

ETHOLOGY OF THE CRITICALLY ENDANGERED JAVAN SLOW LORIS *Nycticebus javanicus* É. Geoffroy Saint-Hilaire IN WEST JAVA

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ABSTRACT

Considered amongst the most endangered primates in the world, Javan Slow Lorises *Nycticebus javanicus* É. Geoffroy Saint-Hilaire are threatened by habitat destruction, and by the wildlife trade for pets and traditional medicines. Despite some studies of captive or rescued and released animals, little is known about the behaviour and ecology of wild animals. We present preliminary behavioral data of the first-ever study of wild *N. javanicus*. The study population, in Cipaganti, West Java, persists in a mosaic habitat including agricultural fields (*talun*) and interspersed trees and patches of bamboo, trees, bushes and abandoned fields. We directly observed animals for some 170 hours during the onset of the dry season, between April and June 2012. Animals spent 31% of their time foraging and feeding, 33% sleeping and resting, 14% traveling, 12% alert, 7% grooming and 1% socializing. They fed mainly on exudates of Green Wattle *Acacia decurrens* (Willd.) (56%) and the nectar of Red Calliandra *Calliandra calothyrsus* (Meisn.) (32%). We found the animals to be relatively gregarious, spending 13% of observations within sighting distance of one another, for 37% of which they were seen in bodily contact. Animals preferred bamboo and Green Wattle over other tree species. We provide recommendations for management in captivity and reintroduction schemes, particularly urging rescue centres to provide gum and adequate social partners. Finally, we stress the importance unprotected, human-modified landscapes can have for this species and for reintroduction programmes.

Keywords: activity budget, behaviour, conservation, diet, habitat use, unprotected habitat

INTRODUCTION

South-East Asia is considered a biodiversity hotspot due to high diversity and a high percentage of endemic species, many of which are threatened by habitat loss (Sodhi et al., 2010). The human influence on nature in the region is immense, and includes deforestation and land modification for agriculture, development, large-scale palm oil plantations, pollution, and hunting of wildlife for traditional medicine or for luxury products (Sodhi et al., 2010). The Indonesian island of Java is amongst the most densely populated places on earth, with a population density averaging 1071 people per km². The Javan Slow Loris *Nycticebus javanicus* É. Geoffroy Saint-Hilaire is one of the species that is highly affected by habitat loss and the pet trade in South-East Asia. The species is listed as Critically Endangered on the IUCN Red List (Nekar et al., 2013b), and on the World's 25 Most Endangered Primates 2012-2014 (Nekar et al., 2014).

The plight of the Javan Slow Loris has long been known in Indonesia. Like other slow lorises, the Javan Slow Loris has a small bear-like appearance with big

eyes, characteristics that make it very desirable in the pet trade. Indeed, it is one of the primates most commonly observed, along with other Indonesian species of Slow Loris, in the illegal trade (Shepherd et al., 2004; Nekar et al., 2009; Shepherd, 2010). Trade in Slow Loris, and in wildlife in general, is fuelled by the extensive use of the internet, including online shops, social networks or sharing platforms (Nekar et al., 2013a).

Some projects have attempted to reintroduce animals that were confiscated from illegal markets, but their attempts have met with limited success (Moore, 2012). Many nocturnal, solitary and arboreal primates are difficult to study (Wiens & Zitzmann, 2003) and lack long-term studies of their behavior and ecology in the wild (Nekar & Bearder, 2011). Likewise, the Javan Slow Loris was listed as Data Deficient until 2006 (Nekar et al., 2013b). Although we now have some information regarding wild Greater Slow Loris *N. coucang* (Boddaert) from Malaysia (Wiens et al., 2006), Pygmy Slow Loris *N. pygmaeus* Bonhote from Cambodia (Starr et al., 2013), and Bengal Slow Loris *N. bengalensis*

(Lacépède) from various parts of its range (Das et al., 2009; Pliosungnoen et al., 2010; Swapna et al., 2010; Rogers & Nekaris, 2011), it is still not clear to what extent these species differ in social organization, diet and home range size, and we cannot plan effective conservation strategies for Javan Slow Loris based on what is known about their congeners. Winarti (2011), Nekaris (2012) and Wirdateti (2012) all identified the agro-forest gardens around Cipaganti, Garut, as containing high numbers of Javan Slow Loris, and urged that long-term studies of the species be undertaken.

Here, we present the first behavioural and ecological data recorded from wild Javan Slow Loris, and compare them with information regarding other slow loris species. These data will inform captive care and release schemes of rescued slow lorises. We give a detailed description of the habitat where Javan Slow Loris are known to occur at relatively high density; report basic morphometric measurements of captured slow lorises; provide an ethogram of wild Javan Slow Loris and describe their activity budget, diet, basic social behaviour and habitat use over the first three months of a planned 1.5 year study.

