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continued on the back inside cover

Caption: Malabar Slender Loris *Loris lydekkerianus malabaricus* © Dileep Anthikkad.

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REVIEW

A review of research on the distribution, ecology, behaviour, and conservation of the Slender Loris *Loris lydekkerianus* (Mammalia: Primates: Lorisidae) in India

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Abstract: The Slender Loris in India includes two subspecies, the Mysore Slender Loris and the Malabar Slender Loris, with unidentified populations at overlapping ranges of the subspecies. Prior to 1996, the knowledge on Indian lorises was mostly limited to laboratory studies, or some anecdotes from the wild. Since late 1990, several intensive field studies have been carried out which informed about the status, ecology, behaviour, conservation issues, and management of the Slender Loris in India. Here, we review all these studies, discuss the major findings and identify directions for future research.

Keywords: Distribution, habitat use, infant development, Malabar Slender Loris, Mysore Slender Loris, reproductive biology, social behaviour, survey methods, taxonomy, time-activity budget.

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Author details: Mewa Singh is a renowned wildlife biologist and has worked on a large number of species, both in the wild and in captivity. He has published over 200 research articles in internationally reputed journals and has trained a generation of students in India and in other countries. Mridula Singh teaches psychology at Maharaja's College, Mysuru and has worked on lion-tailed macaques, and other primates. She has also carried out extensive studies on laboratory rodents, testing the effect of Indian indigenous medicinal plants on behavior and learning. Honnavalli N. Kumara is a Wildlife Biologist in SACON, Coimbatore. His interest lies in understanding population dynamics, behavioural ecology, and conservation of mammals and birds. Shanthala Kumar's interest lies in exploring the population status of mammals, the behavioural ecology of mammals especially of primates, and -mammals/birds-endoparasite interaction. Smitha Gnanaolivu is an independent wildlife biologist/conservationist and has been researching the ecology, behaviour, and threats to the nocturnal primate, the Slender Loris, Loris lydekkerianus since 2012. She is actively associated with Nocturnal Primate Research Group, Oxford Brookes University, Little Fireface Project, and Association of Indian Primatologists. Ramamamoorthy Sasi has worked on primates for several years, and is presently working as a Postdoctoral Fellow in SACON for the NPDF project entitled " Comparative Ecology and Behaviour of Slender Loris (Loris lydekkerianus lydekkerianus) in Dindigal - Madurai landscape, Tamil Nadu'', focusing on ecology, acoustic communication and behaviour in different habitat types.

Author contributions: Mewa Singh conceptualized the idea. Other authors prepared different sections in the article. All authors have equal contribution.

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INTRODUCTION

Till about two decades ago, very little was known about the distribution, ecology, and behaviour of the Slender Loris in India. Because of them being nocturnal, small in size, and largely semi-gregarious, research, especially behavioural studies, on lorises has always been more difficult than on relatively large, diurnal and group living macaques and langurs. Still, considerable research has been carried out on Slender Lorises in southern India during the past two decades or so. Here, we review the status of research on the distribution, ecology, behaviour, and conservation of the Indian Slender Loris. The review would provide a vital synthesis of the published information on the Indian Slender Loris, identify the gaps in knowledge, and point to perspectives and directions for further research on the species.

TAXONOMY

The Slender Loris was first described as *Lemur tardigradus* in 1758 by Linnaeus, based on an illustration in Seba (1735). Geoffroy Saint-Hilaire (1796), under the impression that Linnaeus had described a Slow Loris, described the Slender Loris as a new genus and species *Loris gracilis*. The generic name *Loris gracilis* was conserved by the International Commission on Zoological Nomenclature (1999). Lydekker (1905) took two mounted specimens from Madras, as typical for *Loris gracilis*, and described 'The Ceylon Loris' as *Loris gracilis zeylanicus* on the evidence of another mounted specimen; this is BM 1904.10.12.3, with no precise location apart from Ceylon (Jenkins 1987). In 1908, *Loris tardigradus lydekkerianus* was described from Madras by Cabrera (1908) and *Loris tardigradus malabaricus* was described from Kutta, southern Coorg by Wroughton (1917). However, according to the presently accepted classification, the Slender Loris found in India is named *Loris lydekkerianus* (also occurs in Sri Lanka) and *Loris tardigradus* (now occurs only in Sri Lanka) (Groves 2001). In India, there are two recognised subspecies of the Slender Loris: Malabar Slender Loris, *Loris lydekkerianus malabaricus* (Image 1), found in the wet evergreen forests of the Western Ghats, and Mysore Slender Loris, *L. l. lydekkerianus* (Image 2), found in the relatively drier regions of southern India (Groves 2001; Kumara et al. 2013). However, Kumara et al. (2013) report that Slender Lorises on the eastern slopes of the Western Ghats in Kalakad-Mundanthurai and India Gandhi Wildlife Sanctuary differ from Malabar and Mysore Slender Lorises in coat colour, body size, and circumocular patches, and could be a different subspecies.

