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Interactions between Javan slow lorises (*Nycticebus javanicus*) and domestic and wild carnivores in an anthropogenic landscape in Java, Indonesia

Running head: slow loris carnivore interactions in Java

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Abstract

With increasing replacement of native forests with agriculture, it is important to understand the factors that allow non-human primates to persist, including their interactions with potential predators, both wild and domestic. For small-bodied nocturnal primates, the smaller carnivores and domestic dogs that often characterise agroforestry landscapes may be a particular threat, especially for primates like slow lorises, which rely on canopy connectivity and are particularly vulnerable on the ground. Here we present data collected over 12 years in Indonesia. During a long-term study on Javan slow lorises, we used *ad libitum* sampling to record 703 instances of slow lorises in proximity to wild small carnivores (mainly Javan palm civets, small Indian civets, Sunda leopard cats and Javan ferret badgers) and 62 and 58 interactions with small carnivores and domestic dogs respectively. Most of these interactions were neutral or potentially affiliative, including sharing waterline canopy bridges and sleeping sites. Only two negative interactions occurred between lorises and wild carnivores and give potential predation events were recorded that could be linked to domestic dogs. Slow lorises also altered their behaviour to be less active and more vigilant when small carnivores were present, or dogs were barking. The introduction of a WhatsApp® group facilitated data collection, increasing the detail of observations, and introducing significantly more data on interactions with domestic dogs. Based on this 12-year study, we saw an overall decline in small carnivores, especially nearer to the village, which could be linked to competition with domestic dogs. As habitats continue to decline, and domestic carnivores increase in number, both wild predators and prey may suffer population declines. A better understanding of the role of dogs in this changing landscape is vital.

Keywords: *coexistence; domestic dog; fragmentation; Lorisidae; Viverridae; Felidae; WhatsApp®*

Introduction

Replacement of native forests by plantations and urban sprawl, resulting in small heterogeneous habitat patches, impacts species composition for predators and their prey (Laurance *et al.*, 2014; Wells *et al.*, 2014). Polyculture plantations in the form of agroecosystems have been described as having the potential to harbour higher species diversity than monocultures, and to be a refuge for smaller bodied often nocturnal mammals (Sodhi *et al.*, 2010; Al-Razi *et al.*, 2023). Amongst those species able to use agroecosystems are small carnivores and non-human primates (hereafter primates) (Estrada *et al.*, 2012; Ferreira *et al.*, 2018; Boonratana, 2019). The selective nature of animals that can survive within an agroforest ecosystem will also impact interspecific interactions, including amongst predators and prey and amongst species that cooperate or compete. These interactions may also include domestic species, which have their own functional roles as predators and prey (Wells *et al.*, 2014). Domestic carnivores, especially dogs (*Canis familiaris*) and cats (*Felis catus*), are often free-roaming, and are known to have caused the decline and even extirpation of many native species through predation, competition, and disease transmission (Doherty *et al.*, 2017). Species affected may include primates as well as other carnivores, especially in agroforestry ecosystems and their associated villages on the fringes of forests and protected areas nearer to human settlements (Anderson, 1986; Gerber *et al.*, 2012).

It is well documented that more predation instances are noticed when a study is focussed on the predator, including for nocturnal primates, especially lemurs (Goodmen et al., 1993; Hart, 2007; Sauther et al., 2024). Burnham et al. (2013) emphasised also that few reports of predation on nocturnal primates are reported outside of Madagascar, reporting only five confirmed cases. Since their review, an emerging literature reveals the potential impact of predators in general (e.g., Cuozzo *et al.,* 2021; Makur *et al.,* 2022), including domestic dogs on nocturnal primates. Species predated upon by domestic dogs including mouse lemurs (*Microcebus* spp.), thick-tailed bushbabies (*Otolemur crassicaudatus*), and small-eared galagos (*O. garnetti lasiotis*) (Goodman *et al.*, 1993; Pihlström *et al.*, 2021; Cuozzo *et al.*, 2022). Although no records are available for domestic cats preying on nocturnal primates, a recorded predation attempt on a Rondon's marmoset (*Mico rondoni*), which is in the same body size range as a juvenile slow loris (*Nycticebus* spp.), has been recorded (Oliveira and Fernandes, 2021). Domestic dogs have been reported to attack small Indian civets (*Viverricula indica*), and their pack hunting means they have the potential to kill carnivores of similar body size (Vanak and Gompper, 2010). Moreover, the presence of both domestic cats and dogs near human habitation may impact the density and distribution of small carnivores due to competition for other prey, such as rodents and marsupials (Vanak and Gomper, 2010; Yen *et al.*, 2019).

