Records of small carnivores and of medium-sized nocturnal mammals on Java, Indonesia

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Abstract

Most small carnivores and nocturnal mammals in general on the Indonesian island of Java lack frequent and comprehensive distribution surveys. Nocturnal surveys by direct observations from walked transects (survey effort 127 km, about 254 hours) and fixed-point surveys at a total of 14 areas throughout Java during 2012–2014, supplemented by camera-trapping (705 camera-trap-nights) and direct sightings from Cipaganti, western Java, from two years' research presence, yielded records of Leopard Cat *Prionailurus bengalensis* (121 encounters/2 sites), Javan Mongoose *Herpestes javanicus* (4/2), Yellow-throated Marten *Martes flavigula* (1/1), Javan Ferret Badger *Melogale orientalis* (37/1), Banded Linsang *Prionodon linsang* (2/2), Binturong *Arctictis binturong* (3/2), Common Palm Civet *Paradoxurus hermaphroditus* (145/10), Small Indian Civet *Viverricula indica* (8/1), Javan Chevrotain *Tragulus javanicus* (3/2), Javan Colugo *Galeopterus variegatus* (24/5), Spotted Giant Flying Squirrel *Petaurista elegans* (2/1) and Red Giant Flying Squirrel *P. petaurista* (13/3), as well as of the research's focus, Javan Slow Loris *Nycticebus javanicus*. Nine species also plausibly detectable and identifiable through such surveys were not encountered. Although chance and the selection of survey sites, habitat and methods might explain the absence of most of these nine, the lack of records of Small-toothed Palm Civet *Arctogalidia trivirgata*, Sunda Stink-badger *Mydaus javanensis* and Sunda Porcupine *Hystrix javanica* raises concern about their conservation status on Java. Javan Colugo, thought to be confined to western Java, was recorded three times in two sites 600 km away in the easternmost part of the island, thereby significantly extending its known range. Some species showed remarkable flexibility in their choice of habitat and were relatively common in human-modified and unprotected sites. We report descriptive data on behaviour, ecology and sighting distances from human settlements. Regional population declines and possible local extinctions might go undetected, unless surveys are more frequent and geographically broader. Some of the survey sites presented here would allow for more intensive studies of several species.

Keywords: *Arctogalidia trivirgata*, biogeography, camera-trapping, ecological flexibility, *Galeopterus variegatus*, *Hystrix javanica*, Javan Colugo, nocturnal mammals, Small-toothed Palm Civet, spotlighting, Sunda Porcupine

Pengamatan hewan karnivora kecil dan mamalia nokturnal berukuran sedang di Jawa, Indonesia

Abstrak

Sebagian besar dari Ordo karnivora kecil dan mamalia nokturnal di Pulau Jawa, Indonesia kurang memiliki survey distribusi yang komprehensif. Survey nokturnal melalui observasi langsung di jalur transek (sepanjang 127 km, 254 jam), camera-trapping (705 hari jebak kamera), survey titik-tetap nokturnal di 14 area seluruh Jawa 2012-2014, dan catatan tambahan dari Cipaganti, bagian barat Jawa, dari riset selama dua tahun, menghasilkan catatan penampakan Kucing Kuwuk *Prionailurus bengalensis* (121 perjumpaan, 2 lokasi), Garangan Jawa *Herpestes javanicus* (4/2), Amunin Panan *Martes flavigula* (1/1), Biul Slentek *Melogale orientalis* (37/1), Linsang *Prionodon linsang* (2/2), Binturong Muntu *Arctictis binturong* (3/2), Musang Luwak *Paradoxurus hermaphroditus* (145/10), Musang Rase *Viverricula indica* (8/1), Pelanduk Kancil *Tragulus javanicus* (3/2), Tando *Galeopterus variegatus* (24/5), Tando Totol *Petaurista elegans* (2/1) dan Tando Merah *P. petaurista* (13/3), serta spesies yang menjadi fokus penelitian, Kukang Jawa *Nycticebus javanicus*. Sembilan spesies yang seharusnya terdeteksi melalui survey tersebut tidak diketemukan. Meskipun cara pemilihan lokasi survey, habitat dan metode yang digunakan mungkin menjelaskan absennya sebagian besar dari Sembilan spesies ini, tidak ditemukannya Musang Akar *Arctogalidia trivirgata*, Teledu Sigung *Mydaus javanensis* dan Landak Jawa *Hystrix javanica* menimbulkan kekhawatiran akan status konservasi mereka di Jawa. Tando, yang diduga hanya menempati bagian barat Jawa, ditemukan sebanyak tiga kali di dua lokasi sejauh 600 km sebelah ujung timur pulau Jawa, ini menandakan perluasan yang signifikan dari daerah jelajahnya. Beberapa spesies menunjukkan fleksibilitas yang tinggi akan pilihan habitat dan relatif umum ditemui di lokasi yang tidak dilindungi dan telah dimodifikasi manusia. Kami melaporkan data deskriptif akan perilaku, ekologi, dan jarak perjumpaan dari pemukiman manusia. Penurunan populasi regional dan kemungkinan kepunahan lokal tidak dapat terdeteksi, kecuali survey dibuat lebih sering dan meliputi area geografis yang lebih luas. Beberapa lokasi survey yang dijelaskan disini dapat emnjadi area studi yang lebih intensif bagi beberapa spesies.