The Mysore Slender Loris is greyish-brown in coat colour with narrow circumocular patches and an adult male and a female weighed 275 g each, whereas the Malabar Slender Loris is reddish with large circumocular patches and smaller in size, and a male and a female weighed 180 g each (Kumara et al. 2006). Based on the data from a previous survey (Singh et al. 1999) and from some market animals, Nekaris (2001) reported the mean body weight of an adult Mysore Slender Loris to be 294.4 g and of female to be 259.7 g. In Kalakad-Mundanthurai Tiger Reserve (KMTR), Kar Gupta (2007) reported the mean body weights of males and females to be 205 g and 181 g. Within KMTR, the mean male body weight of 271.6 g at Thalayani was much more than the mean male weight of 181 g at Mundanthurai. Further, the male weight at Mundanthurai ranged between 164 and 260 g in pre-monsoon and between 196–270 g in post-monsoon seasons. Data on the body weight of Malabar Slender Loris are not available from different sites. The body mass, therefore, differs between seasons and habitat types with variations in resources. Extensive data on body weights, therefore, are required. The differences between the subspecies are described only for morphology, and no molecular work is carried out. Therefore, we recommend that a molecular study on the Indian Slender Loris is carried out to determine the status of its taxonomy.

SURVEY METHODS

Various survey methods have been employed depending on the purpose of the assessment. If the purpose of a survey is to determine only presence/absence and also relative population abundance in different habitat types, at large spatial scales that could even run up to 100s of kilometres, linear surveys can be carried out on motorable roads/forest tracks in a four-wheeled vehicle, combined with short distance walks, wherever required. A team of 3–4 researchers can travel in a jeep at a speed of 5–10 km per hour, flashing lights, either hand-held torches or lamps fitted to the jeep battery, in all directions. Singh et al. (1999) first used this method to survey Slender Lorises in Dindigul, which covered 280 km, including 259 km in a jeep and 21 km walk. More extensive spatial surveys were carried out spanning a distance of 734 km covering several forest divisions in southern Andhra Pradesh (Singh et

Image 1. Malabar Slender Loris, *Loris lydekkerianus malabaricus*

Image 2. Mysore Slender Loris, *Loris lydekkerianus lydekkerianus*

al. 2000), 1,041 km, including 703 km in a jeep and 31 km walk, in northern and central Kerala (Radhakrishna et al. 2011), 641 km in a jeep in southern Kerala (Sasi & Kumara 2014), 557.1 km by walk and 844.6 km in a jeep in Tamil Nadu (Kumara et al. 2016), and almost the entire state of Karnataka (Kumara et al. 2006). In all the studies mentioned above, the encounter rate as loris/km represented abundance. In Tumkur and Bangalore forest divisions, having largely scrub forests where motorable roads were not available, a team of researchers (Das et al. 2011) divided the forest fragments into areas where only encounter rates could be determined through single walks with low detention frequency, and other fragments where 8–11 transects per forest fragment were laid and walked 6–8 times each with >40 detections. In the latter case, density estimates were done using the program DISTANCE. At a smaller scale covering 1 km^2, Gnanaolivu et al. (2020) overlaid 1-ha grid cells and walked trails covering a total length of 11.41 km as the sampling distance. Low illuminated headlamps (180 lumens) covered by red cellophane sheets were used for the surveys. The data obtained from repeated walks of 5 nights covering a total sampling distance of 57.05 km was analysed using PRESENCE to determine occupancy and abundance. Even in a further smaller area covering 7.2 ha, Kumara & Radhakrishna (2013) tested the efficacy