Due to their slow climbing locomotion and need for continuous canopy connectivity, slow lorises are particularly vulnerable to loss of habitat connectivity (Al Razi *et al.*, 2022; Choudhury *et al.*, 2022; Quarles *et al.*, 2023). They move awkwardly on the ground, which also may lack substrates to hide in or cling to, meaning one would expect them to be vulnerable to predation in degraded. In our semi-urban study site in West Java Indonesia, Javan slow lorises (*N. javanicus*) have been observed to move as much as 25 m on the ground (Karimloo *et al.*, 2023). Few predation instances, however, have been recorded of slow lorises, mainly in more pristine forest by Bornean (*Pongo pygmaeus wurmbii*) and

Sumatran (*P. p. abelii)* orang-utans, reticulated python (*Python reticulatus*) and changeable hawk eagles (*Nisaetus cirrhatus*) (Utami and van Hooff, 1997; Wiens and Zitzmann, 1999; Svensson *et al.*, 2018; Makur *et al.*, 2022). Translocated slow lorises also are known to have been killed by predators, including monitor lizards (*Varanus* spp.), partly because translocated animals spend unusual amounts of time on the ground (Kenyon *et al.*, 2014).

Indonesia's island of Java provides an interesting location to examine the relationship between slow lorises and carnivores. Java has a history of deforestation for agriculture and urban development stretching back to the first millennium AD, leading to less than 10% of rainforest remaining (Nijman, 2013). This long history of habitat changes likely impacts the relationship between domestic and wild carnivores and primates as they have been able to adapt to habitat changes over a longer time. We have been examining the behavioural ecology of Javan slow lorises in Cipaganti, West Java, Indonesia, since 2011 (Nekaris *et al.*, 2017). Not only do Javan slow lorises use agroforest ecosystems extensively, but for some individuals up to 54% of their home range lies within urban settings (Karimloo *et al.*, 2023). Lack of arboreal connectivity in these urban settings forces animals to the ground, where they may be vulnerable to predators (Birot *et al.*, 2020; Cuozzo et al., 2022). We thus previously implemented and examined the use of arboreal canopy bridges by Javan slow lorises and Javan palm civets (*Paradoxurus musangus javanicus*), noting the use of these bridges by taxa, including the impact of ecological parameters on bridge use (Birot *et al.*, 2020; Nekaris *et al.*, 2021; Nekaris *et al.*, 2020). We also previously explored some aspects of the ecology of three other small carnivore species: small Indian civet (*Viverricula indica*), Sunda leopard cat (*Prionailurus javanensis*) and Javan ferret badger (*Melogale orientalis*) (Campera *et al.*, 2021). Until now, we have not examined any potential interactions between these species, or domestic carnivores – cats and dogs – within the matrix.

As part of a long-term study, data collection methods can change over time and become nuanced to gain more detail about the focal species and those with which they interact. In our nocturnal study, we traditionally use hand-written data sheets with red lights. These factors protect the nocturnal vision of the observers and reduce stress to the animals (Rode-Margono *et al*., 2014). The collection of data via mobile phones is increasing but is still less reported for biodiversity studies (Andrachuk *et al.*, 2019; Njenga *et al.*, 2021). At night, improvements in "dark mode" allow the observer to retain night vision (Kunjir et al., 2024). Furthermore, the emergence of mobile phone towers even in remote areas of Asia, and the increasing adoption of these technologies by younger people, allows novel use of interactive chat groups to monitor data collection (Rahman, 2022). Tools such as WhatsApp® are participative, cost effective and overcome the barriers of time, geography, manpower associated with traditional extension services (Thakur and Chander, 2016). By introducing this technology in our project, we hoped to be able to collect more detailed data than in our traditional datasheets.

With increasing habitat loss, the potential for primates and potential wild predators to come together in the limited space available increases, while at the same time, interactions with domestic carnivores may also increase (Galán-Acedo *et al.*, 2019). Here, we use our long-term dataset to address whether wild carnivores present in our study area are likely potential predators of slow lorises. With decreasing habitat connectivity, and many feral dogs and cats in the village, we also examined their potential threat to slow lorises and

competition with wild carnivores. We thus examine the following questions. How often do slow lorises come into contact with wild and domestic carnivores during follows when they are radio tracked? What is the nature of these interactions? Considering that our long-term study mainly focussed on the slow lorises, we examine the introduction of a WhatsApp® group for *ad libitum* data collection and its implications for recording instances and details of loris and dog interactions that may otherwise not be entered on a scientific datasheet.