Introduction

Sundaland, which encompasses the Sunda shelf, is considered a top biodiversity hotspot based on the large number of endemic species and on the high habitat loss (Myers *et al*. 2000, Brooks *et al*. 2002). Most of its southeastern part, the island of Java, is amongst the most densely populated regions in the world. Java holds only 7% of the land area of Indonesia, but 58% of the human population (BPS 2010), putting an enormous pressure on biodiversity (Sodhi *et al*. 2004, Miettinen *et al*. 2011). More than 90% of Java's natural vegetation has been lost, with much of the remaining natural primary or secondary forest coinciding with areas that are difficult of access

such as mountains (Smiet 1992, Lavigne & Gunnell 2006). Many larger mammals are extinct on the island or have a highly fragmented distribution (Santiapillai & Ramono 1992, Whitten *et al*. 1996, Nijman 2013). Threats include forest decline, but also trade in wild animals for pets, traditional medicine or other economic uses. As trade is mostly unrestrained, the high volumes of wildlife being sold may lead to rapid population declines. Sometimes new trends in demand cause a sudden increase in numbers of wild animals for sale in markets. Examples include the soaring trade in slow lorises *Nycticebus* and owls (Strigiformes) as a result of social or international media presence (Shepherd 2012a, Nekaris *et al*. 2013) as well as the rise in popularity of civet coffee (*kopi luwak*) afflicting Common Palm Civet *Paradoxurus hermaphroditus* (Shepherd 2012b).

Small to medium-sized forest-dwelling mammals are often nocturnal and solitary, therefore, difficult to study (e.g. Lim & Ng 2010). With respect to the island of Java, few distribution surveys have covered small carnivores (many of which are nocturnal) or in general, the nocturnal mammals less popular amongst the general public. Many of these species' recent distribution data stem from chance sightings (Duckworth *et al*. 2008, Robson 2008, Eaton *et al*. 2010, Moore 2011), with formal surveys such as camera-trapping extremely rarely written up in accessible venues (e.g. Marliana & Rühe 2012). Because many populations of nocturnal forest-dwelling animals in Southeast Asia are declining (Ceballos & Ehrlich 2002, Sodhi *et al*. 2004), more frequent studies are required.

In the case of Indonesia, many small carnivores and nocturnal mammals, including some that are endemic, are not included in a threat category on *The IUCN Red List of Threatened Species* (IUCN 2014). Javan Ferret Badger *Melogale orientalis* (Data Deficient - DD), Javan Chevrotain *Tragulus javanicus* sensu stricto (DD) and Javan Colugo *Galeopterus variegatus* (Not Recognised - NR) are endemic to Java or to Java and Bali, but there are few data on their occurrence, levels of tolerance to human disturbance and overall conservation status. To aid in updating *IUCN Red List* status and as a baseline for designing conservation schemes, field data for nocturnal mammals on Java are urgently required.

We present data on various small carnivores and similarly-sized nocturnal mammals of Java collected over a 2½-year period, at most sites by nocturnal spotlight transects, supplemented by camera-tapping and collection of incidental observations at one site and replaced by nocturnal spotlight static watches at another. We detail the location and encounter rate of records of the survey species in different parts of Java and report on various observations on behaviour, ecology and threats. The species considered comprise all carnivores except big cats *Panthera* and Dhole *Cuon alpinus*, all giant flying squirrels *Petaurista*, Sunda Porcupine *Hystrix javanica*, Javan Chevrotain, Javan Colugo, Sunda Pangolin *Manis javanica* and Javan Warty Pig *Sus verrucosus*. Eurasian Wild Pig *Sus scrofa*, also present on Java, was not included, because it is non-native. Javan Slow Loris *Nycticebus javanicus* is reported elsewhere (Voskamp *et al*. 2014).

Survey area

Java has a high level of endemism. Many species occurring on Java are better known from its western part (Whitten *et al*. 1996). Precipitation varies from over 6,000 mm per year in parts of west and central Java to less than 1,500 mm in parts of east Java and along the north coast. The annual average temperature varies from 26 °C to 29 °C at sea level (Whitten *et al*. 1996). Java is largely of volcanic origin with altitudes from 0 to 3,676 m asl. The survey sites lay between sea level and 1,850 m asl. While protected sites consisted mainly of secondary forest in different stages of growth as well as forest plantations of mostly non-native trees, unprotected sites were mosaic-like landscapes (*talun*) with forest and bamboo fragments, agricultural fields and non-native forest plantations. Survey sites, with their protection status, are listed in Appendix I. The long-term study site Cipaganti includes several small streams coming from the mountain, typically narrower than 2 m and usually dry from May to July. While observing lorises in Cipaganti, we often spotted small rodents (especially mice) in trees that are potential prey for most carnivore species discussed in this paper. The vegetation in Cipaganti was very open with no or single tree row canopy connection between most of the natural vegetation.

Data collection

All data were collected as part of a long-term research project on Javan Slow Loris. Survey sites were selected because of (i) the known presence of this species; (ii) species distribution models (Thorn *et al*. 2009); (iii) suitable habitat; and (iv) information where it might occur. Likewise, survey methods and equipment were optimised for detecting lorises. Even the camera-traps were set specifically to examine presence of ground-dwelling potential loris predators. This bias has to be taken into account when interpreting other species' records.

We used data from three expeditions: one (April–June 2012) focussing on 11 sites distributed across Java (Voskamp *et al*. 2014), one (May–July 2013) in East Java, and one (February–May 2014) in West Java. On the expeditions, the main survey method was direct sighting of animals from walked nocturnal transects, replaced at one site by nocturnal static observations. Incidental sightings are included from the period April 2012–May 2014 in an ongoing study of Javan Slow Loris in and around the village of Cipaganti, on the eastern slopes of Gunung Papandayan in West Java (Fig. 1).

The ongoing study in Cipaganti is detailed in Rode-Margono *et al*. (in press). Data from Cipaganti result from observations incidental to routine study of Javan Slow Loris and from camera-traps (Cuddeback Attack IR; Bushnell Trophy cam night vision; 1–6 units set on 283 nights, totalling 705 individual camera-trap-nights). The cameras were set 0.5 m above the ground in small openings or wildlife trails in otherwise relatively dense vegetation (small trees, undergrowth, bamboo), but not in very open space because of the risk of theft. Camera-traps were not baited and were set to operate round the 24-hour cycle. Photographs of the same individual or social group (if identifiable) at the same camera-trap station that were less than 2 hours apart are treated as comprising one record. If identification to species was uncertain, records were excluded. No other location was camera-trapped.