METHODS

Study site

We established our field station in Cipaganti village, near the city of Garut in West Java ($S7^{\circ}6'6'' - 7^{\circ}7'$ & $E107^{\circ}46' - 107^{\circ}46'5''$, Fig. 1) in April 2012. Cipaganti lies in the foothills of Mount Puntang, which is part of the mountain range containing the active volcano Gunung Papandayan. While Gunung Papandayan is recognized as a nature reserve (*cagar alam*), the partly agricultural areas surrounding the nature reserve are not protected. The distance between the edge of the village and the boundary of the protected forest on slopes of the ridges that cannot be cultivated, is approximately 1300 m, while the first contiguous forest is about 2000 m away from the village. The land in between reaches up to 1750 m asl and is covered with a mosaic of cultivated fields (called *talun* by Sundanese people) under crops like tea, beans, chili, tomato, tobacco, potato, cabbage, onion, carrot etc., abandoned fields and shrub patches, bamboo patches, tree plantations and forest patches. Fields are often bordered by trees with a more-or-less connected canopy.

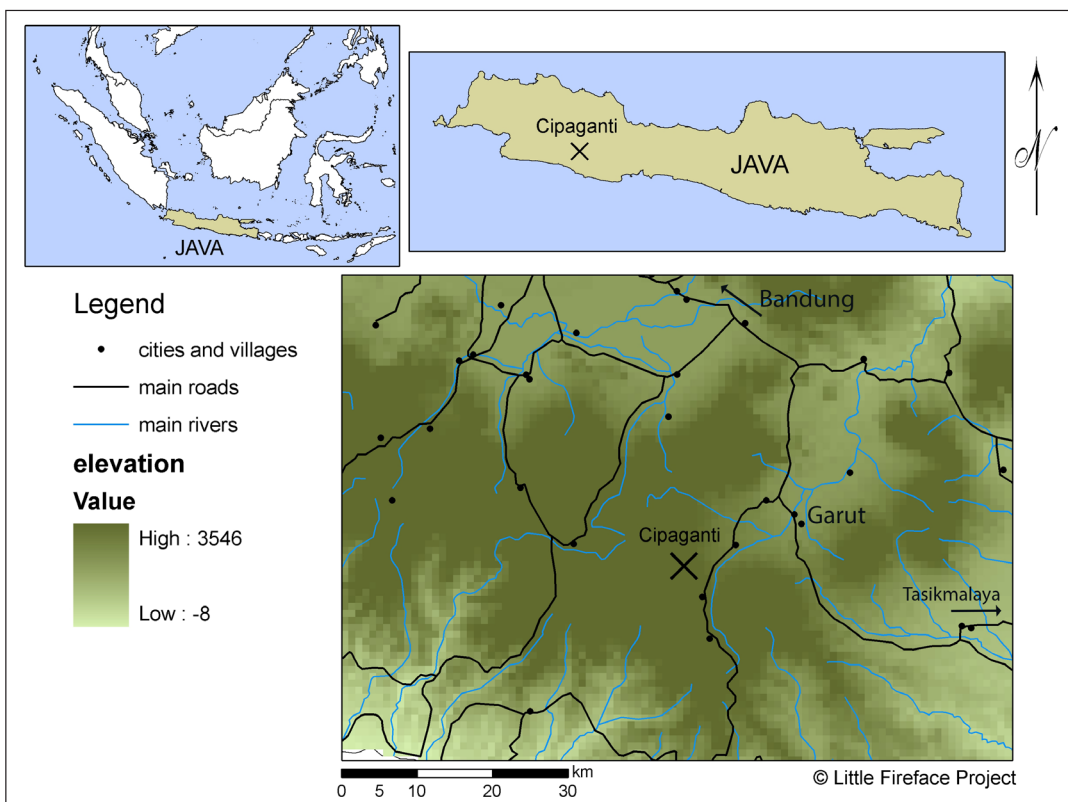


Fig. 1. Location of the field site of the Javan Slow Loris study, adjacent to Cipaganti Village, Garut District, West Java.

We conducted our study during the dry period from April to June 2012. Temperature, humidity and rainfall during the study period are presented in Table 1. The dry period corresponded with low minimum temperatures. During dry periods rivers dried out and some trees shed their leaves (e.g. Japanese Persimmon *Diospyros kaki* L.f., Indonesian Mahogany *Toona sureni* [Blume] Merr.). One of the important nectar-producing plants for slow lorises, Red Calliandra *Calliandra calothyrsus* Meisn., did not bloom during the dry period. The study site comprises about 50 ha and is located between 1300-1650 m asl, adjacent to Cipaganti village. Accordingly, the terrain is steep and difficult to traverse. Human presence and disturbance in the study site are high. Many people work in the fields every day, starting at about 05:00 h. Trees and bushes are regularly cut for wood production or clearance. Furthermore, people set traps for pigs, to protect crops, and traps for birds to sell them into the trade. Hunting or disturbance of pigs during the night has been observed. Bee hives are harvested once per year during the dry season. Landslides are common during the rainy season.

Table 1. Temperature, humidity and rainfall during April to June 2012.