Material and Methods

Study site

We collected data in an agroforestry environment, neighbouring a continuous forest, in the municipality of Cipaganti, Cisurupan District, Garut Regency, West Java, Indonesia (7.2786◦ S, 107.7577◦ E; elevation ~1350 m asl. The adjacent forest is part of Mt Puntang, which is part of the volcanic mountain range containing the nationally protected Mt Papandayan of the Western Java montane rainforests ecoregion. The area consists of an agroforestry system of interconnected crops usually separated by tree rows, with additional trees planted inside farms (Campera *et al.*, 2021).

Data Collection

From 2012 to 2023, we collected nightly focal follows to study the behaviour of Javan slow lorises, six nights a week, from 18:00–0:00 and/or from 0:00 until the focal individual entered a sleep site (c.f., Nekaris *et al.*, 2010). We followed 77 individuals via an antenna (Yagi, Biotrack®, UK) and receiver (Sika, Biotrack®, UK), and here consider instantaneous point sampling data from April 2012–July 2023, and evidence of actual predation until October 2024. We also recorded the presence of other mammals we encountered during observations of Javan slow lorises. From 2012 to 2013, these notes were unsystematic, but from 2014, we created a specific data sheet focussing on wild small carnivores; although the behaviour and habitat use of the carnivores was recorded, here we present how many of each species was seen within proximity (10 m or less) of a Javan slow loris. We included additional *ad libitum* observations relating to wild carnivore proximity to slow lorises on slow loris data collection sheets during collection of 5-minute instantaneous sample points. We used our standard project ethogram to quantify the behaviour of the slow lorises, and include seven categories here (Rode-Margono, et al., 2014). Alert and freezing included the animals in a still position, staring at their surroundings. Travelling involved directed movement over a distance, whereas exploring includes moving back and forth over one or a small set of trees, often foraging or scent marking. We combined resting and sleeping, which are relaxed and still behaviours without any form of vigilance. Autogrooming involved an animal cleaning itself with the tongue, toothcomb or toilet claw. Social behaviours recorded here comprised allogrooming, playing, leading, following, and feeding together. To try to increase the detail of these observations, in September 2017, we introduced a WhatsApp® group called “Stories from the Garden”, where trained researchers were encouraged to write detailed notes from the field during observations. The introduction of this group was in response to limited notes in the *ad libitum* column of the datasheets. Field researchers also could ask other experienced researchers on the group questions directly

from the field. From this point, researchers organically began to add *ad libitum* notes on domestic carnivores. Finally, since 2014, we implemented camera traps on canopy bridges, increasing the number of cameras and bridges from 2 to 18 by 2016. We report here events when Javan slow lorises were found interacting with carnivores on canopy bridges (see Birot *et al.*, 2020 and Nekaris *et al.*, 2020 for details on the methods).

Data analysis

We present the total interactions, including qualitative descriptions, between Javan slow lorises and carnivores, as well as putative predation events. We calculated the proportion of each behaviour in the slow loris activity budget in total and by sex when they were in the presence of civets or leopard cats and when dogs were barking. It was not possible to calculate a proportion for each individual as the events were rare. We then calculated the activity budget (total and divided by sex) considering time budgets for each adult individual followed for at least 100 hours (24 females and 22 males). To examine if the introduction of our WhatsApp® group impacted the detail of descriptions of interactions between lorises and carnivores, we used the word frequency analysis function via NVivo for descriptions in the field notes until 2017 and compared these to the WhatsApp® descriptions. We first grouped synonymous words. We reported the weighted percentages (i.e., the frequency of the word relative to the total words counted) of each word in comments before and after the use of WhatsApp® group. Words with a score of one or higher suggest a significant increase between conditions. We also created word clouds for comments done before and after the use of WhatsApp® group.

Results

We recorded 706 instances of Javan slow loris being in proximity of 10 m or less to other mammals. For 379 of these instances, only the presence of the small carnivore was noted. For 327 of them, the observer provided *ad libitum* comments (e.g., distance between lorises and other mammals, behaviour of the other mammals). Javan palm civets (n=413) were the most common small carnivore spotted in proximity to Javan slow lorises, followed by Sunda leopard cats (n=164), small Indian civets (n=57), Javan ferret badgers (n=10), and binturongs (n=1). Three interactions with wild boar were also recorded and for the other 58 interactions we were unable to identify the species. Figure 1 shows the location in the study area where each species was detected over the years, declining markedly by 2022-2023 particularly near the village, despite these years having the largest numbers of loris behavioural observations from the 12-year period.

