.471, −0.135), and Sunda stink-badger occupancy was greater at sites with lower forest scores. Average detection probability during the 2008–2010 survey was 0.212 ± 0.015 with average occupancy probability of 0.686 ± 0.050.

Our data from the fine-grid survey did not support the hypothesis that Sunda stink-badger occurrence is associated with earthworm abundance (Samejima et al., 2016), at least not at a local scale. We also found no association with leaf litter cover, which can affect the density of endogeic earthworms in other forest types (Jordan et al., 2000; Nachtergale et al., 2002). Leaf litter in tropical forests harbors diverse and abundant invertebrates (Gonzalez and Seastedt, 2000, 2001). Sunda stink-badgers reportedly feed on numerous foods including insects, bird's eggs, carrion, and plants (Long and Killingley, 1983; Neal and Cheeseman, 1996; Payne and Francis, 1985). Our results suggest that Sunda stink-badgers do not rely on earthworms at a fine-scale and are more likely dietary generalists similar to other mephitids (Cantu-Salazar et al., 2005; Donadio et al., 2004; Zapata et al., 2001). It is also possible that the variation in earthworm abundance captured in the fine-grid survey (Table 1) was not sufficient to detect any association with badger occurrence. There may also be a larger-scale influence of earthworm distribution and densities on badger occurrence: soils in DFR may be more fertile compared to other regions in Sabah, which in turn may be more fertile compared to other parts of Borneo where poorer soils may support fewer earthworms overall. The lack of a significant association with leaf litter cover may also be due to limited variation in leaf litter cover or the potential overall high abundance of food in our study sites.

Our results provided mixed support for the suggestion that Sunda stink-badgers are disturbance-tolerant (Samejima et al., 2016). In the fine-grid and coarse-grid surveys, we found no significant association between Sunda stink-badger occupancy and forest disturbance. However, for the 2008–2010 survey in which more Sunda stink-badgers were recorded, we found a higher probability of occupancy in more disturbed forest. Forest scores for the coarse and fine grid surveys were consistently high (DFR: 2.40 ± 0.34 in coarse grid; 2.30 ± 0.35 in fine grid; TPFR: 2.13 ± 0.49 in coarse grid). In contrast, there was more variation in forest score across the three study sites in the 2008–2010 survey (DFR: 2.02 ± 0.05, TPFR: 1.77 ± 0.44; SLFR: 1.67 ± 0.37), which facilitated our ability to detect an effect of forest score on badger occupancy. The association with forest disturbance found in the 2008–2010 survey could be due to the Sunda stink-badger's diet. Generalist species are often adaptable to disturbed and degraded habitats (Devictor et al., 2008), in part due to the abundance of food, such as insects (Lambert et al., 2006). Therefore, Sunda stink-badgers may benefit from, rather than tolerate, disturbed areas.

We found no significant relationship between Sunda stink-badger occupancy and canopy cover or lateral obstruction from understory vegetation. Other skunk species use open canopy and dense understory habitats for denning and predator avoidance (Doty and Dowler, 2006; Lesmeister et al., 2009). In forests, lower percentage canopy cover and dense understory vegetation are indicative of disturbed habitats (Lambert et al., 2006; Mohamed et al., 2013). Our percentage canopy cover and lateral obstruction from understory vegetation represent a limited gradient for forest disturbance (Table 1), which may explain the lack of observed response within our study sites. Further studies are thus needed to determine the impact of forest disturbance on Sunda stink-badger occurrence.

We found no significant association between occupancy probability and distance to oil palm plantation, bare earth, or shrub landcovers. It is likely that average distance to water and oil palm plantation in this study may have been too great (>500 m) to reveal a stronger effect or association, though the ranging behavior of the species is not known. Though mean distances to bare earth and shrub landcovers were <250 m, we did not find any strong associations with occupancy which supports why the species has been recorded in open gardens adjacent to forests and near villages (Payne et al., 1985; Samejima et al., 2016). As our results did not suggest any strong relationships with particular land-covers, the Sunda stink-badger might not be impacted by forest disturbance, although density and population estimates within different forest types are needed to confirm this.

It remains unknown why the current distribution of the Sunda stink badger on Borneo is patchy. Our results represented conditions within three forest reserves sustainably managed or recovering from overharvest in central Sabah, Malaysia. In contrast, areas of Kalimantan where Sunda stink-badgers were previously considered common have experienced more intensive human disturbance (i.e. large-scale conversion to oil palm plantations; Samejima et al., 2016). There may be a disturbance threshold, where higher degrees of disturbance (e.g. large-scale conversion to oil palm and intensively logged areas) might result in lower probabilities of occupancy. Though Sunda stink-badgers have been recorded in oil palm plantations and forest patches within plantations (Bernard et al., 2014; Yue et al., 2015), these records occurred in close proximity to forest, and presence of forest may be important for their occurrence in oil palm plantations. Additional surveys across a larger gradient of habitat disturbance are needed to better assess the range of conditions that can support