Temperature day (°C) 06:00-18:00 h	
Average	22.6 ± 2.9
Minimum	12.4
Maximum	28
Temperature night (°C) 18:00-06:00 h	
Average	18.9 ± 2.2
Minimum	12.6
Maximum	26.7
Humidity (%)	
Average	74.1 ± 8.9
Minimum	33
Maximum	91
Rainfall 24 h (mm)	
Average	0.6 ± 2
Minimum	0
Maximum	11.7

Radio-tracking

As trapping success for slow lorises is low (Wiens & Zitzmann, 2003), we captured animals by hand. We did not sedate animals, but processed them immediately at the place of capture, and released them afterwards on the same tree. We used leather gloves for bite protection and rubber gloves for infection control. We determined the sex of the animals, checked for pregnancy using abdominal palpation, and assessed stage of the oestrous cycle (Manley, 1966; Izard et al., 1988). We also monitored lactation by checking for elongated nipples and milk expression (Wiens & Zitzmann, 2003). We weighed animals using spring balances (Pesola®, Canada). Age classes were determined by body mass and pelage pattern and length. Adults had body masses greater than 750 g, juveniles between 250 g and 750 g, and infants below 250 g. As body mass varied substantially, and sub-adults can reach adult size while retaining juvenile pelage coloration and length, mass was considered an inconclusive indicator of adolescence. The pelage of infants and juveniles was fluffy and contained long hairs with white tips which gave the appearance of frosting; the transition between this condition and an adult coat pattern without white tips contributed to the categorization of sub-adults (Fig. 2). We examined the general condition of captured animals. Head-body length was defined as the distance between the base of the tail and the tip of the nose, and measured using a tape measure. Animals were stretched out as far as the natural body shape allowed and the measurement tape was applied along the middle of the back and head. We attached radio collars (17 g, on average 1.9% of body weight, BioTrack, UK) to adult animals, and marked them individually by fitting one or two coloured stainless-steel bead chains (2 mm per bead) around their wrists.

We followed the radio-collared lorises in two shifts during the night, from 18:00 h to 00:00 h and 00:00 h to 06:00 h (following Wiens & Zitzmann, 2003), covering one animal per shift. We tracked animals with the aid of an antenna (6 and 8 element flexible Yagi antenna, Biotrack, UK) and receiver (R1000, Communication Specialists, US). If uncollared but identifiable animals were encountered, they were observed as long as possible until they moved away. We used instantaneous behaviour sampling with 5-minute intervals and took *ad libitum* notes (Altman, 1974; Nekaris, 2001). The behavioural ethogram is included as Appendix 1. At each sample point we also recorded the tree species used by the animal, and the distance to the closest Slow Loris, if present. For the latter we used the categories “in bodily contact” or “less than a body length



Fig. 2. Javan Slow Lorises change their coat pattern, colour and fur density as they age. Shown here are a very pale infant (~4 weeks old) with fluffy fur; juvenile with characteristic pale coat with very dark markings and very long fur; and typical brown adult with shorter fur and paler markings.

away”, “less than 5 m distance”, and “within sighting distance”. We included all vegetation of more than 1 m height in our vegetation dataset, because we observed animals moving on bushes and other small plants. A tree was defined as having a minimum diameter at breast height (DBH) of 2.5 cm, and being at least 3 m high. If the animals were feeding, we noted the food type and recorded qualitative observations of the feeding method.

In order to test whether slow lorises showed a preference for certain tree species, we recorded available tree species in the study site along nine, approximately-1-km-long, parallel line transects through the home ranges of the radio-collared animals. We used point intercept transects with intercepts of 15 m (Hill et al., 2005; Rode et al., 2013). At each point we recorded the nearest tree species, and classified the vegetation type as cultivated field, abandoned field, bush, bamboo patch, tree patch or path (Rode et al., 2013). This method was deemed appropriate as we needed to minimize damage to the crops of the local farmers. We took samples of the tree species used by the animals, which were identified at the Indonesian Institute of Sciences, Research Center for Biology (LIPI).

We used descriptive statistics (means and standard deviations), and calculated differences in activity budgets between the sexes using a Pearson Chi-square test (Dytham, 2001), only including radio-collared adult animals with more than 100 observation points. We grouped feeding and foraging, sleeping and rest-

ing, alert and freezing, and social activity (aggression, playing, other social activities) for the activity budget. For the general activity budget we merged auto- and allogrooming into a single category (“grooming”) such that the latter was not considered in the category “social behaviour”, while for the analysis of social behaviour we also considered allogrooming. Social activity and distance between animals were recorded for all animals. We used a Pearson Chi-square test to detect if there were differences between the frequency at which the lorises used certain tree species and the frequency at which these species occurred in the dataset of available trees at the site. The null hypothesis was that there was no difference between the frequencies at which the animals used the different tree species and the frequency of available tree species, meaning that the lorises used trees at the study site randomly. A positive deviation from the null hypothesis was interpreted as a preference for the more frequently used tree species. We included only the ten most frequently used tree species in our analysis. All other trees used were added as a single category into the analysis.

