

Predicted distribution of the otter civet *Cynogale bennettii* (Mammalia: Carnivora: Viverridae) on Borneo

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Wilting et al. (2016: Table 2) list all co-authors' affiliations.

Abstract. The otter civet *Cynogale bennettii* is a small carnivore of the family Viverridae, native to Indonesia (Kalimantan and Sumatra), Malaysia (Sabah, Sarawak and mainland), Brunei Darussalam and southern Thailand. Across its range, its distribution is patchy and the species has been assumed to be a wetland specialist favouring peat-swamp and fresh-water swamp forests and primary forest, although also infrequently recorded in logged and secondary forests. The otter civet is listed as CITES Appendix II and listed as Endangered on The IUCN Red List of Threatened Species because of substantial habitat loss and inferred population decline from habitat loss across its range. The destruction, degradation and drying of wetlands is likely to be the greatest threat to it. Much remains to be discovered about the life history and ecology of this species. We compiled 132 occurrence records and used a subset of these (64 Spatial Filtering Model and 23 Balanced Model) together with the land-cover assessment of 11 respondents to predict habitat suitability on Borneo. The resulting model predicted a high proportion of Borneo to contain suitable habitat for the otter civet with most coastal areas, swamp forests and lowland forest areas predicted to be highly suitable. Of particular importance for the persistence of otter civet populations are the central forest block in Sabah, much of the production forest in Sarawak, and the lowland peat-swamp forests of Central Kalimantan. Greater survey effort is required in Brunei and throughout the remaining four Kalimantan provinces because most records from these areas were historical.

Key words. Borneo Carnivore Symposium, Brunei, conservation priorities, habitat suitability index, Indonesia, Malaysia, species distribution modelling, survey gaps

Abstrak (Bahasa Indonesia). Musang Air adalah karnivora kecil dari famili Viverridae. Jenis ini adalah jenis asli dari Indonesia (Kalimantan dan Sumatera), Malaysia (Sabah, Sarawak, dan Semenanjung), Brunei Darussalam dan Thailand Selatan. Di semua kawasan jenis ini dijumpai, sebarannya tidak merata dan diasumsikan sebagai jenis spesialis lahan basah, seperti hutan gambut, hutan rawa dan hutan primer, walaupun kadang-kadang juga dijumpai di hutan bekas tebangan dan hutan sekunder. Musang Air termasuk dalam daftar CITES Appendix II dan berstatus genting dalam Daftar Jenis Terancam Punah IUCN, dikarenakan kehilangan habitat utama dan penurunan jumlah populasi di seluruh kawasan sebarannya. Pengrusakan dan degradasi serta pengeringan lahan basah merupakan beberapa ancaman utama dari karnivora yang tidak banyak diketahui ini. Masih banyak yang harus diungkapkan tentang jenis ini, seperti kehidupan dan ekologi. Kami mengumpulkan 132 catatan temuan dan menggunakan sebagian dari data ini (64 Model Spasial Tersaring dan 23 Model Penyeimbang) dan secara bersamaan melakukan penilaian kelas tutupan lahan dari 11 responden untuk memprediksi kesesuaian habitat di Kalimantan. Prediksi hasil modeling menyatakan bahwa sebagian besar pulau Borneo sesuai untuk habitat Musang Air terutama di wilayah pesisir, hutan rawa dan hutan dataran rendah. Kawasan yang penting untuk Musang Air di Borneo adalah hutan di bagian tengah Sabah, beberapa hutan produksi di Sarawak, dan hutan dataran rendah-hutan gambut di Kalimantan Tengah. Upaya penelitian dan survey diperlukan di Brunei dan Seluruh Propinsi di Kalimantan (Indonesia), karena kebanyakan data yang terkumpul selama ini hanya dari catatan lama.