Most interactions between carnivores and lorises were neutral, whereby the animals passed near each other, or where one animal was foraging near another. For example, we recorded nine instances of a Javan palm civet passively foraging near a parked infant loris. We recorded two instances where adult females actively and curiously approached a Javan palm civet, which ignored them, and another of an adult male loris and civet sniffing each other, then separating. We recorded one aggressive interaction between a Javan palm civet and an adult female slow loris (involving a chase by the palm civet, resulting in the two going in opposite directions). We recorded one seemingly aggressive incident where a small Indian civet, which appeared to be foraging, continually approached an adult male loris, who stood "frozen" until the civet left. We recorded one interaction where the researcher suggested

that a Sunda leopard cat "wanted to attack" an adult female slow loris, based on the cat's pouncing and crouching behaviour. We recorded regular sharing of a bamboo sleeping site (about 3 m apart) of an adult female slow loris, her mate and two offspring and a Javan palm civet and offspring for a ten-month period. Considering the waterline canopy bridges, civets and lorises both regularly used the bridges, but the cameras only recorded two instances of a Javan slow loris and a Javan palm civet crossing a bridge at the same time, whereby the loris needed to move underneath the civet; we recorded one instance where a Javan palm civet lead across the bridge, followed by a loris (Figure 2).

Over the 12 years, we never witnessed a predation event, but of 32 deceased animals, eight showed potential signs of interference by carnivores or other animals (Figure 3). One adult male had what seemed to be a snake bite on his hand. Two disappeared leaving only the radio collar with bite marks, but these also could have been bite marks of a loris chewing the collar off. One adult female was found dead on the ground with bite marks on the back and thighs. Another young adult male who was not able to settle after dispersal was found hanging from a chayote (*Sechium edule*) frame, missing both legs and a left arm. Two elderly adult females found dead had either a head or limbs missing, and a young female was found dead under a pumpkin frame, but too decomposed to look for bite wounds. In all these cases, it was conjectured that bites and interference with the corpse were likely from a dog. We cannot say, however, if a carnivore interfered with an already dead body of an individual or was the cause of death.

As noted above, most records of small carnivores comprised location data only with no comments on their behaviour. In 2017 a WhatsApp® group was introduced in an attempt to increase detailed comments on lorises in general and on the behaviour of carnivores and their interactions with lorises. The number comments increased from 43.3% to 51.1% after the introduction of the WhatsApp® group. Of these comments, the number of comments with details on the behaviour of carnivores was 31.6% (13.7% of the total number of comments) before and 65.7% (33.6% of the total number of comments) after the introduction of the WhatsApp® group. After the introduction of the WhatsApp group observers provided more details on the behaviour of carnivores, whilst before its introduction most of the information was descriptive. The word clouds and the table both show that before, terms were more descriptive, for example the distance to the path or other environmental features and area where the individuals were found. Afterwards, terms linked to their behaviour and ecology (such as "froze", "alert" or "fled") had significantly higher weights, as shown by the NVIVO analysis (Table 1, Figure 4).

A notable change after the introduction of the WhatsApp® group was the inclusion of records of response to dogs. Although we never saw a direct interaction between dogs and slow lorises, researchers included statements like "he is silent maybe because the dogs keep barking" or "she is resting in the eucalyptus tree…she looks like she didn't want to take the risk to meet the dog". We recorded the behaviour of slow lorises 58 times when dogs were present and barking (17 times before the introduction of the WhatsApp® group, 41 after the introduction of the WhatsApp® group). Comparing also with the 62 observations when they were in proximity to civets or leopard cats, qualitatively, lorises changed their behaviour when in proximity to carnivores compared to their normal behaviour, showing more alert

and freeze behaviours. When dogs were barking, they also fed and travelled more, whereas in the presence of civets and leopard cats, they were more likely to be social (Table 2).

Discussion

Here we show that a range of both domestic and wild carnivores live alongside Javan slow lorises in a disturbed agroforestry matrix in West Java Indonesia. We show that during loris follows, there was limited interaction between these carnivores and slow lorises, with most interactions being neutral or affiliative. Lorises were however more vigilant when wild carnivores and dogs were present, and of several animals that died, they likely were at least manipulated by carnivores, probably domestic dogs. We acknowledge that we were studying the lorises and not the carnivores, but we still feel that these data provide an insight into their interactions, including that domestic dogs are speculatively a greater predator threat than other native small carnivore species.