RESULTS

In April and May 2012 we captured 12 *N. javanicus* (Table 2). Three of these animals were not collared because they were juveniles or because we were out of collars. On various occasions uncollared animals were sighted. The female adult individuals RO and EL were lost on 11 June and 6 July, respectively. RO was initially

Table 2. Details and basic morphometrics of twelve Javan Slow Lorises.

No.	ID	Sex	Age	Date captured	Weight (g)	Head and body length (cm)	Hand span (mm)	Foot span (mm)	Obs.	Days
1	GU	Male	Adult	17/04/2012	885	36.9	63	75	284	26
2	EN	Female	Adult	18/04/2012	740	33.6	61	75	339	22
3	YO *	Male	Sub-adult	19/04/2012	740	28.4	57	73	37	9
4	HE *	Female	Sub-adult	20/04/2012	676	31.3	57	78	4	4
5	AZ	Male	Adult	20/04/2012	855	-	70	71	121	16
6	ON	Female	Adult	20/04/2012	994	31.5	53	64	118	14
7	TE	Female	Adult	07/05/2012	765	31	51	68	247	22
8	MO	Male	Adult	08/05/2012	945	33.7	60	78	175	11
9	EL	Female	Adult	09/05/2012	935	31.2	64	82	165	8
10	RO	Female	Adult	11/05/2012	904	31.6	60	79	162	7
11	CH	Female	Adult	11/05/2012	915	31.3	57	74	205	15
12	MR *	Male	Adult	12/05/2012	904	33		64	27	7
13	TA *	Unknown	Juvenile	-	-	-	-		40	9
14	LU *	Unknown	Infant	-	-	-	-		1	1
	UN *	-	Adult	-	-	-	-		64	16
Average adult males (n = 4; 3)					897.25 ± 37.7	34.5 ± 2.1	64 ± 5	72 ± 4	1989	
Average adult females (n = 6)					875.5 ± 100.5	31.7 ± 0.1	58 ± 5	74 ± 7		

* Animals that were not radio-collared.

brought to the field station by local inhabitants and was suspected to have been in captivity. When she was released at the site where people claimed they had found her, she started to travel very long distances, and was finally lost in the nearby protected forest area. The collar of EL broke and, although there were a few sightings of her, we could not catch her again.

We followed the radio-collared animals for 327.75 hours on 70 days between 4 April and 1 August 2012. We collected 1,989 5-minute observation points, totaling 165.75 hours of direct observation. Thus, the animals were out of sight 50% of the time.

Figure 3 shows the activity budget for nine adult Javan Slow Loris. Animals spent 33±15% of the observation time sleeping and resting, 31±14% feeding and foraging, 14±7% traveling, 12±5% being alert and freezing, 7±4% grooming, 2±2% engaging in other activities, and 1±2% engaging in social activities (n=1996)

Although individual variation was detected, preliminary results suggest that females spent more time foraging while males were more alert, travelled more and showed more social behavior ($\chi^2=70.971$, $df=9$, $p<0.001$, $n=1660$). This result may have been influenced by one prolonged bout of aggression between the adult male GU and an uncollared individual, and the intensive relationship between GU and the juvenile male YO (including social activities like playing, allogrooming and following each other). Removing GU from the analysis resulted in a still-significant test outcome in broad behaviour type ($\chi^2=73.010$, $df=9$, $p<0.001$, $n=1396$) but no significant difference between sexes in social behaviour subcategories.

Animals were seen within sighting distance of other lorises in 13% of the observations (n=258). In 57% of these cases (n=147), animals were closer than 5 m, while in 37% of cases (n=96), animals were in bodily

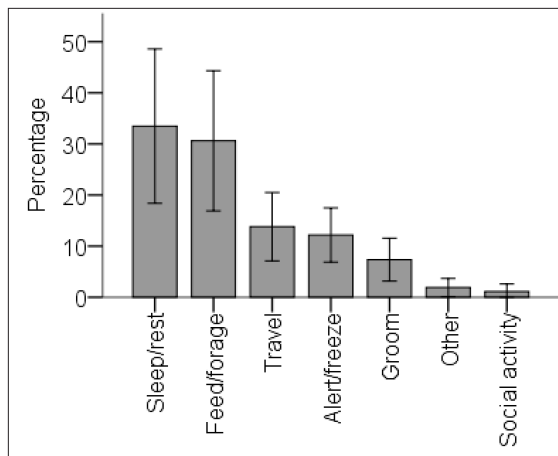


Fig. 3. Proportion of instantaneous sample points of nine radio-collared and unidentified adult Javan Slow Lorises ($n=1590$). Error bars denote ± 1 standard deviation.

contact or less than a body length away. Social behaviours recorded ($n=40$) included allogrooming (38%), playing (35%), aggression (15%; only one incident, between two adult males, spanning several observations) and other social behaviours (13%). We also observed following and sleeping in contact with another animal.