of line transects, with transects of varying length, and belt transect with varying strip width methods against the known number of lorises in the study area. They demonstrated that both methods underestimated the loris density. However, since the underestimates were not too different from the actual density, they suggested that the line transect method and a belt transect method with a 20-m strip width could still be used for population density estimates of Slender Lorises. In a recent article, Kumara (2020) discussed random search, trail walk, line transect, total count, and belt transect survey methods employed to estimate population abundance/density of pottos and lorises and concluded that the survey designs and methods should be such that these can be replicated and ensure a precise estimate. Since surveys on lorises can be carried out only at nights with flashlights/headlamps so that reflections from the eyes of lorises could reveal their presence, care must be taken to use lights that do not hurt the eyes of the animals. If a vehicle is used and the distance between the researcher and the expected location of a loris is considerable, jeep battery fitted lights could be used as flashes. If the survey for presence/absence or encounter rate is being conducted on foot, torches such as a 3-battery Maglite or headlamps emitting red lights could be quite valuable.

Nocturnal primates have sensitive visual systems highly adapted for foraging and travelling in darkness and, therefore, can be susceptible to the adverse effects of night-time light exposure. Nocturnal primates also have retinas dominated by rod cells, which respond more strongly to white than red light. Existing evidence, therefore, suggests that exposure to white light could have deleterious effects on nocturnal primates (Weldon et al. 2020). Nocturnal subjects showed fewer behavioural and physiological impacts of exposure to night lighting when red lights were used than blue, proving that using red lights for nocturnal behavioural studies is ideal (Fuller et al. 2016). Observations from close distances should be carried out using headlamps such as Petzel headlamps, covered with red filters as lorises are not disturbed by a red light compared to white light. However, if the areas to be surveyed extend over hundreds of kilometres, where surveys are mostly carried out using jeeps on the highways, and the distance between the observer and the loris could be from 100 m to more than 500 m or so, highly diffused white light could still be used as a quick flash from a considerable distance. Once a loris is detected, the animal should be approached only with red filtered lights for closer observations.We again emphasize that even the diffused white light should be used only under exceptional circumstances and must be avoided as much as possible. There are several kinds of spotlights now available for field observations, as extra trail lights, and for spotting and filming animals from a vehicle (Nekaris et al. 2020). Since the lorises are active almost throughout the night, and in different light phases, the assessment can be carried out at any time of the night and also at any time of the light phase (Kumara & Radhakrishna 2013).

Since large areas of possible Slender Loris presence including relatively drier vegetation types in the states of Telangana, Andhra Pradesh, Odisha, Chhattisgarh, and Jharkhand, where motorable roads/forest tracks are available in many places, and relatively wetter regions in the Western Ghats where only walks are possible, are yet to be explored, a combination of methods discussed above, depending on the objectives, could be used for the surveys. Since surveying the entire distributional range of a species is often not possible, habitat modelling such as ecological niche modelling, combining occurrence records with climatic and environmental parameters, has helped to map the potential distribution of the Slender Loris (Kumara et al. 2009, 2012), and projecting the susceptibility of its habitat in the future (Subramanayam et al. 2021).

DISTRIBUTION

Schulze & Meier (1995) provided the first proper distribution map of the two subspecies of the Slender Loris. However, this map was based on anecdotal records in literature and not on direct field surveys. In the mid-1990s, the primate research team from the University of Mysore initiated systematic field surveys. Since then, Slender Lorises have been surveyed in selected regions of Dindigul (Singh et al. 1999), southern Andhra Pradesh (Singh et al. 2000), large areas of Karnataka (Kumara et al. 2006), northern and central Kerala (Radhakrishna et al. 2011), Tumkur and Bangalore forest divisions (Das et al. 2011), southern Kerala (Sasi & Kumara 2014), large areas of Tamil Nadu (Kumara et al. 2016), and Aralam Wildlife Sanctuary (Gnanaolivu et al. 2020). The actual surveys carried out so far have reported the extent of the distribution of the Malabar Slender Loris from the southern tip of the Western Ghats up to 15.8 ^{o}N in the Belgavi district of Karnataka, the subspecies occurring primarily in the wet forests on the western slopes of the Ghats. The Mysore Slender Loris, occurring from the southern tip of India in Tamil Nadu, has been observed up to 14.2 ^{o}N in the Nellore district of Andhra Pradesh, and it is found in dry deciduous and scrub forests.Using

the available sight records and environmental variables, Kumara et al. (2009, 2012) have modelled the potential distribution of the Slender Loris, and it appears that the Malabar Slender Loris could be present still northwards in the Western Ghats, and the Mysore Slender Loris could occur further north-east, probably up to Odisha. Singh et al. (2000) started the surveys in southern Andhra Pradesh but the surveys had to be stopped at about 14 °N as the forests north-east of the surveyed regions had presence of leftist militants, and the research team was not allowed to enter the forests in the nights. Therefore, we strongly recommend further surveys to determine the actual extent of the distribution of the Slender Loris. Even within the known distributional range, several regions still need to be explored for the presence and abundance of Slender Lorises.