Despite studying Javan slow lorises in an agroforestry system, we recorded them in proximity to five native carnivore species. The small carnivore groups that occurred alongside slow lorises have similarities to those found in other studies of both agroforest and forested ecosystems. For example, in lemon gardens in Bangladesh, Bengal slow lorises (*N. bengalensis*) also occur most commonly alongside common palm civets (*Paradoxurus hermaphroditus*), masked palm civets (*Paguma larvata*) and large Indian civets (*Viverra zibetha*). Leopard cats were present, but at lower numbers (Al Razi *et al.*, 2023). Similarly, in plantation compared with primary forest in Thailand, common palm civets and slow lorises were able to persist in both forest types, though no small cats were reported (Pliosungnoen *et al.*, 2010). In protected semi-evergreen forest, the situation is similar for Southern pygmy loris (*Xanthonycticebus pygmaeus*), with common palm civets being the most common, followed by masked civets and leopard cats (Starr *et al.*, 2012). In all three of these studies, slow lorises were more common in more disturbed areas of the study sites. Similarly, slow lorises tend to be less abundant in the secondary forest, perhaps due to lack of canopy connectivity or gum trees, which is their main food (Nekaris *et al.*, 2010). In all of these studies, small wild cats were amongst the least common in the agroforest areas compared to more forested areas, confirming that they can persist, but in not as high numbers as in unlogged forest (Sodhi *et al.*, 2010). Again, as in our study, slow and pygmy lorises were not observed to be preyed upon by small carnivores.

Despite the presence of a number of carnivore species in this study, our sightings of them declined over the years, which may be linked to a decrease in prey. Despite their ability to persist in some agroforest ecosystems, many small carnivores have shown worldwide declines (Ferreira *et al.*, 2018). *Eucalyptus* plantations have replaced a large host of native trees, and, as in our study site, may be provided for free by the government to encourage soil stability and maintain watersheds (Gerber, 2011). Despite the loss of native trees, such plantations may still host abundant prey for small carnivores, and can act as a vital refuge, especially when near a forest edge (Moreira-Arce *et al.*, 2015; Boonratana, 2019). This could be due to changing farming techniques in our area, resulting in fewer rodent predators (for example changing from ground crops that provide extensive cover for rodents to raised pumpkin growing frames) (Nekaris *et al.*, 2010; Campera *et al.*, 2021), but also perhaps to the presence of domestic dogs. Yen *et al.* (2019) found that dogs impacted the density and activity of several small carnivores, including civets and ferret badgers. Indeed, dogs were

shown to have a greater impact than domestic cats, partly attributed to their greater roaming from urban areas. Our team never recorded cats in the agroforest gardens, whereas dogs were recorded 58 times. Campera *et al.* (2021) found that small rodents as identified via camera traps were more abundant in the forest than in the gardens and influenced the spatial and temporal distribution of Javan palm civets. Further studies should examine the small mammal availability at our study site. Furthermore, quantifying the number of dogs over time will help us to understand their potential impact on native carnivore numbers.

Despite the potential lack of prey, we found limited evidence that native small carnivores were a threat to Javan slow lorises, even showing friendly interactions and sharing a sleeping site. Although they were more vigilant in the presence of small carnivores, Javan slow lorises also engaged in more social behaviour, including playing and allogrooming, suggesting that they felt relaxed in their presence. The two most common small carnivores were Sunda leopard cats and Javan palm civets. Leopard cats can climb trees and young slow lorises (which weigh less than 350 g, as opposed to 910 g adults) especially could be vulnerable to these cats. Yet we never saw a leopard cat in a tree, despite availability of climbing trees in the hedge rows of fields. Kodkod cats (*Leopardus guigna*) reduced hunting of arboreal prey in an agroforestry system, perhaps due to the lack of complex arboreal structure, reducing the effectiveness of their prey capture (Moreira-Arce *et al.*, 2015). Perhaps for similar reasons leopard cats in our area were strictly terrestrial during our observations. To the contrary, Javan palm civets were spotted most often in the trees. Only a single "chase" between the two was observed, with other observations including animals sharing sleeping sites, resting in proximity in trees, and using human-made canopy bridges at the same time. These observations suggested to us that Javan palm civets are at least not common predators to Javan slow lorises. Still, brown palm civets (*Paradoxurus jerdoni*) are known predators to the much smaller Malabar slender lorises (*Loris malabaricus* – 220 g), using team hunting techniques to kill an adult the same size as a juvenile Javan slow loris (Gnanaolivu and Singh, 2019). At our site, very young animals do from time to time disappear, and it is possible that they are victims of predation. The potential to collect civet scats is limited due to a high collection demand for "civet coffee" in our area, but collaboration with scat collectors in the future may help to yield more information on them as potential predators.