Abstrak (Bahasa Malaysia). Musang Memerang (Musang Air) *Cynogale bennettii* adalah sejenis karnivora kecil dari keluarga Viverridae. Spesies ini terdapat di Indonesia (Kalimantan dan Sumatra), Malaysia (Sabah, Sarawak dan Semenanjung Malaysia), Brunei Darussalam dan selatan Thailand. Di semua tempat di mana ia dijumpai, taburannya berkelompok-kelompok dan tidak seragam. Spesies ini dianggap khusus kepada kawasan tanah lempab (lahan basah) (wetlands) dengan lebih menggemari hutan paya gambut (hutan rawa gambut) (peat-swamp forest) dan hutan primer, tetapi ia juga direkodkan di hutan yang sudah dibalok dan hutan sekunder. Musang Air disenaraikan di Lampiran II (Appendix II) CITES dan disenaraikan sebagai spesies Terancam (Endangered) menurut Senarai Merah IUCN (IUCN Red List of Threatened Species) disebabkan pengurangan populasinya yang ketara di semua tempat di mana ia dijumpai. Kemusnahan, degradasi dan pengeringan kawasan tanah bencah mungkin merupakan ancaman utama terhadap spesies yang tidak banyak diketahui ini. Masih banyak yang perlu dipelajari tentang kehidupan dan ekologi spesies ini. Kami mengumpulkan 132 rekod penemuan Musang Air dan menggunakan sebahagian daripada rekod ini (64 Model yang ditapis secara spasial dan 23 Model Seimbang) bersama-sama dengan penilaian kelas tutupan tanah/habitat dari 11 saintis untuk meramalkan kesesuaian habitat bagi spesies ini di Borneo. Model yang kami bina meramalkan sebahagian besar Borneo terdiri daripada habitat yang sesuai bagi spesies ini di mana kebanyakan kawasan pinggir laut, hutan paya dan hutan kawasan rendah diramalkan sesuai baginya. Kawasan-kawasan yang

dianggap penting bagi pemuliharaan spesis ini adalah kawasan hutan di pertengahan Sabah, kebanyakan kawasan pembalakan di Sarawak, dan hutan rawa gambut di kawasan rendah di Kalimantan Tengah. Lebih banyak kerja pemantauan perlu dilakukan di Brunei dan di keempat-empat daerah di Kalimantan kerana kebanyakan rekod dari kawasan ini adalah rekod lama.

INTRODUCTION

The otter civet *Cynogale bennettii* Gray, has a Sundaic distribution and is found in Malaysia, Indonesia (Sumatra, Borneo), Brunei and Thailand (Veron et al., 2006; Chutipong et al., 2014). The English name for this species refers to its (assumed) semi-aquatic life style. Several morphological adaptations, such as broad, webbed feet and muscles which close the nose and ears from intruding water, indicate a higher degree of specialisation than is found in some other small carnivores associated with water, such as the aquatic genet *Genetta piscivora* (J. A. Allen), or the marsh mongoose *Atilax paludinosus* (G. [Baron] Cuvier) (Medway, 1978; Lekagul & McNeely, 1977; Yasuma, 1994; Veron et al., 2006). The otter civet (Fig. 1) is speculated to hunt by lying in ambush in water (Schreiber et al., 1989). It is assumed that this species feeds on fish, crabs, molluscs, small mammals and birds (Lekagul & McNeely, 1977). It is considered to be nocturnal, although occasionally active during the day (Sebastian, 2005; Cheyne et al., 2010a, b; Ross et al., in press; Borneo Carnivore Database). The otter civet might also den in cavities in trees (SMC, pers. obs.).

The otter civet is protected under Indonesian Law (PP 7 Tahun 1999), is Totally Protected in Malaysia (Wildlife Conservation Act 2010, peninsular Malaysia; Wildlife Conservation Enactment of 1997, Sabah and the Wildlife Protection Ordinance 1998, Sarawak), and protected in Thailand (Wild Animal Reservation and Protection Act 2003) but has no national protection status in Brunei. The otter civet is categorised as Endangered on The IUCN Red List of Threatened Species (IUCN, 2015). It has been found in many parts of Borneo, including Samunsam Wildlife Sanctuary (Sebastian, 2005); Bukit Sarang Conservation Area (Belden et al., 2007); Deramakot, Tangkulap and Segaliud Lokan forest reserves (all logging concessions) (Wilting et al., 2010); Danau Sentarum National Park (Jeanes & Meijaard, 2000); primary and selectively logged parts of the Yayasan Sabah Forest Management Area (Heydon & Ghaffar, 1997); Tanjung Puting National Park; Sabangau National Park and forest complex; Gunung Palung National Park; Kutai National Park; Sungai Wain Protected Forest;



