

ACTIVITY SCHEDULE AND HABITAT USE OF THE SLENDER LORIS *LORIS TARDIGRADUS LYDEKKERIANUS*¹

SINDHU RADHAKRISHNA² AND MEWA SINGH³

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The behavioural ecology of the nocturnal prosimian *Loris tardigradus lydekkerianus* in its natural habitat was studied for a period of 21 months. Twenty-eight identified study individuals belonging to different age-sex categories were observed for 2364 hours. Data collected on the general activity schedule of the species showed changes in response to the phases of the moon, and seasonal variations. Insects made up the greater portion of the diet of the slender loris, with fruits and gum being included to a small extent. Intersexual differences were seen in the height of trees used by the animals and heights at which the animals preferred to stay in the trees.

INTRODUCTION

The slender loris (*Loris tardigradus*) is one of the two nocturnal prosimians found in India. The species has been declared Vulnerable (IUCN 2000), yet little has been done to conserve this primate in the wild. The major stumbling block is the lack of complete information on its behaviour in its natural habitat. Though it was used extensively in anatomical studies (Rao 1927, Swayamprabha 1983, Manjula 1984, Sarma and Kadam 1984) in the past and its reproduction studied in detail (Ramaswami and Kumar 1962, 1965; Ramakrishna and Prasad 1962, 1967; Kadam and Swayamprabha 1980; Izard and Rasmussen 1985), very little is known about its behaviour in the wild.

In September 1996, a population survey of the slender loris conducted by Singh *et al.* (1999) discovered high densities of the subspecies *lydekkerianus* in the scrub jungles of the Eastern Ghats, South India. Singh *et al.* (1999)

recommended that these fragmented populations needed to be conserved, and emphasized the need for a long-term behavioural study to provide more data for management strategies. A study was therefore undertaken on the social behaviour of the slender loris *L.t. lydekkerianus* in its natural habitat. The data collected on its activity budget and habitat use is presented here.

STUDY AREA

The Beerangi Karadu hill range (10° 29' N, 78° 10' E, altitude: 400 m above msl) of Ayyalur Forest range was chosen, as an earlier study (Singh *et al.* 1999) reported a high density of slender loris in this area. The climate is hot and humid (max. temp.: 34.19°C, min. temp.: 23.34°C, relative humidity: 80.74%), and the annual rainfall (mean: 869.6 mm) is received mostly from the northeast monsoon during September-October. The area spans about 16 ha of open dry scrub jungle. A road runs through, bisecting it into two different habitats. On one side lies the Reserved Forest, secondary degraded habitat rising uphill, and vegetation mainly *Acacia*, *Euphorbia*, *Azadirachta*, *Albizia* and *Cassia*. Though tree felling is illegal, it went on surreptitiously all the time. On the other side of the road lies a *Tamarindus* and *Eucalyptus* orchard, and fields bordered by *Cocos nucifera*.

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²Department of Psychology, University of Mysore, Mysore and National Institute of Advanced Studies, Bangalore, Karnataka, India.

Present address: National Institute of Advanced Studies, Indian Institute of Science Campus, Bangalore 560 012, Karnataka, India.

³Department of Psychology, University of Mysore, Manasagangothri, Mysore 570 006, Karnataka, India.

Except for the odd row of trees that provide contiguity, being planted closely, there is little canopy in this part of the study area. *Prosopis*, *Commiphora* and *Azadirachta* overgrown with lianas, provide a natural fence along the road; this was an important area of ranging for the lorises.

METHODS

The study began in October 1997 and concluded in June 1999. Observations of the first month were used to prepare an ethogram and decide upon a suitable sampling method. Observations were conducted on foot every night from dusk to dawn (1800 to 0600 hrs). An animal was first spotted by its unique orange-red tapetal reflection to light, from more than 100 m away. It was then approached for identification and followed the rest of the night. Petzl headlamps covered with red cellophane were used, as red light did not disturb the animals and ensured better observation (Charles-Dominique 1977, Charles-Dominique and Bearder 1979).