We recorded animals feeding 81 times (4.7% of observations). In 68 cases we could identify the food items. Animals fed mainly on the gum of Green Wattle *Acacia decurrens* Willd. (56%), the nectar of flowers of Red Calliandra (32%), and insects (7.4%). In only two cases, animals fed on fruit (Japanese Persimmon and Jackfruit *Artocarpus heterophyllus* Lam.). Amongst the insects consumed were caterpillars (Lepidoptera), grasshoppers (Orthoptera) and cockroaches (Dictyoptera), taxa that may be perceived as pest species by local farmers. When feeding on exudates, animals climbed up and down the trunks and branches and checked existing, loris-made gouge holes, or created new holes. They then licked the leaking exudates or expanded the holes by anchoring their teeth and gouging strongly or chiseling away the bark. The nectar of Red Calliandra was eaten as described by Moore (2012), by climbing among the terminal branches of the tree or bush, stabilizing themselves in a standing or hanging position, and grabbing and bending the flower towards them using one or both hands. They then licked the nectar accumulating between the stamens without damaging the flower.

In total, 261 'available' trees and 1,875 used trees of 38 species were recorded (Appendix 2). Comparing the numbers of the ten most commonly used tree

species with randomly sampled trees, we found that slow lorises preferred bamboo (String Bamboo *Gigantochloa apus* [Schult.] Kurz, and Sweet Bamboo *G. atter* [Hassk.] Kurz), Green Wattle, and Red Calliandra, but used other common species less than expected (Cajeput Tree *Melaleuca leucadendra* (L.) L., Chinese Mahogany, Japanese Persimmon and other species) ($\chi^2=205.926$, $df=10$, $p<0.001$, $n=2136$). On the transects we recorded 65% of the points to be in cultivated fields, 18% in abandoned fields, 8% in bush area, 5% on paths, 3% in tree patches and 2% in bamboo patches ($n=354$).

DISCUSSION

Our study area is situated in an area of Java where most land has been modified by humans (Smiet, 1990; Lavigne & Gunnell, 2006). Natural habitat remains only in inaccessible places such as at high altitude and on steep slopes (Smiet, 1992; Lavigne & Gunnell, 2006). At our study site, slow lorises live in agricultural areas (*talun*) where humans live and work. They are confined to habitat fragments surrounded by fields, threatened by habitat loss through the cutting of trees and bamboo, and exposed to human activities mainly during the day. Our transect data show that 83% of the land comprises cultivated and abandoned fields. The area is not protected and thus lorises rely on the good will of people for their survival. This situation is similar for other threatened primates throughout Asia, such as Purple-faced Langurs *Trachypithecus vetulus* (Erleben) (Moore et al., 2010) and Hainan Gibbons *Nomascus hainanus* (Thomas) (Zhou et al., 2005). Effects of degraded and human-altered habitat on primates may include reduced feeding resources, fewer sleeping or hiding places, higher susceptibility to invasive or aerial predators, increased hunting pressure, disturbance and higher exposure to parasites (Wright et al., 2009; Schwitzer et al., 2010b, 2011). Slow lorises, however, apparently can sufficiently adjust to human-modified habitats like this mosaic landscape of agricultural fields, bamboo stands and forest fragments.

We determined the activity budget of adult Javan Slow Loris. In accordance with other studies (Table 3), the percentages of resting and sleeping, being alert and freezing were relatively high, in contrast to the findings of Wiens & Zitzmann (2003), who reported low frequencies of resting and sleeping in Malaysian *Nycticebus coucang*. Our study and that of Swapna et al. (2010) were conducted during the dry, cold season. A combination of season, temperature and moonlight may have affected the level of activity and alertness.

Nocturnal primates are described as lunar-phobic, lunar-philic or lunar-neutral, depending on whether they decrease, increase or do not change their level of activity during bright moonlit nights. Increased activity may be related to higher foraging efficiency (Gursky, 2003) and better detection of predators (Bearder et al., 2006; Nash, 2007). Rogers and Nekaris (2011) report that Bengal slow lorises in Cambodia become more active during the dark moon phase. Rode et al. (2014, in press) found Javan Slow Loris to be lunar-phobic but attributed this behaviour to predator-independent factors such as availability of arthropod prey. Although Pygmy Loris seemed unaffected by light on warm nights, Starr et al. (2012) found them to be lunar-phobic on cold, bright nights, probably as a result of the higher risk of detection by predators and heat loss.

Solitary mammal species usually forage alone during their active period, yet may still be in contact with conspecifics (e.g. via olfaction or vocalizations), sleep in groups or live in complex social networks (Waser & Jones, 1983). Several studies in captivity concluded that *Nycticebus* spp. are very gregarious given the opportunity. Animals spent one third of their time in proximity and shared nest boxes (Ehrlich & Musicant, 1977) and rarely engaged in agonistic behaviours (Daschbach, 1983; Ehrlich & MacBride, 1989). Although animals occasionally show aggressive behaviour in rescue centres, this might be a by-product of the trauma animals have experienced in the pet trade, and rescue centres may house up to eight animals in social groups (Moore, 2012). In wild Javan Slow Loris, we only observed one case of aggression in three months. In studies of *N. bengalensis*, *N. pygmaeus* and *N. coucang*, social activities clearly occurred outside the sample points that made up activity budgets, as the frequency of social activities recorded was relatively low (Table 3). *Nycticebus coucang* and *N. javanicus* individuals were often observed within sighting distance of one another (13%

for *N. javanicus*, this study; 8% for *N. coucang*, Wiens, 2002). We have shown that the social behaviours of wild *N. javanicus* are similar to those of other species of lorises studied in the wild, including allogrooming, playing, following, and sleeping in contact with another animal (Wiens & Zitzmann, 2003). Javan Slow Loris thus do not qualify as gregarious, but they are definitely social.