Fig. 1. Otter civet *Cynogale bennettii* camera-trapped in Sabangau Peat-swamp Forest, Central Kalimantan on 26 May 2009, with logging canal in background (photograph by Susan M Cheyne/OuTrop).

and Bukit Perai-Bukit Rongga Protected Forest Complex and Bukit Batikap Protected Forest. Information from non-protected areas is limited, based on personal communications with delegates at the Bornean Carnivore Symposium (BCS) in 2011.

RESULTS

Species occurrence records. The species is distributed around the coastal and lowland wetland forests on Borneo based on distribution records submitted to the BCS and used for modelling (Fig. 2). Of 132 Bornean locality records for the otter civet, only 45 were recent (2001–2011). Forty records had a precision of within 0.5 km and 68 had a precision over 5 km (Categories 4 and 5); we excluded these latter records from the model (Table 1). Records came from locations across most of Borneo although there was a high concentration of records from Sabah and none from South Kalimantan (Fig. 2). To account for the greater survey effort in Sabah the model used only a subset of 23 records (Balanced Model) or, for Sabah only, 64 records (Spatial Filtering Model) (for details see Kramer-Schadt et al., 2016).

Habitat associations. The land-cover class habitat scoring of 11 respondents showed a general belief that most of the 15 habitat categories were partly unsuitable (Table 2). Swamp forest and lowland forest with wetlands were considered most suitable. However the large range of values from the respondents suggest uncertainty as to the suitability of mangroves, old plantations and water or fishpond areas for otter civet, based on the range of land-cover reclassification data (Table 2). This shows how little is known about this

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Table 1. Summary of the occurrence records for otter civet *Cynogale bennettii* on Borneo.

Spatial Precision	Total No. of Records	No. of Records in M ₁	No. of Records in M ₂	No. of Recent Records 2001–2011
Category 1 below 500 m	40	7	35	40
Category 2 500 m – 2 km	6	1	6	0
Category 3 2–5 km	37	15	23	1
Category 4 above 5 km	16	-	-	4
Category 5 (no coordinates*)	33	-	-	0
Total	132	23	64	45

M₁ = Balanced Model; M₂ = Spatial Filtering Model (2 km); *only coarse location description was available.

Table 2. Land-cover reclassification for otter civet *Cynogale bennettii* based on the questionnaire results of 11 respondents working on carnivores on Borneo.

Land-cover Class	Mean of Reclassification	Range of Reclassifications
Lowland forest	3.36	3–4
Upland forest	2.00	0–3
Lower montane forest	1.13	0–2
Upper montane forest	0.38	0–1
Forest mosaics/lowland forest	1.72	*
Forest mosaics/upland forest	1.32	#
Swamp forest	3.50	2–4
Mangrove	2.33	1–4
Old plantations	0.88	0–3
Young plantations and crops	0.11	0–1
Burnt forest area	0.00	0–0
Mixed crops	0.22	0–1
Bare area	0.00	0–0
Water and fishponds	0.80	0–4
Water	0.30	0–3

*/#Calculated based on the mean of the reclassification of old plantation and *lowland forest or #upland forest, respectively.

Habitat suitability rank ranges from 0 (unsuitable) to 4 (most suitable); further detail, and on land-cover classes, in Kramer-Schadt et al. (2016).

species and highlights that caution should be taken when interpreting the model outputs.

Habitat suitability index (HSI) model. The final habitat suitability model (see Kramer-Schadt et al. (2016) for methods) predicted that a large proportion of Borneo is potentially suitable habitat for the otter civet (Fig. 3). The least suitable areas were predicted to be South Kalimantan and the high-altitude interior of the island. The peat-swamp areas, in particular of Sabah and a large area of Sarawak, were predicted to be highly suitable.