At other survey sites, transects along existing paths and roads, or fixed-point surveys (one site) used teams of at least two people walking at an average speed of approximately 500

Fig. 1. Survey sites for nocturnal mammals in Java, Indonesia, in 2012–2014. Nine out of 14 sites are in protected areas. 1 = Ujung Kulon; 2 = Carita; 3 = Gunung Gede Pangrango and Cimungkat*; 4 = Cipaganti* and Pangalengan*; 5 = Sumedang*; 6 = Tasikmalaya* and Limbangan; 7 = Dieng Plateau; 8 = Gunung Bromo; 9 = Meru Betiri; 10 = Ijen Plateau; 11 = Alas Purwo. * = unprotected area.

m/hour, scanning all levels of vegetation using headlamps with a combination of either red (see Nekaris *et al*. 2008) or white filters. Transects were walked during ~18h00–02h00. Fixed-point surveys were conducted between 18h00 and 04h00. At each point, three spots 10 m from each other were selected. At each spot the observer stood silently and systematically scanned all levels of the vegetation for 5 minutes, adding up to individual points surveyed for 15 minutes. Surveys were repeated after a minimum of four hours. The individual points were placed randomly along a 1,700-m transect. During fixed-point surveys, red light was used whenever possible, aided with white light if terrain was difficult. Survey effort for each area is reported in Appendix 1; Cipaganti is included twice, with the first two visits included as a transect survey comparable to the others, and the later period included as the long-term study.

Table 1 lists the small carnivores and similarly-sized mammals considered by the surveys. For each animal sighting we recorded the location using Garmin GPS 60 and 62st, date, time and weather conditions (see Sutherland 2006). We recorded animal species, number of individuals and, if observed in a tree, the height of animal and height of tree (Nekaris *et al*. 2008). We recorded *ad libitum* observations about the sex, age class, behaviour, and reaction towards and distance from the observers. Camera-trap photographs were excluded when reporting the height of the animals in trees, because of the bias of camera placement. For a representative sample of sightings we measured the distance to the nearest human settlement of five or more houses using Google Earth V (7.1.1.1888).

Table 1. Small carnivores and similarly-sized species considered in this survey of various sites in Java, Indonesia, 2012–2014.

Family	Species	*IUCN Red List*[1]	National law[2]
Order Carnivora			
FELIDAE	Fishing Cat *Prionailurus viverrinus*	EN A2cd+4cd	P
FELIDAE	Leopard Cat *Prionailurus bengalensis*	LC	P
HERPESTIDAE	Javan Mongoose *Herpestes javanicus*	LC	NP
MEPHITIDAE	Sunda Stink-badger *Mydaus javanensis*	LC	P
MUSTELIDAE	Indonesian Mountain Weasel *Mustela lutreolina*	DD	NP
MUSTELIDAE	Javan Ferret Badger *Melogale orientalis*	DD	NP
MUSTELIDAE	Asian Small-clawed Otter *Aonyx cinereus*	VU A2acd	NP
MUSTELIDAE	Smooth-coated Otter *Lutrogale perspicillata*	VU A2acd	NP
MUSTELIDAE	Yellow-throated Marten *Martes flavigula*	LC	NP
PRIONODONTIDAE	Banded Linsang *Prionodon linsang*	LC	NP
VIVERRIDAE	Binturong *Arctictis binturong*	VU A2cd	P
VIVERRIDAE	Common Palm Civet *Paradoxurus hermaphroditus*	LC	NP
VIVERRIDAE	Small Indian Civet *Viverricula indica*	LC	NP
VIVERRIDAE	Small-toothed Palm Civet *Arctogalidia trivirgata*	LC	NP
Order Cetartiodactyla			
SUIDAE	Javan Warty Pig *Sus verrucosus*	EN A2cd	NP
TRAGULIDAE	Javan Chevrotain *Tragulus javanicus*	DD	P
Order Dermoptera			
CYNOCEPHALIDAE	Javan Colugo *Galeopterus variegatus*	NR	P
Order Pholidota			
MANIDAE	Sunda Pangolin *Manis javanica*	EN A2d+3d+4d	P
Order Rodentia			
HYSTRICIDAE	Sunda Porcupine *Hystrix javanica*	LC	P
SCIURIDAE	Red Giant Flying Squirrel *Petaurista petaurista*	LC	NP
SCIURIDAE	Spotted Giant Flying Squirrel *Petaurista elegans*	LC	P

[1]Global status on *The IUCN Red List of Threatened Species* (IUCN 2014): DD = Data Deficient, EN = Endangered, LC = Least Concern, NR = Not Recognised, VU = Vulnerable.
[2]Protection status in Indonesia, according to Lampiran Peraturan Pemerintah Nomor 7 Tahun 1999 & Undang-Undang No. 5 Tahun 1990. P = protected, NP = not protected.

Results

Combined transect survey efforts were 82.1 km for protected areas and 44.8 km for unprotected areas. All methods combined recorded 12 of the target species: Leopard Cat *Prionailurus bengalensis* (121 encounters / 2 sites), Javan Mongoose *Herpestes javanicus* (4/2), Yellow-throated Marten (1/1), Javan Ferret Badger (37/1), Banded Linsang *Prionodon linsang* (2/2), Binturong *Arctictis binturong* (3/2), Common Palm Civet (145/10), Small Indian Civet *Viverricula indica* (8/1), Javan Chevrotain (3/2), Javan Colugo (24/5), Spotted Giant Flying Squirrel *Petaurista elegans* (2/1) and Red Giant Flying Squirrel *P. petaurista* (13/3) (Table 2), but not Fishing Cat *Prionailurus viverrinus*, Sunda Stink-badger *Mydaus javanensis*, Asian Small-clawed Otter *Aonyx cinereus*, Smooth-coated Otter *Lutrogale perspicillata*, Small-toothed Palm Civet *Arctogalidia trivirgata*, Indonesian Mountain Weasel *Mustela lutreolina*, Javan Warty Pig, Sunda Pangolin or Sunda Porcupine. The only other wild mammal larger than rats (Muridae) and treeshrews *Tupaia* camera-trapped was Eurasian Wild Pig, with 17 camera-trap records in groups up to seven animals between August 2012 and March 2013. Pigs were often encountered directly in Cipaganti, especially during the dry season (farmers report that they descend from the higher forest area to search for food), but mostly in undergrowth so that species identification was not possible.