When we started our study, we did not consider recording the many domestic dogs in the area as potential predators and it was not a feature of our datasheets. It emerged as a theme in *ad libitum* data, and later in our WhatsApp® group. These data suggest that dogs may pose the greatest threat to slow lorises in our area. Dog barking did induce vigilance in lorises, and several deaths may be attributed to dogs. The most probable death was an unsettled younger male, whose lower half was found hanging from a chayote (*Sechium edule*) frame and was clearly eaten by a carnivore. This animal, like many lorises in our study site, made regular use of the frames, which are on average 1.6 m high, but undulate, and are supported by uprights. These frames dominate the landscape (Nekaris et al., 2017). At the frames' lower points, dogs can easily access lorises moving through them. Another dead female who had seemed otherwise healthy was found severely decomposed beneath one of these frames. Two elderly females might have died from natural causes, but bite marks on one and the missing head of another suggest postmortem manipulation. In the first case,

only bites were present, whereas in the second, legs were missing. Cuozzo *et al.* (2022) highlighted that in South Africa, thick-tailed bushbabies (*Otolemur crassicaudatus*) were also killed but not eaten by dogs, also in an agricultural area. Of further note is that the first animal, whose lower half was consumed, was a dispersing male who was not able to settle, and was in general sickly (Campera *et al.*, 2020). His movements were erratic, and he was not showing signs of strong health. Similarly, the oldest female (minimum of 16 years) whose limbs were eaten had lost significant weight, had broken canines, missing fingers, and was showing signs of ill health. This pattern is again echoed by one of the galago deaths reported by Cuozzo *et al.* (2022), which also had physical ailments, perhaps making it less able to flee from dog predators. Pihlström *et al.* (2021) suggest that dogs are probably a much larger threat than is recorded by field researchers. A dog that killed a small-eared galago (*Otolemur garnettii lasiotis*) in their study was lame, with only three working legs, and was not used for hunting. In their case, although an attempt was made to recover the galago, in the attempt the dog secured part of the galago and ate it. Dogs in our area are generally only owned for house defence or for hunting (normally aggressive pigs), and thus are specially trained to increase their fierceness (Mulyanto *et al.*, 2021). Since slow lorises go to the ground relatively often (Karimloo *et al.*, 2023), it is notable that in 12 years we only recorded five potential deaths.

These data were collected as part of a long-term study on the behavioural ecology of Javan slow lorises. We note that an important outcome of gaining more data on sympatric animals came from the introduction of our WhatsApp® group. Devices such as camera traps are useful in recording other taxa too, but often sympatric taxa are not recorded during focal follows or are not recorded in detail. For us, our team was really focussed on wild animals, and we did not have a section for dogs on the datasheet, and dogs also rarely appeared in *ad libitum* data. Furthermore, most researchers on our project simply did not write detailed *ad libitum* notes. The use of WhatsApp clearly opened up the creativity and detail for our researchers. This was even more the case with domestic dogs. When the dogs were particularly loud or close to the loris, researchers clearly felt the need to type about it. Internet connection is excellent in our area, and even school-aged Indonesian students frequently have a mobile phone and communication via WhatsApp® (Balestri *et al.*, 2023). Mulyono *et al.* (2021) showed that Indonesian students using WhatsApp® to enhance their learning during the pandemic showed a high level of acceptance to the technology, which was in part linked to students' connectedness with their peers, and its usefulness for discussion. Indeed, we found that researchers in the field enjoyed interaction with their peers and senior researchers, to whom they could ask instant questions while in the field. They are particularly useful when some team members could not be at the study site or even in the country, allowing them to still be in direct communication whilst data are being collected. Having experienced the usefulness of this technology, we now can ask for more details to be collected on the spot, and we hope this will illuminate the details of these types of interspecific interactions further.

In conclusion, we have worked for more than a decade in an agroforestry environment on the island of Java. This environment is home to a relatively rich array of nocturnal mammals, but the numbers of carnivores seem to be slowly declining. At the same time, though wild carnivores do not seem to be a serious threat to populations of Critically Endangered slow lorises, dogs appear to be an emerging threat. The greatest risks are posed in areas where

414 animals may have to move on the ground or are low to the ground in agricultural
415 plantations. An interesting area of future research would be to study the ranging patterns
416 and diet of domestic dogs to improve our understanding of their impact on wildlife. Future
417 conservation programmes should focus on increasing canopy connectivity and monitoring
418 populations of small mammals to understand the food availability and ecological dynamics
419 of this important habitat. We should also embrace new technologies to help us with these
420 tasks.

421

422

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Statements

Statement of Ethics

All research in this work was approved by the Oxford Brookes University University Research Ethics Subcommittee for Ethics in Animal Research.

Conflict of Interest Statement

The authors have no conflict of interests to declare.

Author Contributions Statement

Nekaris and Balestri wrote the main draft of this paper, and all other authors read and agreed the content. Nekaris, Hedger, Imron and Nijman contributed to project management and supervision. Nekaris secured the funding for this project. Nekaris, Balestri, Hedger, Campera, Adinda, Ahmad, Manson, and Saepurohman collected data. Nekaris and Hedger managed the data. Nekaris, Balestri, Campera and Hedger analysed and visualised the data.

Data Availability Statement

The data that support the findings of this study can be made available through contacting the corresponding author.