The mapped predictions of the habitat suitability index model (Fig. 3) need to be interpreted with caution (see Kramer-Schadt et al. (2016) for more details). Of note, some

areas, particularly in South and West Kalimantan had little information, reflecting the lower survey efforts in these areas. Although search-effort bias has been minimised during the modelling, these areas might still be underrepresented in the distribution map, especially if they are climatically distinct from the rest of Borneo. This is particularly likely for South Kalimantan which has a more pronounced dry season (see Kramer-Schadt et al., 2016: Fig. 3A). Thus, unless there are records sufficiently spatially precise to have been used in the model, the prediction cannot accurately reflect the potential for occurrence in that region. In general, only further surveys could determine if the lower predictions are because of the minimal survey efforts or reflect a genuine lower suitability of these areas for the species, perhaps because of different climatic conditions or because large

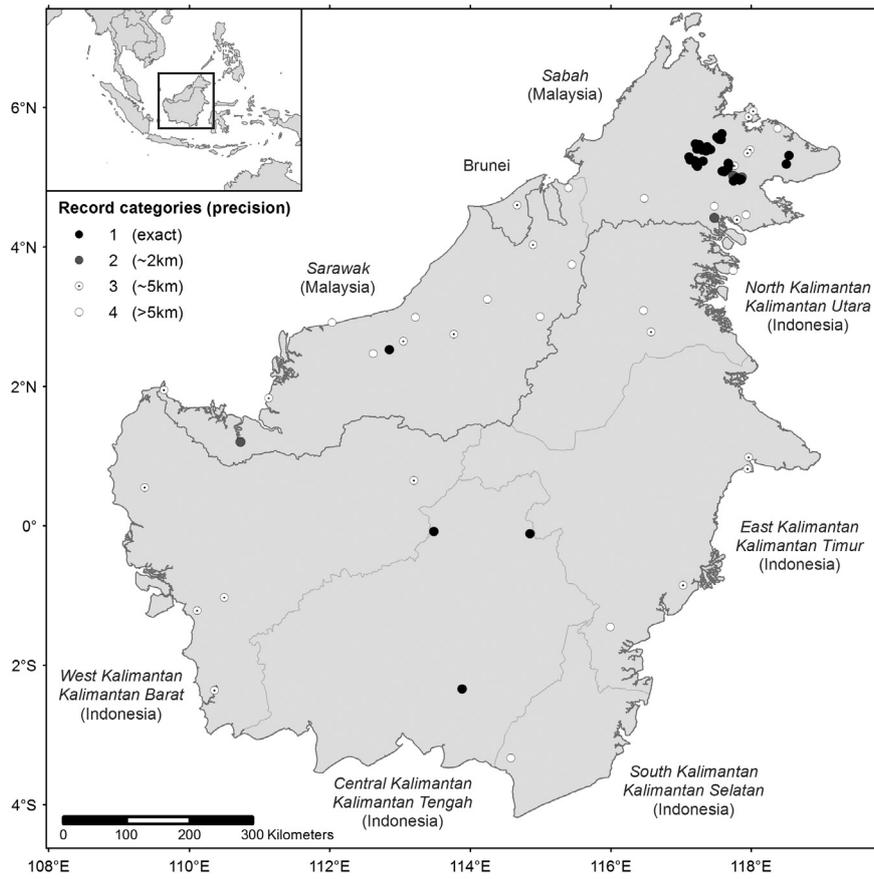


Fig. 2. Location of otter civet *Cynogale bennettii* occurrence records across Borneo, showing categories of spatial precision as well as country and state boundaries.