Slow lorises feed on gum, invertebrates, nectar of flowers, fruit, small vertebrates, mollusks, bird eggs, leaves, bark, bamboo and fungi (Table 4) (Tan & Drake, 2001; Wiens, 2002; Wiens & Zitzmann, 2003; Winarti, 2003; Pliosungnoen & Savini, 2008; Streicher et al., 2009; Nekaris et al., 2010; Swapna et al., 2010; Rogers & Nekaris, 2011; Winarti, 2011; Starr & Nekaris, 2013; Streicher et al., 2013). Nash & Burrows (2010) reviewed several primate species that form part of a gum-feeding guild. Some species use gum opportunistically while searching for insects on tree surfaces or as a staple or fallback food in times of food shortage (Porter et al., 2009; Streicher, 2009). For other species gum is an obligatory dietary component. Only a few species are able to stimulate exudate flow actively by gouging. This behaviour is shown by the callitrichine genera *Callithrix* (Erleben), *Callibella* (van Roosemalen & van Roosemalen), *Mico* (Lesson) and *Cebuella* (Gray), the Masoala Fork-marked Lemur *Phaner furcifer* (Blainville) and the Southern Needle-clawed Galago *Euoticus elegantulus* (Le Conte) (Vinyard et al., 2003; Schwitzer et al., 2010a). Sixty-five per cent of the diet of *Phaner* is gum, which is available all year round. *Euoticus elegantulus* (Le Conte) includes gum as 75% of its diet; the rest consists of insects and fruit (Charles Dominique, 1977). All *Nycticebus* species gouge, and spend a considerable amount of their feeding time consuming exudates (*Nycticebus pygmaeus*: Tan & Drake [2001]; Nekaris et al. [2010]; Starr & Nekaris [2013]; Streicher et al. [2013]; *N. coucang*: Barrett [1984]; Wiens et

Table 3. Activity budget of *Nycticebus* species.

	<i>N. bengalensis</i> ¹	<i>N. bengalensis</i> ²	<i>N. coucang</i> ³	<i>N. javanicus</i> ⁴
Rest, sleep	40.5	41; 7	5.4	33
Travel	23.2	36 (incl. forage)	-	14
Forage, feed	5.1; 22.3	6 (only feed)	20.5 (only feed)	31
Groom	7.2	4	-	7
Alert	-	7	-	12
Social	0.4	0	3.5	1

1=Swapna et al., 2010; 2=Rogers & Nekaris, 2011; 3=Wiens & Zitzmann, 2003; 4=this study

al. [2006]; Nekaris & Munds [2010]; *N. bengalensis*: Pliosungnoen & Savini [2008]; Nekaris et al. [2010]; Swapna et al. [2010]; Das et al. [2014]; *N. javanicus*: Winarti [2003]; Nekaris et al. [2010]; Winarti [2011]; and Bornean Slow Loris *N. menagensis* [Trouessart]: Nekaris et al. [2010]) (see Table 4). Nekaris et al. (2010) reviewed exudate feeding in Asian lorises, and listed 12 plant families exploited by *Nycticebus* for exudates. *Nycticebus javanicus* was seen feeding on exudates of Fabaceae, Arecaceae and Moraceae (Nekaris et al., 2010; Winarti, 2011). Nectar is another important component of the diet (Table 4). Re-introduced Javan Slow Loris spent 90% of their feeding time consuming nectar (Moore, 2012). Javan Slow Loris feed on the nectar of Red Calliandra (Moore, 2012; this study) and Banana *Musa × paradisiaca* L., Family Musaceae (Winarti, 2011). Pliosungnoen & Savini (2008) saw *N. bengalensis* feeding on *Parkia* flowers (R.Br.), Family Fabaceae. Porter et al. (2009) observed the Goeldi's Monkey *Callimico goeldii* (Thomas) in Bolivia using pod exudates of *Parkia* flowers as a fallback food during the dry season. Our study was conducted during the onset of the dry season and dietary component proportions may differ between seasons (Charles-Dominique, 1977; Hladik et al., 1980). Considerable seasonal differences in feeding budgets were observed for *N. bengalensis* and *N. pygmaeus* (Swapna et al., 2010; Starr & Nekaris, 2013). The proportion of gum in the diet was higher in the winter, while more nectar and insects were consumed in the summer by *N. bengalensis* (Swapna et al., 2010). *Nycticebus pygmaeus* did not feed on nectar or fruits in the cold season at all, and more than doubled the proportion of insects they consumed (Starr & Nekaris, 2013). In this study, feeding on insects was likely to be underestimated as it often involved very fast movements between sampling intervals, and could easily be missed, especially when animals were in very dense habitat like bamboo or bushes. Slow lorises consume some insect taxa that are potentially harmful for crops; thus they play an important role in pest control. Even though we saw animals feeding on two different fruits (Japanese Persimmon and Jackfruit) also consumed by humans, this occurred rarely and did not qualify Javan Slow Loris as a pest species. We never observed animals feeding on vegetables planted in the fields.