**Table 2**

Parameter estimates from candidate models for detection and occupancy of Sunda stink-badgers from surveys in Deramakot Forest Reserve (DFR), Tangkulap-Pinangah Forest Reserve (TPFR), and Segaliud Lokan Forest Reserve (SLFR), Sabah, Malaysia during years 2008–2010 and 2014–2015. Bold models only represent best supported models based on difference in Akaike's Information Criterion score (ΔAIC). SE = standard error; CI = 95% confidence interval.

| Survey | Model | Coefficient | Estimate (SE) | CI | ΔAIC |
|---|---|---|---|---|---|
| Coarse-grid survey (2014–2015) | Detection[a] | | | | |
| | **Site** | **b1(TPFR)** | **−1.540 (0.493)** | **−2.507, −0.574** | **0.00** |
| | Null | – | – | – | 8.33 |
| | Camera placement | b1(road) | −0.419 (0.452) | −1.305, 0.467 | 10.94 |
| | | b2(mixed) | 0.317 (0.780) | −1.211, 1.845 | |
| | Occupancy[b] | | | | |
| | **Distance to water** | **b1(distance to water)** | **−0.720 (0.382)** | **−1.467, 0.027** | **0.00** |
| | Distance to bare earth | b1(distance to bare) | −0.445 (0.316) | −1.063, 0.174 | 2.47 |
| | Null | – | – | – | 2.76 |
| | Canopy cover | b1(canopy cover) | 3.030 (2.390) | −1.648, 7.709 | 2.82 |
| | Distance to shrub | b1(distance to shrub) | −0.265 (0.287) | −0.827, 0.296 | 3.83 |
| | Distance to plantation | b1(distance to plantation) | −0.199 (0.322) | −0.830, 0.431 | 4.37 |
| | Forest score | b1(forest score) | −0.369 (0.681) | 91.702, 0.965 | 4.47 |
| | Lateral obstruction | b1(lateral obstruction) | 0.377 (1.950) | −3.445, 4.200 | 4.73 |
| Fine-grid survey (2015) | Detection[c] | | | | |
| | **Null** | – | – | – | **0.00** |
| | **Camera placement** | **b1(road)** | **0.045 (0.293)** | **−0.528, 0.618** | **1.98** |
| | Occupancy[d] | | | | |
| | **Canopy cover** | **b1(canopy cover)** | **−5.270 (4.210)** | **−13.522, 2.982** | **0.00** |
| | **Leaf litter cover** | **b1(leaf litter cover)** | **−0.775 (0.482)** | **−1.720, 0.169** | **0.06** |
| | **Null** | – | – | – | **0.82** |
| | Forest score | b1(forest score) | −0.802 (1.030) | −2.828, 1.224 | 2.18 |
| | Lateral obstruction | b1(lateral obstruction) | −0.812 (2.160) | −5.043, 3.420 | 2.68 |
| | Earthworm abundance | b1(earthworm abundacne) | 0.097 (0.289) | −0.469, 0.664 | 2.69 |
| 2008–2010 Survey | Detection[e] | | | | |
| | **Null** | – | – | – | **0.00** |
| | Camera placement | b1(road) | −0.001 (0.173) | −0.341, 0.338 | 2.00 |
| | Site | b1(SLFR) | −0.214 (0.247) | −0.697, 0.269 | 3.23 |
| | | b2(TPFR) | −0.125 (0.254) | −0.622, 0.372 | |
| | Occupancy[d] | | | | |
| | **Forest score** | **b1(forest score)** | **−1.300 (0.596)** | **−2.471, −0.135** | **0.00** |
| | Null | – | – | – | 4.42 |
| | Distance to plantation | b1(distance to plantation) | −0.274 (0.208) | −0.680, 0.133 | 4.66 |
| | Distance to water | b1(distance to water) | −0.120 (0.199) | −0.508, 0.269 | 6.07 |
| | Distance to bare earth | b1(distance to bare) | −0.103 (0.180) | −0.456, 0.250 | 6.10 |
| | Distance to shrub | b1(distance to shrub) | 0.008 (0.203) | −0.389, 0.407 | 6.41 |

[a] Occupancy was constant, and b1(TPFR) expresses the difference in detection relative to DFR; b1(road) and b2(mixed) express the difference in detection relative to animal trails.

[b] Conditional on best detection model including different detection in survey site.

[c] Occupancy is constant, and b1(road) expresses the difference in detection relative to animal trails.

[d] Null model was best detection model; detection was held constant.

[e] Occupancy was constant, and b1(road) expresses the difference in detection relative to animal trails; b1(SLFR) and b2(TPFR) express difference in detection relative to DFR.

Sunda stink-badgers. Additionally, studies assessing the possible impact of hunting on Sunda stink-badger populations and distribution are warranted, as over-hunting remains a possible reason for the species' patchy distribution on Borneo (Samejima et al., 2016). Understanding the effects of habitat disturbance and hunting pressure (e.g. through hunter interviews) will be particularly useful for future management of the Sunda stink-badger as forests on Borneo continue to be degraded by human activities.

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