The occupancy, relative abundance and densities

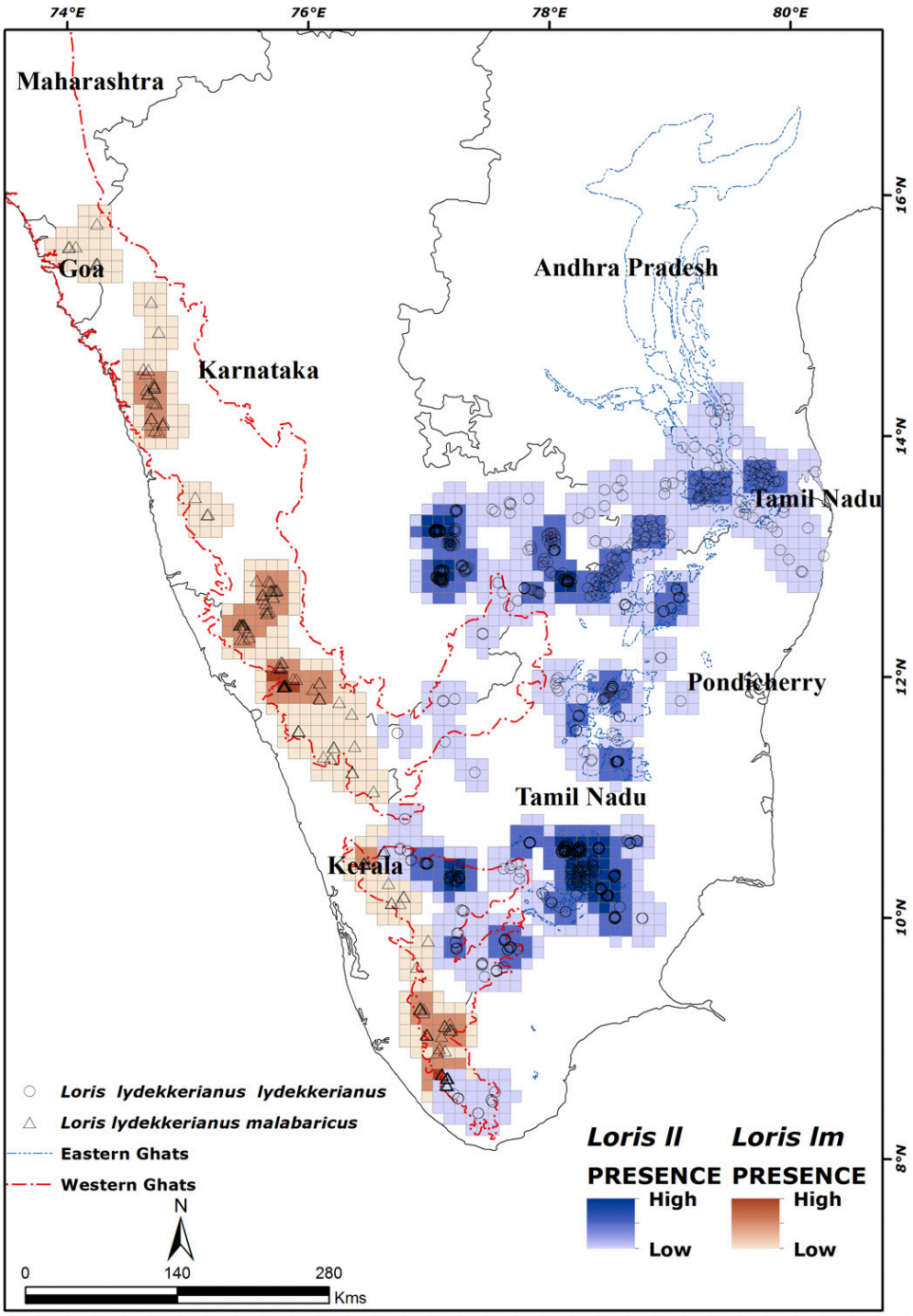

Figure 1. Distribution and hotspots of *Loris lydekkerianus lydekkerianus* and *L. l. malabaricus* in surveyed sites in India.