Few studies have reported the tree species that *Nycticebus* uses during general activity. The amount of bamboo in a forest seems to have a positive effect on the encounter rates of *N. javanicus* (Voskamp et al., 2014). Bamboo species seem to be important as sleeping and resting sites (Winarti, 2003, 2011; Dah-

rudin & Wirdateti, 2008). *Nycticebus bengalensis* was found more often in plantations with high numbers of *Acacia* (Mill.) and *Leucaena* (Benth.) trees and *Bauhinia* (L.) lianas (all members of the legume family Fabaceae) as compared with primary forest (Pliosungnoen et al., 2010). Diet is also likely to influence tree species preferences. Fabaceae, for instance, are used by all *Nycticebus* species as sources of exudates (Nekaris et al., 2010). In this study, Green Wattle and Red Calliandra were preferred for their gum and nectar. As for diet, the preferences of lorises for certain tree species may change with the season. Non-preferred tree species may not play a special role in the animals' diet or sleeping-site choice, but may be used during travel. Almost all tree species recorded in this study as used by Javan Slow Loris are non-native. Nevertheless, we found a healthy population of lorises in this habitat and the animals seemed to have adapted well to the dietary options, habitat structures and relatively confined space provided by this human-modified landscape.

Adjustment to human-modified mosaic landscapes and exotic tree species bear important implications for the re-introduction of confiscated animals that might have been caught in those habitats. One of the possible reasons for failed re-introductions of Javan Slow Loris to the wild is that animals that have grown accustomed to agricultural areas and their component plant species are released into dense rainforests; newly released Javan Slow Loris often moved out of the old stage forests where they were released into agricultural areas up to a few kilometers away (Moore, 2012).

RECOMMENDATIONS

Although slow loris species differ in aspects of their ecology, we found Javan Slow Loris to have similar needs in terms of fundamental feeding and social activities to other slow loris species. Whether in zoos, rescue centres or when preparing rescued animals for release, we stress the importance of providing social partners, and including gum in the animals' diet. For the Javan Slow Loris, in particular, certain tree species are important for species conservation planning and for the specific protection of the modified habitats in our study area (String Bamboo, *Gigantochloa apus*; Sweet Bamboo, *G. atter*; Green Wattle, *Acacia decurrens*; Red Calliandra, *Calliandra calothyrsus*). Javan Slow Loris can thrive in human-altered habitat that is very different from dense rainforest and are surprisingly adaptable to exotic plant species. The provenance of confiscated animals and their behavioural and ecological adaptation to their original habitats must be con-

Table 4. Feeding budgets of *Nycticebus* species.

	<i>N. bengalensis</i> ^{1*}	<i>N. bengalensis</i> ²	<i>N. coucang</i> ³	<i>N. javanicus</i> ⁴	<i>N. pygmaeus</i> ⁵	<i>N. pygmaeus</i> ^{6*}
Exudates	86.5	80.9	43.3	55.9	60	50
Insects	2.9	2.3	2.5			
(Arthropods)	7.4	40	20			
Nectar	6.4	3.2	31.7	32.2		10
Fruit	0.3	4.5	22.5	2.9		18
Fungi						3
Bamboo						5
Vertebrates						1
Bark	1.9	7.3				
Bird eggs	1.2					
Tender leaves		1.8				
Bouts	329	243	139	68	27	168

1=Swapna et al., 2010; 2=Das et al., 2014; 3=Wiens et al., 2006; 4=this study; 5=Streicher et al., 2013; 6=Starr & Nekaris 2013; *=averaged between seasons

sidered in re-introduction programs. When evaluating suitable release sites, native equivalents of exotic agricultural and native rainforest species must be identified. Finally, human-modified landscapes should be included in habitat protection schemes, and community-based conservation should be emphasized.

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Appendix 1. Ethogram for Javan Slow Loris.

	Behaviour	Definition
1	Alert	Remain stationary like in “rest” but active observation of environment or observer
2	Feed	Actual consumption of a food item
3	Forage	Movement associated with looking for food (often includes visual and olfactory searching)
4	Freeze	Interrupt locomotion to maintain motionless, rigid posture in standing or sitting position for at least three seconds, extremely slow movement not associated with foraging
5	Groom	Autogroom, lick or use tooth comb on own fur
6	Rest	Remain stationary, often with body hunched, eyes open
7	Sleep	Remain stationary in huddled position with head between the knees, or eyes visible but closed
8	Social	All interactions with conspecifics, including aggression, allogrooming, play and other social behaviours
8a	Aggression	Fight, bite (including attempts), threat, chasing; often accompanied by agonistic vocalizations
8b	Allogroom	Lick or comb with toothcomb other loris’ face or fur - usually while clasping him or her
8c	Play	Behaviours serving no immediate, definable purpose, including friendly attempted bites or manual attacks and clasping, dangle by feet, wriggle body with arms over head. No vocalizations as when fighting
8d	Other social	Social activity while being in contact or close proximity (<5 m), like mating, social follow, sniffing, social explore
9	Travel	Continuous, directed movement from one location to another
10	Other	Other behaviours not included above