Several species were frequently recorded close to human settlements (Fig. 2). Leopard Cat and Common Palm Civet came to the perimeter of villages and Javan Colugo was seen within villages, twice at sport fields surrounded by trees. Cipaganti yielded numerous lengthy sightings of small carnivores at distances of 5–20 m. Leopard Cat and Common Palm Civet in Cipaganti seemed relaxed and uninterested in the observers, several times staying in view for 10–30 minutes, generally resting. One Leopard Cat was observed grooming for 20 minutes (Fig. 3); another crossed a stream, where it caught and consumed a large whitish rodent on the bank. Common Palm Civet frequently walked along or sat on rubber-coated water hoses (used for irrigation) suspended aerially between trees. The camera-traps recorded both Leopard Cat and Common Palm Civet faecal and scent marking a single large stone. In one case a Leopard Cat scent-marked the stone, then two days later a Common Palm Civet faecal-marked the same stone after sniffing at the exact spot of the Leopard Cat mark. Whether this was responsive marking is unknown. Only one Javan Colugo was seen gliding. The others were stationary on trees or poles. If disturbed, they remained where they were or 'hopped' up the tree.

In terms of habitat use, Leopard Cat and Javan Chevrotain were found exclusively on the ground, whereas Banded Linsang and Binturong were observed on the ground and in trees. In Cipaganti, where canopy cover is very open, a Binturong on the path turned immediately on illumination and disappeared. In the second sighting there, the Binturong rested in 12 m-high bamboo, apparently comfortable despite its size, 4 m up. The

Table 2. Number of encounters and distribution of nocturnal mammals and small carnivores at various sites on Java, Indonesia, 2012–2014.

Location	LC	JM	JFB	YtM	BL	B	CPC	SIC	JCh	JCo	SGFS	RGFS	Total
Ujung Kulon*							5		1	2			8
Carita*										12			12
Gunung Gede*					1	1	4						6
Dieng Plateau*							4						4
Gunung Bromo*							1						1
Ijen Plateau*										1		1	2
Meru Betiri*		2					9		2	2		5	20
Alas Purwo*							5						5
Cipaganti	1						3						4
Sumedang							3						3
Tasikmalaya	1						2			7			10
Pangalengan (fixed-point survey)							1				2	7	10
Cipaganti: direct observation	106		3		1	2	71	7					190
Cipaganti: camera-trap	13	2	34	1			37	1					88
Grand Total	121	4	37	1	2	3	145	8	3	24	2	13	363
Encounter rate per km protected area	0	0.02	n.a.	n.a.	0.01	0.01	0.34	n.a.	0.04	0.20	n.a.	0.06	0.55
Encounter rate per km unprotected area	0.02	0	n.a.	n.a.	0	0	0.18	n.a.	0	0.18	n.a.	0.02	0.29
Total encounter rate per km	0.01	0.01			0.01	0.01	0.28		0.02	0.19		0.05	0.46

* = Protected locations. Sightings in Cipaganti (direct observations) are not used in encounter rates.

Species: LC = Leopard Cat, SIC = Small Indian Civet, JFB = Javan Ferret Badger, YtM = Yellow-throated Marten, JM = Javan Mongoose, BL = Banded Linsang, B = Binturong, CPC = Common Palm Civet, JCh = Javan Chevrotain, JCo = Javan Colugo, RGFS = Red Giant Flying Squirrel, SGFS = Spotted Giant Flying Squirrel (Table 1 gives scientific names). 'n.a.' signifies that the species was found only by methods other than nocturnal walked transects. Two survey sites, Limbangan and Cimungkat (Appendix 1), are omitted because no animals were seen.

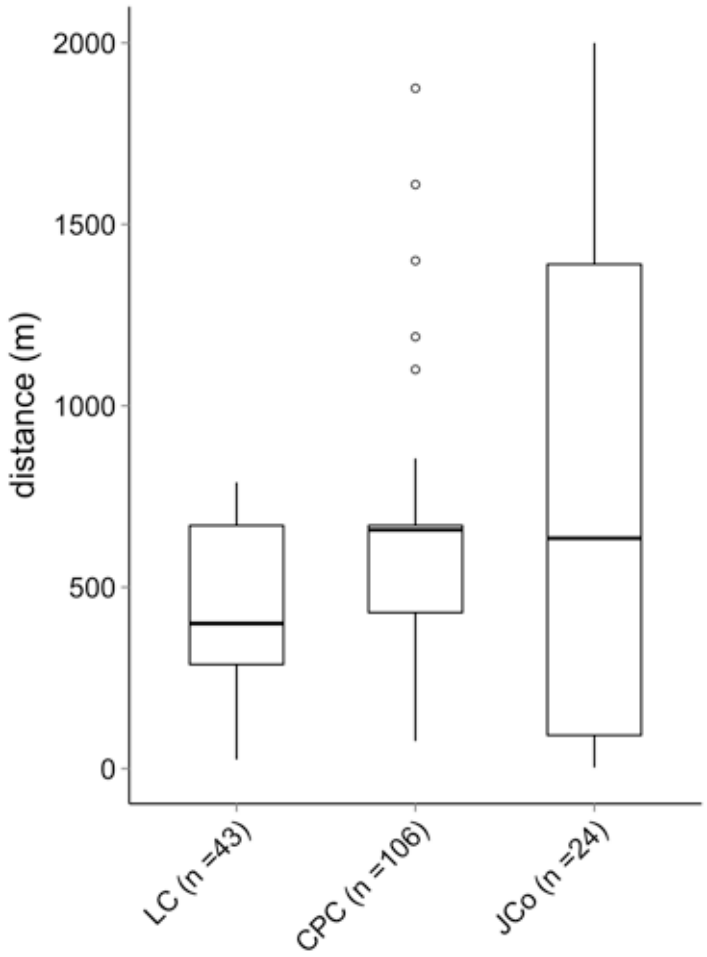

Fig. 2. Median distances (in meters) from individual sightings of three species of nocturnal mammal to human settlements (of at least five houses). The box indicates the 75th and 25th percentiles, the whiskers show the maximum values of the data, circles indicate outliers. All surveys and the long-term study in Cipaganti were included. LC = Leopard Cat *Prionailurus bengalensis*, CPC = Common Palm Civet *Paradoxurus hermaphroditus*, JCo = Javan Colugo *Galeopterus variegatus*.