Instantaneous point and *ad libitum* sampling techniques (Altmann 1974, Anon. 1981) were used. A five-minute instantaneous sampling technique was employed to record the behavioural categories of the animal at night. A total of 22,834 instantaneous scans were collected: 21,019 scans on 28 identified individuals and 1,815 scans on unidentified lorises. Study animals were identified by distinctive physical markings on their bodies and locomotory idiosyncrasies. Each scan recorded information on the identity of the individual, behaviour the animal was engaged in, time, moon phase, tree species, tree height, height of focal location of animal on tree, identity of nearest neighbour, inter-individual distance and vocalization. *Ad libitum* sampling was used to describe events (copulation, agonistic interactions) that occurred too quickly for regular sampling methods, or the sequences in activities like social behaviour, feeding, etc. which were

not adequately represented in the focals.

Six main behavioural categories were recognized: locomotion, exploration, feeding, inactivity, social, and self-directed. Locomotion refers to activity that occurred with no ostensible purpose of exploration. Its sub-categories were locomote, shift from one tree to another, shift from tree to ground, hesitation to complete shift to tree or ground, movement of just a pace or two. Exploration was defined as activity to investigate the environment. The sub-categories were forage, urine-mark and sniff. Feeding was recorded when a loris was observed ingesting. Food materials belonged to one of the three categories: insects (arthropods and other invertebrates), plant material (all plant parts) and gum (plant exudates). Inactivity was recorded when the animal was totally passive: sit, freeze, sleep, and pause. Social behaviour included all associative and agonistic encounters. Sub-categories of social behaviour were sleep together with other individual(s), locomote/ sit/ autogroom near another individual, allogroom, play, aggressive vocalization, physical fight, sniff conspecific, approach, carry infant, and carried by mother. Self-directed activities were those performed by the animal on itself: scratch, urine-wash, autogroom.

The hours of loris activity were divided into thirteen categories, beginning from 1730 to 0530 hrs, with each category representing an hour. The phases of the moon were divided into two main categories according to the amount of light available: the light phase, from half-moon to full moon and then to half-moon, and the dark phase, from half-moon to new moon and then to half-moon. Rainfall conditions were recorded as the dry season from January to June and the wet season from July to December. Height of the tree and the height of the animal on the tree were classified into seven categories: undergrowth/ base of tree, < 1 m, 1-3 m, 3-5 m, 5-8 m, 8-10 m and 10-15 m. None of the trees in the study area were taller than 15 m.

Data Analysis

Data analysis was carried out using the statistical package SPSS for Windows, Version 9.0. Percent values of scans were calculated for the habitat and behavioural variables. *z* tests (Gibbons 1971) were used in binomial situations to test for significant differences in the proportion of scans for any behavioural category. Chi Square goodness-of-fit tests were used to check if a particular behaviour or habitat variable was more significant than another. Intersexual differences were subjected to two-tailed analysis of variance test. Pearson correlation was used to test the degree of correlation between climatic factors and activity variables of the species. A step-wise multiple regression analysis was also run to see if climatic variables affected the activity schedule of the animal.

RESULTS

Activity Budgets

Calculation of percent scans showed that 47.27% of the general activity schedule of the

species was exploration and 26.90% was inactivity. The number of scans for the different behavioural categories significantly differed from each other ($\chi^2 = 20877.39$; $df = 5$; $P < 0.01$). The general activity schedule of the species was analysed for changes with respect to the hours of the night, moon phases and climatic variables (Table 1). The proportion of scans was significantly higher before midnight (1730 to 2330 hrs) for the behavioural categories: locomotion and self-directed; the proportion of scans for social behaviour was significantly higher after midnight (2330 to 0530 hrs). The proportion of scans was significantly higher in the dark phase of the moon for the exploration category and in the light phase for the inactive category. All the behavioural categories showed significant changes for the dry and wet seasons: locomotion, feeding, inactivity and self-directed behaviour increased in the dry season while exploration and social behaviour increased in the wet season.