Note: based on observations in this study and from Nekaris, 2001, Fitch-Snyder et al., 2001 and Daschbach et al., 1983

Appendix 2. List of plant species that were used by Javan Slow Loris during this three month study, their use by local people and the percentage of samples: used by Slow Lorises (n=1,875), and presence in transects (n=261).

	Scientific name	Family	English common name	Trees used for	% used	% random
1	<i>Gigantochloa apus</i> (Schult.) Kurz, <i>Gigantochloa atter</i> (Hassk.) Kurz	POA	String Bamboo, Sweet Bamboo	2, 5	37	4
2	<i>Melaleuca leucadendra</i> (L.) L.	MRT	Cajeput Tree	3, 4, 5	<u>22</u>	39
3	<i>Acacia decurrens</i> (Willd.)	FAB	Green Wattle	6	9	2
4	<i>Persea Americana</i> (Mill.)	LAU	Avocado	1, 3	9	9
5	<i>Calliandra calothyrsus</i> (Meisn.)	FAB	Red Calliandra	6, 7	7	4
6	<i>Toona sureni</i> (Blume) Merr.	MEL	Suren, Indonesian Mahogany	3, 4	<u>5</u>	10
7	<i>Grevillea robusta</i> (A.Cunn. ex R.Br.)	PRT	Silky Oak	3, 4	3	3
8	<i>Artocarpus heterophyllus</i> (Lam.)	MOR	Jackfruit	1, 3, 8	2	2
9	<i>Diospyros kaki</i> (L.f.)	EBN	Japanese Persimmon	1, 3	<u>1</u>	3
10	<i>Coffea Arabica</i> (L.)	RUB	Arabica Coffee	1, 6	<1	<1
11	<i>Casuarina junghuhniana</i> (Miq.)	CAS	?	3	<1	4
12	<i>Musa acuminata</i> (Colla)	MUS	Banana	1, 9	<1	7
13	<i>Schima wallichii</i> (Choisy)	TEA	Needle Wood	3	<1	<1
14	<i>Dendrocalamus asper</i> (Schult.) Backer	POA	Giant Bamboo	2, 5	<1	
15	<i>Maesopsis eminii</i> (Engl.)	RHM	Umbrella Tree	3, 4	<1	4
16	<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob.	CMP	Siam Weed, Christmas Bush	6, 7	<1	<1
17	<i>Ageratina riparia</i> (Regel) R.M.King & H.Rob., <i>Lycianthes denticulata</i> (Blume) Bitter, <i>Gaultheria</i> sp.(L.)	CMP, SOL, ERI	Mistflower, ?, ?	6	<1	
18	<i>Gigantochloa</i> sp. Kurz ex Munro	POA	Clumping Bamboo (genus)	2, 5	<1	<1
19	<i>Cestrum aurantiacum</i> (Lindl.)	SOL	???	7	<1	
20	<i>Citrus aurantiifolia</i> (Christm.) Swingle	RUT	Key Lime (?)	1	<1	<1
21	<i>Aleurites moluccanus</i> (L.) Willd.	EUP	Candlenut	1, 3	<1	
22	<i>Arenga pinnata</i> (Wurmb)	PAL	Sugar Palm	1, 3, 9	<1	
23	<i>Calliandra tetragona</i> (Willd.) Benth.	FAB	White Calliandra	6, 7	<1	
24	<i>Brugmansia suaveolens</i> (Humb. & Bonpl. ex Willd.) Bercht. & J.Presl	SOL	Angel Trumpet	5, 7	<1	
25	<i>Eriobotrya japonica</i> (Thunb.) Lindl.	ROS	Loquat	1, 6	<1	
26	<i>Camellia chinensis</i> (Sims) Kuntze	TEA	Tea	1, 6	<1	
27	<i>Manglietia blumei</i> Prantl	MAG	?	3		3

28	<i>Cinnamomum burmanni</i> (Nees & T.Nees) Blume	LAU	Indonesian Cinnamon	1, 3, 4	1
29	<i>Carica papaya</i> (L.)	CRC	Papaya	1	1
30	<i>Anthocephalus cadamba</i> (Roxb.) Miq.	RUB	Common Bur Flower, Kadamb	3, 4	<1

n=1875 **n=261**

Bold numbers indicate that tree species were used significantly more often by lorises than expected by chance, numbers underlined indicate that the trees were used significantly less often. 1=Consumption (including smoking), 2=construction material, 3=house (including traditional roof), 4=furniture, 5=garden (flower, fence, stable), 6=fire wood, 7=natural prevention of erosion, 8=mortar, 9=packing material.