Fig. 3. Leopard Cat *Prionailurus bengalensis* at Cipaganti, western Java, Indonesia on 4 March 20h13 at 20h30 (Photo: E. J. Rode-Margono). This animal was approached to 6 m and observed for 20 minutes.

Binturong in Gunung Gede Pangrango (closed canopy) was spotted on the path and moved under an observer platform. The Linsang in Cipaganti crossed an asphalt road in an agricultural area with farms, fields and interspersed trees, then disappeared in tall grass and undergrowth. A stream about 3 m wide was less than 500 m away, the nearest larger continuous forest about 1,500 m. The Linsang in Gunung Gede Pangrango was sighted about 6 m up in an 8 m-high tree in closed-canopy habitat. We typically sighted Common Palm Civet in trees, at a median height of 5 m (range 0–33 m; 54 records), and Colugo at 8.5 m (range 2–18 m; 24 records). Height of the trees used by Common Palm Civet was 11 m median (range 6–35 m; 38 records) and by Colugo, 14 m (2–30 m; 23 records).

Common Palm Civet was seen feeding once each on Jackfruit *Arctocarpus heterophyllus* and a fig *Ficus*. In Cipaganti, civet faeces contained coffee beans *Coffea arabica*, birds, small mammals and invertebrates. Camera-traps recorded ferret badgers digging, sniffing and extracting items from the ground, once in a duo.

Concerning sociality, in Cipaganti, six direct observations of immature solitary Leopard Cats, supplemented two (December 2012, April 2014) where a small individual accompanied a large one. Camera-trap video revealed an adult and a juvenile Leopard Cat playing (April 2014). Four times we saw Common Palm Civet kittens: in Tamanjaya an adult with four kittens (roughly 1–2 months old) in a tree trunk fork 14 m up a 20 m tree (March 2012), and in Cipaganti one adult with three kittens on the ground (January 2012, kittens about a third of the mother's body length), one mother–infant duo (June 2012), and one single young (July 2012). Also in Cipaganti, a civet nest (not identified to species) in the base of a banana trunk lined with dead banana leaves, checked on three consecutive days contained at least two kittens (April 2012). The sole Yellow-throated Marten record was a camera-trapped duo of the same size (September 2013; Fig. 4). In two cases, Colugos carried their relatively small but active baby in the patagium while suspending from horizontal branches (March 2012, Ujung Kulon; April 2012, Tasikmalaya). A single juvenile Colugo (about 50% the linear size of an adult) was parked in relatively dense terminal branches (March 2012, Ujung Kulon). Red Giant Flying Squirrel was observed in groups of 2–4 individuals at Pangalengan (April 2014), the Ijen plateau and Meru Betiri (both June 2013); the Spotted Giant Flying Squirrels in

Fig. 4. Yellow-throated Marten *Martes flavigula* at Cipaganti, western Java, Indonesia on 12 September 2013 at 05h40 (Photo: Little Fireface Project).

Fig. 5. First civet trap sighted in Cipaganti, in November 2013 (Photo: W. Tarniwan).

Pangalengan were a duo (April 2014). A duo of Javan Chevrotain comprised animals of similar size (June 2013).

Despite reports of hunting from neighbouring communities, in Cipaganti we have only one report of hunting of nocturnal mammals. In November 2013 we found a civet trap set possibly to catch animals for civet coffee farms (Fig. 5). We dismantled the trap for four nights; on the fifth it was gone. Local people reported that the trap was set by outsiders; the land owner said he had chased the poacher off. The trapping was illegal because it was on private land. In Carita, we encountered two hunters with rifles in the protected forest hunting for Colugo. They reported that local people use it for food and medicine.

Discussion

Faunal community and biogeography

Many nocturnal mammal species remain poorly studied, leading to gaps in knowledge not only of their behavioural ecology and taxonomy but also of their current distribution, abundance and conservation status. Three of 21 species in the survey's remit are listed as Data Deficient on the *IUCN Red List*, yet by no means are the other species well known on Java, or even globally. To our knowledge Java has hosted no long-term study of any of these species. Two of the Data Deficient species were found, Javan Chevrotain and Javan Ferret Badger. Both are endemic to Java and Bali (where occurrence of the chevrotain is not confirmed) (IUCN 2014). Nine of the 21 species were not encountered: Fishing Cat, Sunda Stink-badger, two otter species, Small-toothed Palm Civet, Indonesian Mountain Weasel, Javan Warty Pig, Sunda Pangolin and Sunda Porcupine. This might reflect rarity of these species on Java or coverage of sites and/or use of methods unlikely to find them.

Fishing Cat seems to be associated with coastal areas on Java (Melisch *et al*. 1996), so its absence from the survey sites, all inland, is unsurprising. Indonesian Mountain Weasel is so poorly known that its activity patterns have not been demonstrated. Other tropical Asian weasels seem to be diurnal (e.g. Abramov *et al*. 2008, Ross *et al*. 2013) and if this one is similar, than the lack of records from spotlighting is uninformative about its status. Moreover, the lowest-altitude record traced by Meiri *et al*. (2007) was from 1,400 m. Few sites were surveyed above this altitude (Appendix 1). Otters depend on water and are rarely camera-trapped without specific positioning. The stream at Cipaganti was dry during dry weather periods. At the few sites with seemingly suitable habitat (e.g. Bodogol, Gunung Gede Pangrango), survey effort was probably too low to warrant sightings. Javan Warty Pig was still present in several locations in West Java in 2003 (Semiadi & Meijaard 2006). Although difficult to confirm on spotlight surveys, looking similar to Wild Pig, it should be relatively easy to camera-trap when present. None of the many camera-trapped pigs in Cipaganti were Warty Pig. Although possible to camera-trap, Sunda Pangolin is difficult to spotlight, as it is elusive, tends to freeze when disturbed and has non-reflective eyes. It perhaps inhabits some survey sites, although seems unlikely to occur at the camera-trapped site of Cipaganti.