598 Table 1. Using the word frequency analysis function in NVivo, here we show words with
599 more than 1% weighted percentage in frequency before and after the use of WhatsApp®.

Before WA	Weight	After WA	Weight
Individual	6.83	Alert	2.79
Area	3.63	Labu	2.35
Path	3.31	Civet	2.26
Point	2.40	Walking	2.21
Near	2.27	Meters	2.16
River	2.24	Path	2.07
Datasheet	1.76	Travelling	1.69
Using	1.76	Exploring	1.65
Created	1.71	Looking	1.63
Information	1.65	Away	1.51
Looking	1.42	Climbing	1.51
Walking	1.35	Ground	1.46
Labu	1.07	Bamboo	1.32
		Observer	1.29
		Around	1.27
		Near	1.27
		Loris	1.22
		Area	1.03
		Individual	1.03
		River	1.03

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604 Table 2. Behaviour of Javan slow lorises when they were observed within 10 m of a civet or
605 a leopard cat (n=62); when dogs were barking (n=58); and in normal conditions (n=22633).
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Behaviour	Civet or Leopard Cat			Dog Barking			Normal Conditions		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Alert and freeze	33.9	34.9	33.3	34.9	33.3	34.6	13.2	13.7	12.7
Travel	14.5	15.6	13.3	23.3	26.7	23.1	18.6	17.8	19.3
Explore	17.7	15.6	20.0	14.0	13.3	15.4	36.4	35.4	37.3
Feed and forage	9.7	3.13	16.7	14.0	13.3	11.5	7.7	7.5	7.8
Rest and sleep	9.7	12.5	6.7	9.3	6.7	11.5	13.2	13.4	13.1
Autogroom	3.2	3.1	3.3	2.3	6.7	0.0	6.9	7.7	6.1
Social	11.3	15.6	6.7	2.3	0.0	3.8	3.7	3.7	3.8

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Figure Headings

Figure 1 – Maps of the study area near Cipaganti, West Java, Indonesia showing the location of sightings of small Indian civets (A), Javan palm civets (B), and Sunda leopard cats (C) from 2017-2023, including photographs of each species (courtesy of Little Fireface Project). The location of the study area in Indonesia is shown in the lower right corner. Please note that these sightings overlap with the areas of intense use by more than 35 slow loris individuals intensively followed by the project team.

Figure 2 – Screenshots of camera trap video showing (A) a Javan slow loris following a Javan palm civet on a waterline bridge (note the eyeshine in the background) and (B) a Javan palm civet approaching a Javan slow loris at the junction of two bridges, where they eventually had to pass each other (courtesy of Little Fireface Project).

Figure 3 – clockwise from upper left. A young adult female found decomposed under a chayote from (*in situ*); the recovered body of an elderly female found with the head seemingly torn off; the body of a young adult male found dead in a chayote frame (*in situ)* with the lower portion of the body chewed off.

Figure 4 – Word clouds of the comments made by researchers in the *ad libitum* notes regarding the behaviour of small carnivores and their interactions with Javan slow lorises before and after the introduction of a WhatsApp® group in 2017, showing the increased weight of words linked to behavioural ecology after (B).