A Pearson correlation test of the climatic variables and the activity budget presented

Table 1: Activity budget of the slender loris

	Locomotion scans	Exploration scans	Feeding scans	Inactivity scans	Social scans	Self scans
General Activity Schedule	2998 (13.17%)	10757 (47.27%)	565 (2.48%)	6122 (26.90%)	1557 (6.84%)	758 (3.33%)
Night hours						
1730-2330 hrs	1414 (13.68%)	4873 (47.16%)	272 (2.63%)	2764 (26.75%)	621 (6.01%)	390 (3.77%)
2330-0530 hrs	1584 (12.75%)	5884 (47.37%)	293 (2.36%)	3357 (27.02%)	936 (7.54%)	368 (2.96%)
<i>z</i> values	2.07*	0.32	1.32	0.47	4.54**	3.40**
Moon Phases						
Light Phase	1534 (13.18%)	5216 (44.80%)	279 (2.40%)	3409 (29.28%)	801 (6.88%)	403 (3.46%)
Dark Phase	1464 (13.17%)	5541 (49.86%)	286 (2.57%)	2713 (24.41%)	756 (6.80%)	355 (3.19%)
<i>z</i> values	0.001	7.63**	0.86	8.29**	0.23	1.13
Seasonal						
Dry Season	1352 (16.77%)	2208 (27.39%)	240 (2.98%)	3512 (43.56%)	273 (3.39%)	477 (5.92%)
Wet season	1140 (12.70%)	4709 (52.48%)	206 (2.30%)	1967 (21.92%)	731 (8.15%)	220 (2.45%)
<i>z</i> values	7.50**	33.30**	2.78**	30.19**	13.17**	11.40**

*: $p < .05$ **: $p < .01$

Table 2: Step-wise multiple regression on climatic variables and activity schedule of species

Step	Model	Dependent Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig
			B	Std error			
			Beta				
I	(Constant)		-24.23	11.03		-2.20	0.06
	Temp Max	Locomotion	1.14	0.32	0.76	3.55	0.01
II	(Constant)		26.65	4.41		6.04	0.000
	Rainfall	Exploration	0.15	0.04	0.79	3.88	0.004
III	(Constant)		41.98	4.02		10.45	0.000
	Rainfall	Inactivity	-0.11	0.04	-0.72	-3.07	0.010
IV	(Constant)		50.48	12.68		3.98	0.004
	Temp Min	Self	-1.84	0.53	-0.73	-3.46	0.010
	Rainfall	Self	-0.03	0.01	-0.56	-2.64	0.030

significant negative correlations for rainfall and locomotion ($r = -0.60$), rainfall and inactivity ($r = -0.72$) and, minimum temperature and self-directed ($r = -0.61$). Significant positive correlations were seen for rainfall and exploration ($r = 0.79$), humidity and feeding ($r = 0.60$) and, maximum temperature and locomotion ($r = 0.76$). The results of a stepwise multiple regression (Table 2) on climatic variables and activity schedule showed that maximum temperature was the best predictor for locomotion, rainfall for exploration and inactivity, and minimum temperature and rainfall for self-directed behaviour. For the categories social and feeding, no variables were entered.

Feeding

Insects formed a significantly higher percentage in the diet of the slender loris ($\chi^2 = 876.69$; $df = 2$; $P < 0.01$) at 91.48%, with plant material and gum forming 6.61% and 1.9% respectively. The insects consumed included ants (Hymenoptera), termites (Isoptera), stick insects (Phasmatodea), pungent smelling beetles (Coleoptera), silkworms, butterflies and moths (Lepidoptera), and several varieties of grasshoppers (Orthoptera) and slugs (Mollusca).