of Slender Lorises vary in different vegetation types and altitudes. In Dindigul (Singh et al. 1999), they were absent in dense thorn forests and were found in umbrella thorn forest and Euphorbia open forests, croplands close to forests, mixed deciduous forests and croplands away from forests with an encounter rate of 3.6, 2.8, 0.6, and 0.4 per km, respectively. They were located at 300 to 500m in southern Andhra Pradesh (Singh et al. 2000), the encounter rates of lorises in trees, bushes, and ground were 51 %, 47 %, and 2 %, respectively. The per cent sightings at heights of <3 and 3–6 m were 58 and 42, respectively. Three distinct population clusters of lorises at Kaundinya Wildlife Sanctuary complex, Tirumala Hills forests complex and Seshachalam Hills forests were identified. In the forest fragments of the Tumkur and Bangalore forest divisions, the loris encounter rates varied from 0.18 /km to 7.89 /km. Ujjani, Ippadi, Nagavalli, and Savandurga forest patches had a density of 1.85 /ha, and these areas were suggested for long term loris conservation. Though largely Malabar in most districts, both subspecies of the Slender Loris are found in Kerala with Mysore Slender loris occurring in Palakkad and Nemmara forest divisions, and in Chinnar and Neyyar wildlife sanctuaries (Radhakrishna et al. 2011; Sasi & Kumara 2014). In northern and central Kerala, lorises in evergreen, dry deciduous, moist deciduous, and plantations are 44.4, 35.0, 14.5 and 5.9 per cent, respectively. In southern Kerala, lorises were encountered with a rate of 0.31, 0.02 and 0.04 /km in moist deciduous, evergreen, and plantation vegetations, respectively. Though occurring primarily below 300 m, lorises in Kerala are found up to 1,500 m. Overall, there are three population clusters in Kerala, including Neyyar Wildlife Sanctuary up to Ariankavu Pass, from Ariankavu Pass to Palghat, and north of Palghat up to Aralam. With an encounter rate of 1.33 /km, occupancy of 0.48, and an estimate of the abundance of 2.40 /ha, Aralam appears to have the healthiest population of the Malabar Slender Loris (Gnanaolivu et al. 2020). The Mysore Slender Loris has also been reported from Peppara Wildlife Sanctuary (Kangavel et al. 2013). However, Sasi & Kumara (2014) reported Malabar Slender Loris in Peppara. This region, therefore, requires further verification. In KMTR, the loris densities in dry evergreen, dry deciduous, and scrub forests and plantations were 4.0, 1.0, and 0.3 / ha, respectively (Kar Gupta 2007). Within habitat, lorises appear in places with more tree density and canopy contiguity and less branch lopping and human disturbance (Kar Gupta 1998). Surveyed in large areas of Tamil Nadu (Kumara et al. 2016), the relative abundance of lorises varied from 0.01 /km to 2.21 /km in different regions. Most of the loris populations are found in south-central districts. Though mostly below 300 m, lorises are found up to an altitude of 1,257 m. Scrub, dry deciduous, plantations, and evergreen forests had encounter rates of 0.73, 0.18, 0.07, and 0.02 /km, respectively. Reserved forests, protected areas, and private lands had 0.79, 0.09, and 0.12 %, respectively of the loris populations. Only Mysore Slender Lorises were sighted in Tamil Nadu; however, no surveys were carried out in several hill regions with evergreen forests; it may be possible to find Malabar Slender Lorises in these wet regions. Further, even in the large surveyed areas, only presence/absence and relative encounter rates have been recorded. More systematic data through the occupancy framework in selected places with considerable loris presence needs to be collected and analysed using sophisticated modelling techniques to prioritise areas for loris conservation. Most of the surveys have been conducted in protected areas, reserve forests, and agricultural lands; we recommend surveys in urban areas also since sizable populations of lorises are reported even from large cities such as Bengaluru. Figure 1 shows the latest available information on the distribution and relative abundance of the Slender Loris in India.