The absence of records of three species raises concern. We surveyed in many of Java's protected and most natural areas (such as unprotected forest plantations). Although survey effort at some sites was low, the total spotlighting effort should have revealed at least some sightings of Small-toothed Palm Civet, Sunda Porcupine and Sunda Stink-badger, probably frequently, if at all common and widespread in the surveyed areas. However, inspection of the patterns of records of those nocturnal species that were recorded shows that it is possible that the lack of these species' records is a chance effect rather than an indication of genuine rarity in Java. Discounting Javan Mongoose and Yellow-throated Marten, which are mostly diurnal and so stood little chance of detection on the spotlight transects or static counts, all other species in Table 2 are largely or entirely nocturnal. Five of these ten species were found only 0–2 times in all spotlight transects and static counts combined. This suggests the further species not dissimilar to them in status may have been overlooked in the spotlight survey sites simply by chance. This possibility is effectively proven by the difference in species recorded at Cipaganti between spotlight transects (two species) and the incidental sightings and camera-trapping (eight species). Thus, it is quite plausible that the other surveyed areas have faunas as rich as, or even richer than, Cipaganti's.

The difference in species found between the methods used at Cipaganti has a major implication in interpreting the findings for the other survey sites. Any species that does not occur at Cipaganti, and stood a similar chance of being spotlighted at any of the other sites as did half the nocturnal species in Table 2, could have been overlooked entirely. Without the long-term loris study (with its camera-trapping and volumes of incidental direct observations) at Cipaganti, Yellow-throated Marten, Small Indian Civet and Javan Ferret Badger would have had no records either. It is thus possible that the three 'surprising absences' from all survey sites, Sunda Porcupine, Small-toothed Palm Civet and Sunda Stink-badger, simply do not occur at Cipaganti (which is, after all, a non-protected area of highly disturbed habitat) and were overlooked in other areas. Their island-wide status in Java is thus not necessarily that dissimilar to that of Small Indian Civet, Javan Ferret Badger and Yellow-throated Marten. However, this cannot be determined without further information.

Sunda Stink-badger is readily camera-trapped and seen during spotlighting surveys with some regularity although apparently rarely commonly (e.g. Wilting *et al*. 2010, Rustam & Giordano 2014). It remains numerous in at least northern Borneo (Samejima *et al*. in prep.) and the Javan populations have not been suggested to be taxonomically highly distinct. Java constitutes a large proportion of its world range (otherwise, Sumatra, Borneo and the North Natunas). The other two 'surprising absences' raise higher global concerns because they are endemic at some taxonomic level to Java (Small-toothed Palm Civet) or to Java and a few smaller islands to the east (Sunda Porcupine). Allied (sub)species of the civet and the porcupine are readily spotlit (e.g. Duckworth 1992, Willcox *et al*. 2012). Whilst ground-level camera-trapping is unlikely to detect the civet (Willcox *et al*. 2012), Sunda Porcupine should be easily camera-trapped (e.g. Datta *et al*. 2008). Although the porcupine is protected by Indonesian law, we have traced nothing on the species's field status within the last 30 years or more. The distinctive Javan form of Small-toothed Palm Civet is treated by the *IUCN Red List* within a single species covering the genus's entire range. The genus lacks a taxonomic revision since van Bemmel (1952), when taxonomic thinking differed greatly from today's. The failure to find it in over 250 hours walked spotlighting suggests that the possibility, considered by Eaton *et al*. (2010), that the paucity of recent records might relate to limited appropriate survey effort rather than true rarity, is unlikely. Targeted searches for this civet should not be delayed until – whenever it might happen – the genus receives a modern taxonomic review.

Javan Colugo was believed to occur only in western Java east to Pangandaran, close to the border with Central Java (IUCN 2014). Records at the Ijen plateau and Meru Betiri National Park in the island's far east (Fig. 6) represent an extension of known range of some 600 km. All observations were made below 900 m asl. We surveyed no lowlands between Tasikmalaya and Meru Beteri, so targeted search might find the species in Central Java as well.

Unresolved taxonomic issues may lead to (regional) extinctions

Regional extinctions are especially likely to equate to global extinctions of cryptic species where the taxonomy has not been reviewed recently, as is the case for of many species in Java. Some recent taxonomic studies that included Javan taxa found them distinct, including Javan Slow Loris (Wirdateti *et al*. 2006, Nekaris & Jaffe 2007), Javan Colugo (Janečka *et al*. 2008) and Javan Chevrotain (Meijaard & Groves 2004), adding to animals long considered species endemic to Java (and in some cases Bali) such as Javan Ferret Badger and Javan Warty Pig. Javan Chevrotain and Javan Ferret Badger may each even comprise two clearly defined subspecies distributed allopatrically in the west and the east of the island (Long 1992, Meijaard & Groves 2004). Yellow-throated Marten and Small-toothed Palm Civet on Java are both particularly distinct from the respective species's populations elsewhere (Schreiber *et al*. 1989). It is possible that among groups with no comprehensive recent taxonomic review that there are species, currently unrecognised, endemic to Java or nearly so. Where these are also in decline, extinction may be facilitated by a lack of conservation interest in what is currently perceived as only an indistinct taxon at best.

Fig. 6. Javan Colugo *Galeopterus variegatus* at Meru Betiri National Park, East Java on 1 June 2013 (Photo: Guillaume Douay). This represents an eastward extension of known range of some 600 km.