Study individuals were seen feeding on the fruits of *Securinega leucopyrus* and *Ziziphus oenoplia*. They were also observed to stick their heads into the flowers of *Eucalyptus*, *Tamarindus* and *Agave americana* and suck at the pods of *Prosopis juliflora*. It could not be determined if they were sucking the nectar from the flowers or eating the ants in the pods and flowers. Study individuals were also seen licking gum from the bark of *Albizia* and *Acacia* trees. In a typical gum lick, the loris would cling to a tree trunk vertically, scrape at the bark with its toothcomb and lick the exposed sap. A gum lick usually lasted about two to five minutes, but in one case, a female licked gum from an *Acacia planifrons* for 15 minutes. Lorises were observed to cling vertically inside the *Euphorbia*, but it could not be ascertained if they actually licked gum from the plant.

Habitat Use

The tree and plant species most commonly used by the slender loris included *Albizia amara*, *Acacia ferruginea*, *A. planifrons*, *A. leucophloea*, *A. nilotica*, *Prosopis juliflora*, *Euphorbia tortilis*, *Agave americana*, *Azadirachta indica*, *Tamarindus indica*, *Eucalyptus grandis*,

Canthium parviflorum, *Cassia fistula*, *Cassia auriculata*, *Securinega leucopyrus*, *Commiphora berryi*, *Strychnos nux-vomica*, *Holoptelea integrifolia*, *Bauhinia racemosa*, *Ziziphus oenoplia*, *Dichrostachys cinerea* and *Ipomoea staphylina*. The four *Acacia* species (37.77%) were the main tree species used by the slender loris. The other important tree species were *Azadirachta* (15.04%), *Euphorbia* (13.10%), *Albizia* (9.92%), and *Tamarindus* (6.12 %).

Lorises used trees 3-5 m and 5-8 m tall most often and almost equally (36.36% and 37.40% respectively). They stayed most often at heights of 3-5 m (51.26%), and 1-3 m (26.62%). The height of the tree used and the level at which the loris ranged, were found to be different for males and females.

Univariate analysis of variance of tree height and the sexes showed that both adult males and females used the 3-7 m category most often (Mean: males = 80.16, females = 68.92). A significant interaction between the tree heights and the sexes (ANOVA: $F_{3,36} = 3.93$; $P < .05$) indicated that, whereas the males used trees of 3-7 m more than the females, the females used trees of 1-3 m more than the male, (Mean of 1-3 m: females = 22.88, males = 9.61).

Univariate analysis of variance of animal height and the sexes showed that both adult males and females stayed at heights of 3-5 m most often (Mean: males = 61.43, females = 41.16). A significant interaction between the sexes and animal height (ANOVA: $F_{3,36} = 4.41$; $P < 0.01$) indicated that, whereas males stayed at 3-5 m more than the females, females stayed at 1-3 m more than the males (Mean of 1-3 m: females = 34.71, males = 24.42).

DISCUSSION

Activity Budgets

Slender lorises spend a large part of their activity schedule in exploration, followed by inactivity. Self and social behaviours account for very little time, hardly 10% of their activity

schedule. Though the results show that the time spent on feeding is minimum, the data only comprised observed feeding instances, which are difficult to record in a small-bodied, predominantly insectivorous, cryptic animal (but see Nekaris 2000). Slender lorises do not spend most of their waking life in social contact, as has been described for pottos (Anderson 1971). Even when a mother and offspring shared the same range, there was little contact between them at night. Most of the social behaviour was restricted to dusk and dawn, when the animals met to sleep together. Sleep group formation at dawn and the split-up at dusk was usually accompanied by allogrooming and play-wrestling. Though animals did sometimes meet during the night to allogroom and play-wrestle, they were not observed meeting to groom or sleep after the first five or six hours of activity as reported by Goonan (1993). Bushbabies travel faster and cover greater distance during lighter phases of the moon, due to greater ease in navigation under better viewing conditions (Bearder pers. comm.). In the slender loris, increased exploration is seen in the darker phase of the moon. This may be related to the cryptic strategy used by the slender loris that depends on stealth and concealment for protection from predators.