BEHAVIOUR

Although field studies on the ecology and behaviour of the Slender Loris in India started in the late 1990s, only four extensive field studies are complete, and one is in progress. The completed studies are Radhakrishna (2001), who studied Mysore Slender Loris in a tropical thorn forest near Ayyalur in Dindigul Forest Division between October 1997 and June 1999, spanning over 21 months. Nekaris (2000) also studied the same population for 10 months between October 1997 and August 1998. Radhakrishna & Kumara (2010) studied Mysore Slender Loris at Malapatti in Tamil Nadu between October 2005 and June 2007. Kar Gupta (2007) studied the Slender Loris population at Kalakad-Mundanthurai intermittently for several years from 1997 to 2003. The only relatively long-term study on the Malabar Slender Loris by Smitha Gnanaolivu at Aralam, Kerala, is recently completed. In observations during studies on behaviour, the most widely used method has been instantaneous scan sampling and opportunistic sampling. Unlike diurnal primates, it is pretty challenging to keep a Slender Loris under continuous watch to employ focal animal sampling with fixed durations. Nekaris (2001) used three methods, viz., instantaneous point samples pooled, means of

individual lorises, and behaviour at the moment of first contact (Opportunistic sampling) for the study of activity budgets, and found no significant difference between the three data sets. Instantaneous scan sampling, and also focal animal sampling, are suitable in dry deciduous forests or scrub forests, where the lorises are relatively easily visible. On the other hand, for the species in dense forests or wet forests, the visibility reduces, and the dense foliage hides the lorises even after we habituate them. Thereby opportunistic sampling, and if possible, instantaneous scan sampling, are better in areas with low visibility. Kar Gupta (2007) carried out the only study on Slender Lorises in India using radio telemetry which provided detailed information on home ranges, socialization, diet, and habitat.

Time Activity Budgets

In the scrub forests of Ayyalur, Slender Lorises spent 13.17, 47.27, 2.48, 26.90, 6.84, and 3.30 per cent of their time on locomotion, exploration, feeding, inactivity, social interactions, and self-directed behaviours, respectively (Radhakrishna & Singh 2002a). The time spent on exploration and social behaviour was more in the wet season, and on other activities, it was more in the dry season. Increased exploration and decreased inactivity were observed during the dark moon phase compared to the light moon phase. Locomotion and self-directed behaviours were higher before midnight whereas social behaviour was higher after midnight, as compared to other activities. The maximum temperature best predicted locomotion, rainfall predicted exploration, and inactivity, and minimum temperature and rainfall predicted self-directed behaviour. Social behaviour and feeding did not correlate with any of the environmental variables. Nekaris (2003) reported in the same population that lorises awoke between 1800 and 1900 h and ceased their activity between 0500 and 0600 h. The activity of lorises increased between 2000 h and midnight, and again at 0400 h, after which the activity decreased. Inactivity, travel, forage, feed, and groom occurred accounted for 43.6, 14.9, 33.5, 0.8, and 6.4 per cent of scans, respectively. Social grooming mainly occurred at dawn and dusk assemblies. Long-term studies in the future need to bring out details on the differences in time-activity budgets of various age-sex classes and in different seasons.

Use of Space

Animals, whether living solitary or in groups, restrict their movement to a circumscribed area generally called a home range, with more intensive use of a smaller area called core area within the home range. Data on home ranges in the Slender Loris are available from three field studies. Radhakrishna & Singh (2002b) recorded home ranges of eight adults, four subadults, and four juvenile Slender Lorises during their fieldstudy of 21 months in Ayyalur forests. A female Slender Loris had a mean home range size of 1.2 ha with a mean core area of 0.15 ha and moved over a mean path length of 119 m with a total night length of 234 m. The adult male mean home range and core area sizes were 2.36 ha and 0.37 ha, with mean path and night lengths of 241 m and 328 m. The mean home range of juveniles was 0.14 ha and 0.70 ha in the pre-and post-weaning periods, respectively, with path and night lengths of 42 m and 104 m pre-weaning, and 105 m and 255 m post-weaning. The mean home range of a subadult was 0.97 ha, and path and night lengths were 116 m and 244 m. The home ranges of adult females were almost exclusive, with a small mean overlap of 0.043 ha with no overlap in core areas. On the other hand, the home ranges of adult males had a mean of 0.73 ha overlap with the ranges of females. Interesting, a male's home range overlapped with several females, but the overlap was considerably more with one particular female. In the same study area, Nekaris (2003) reported the mean home ranges of adult males, adult females and subadult males to be 3.6 ha, 1.59 ha, and 1.17 ha, respectively. Nekaris also reported little overlap of home ranges between females and considerable overlap of male ranges with females and other males. Kar Gupta (2007), in another population in KMTR, reported adult male and adult female mean home ranges as 27.67 ha and 5.75 ha, respectively in radio-tracked animals. Male home ranges largely overlapped, and female ranges also had 11–44% overlap, but females were never seen together, indicating territoriality. Parous females had smaller home ranges than nulliparous females. Several points need to be considered here to compare the data on home ranges from these various studies. First, the study of Kar Gupta was in a mixed deciduous forest with tall trees, whereas studies of Radhakrishna & Singh and Nekaris were in a mainly scrub forest with no tall trees. Second, the taxonomic status of the KMTR population is undecided (Kumara et al. 2012). Third, the difference in the home range sizes in the same population in the studies of Radhakrishna & Singh and Nekaris is due to different home range measurement methods. In the study of Radhakrishna & Singh, the location of an animal was marked in each scan. After a study of 21 months, the outermost points of the range were connected by straight lines and physically measured on the ground, calculating the total area of the range. The area used by