Surprising habitat flexibility in some species

The all-species spotlighting encounter rate was higher in protected areas (total 0.55 sightings/km) than in unprotected areas (total 0.29 sightings/km) (Table 2), but many species were found in human-modified landscapes. At Cipaganti, local farmers start in the fields before dawn so animals are perhaps habituated to human presence. Average, minimum and maximum distances of sightings from human settlements are influenced by the choice of survey sites, but individual records of animals close to human settlement confirm the adaptability of the respective species.

Common Palm Civet was often recorded in agricultural (*talun*) fields and plantations, where it did not fear human presence. In forests elsewhere, Common Palm Civet uses the highest and tallest trees especially for resting, but the canopy is also its foraging habitat (Joshi *et al*. 1995, Su Su & Sale 2007). Our sightings overall were somewhat lower (median 5 m), probably because most were in agricultural areas, where trees are short and animals often use the ground to forage or pass between vegetation fragments.

All but one of the 121 Leopard Cat records were at Cipaganti. Leopard Cat is the most common cat species in Southeast Asia (Nowell & Jackson 1996, Sunquist & Sunquist 2002): our observations are consistent with previous studies showing

its occurrence in both natural habitats and human-modified areas such as agricultural landscapes; its diet, mainly small rodents, might contribute to its tolerance of human-modified habitat (e.g. Rajaratnam *et al*. 2007, Mohamed *et al*. 2009).

All 37 Ferret Badger records were in the *talun* fields of Cipaganti. Javan Ferret Badger lives in both primary forest (e.g. Gunung Gede, Gunung Halimun and Meru Betiri) and near human settlements and tourist trails (Seidensticker & Syuono 1980, Yossa *et al*. 1991, Brickle 2007, Duckworth *et al*. 2008). Nearly all records (34 of 37) were from camera-traps. There was much opportunity for direct observation in the camera-trap survey area, so the resultant small number of Ferret Badger sightings suggests a general elusiveness of this species. Hence, the spotlight surveys might well have overlooked it at other sites.

Seven of 24 Javan Colugo sightings were in agroforest, or even in villages, although Sunda Colugo *G. volans* sensu lato (i.e. including Javan Colugo) has been said to depend on forests with relatively high trees (Lim 2007). This apparent dependence may be biased by the choice of study sites with tall trees (Rode-Margono *et al*. in press). Colugo is strictly arboreal and cannot walk on the ground (Lim 2007). We detected all individuals at heights between 2 m and 18 m. None glided when disturbed: they either froze or moved up the tree. Rather than escape, Colugo seems to rely on camouflage: cryptic coloration and rare vocalisation (Lim 2007, Lim & Ng 2010). All sites with Javan Colugo records also held Javan Slow Loris. The two species might occupy different feeding niches, with colugos feeding mainly on leaves and possibly tree sap (Lim 2007), and lorises on gum, nectar and insects (Wiens *et al*. 2006).

Binturong is usually arboreal (e.g. Nettelbeck 1997). Two of our three sightings were of animals on the ground. Just as with slow loris in areas of discontinuous canopy (Rode-Margono *et al*. in press), Binturong may be forced to use the ground to cross between natural habitat patches. That they do so perhaps indicates adaptability to this kind of habitat.

Following the immense forest loss on Java, many disturbance-sensitive species or species that depend on lowland forest occur in only small, isolated populations with few recorded sightings (Schreiber *et al*. 1989, Melisch *et al*. 1994). We encountered Javan Chevrotain only a few times overall (that said, it was the fourth-most frequently spotlit species in Table 2 and the most frequently spotlit ground-dwelling species), always inside protected areas. This potentially indicates sensitivity to human disturbance. It is presumed to occur mostly in forest and it might need dense understory vegetation (Hoogerwerf 1970, IUCN 2014). By contrast, the low encounter rate of Banded Linsang might reflect survey methods unsuitable for this species (see Cheyne *et al*. 2010). It is reputedly tolerant of disturbed forests and edge habitat (Lim 1973, Van Rompaey 1993).

Threats to study species

Although only one of the 12 species found is categorised by the *IUCN Red List* as globally threatened, all face potential threats, such as habitat loss, disturbance and hunting for wildlife trade (Ceballos & Ehrlich 2002, Shepherd *et al*. 2004, Sodhi *et al*. 2004, Corlett 2007). Species differ in the extent to which these actually pose severe threats. Trade is one of the biggest threats to many Southeast Asian medium-sized mammals and to some bird species such as raptors. Off-takes from wild populations are high (Shepherd *et al*. 2004, Nijman 2010, Shepherd 2012a, 2012b). In Indonesia, numbers of wild civets and Leopard Cat in trade are increasing drastically. Leopard Cat is commonly offered for sale in markets either as pets (often young animals with removed teeth) or skins, even though legally protected (Shepherd *et al*. 2004, Shepherd 2012b). Some civets, especially Common Palm Civet, are in demand for civet coffee (*kopi luwak*) and as a new trend in pets (Shepherd 2012b). Pangolins are heavily traded for traditional medicine (Lim & Ng 2007). Colugos are hunted for consumption in western Java and populations are declining in Southeast Asia (IUCN 2014). Species such as Javan Porcupine, Sunda Colugo, Javan Chevrotain, Sunda Pangolin and Binturong are hardly ever seen at main wildlife markets (Shepherd 2012b), but this does not prove that they are not traded. Sunda Pangolin is numerous in illegal international trade (e.g. Pantel & Chin 2009, Nijman 2010). Porcupines are much traded in Sumatra, Kalimantan and mainland Southeast Asia; thus trade is highly likely also in Java (C. R. Shepherd *in litt.* 2014). Javan Ferret Badger has recently started to appear in wildlife markets (Shepherd 2012b, EJR-M unpubl. data). A sudden rocketing of wildlife trade for particular animals can arise through new trends like civet coffee and the pet trade in lorises or owls following their media appearance in Web 2.0 platforms and movies (Shepherd 2012a, 2012b, Nekaris *et al*. 2013). It is not possible to predict which other species may be similarly affected in the future.