In the study area, the rains of September-October caused a rise in the number of hymenopterans. Just after these rains, the *Eucalyptus*, *Acacia leucopholea* and *Azadirachta* flowered, and *Securinega* fruits appeared. This also probably caused an increase in the insect population. The increased explorations in the wet season could be attributed to these reasons. Animals were observed to continuously forage for insects in the first rain. The long foraging was followed by a long session of grooming. This explains why rainfall is a strong predictor of exploration, and to a smaller extent of self directed behaviour. Muller *et al.* (1985) suggest that the slender loris copes very

well with high environmental temperatures on account of its long and slender limbs, small size and increased heat loss through evaporation. This may explain why the species shows increase in locomotion with rise in temperature.

Feeding

Slender lorises are predominantly insectivorous (Phillips 1931, Petter and Hladik 1970, Still 1905), they also eat flowers and fruits (Roonwal and Mohnot 1977, Johnson 1984). The present study records that they also feed on gum. Gums are complex polymerised sugars with protein and trace minerals, and are consumed by small-bodied primates to survive seasonal shortages of fruits and insects, and to make up for the low calcium levels in fruits and insects (Bearder and Martin 1980, Bearder 1987). It has been proposed that slender lorises would include a large amount of toxic insect prey in their diet (Rasmussen 1986, Rasmussen and Nekaris 1998). In the present study, some amount of repugnant insects was eaten (as evidenced by the slobbering and urine-washing displayed when eating the pungent smelling beetles). But as a complete identification of insects was not done, the extent of their role in the slender loris diet is not known (but see Nekaris 2000). Slender lorises have been reported to drink milk and water in captivity, by licking it off their fingers or lapping it like a dog from the bowl (Subramoniam 1957, Schulze and Meier 1995), but the study animals were never seen to consume anything liquid. They were frequently observed to suck on the thorns of *Acacia* trees, but it could not be ascertained if they did so to obtain liquid nourishment, or feed on insect larvae (Nekaris, pers. comm.). Study animals were never observed to eat invertebrates beyond the arthropod level (but see Nekaris 2000), though slender loris have been reported to feed on baby mice, birds, and gerbils in captivity (Kinnear 1919, Phillips 1931, Subramoniam 1957, Bishop 1964).

Habitat Use

The predominant use of *Acacia* by the observed lorises is probably due to the high insect densities on these trees. *Acacia* also provides gum and plant matter. Furthermore, the thorns must also prove a deterrent to predators. Wherever *Acacia* was available, study females preferred to leave their month-old infants in these trees (pers obs.). Next to *Acacia*, *Azadirachta* and *Tamarindus* were used for parking infants (pers obs.), possibly because of their height and the insect densities they support (Singh *et al.* 1999). All the major tree species used provide food and protection, either in terms of height from the ground (*Azadirachta*, *Tamarindus* and *Albizia*) or by way of thorns (*Acacia* and *Euphorbia*).

Slender lorises prefer to stay at heights of 3-5 m from the ground and use trees of heights 3-8 m. Nekaris (2000) observes that slender lorises used trees of mean height 5.6 m and ranged at an average height of 3.5 m. Height preference in the slender loris is probably related both to dietary requirements and safety from predators. Male slender lorises show greater locomotion than the females (Radhakrishna 2001). This probably results in them making a greater use of the connecting terminal branches found higher up in the trees. This would explain why male slender lorises tend to stay at greater heights and use taller trees more than the females.

CONCLUSION

These findings on activity patterns, diet and substrate use in the slender loris have important implications for its conservation. The slender loris has (a) a predominantly insectivorous diet, (b) preference for common tree species such as *Acacia*, *Azadirachta* and *Euphorbia* and (c) a high reproductive potential (Radhakrishna 2001). Several populations have also been found in close proximity to human habitations (Singh *et al.* 1999). Significant threats faced by the study population include

disturbances caused by tree felling, resulting in loss of canopy contiguity, and deaths caused by vehicular traffic (Radhakrishna 2001, Singh *et al.* 1999). If these factors could be controlled, the management of slender loris for long term survival in the wild would become easier.

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