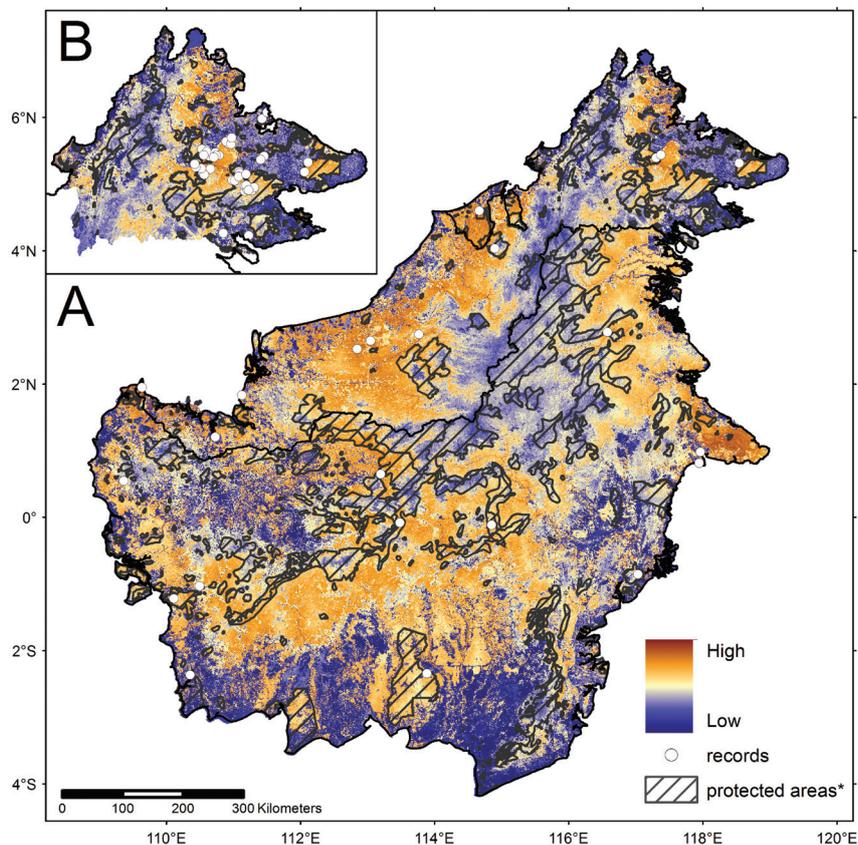


Fig. 3. Predictive Habitat Suitability Index (HSI) models for otter civet *Cynogale bennettii* including location records used in models. A, Balanced Model for the island of Borneo; B, Spatial Filtering Model for Sabah, Malaysia. Sources for protected area information: see Kramer-Schadt et al. (2016).

areas have been transformed to unsuitable land-cover (see Kramer-Schadt et al., 2016: Fig. 3B).

DISCUSSION

Habitat suitability. The predicted distribution is patchy and restricted to low to moderate elevation areas and wetlands. Little is known of the habitat and ecology of the otter civet and further studies are required. This species is thought to be largely confined to lowland and peat-swamp forests (Cheyne et al., 2010b), although there are recent records from lowland dry forest. It has also been recorded in secondary (logged) forests and bamboo forests, although its long-term persistence in these habitats is unknown (Heydon & Ghaffar, 1997; Veron et al., 2006). The otter civet has also been recorded from freshwater swamp forest and limestone forest, surrounded by acacia plantation in Bukit Sarang Conservation Area, Sarawak (Belden et al., 2007). On the basis of the predicted distribution the following priority areas are proposed. Much of the wetter lowland habitat has already been destroyed by repeated fire (IFFM, 1998; Bechteler & Siegert, 2004; Fredriksson et al., 2007; Harrison et al., 2009). If this were not the case, then many areas including the Mahakam lakes area in East Kalimantan (with ample freshwater and peat swamp areas) would also still be suitable habitat for the otter civet.

East Kalimantan and North Kalimantan, Indonesia. Large areas of East Kalimantan were predicted to be unsuitable. Of the area predicted to be suitable, much lies outside protected areas with the exception of Sungai Wain Protected Forest near Balikpapan Bay. High-elevation areas are predicted to be unsuitable with the exception of Berau district (although no records exist from this area as of late 2015; SMC, unpublished data). The wetland delta areas of the Sungai [=River] Bengalun in the north and the Sungai Mahakam in the south were not predicted to be suitable. This could reflect high human disturbance or a bias in the model stemming from limited search effort insufficient to have generated otter civet records in these areas. The karst landscape of the Sangkulirang–Mangkalihat peninsula was predicted to be highly suitable, perhaps because of good forest cover quality and lower disturbance. More information is needed for karst forests because recent surveys have identified few above-ground rivers (GMF, pers. obs.).