The causal relations between numbers of animals in trade, consumer demand, population trends in the wild and law enforcement or protection of the species are not clear. Whether a drop in animals in trade is caused by a decreasing wild population or by other reasons, and whether an increase in numbers in trade may be followed by a decrease of wild populations can be assessed only if wild populations are reasonably monitored, but this is not the case in Java. Sudden declines of common species by human exploitation can drive Least Concern species to Critically Endangered status or even (local) extinction quickly (see Casey & Myers 1998, Gaston & Fuller 2007).

Ongoing deforestation and modification of natural habitat (see Lavigne & Gunnell 2006) affect species that are less flexible and more dependent on dense forest, particularly those needing lowland habitat with minimal human disturbance. Most species detected in this study were encountered in unprotected areas, except for Javan Chevrotain, which was seen so few times in total that the lack of records from unprotected areas might simply have been a chance effect. Most species' encounter rates were higher in protected areas, although this could be a spurious result from relatively low survey effort in non-protected areas. The clear difference in all-species encounter rates between protected and non-protected areas was mainly, perhaps entirely, driven by Common Palm Civet. The lack of otherwise clear differences raises concerns about the effectiveness of protected areas on Java. Many Indonesian protected areas are not well managed, with ongoing heavy resource exploitation and forest clearing (e.g. Curran *et al*. 2004, Sulistyawati *et al*. 2006, 2008, Bickford *et al*. 2007, Zuhri & Sulistyawati 2007). This may severely inhibit their species conservation role: well managed protected areas should hold wildlife communities radically different from those in heavily anthropogenic areas.

Conclusions and recommendations

These surveys considered 21 species of small carnivores and similarly-sized mammals, including three categorised by the *IUCN Red List* as Data Deficient and six as globally threatened. With only 12 of these 21 species found, the 'absence' of the other nine requires consideration. Most can plausibly be explained by a chance effects and/or the selection of survey sites, habitat and methods inappropriate to the species. However, it is less likely that Small-toothed Palm Civet, Sunda Stink-badger and Sunda Porcupine were common in the surveyed areas. The porcupine is unmistakeable and the stink-badger highly distinctive; both are rather noisy, non-elusive ground-dwellers. Given that surveyors had to scrutinise giant flying squirrels to distinguish the two Javan species, it is unlikely that they could have overlooked Small-toothed Palm Civet at all frequently. Given the wide spread of surveys, the lack of these species' records thus raises concerns about their island-wide conservation status. We highly recommend a reassessment of the conservation status of Sunda Porcupine (including its current *IUCN Red List* status of Least Concern, with abundant population and stable population trend) and intensive taxon-specific surveys for all three species on Java.

Even for presently common species, sudden new threats such as trade of Common Palm Civets for civet coffee might lead to rapid declines. We highly recommend (i) regular surveys of wild populations and (ii) alertness when volumes and/or prices of any species offered on markets change strongly and suddenly.

Four species (Javan Ferret Badger, Javan Colugo, Javan Chevrotain and Javan Warty Pig) are confirmed or suggested to be species endemic to Java (and for some species, also Bali and/or small islands). Others probably remain to be defined. This exacerbates the gravity of the conservation situation caused by habitat destruction, habitat fragmentation and the exploitation for trade or local use. Taxonomic review of those species not yet covered is warranted.

Finally, many species considered here have not been subject to long-term studies anywhere, with a near absence of those studies on Java. Long-term studies of Javan populations, especially the lesser known and Data Deficient species, are needed. We have identified several easily accessible study sites, namely Garut regency and Tasikmalaya regency in West Java, where many species occur, and where long-term studies including radio-tracking, humane trapping and genetic investigations would be possible.

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Appendix 1. Survey sites for nocturnal mammals across Java, Indonesia, 2012–2014: location, habitat(s), altitudinal range and spotlight transect effort.

Survey site	Location	Regency, province	Habitat(s)	Altitude (m)	Effort/km
Ujung Kulon National Park*	Tamanjaya	Pandeglang, Banten	Secondary forest	0–110	1.8
Carita Nature Recreation Park*	Carita	Pandeglang , Banten	Forest plantation	20–220	3.1
Gunung Gede Pangrango National Park*	Bodogol, Cibodas	Sukabumi / Bogor / Cianjur, West Java	Secondary forest	800–860, 1,150–1,170, 1,370–1,580	18.7
Limbangan*	Gunung Masgit Kareumbi Game Reserve	Tasikmalaya, West Java	Secondary forest	810–850	2.8
Dieng Plateau, Telaga Sumurup Strict Nature Reserve*	Sokokembang	Wonosobo, Central Java	Secondary forest	600–670	5.1
Bromo-Tengger Semeru National Park*	Pronojiwo; Gunung Bromo	Malang, East Java	Secondary forest	760–910	6.0
Alas Purwo National Park*	Rowobendo, Sadengan, Sumurtrong	Banyuwangi, East Java	Forest plantation (teak), secondary forest	10–110	15.4
Meru Betiri National Park*	Bandealit, Sumber Salak, Rajegwesi, Sukamade	Banyuwangi, East Java	Late stage secondary forest	10–170	29.2
Ijen Plateau Strict Nature Reserve* / unprotected	Kawah Ijen, Ceding, Kalisat, Sidomulyo	Bondowoso / Jember, East Java	Agricultural area/ forest plantation	650–1,740	10.0
Cimungkat	Southeast boarder of Gunung Gede Pangrango NP	Cianjur, West Java	Late stage secondary forest	1,150–1,170	3.1
Cipaganti**	Gunung Papandayan	Garut, West Java	Agricultural area	1,350–1,560	8.9*
Pangalengan	Gunung Papandayan	Garut, West Java	Agricultural area	1,690–1,850	Fixed point surveys
Sumedang	Sumedang	Sumedang, West Java	Forest plantation	560–690	7.6
Tasikmalaya	Bantarkalong, Ciamis, Raksajaya	Ciamis / Tasikmalaya, West Java	Agricultural area/ forest plantation	420–850	15.2

Total study effort was 126.9 km. * indicates protected areas. ** Effort (in km) for the initial survey in Cipaganti before the field study on Javan Slow Loris. The altitude range is that surveyed, not necessarily the total of the protected area or other land unit.