an animal in at least 15 % of the scans was considered as the core area. Since Slender Loris ranges were relatively small, such actual ground measurement could accurately assess the range. Nekaris, on the other hand, used the minimum convex polygon method that usually tends to overestimate the home range size, especially if rarely visited points are used in the data (Harris et al. 1990). Therefore, it is recommended that the data on home ranges of the slender loris are collected from various habitat types, and similar measurement methods are used for comparison. The home range of the Malabar Slender Loris seems to be smaller than that of the Mysore Slender Loris, as, in the occupancy sampling, two lorises were found in a grid of 1 m^2 in many of the grids (Gnanaolivu et al. 2020). Further, no systematic data on home ranges of the Malabar Slender Loris are yet available; a long-term study on this subspecies, preferably with the use of radio collars, is suggested.

Feeding and Habitat Use

Till the late 1990s, most of the information on food items of the Slender Loris came from studies in captivity, where animals often adapt to food items that may not even be available in their natural habitats. Radhakrishna & Singh (2002) first reported a 21-month-long field study on the feeding ecology and habitat use of the Mysore Slender Loris at Ayyalur. Insects, plant material and gum comprised 91.48, 6.61, and 1.9 %, respectively, of the loris diet. Lorises also fed on fruits of *Securinega leucopyrus* and *Ziziphus oenoplia* and gum from *Albizia* and *Acacia* sp. In the same population at Ayyalur, Nekaris & Rasmussen (2003) addressed three main issues related to the feeding ecology of the Mysore Slender Loris: what is the proportion of different items in the diet of the loris, how do the lorises counter toxicity, and how are the resources dispersed? They reported that 96 % of the diet of the loris consisted of vertebrate and invertebrate prey. About 49 % of the prey was unidentified, and of the identified prey (31 %), *Hymenoptera* and *Isoptera* amounted to 63 % of the prey items. Most of the prey was small, and one case of adult female feeding on a lizard was observed. Since some insects such as cockroaches, termites, some ant species, true bugs and beetles are likely to be toxic, feeding on these items was accompanied by urine washing, head shaking, sneezing, and slobbering by the lorises. Since 71 % of the loris diet was found to occur in patches indicating clumped distribution, males and females were often found to feed together without any agonistic interactions pointing to gregariousness in the Mysore Slender Loris. A comparative study on the feeding ecology by the Mysore Slender Loris was carried out by Radhakrishna & Kumara (2010) in a mosaic habitat of small agricultural farms, thickets, and orchards at Malapatti. Interestingly, insects here constituted only 60 % of the diet of lorises, along with flowers and exudates, fruits and seeds, and animal prey constituting 13 %, 24 %, and 3 %, respectively. On two occasions, an adult female was observed to feed on a mouse and a gecko. Lorises fed on flowers of *Madhuca longifolia*, pods and seeds of *Prosopis juliflora*, fruits of *Psidium guajava* & *Syzygium cumini*, and dried gum or sap from *Prosopis* & *Tamarindus indica*. At Ayyalur (Radhakrishna & Singh 2002), lorises were found in trees of *Acacia*, *Azadirachta*, *Euphorbia*, *Albizia*, and *Tamarindus* in 37.77, 15.04, 13.1, 9.92, and 6.12 per cent scans, respectively. Lorises mostly used 3–7 m height trees, and both males and females were usually found at 3–5 m height. In the KMTR population, Kar Gupta (2007) analysed 30 faecal samples of 20 lorises and found that more than 75 % of samples had insect body parts, and the rest was plant matter. Some captured animals, when given a choice, preferred live crickets to fruits. Though the lorises used 76 species of trees, only 9 % accounted for 52 % of the total use. Likewise, only three species, of the 32 species of climbers used, comprised 60 % of the total use. Lorises were at a height between 3 m and 5 m 53 % of the time. For 71 % of their time, lorises were found in tree/climber complexes with canopy continuity on all four sides. The mean height of sleeping trees was 8.4 m. On the contrary, in the only such study on the Malabar Slender Loris (Gnanaolivu et al. 2020) in Aralam, tree species richness, tree felling and branch lopping were the major positive determinants of loris occupancy and abundance and climber cover negatively correlated with loris occupancy. Nekaris (2005) reported that the Mysore Slender Lorises captured fast-moving *Lepidoptera*, *Odonata*, and *Homoptera* using both hands from terminal branches and slow-moving *Hymenoptera* and *Coleoptera* with a one-handed grab from the sturdy middle branches. Lorises mostly detected the prey visually, indicating it to play an important role in selecting visual convergence in early primate evolution, with the exploitation of fruit accounting for the evolution of other key primate traits. Kumara et al. (2005) reported a novel behaviour in a Malabar Slender Loris feeding on red ants. The animal placed its hand on a branch that had red ants in large numbers. Due to saliva on the back of the hand of loris, ants would stick on it, and the animal licked the ants from its hand. This behaviour was observed to be repeated nine times before the animal went out of sight. The above review of the feeding ecology and habitat use by the Slender Loris indicates