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632 Figure 1
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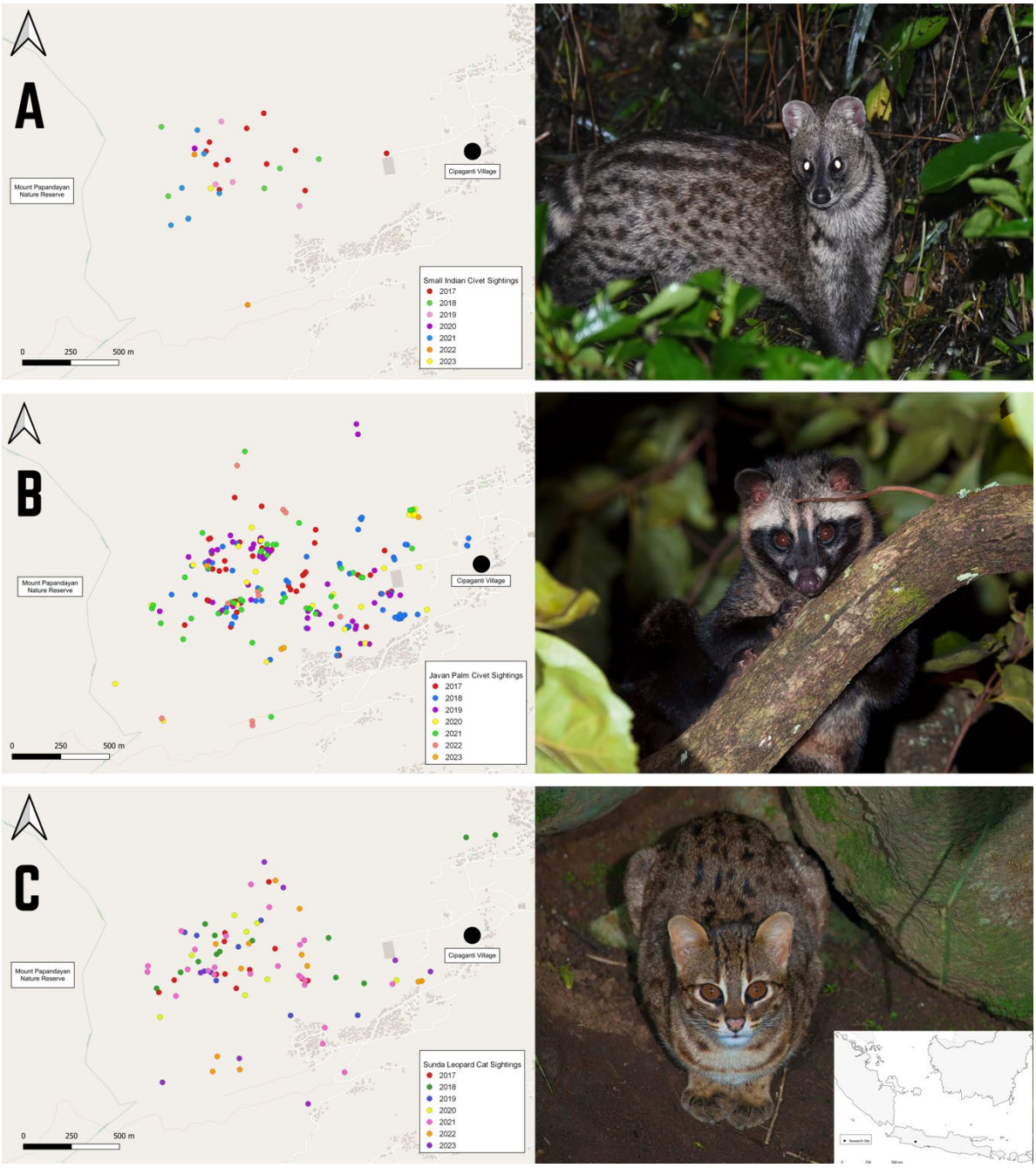

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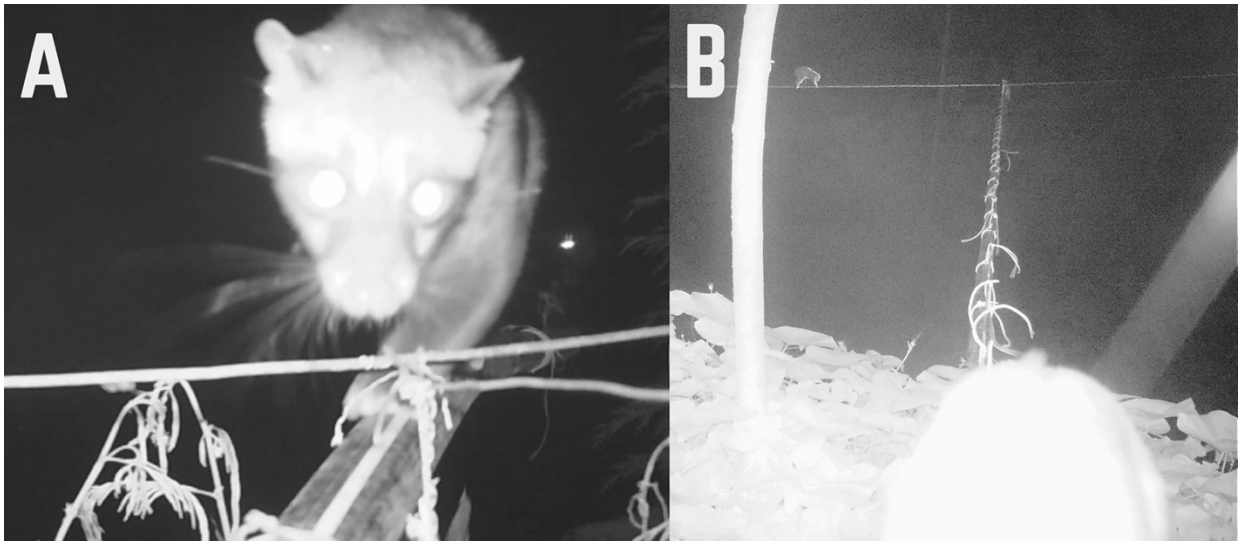
636 Figure 2



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