South Kalimantan, Indonesia. Nearly all South Kalimantan was predicted to be poor habitat. The models did not include any records from South Kalimantan; possibly reflecting low survey effort rather than a true absence. This area of Borneo has the harshest dry season (extracted from Hijmans et al., 2005, 2015), which could provide a basis for a natural absence of otter civet. Thus more extensive surveys are needed in the province's wetland areas.

Central Kalimantan, Indonesia. Our predictive models suggest that this province contains the largest areas of suitable habitat including the extensive peat-swamp forests, particularly the Sabangau catchment and the Katingan–Kahayan floodplain. The higher-elevation areas further inland

such as around the Müller and Schwaner ranges are predicted to be unsuitable. Most of the widespread peat-swamp areas in this province are not protected.

West Kalimantan, Indonesia. Most of West Kalimantan was predicted to be of low suitability and few records were obtained. Possibly this reflects low survey effort; more surveys are needed in this province. The areas of highest predicted suitability are the scattered peat-swamp forest areas (e.g., Gunung Palung National Park and the Bukit Perai–Bukit Rongga Protected Forest Complex), but much of the predicted range is outside protected areas.

Sabah, Malaysia. Much of Sabah was predicted to be suitable, with the exception of montane areas. Sabah has retained good forest cover with many areas affording some level of protection despite also being designated as commercial forest. The central forest block in Sabah was identified as a priority area containing both Danum Valley and Maliau Basin Conservation Areas. Eastern Sabah contains extensive oil palm estates and overall less suitable habitat; here a key protected area is Tabin Wildlife Reserve.

Sarawak, Malaysia. Most of Sarawak was also predicted to be suitable habitat except the south-eastern portion. Predicted priority protected areas are the Loagan Bunut National Park and the contiguous, proposed Batu Laga Wildlife Sanctuary and Hose Mountains National Park, although the higher-elevation areas of the latter, around Bukit Batu, are likely to be unsuitable. Records exist from two protected areas (Samunsam Wildlife Sanctuary and Bukit Sarang Conservation Area).

Brunei Darussalam. Most of Brunei was predicted to be suitable but only one historical record (in the Tasek Merimbun) exists. Thus, Brunei is a priority for further investigation of current distribution, status and threats.

General threats. Destruction, degradation and draining of wetlands through fire and illegal logging are likely to be the greatest threats to otter civet habitat. Clear-cut logging is a major factor contributing to the decline in suitable habitat (often followed by conversion to non-forest habitats like oil palm plantation). Even selective logging might render occupied areas unsuitable if the most specialised civets, such as otter civet, are less tolerant of logged forests than are generalist ones. Combined, this loss of primary forest may be responsible for the current rarity of the otter civet (Veron et al., 2006). Pollution of waterways (e.g., mercury from gold extraction) is also a potential threat. The wildlife trade and local consumption might adversely affect this species although there is no meaningful information base from which to assess this.

CONSERVATION PRIORITIES

Conservation priorities for this species are interlinked: protection and restoration of wetland habitat is vital. This links to the need for more information on distribution, habitat preference, population size and trend, and human impacts.

Surveys are needed to determine otter civet distribution outside protected areas, potential impacts of mercury in rivers (relevant to all wetland specialist species) and otter civet tolerance to secondary habitats, including riverine areas in plantations and other areas that maintain some natural vegetation. These habitats require urgent action to maintain their high quality; e.g., protection of swamp-forest and riverine habitat, blockage of drainage canals in swamp-forest, and the prevention of illegal harvesting of timber and hunting to encourage persistence of this species in the long-term. Especially lacking is information on the prevalence of otter civet in national and international trade. Otter civet is reported infrequently in seizures (e.g., Shepherd & Shepherd, 2010), but misidentification might lead to under-reporting in the illegal wildlife trade. In areas (protected or otherwise) with long-term research presence, monitoring of population trends would be valuable. In particular, the species is very poorly known in Indonesian Borneo with only 16 confirmed recent records compared with 115 from Sabah and Sarawak. There are no records, historical or recent, from South Kalimantan.

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