significant differences among populations inhabiting different habitat types. Though insects appear to be the primary diet of the loris, the species appears to be quite adaptive to feed on other items, including plant matter in areas where insects abundance may be low. Further studies are needed to determine loris diet and habitat use in more habitat types and in different seasons. Resource abundance would also need to be determined seasonally in the study regions.

Predation on lorises

Are lorises preyed upon? Although several potential predators such as domestic and wild cats, snakes, owls are reported, direct attacks on Slender Lorises have rarely been observed in the field. However, Gnanaolivu & Singh (2019) reported the first direct observation of predation, perhaps in a century, by a Brown Palm Civet *Paradoxurus jerdoni* on an adult female Malabar Slender Loris in Aralam in Kerala when two civets cornered a loris female to the end of a tree branch and using its sharp teeth, one civet grabbed the loris at its neck and thorax region, and disappeared in thick foliage.

Reproductive Biology

It is known since long that there are two oestrus periods, one in June–July and another in October–November, in the Slender Loris (Ramaswami & Kumar 1962), though Ramaswami & Kumar (1965) vehemently argued that conception in a female could take place only once in a year. Slender Loris males show spermatogenic activity throughout the year (Ramakrishna & Prasad 1967), though the size and the shape of male testes in the wild have been observed to differ from night to night (Nekaris 2003). Different testes size in captive lorises was also observed depending on temperature. The big scrotal testes and enlarged veins in the auricles helped to emit heat during too high ambient temperatures (Helga Schulz, pers. comm.).

Radhakrishna & Singh (2004a) report the first systematic study based on a 21-month-long observations on the wild Mysore Slender Lorises. A female reached sexual maturity at the age of about one year. Females showed two oestrus peaks, one in April–June and another in October–December. No oestrus was observed in January and July–September. Copulation was preceded by allogrooming between the female and her sleeping male partner. The male maintained intromission lasting up to 10 minutes even after ejaculation, and often deposited copulatory plugs. Mating was promiscuous, and three to four males mated with a female in succession, including a 'stranger' male, which was never seen earlier in the area ranged by a female. Though a female never 'presented' to a male for mating, promiscuous mating even with unknown males appears to be a subtle strategy to avoid inbreeding. Males are also polygynous. Males also indulged in intrasexual fights to access a female in oestrus, and they often harassed the mating pair. The mean gestation period was 164 days with an error margin of five days. Births occurred in March–May, July and October–December. Of the 14 births recorded during the study period, eight were singletons, and six were twins. This observation indicated that a female could roughly produce up to four infants during 12–14 months. One study female produced five infants during the study period of 21 months. The mean inter-birth interval was seven months. Juvenile to adulthood survivorship was 50 %. Some variations from the above pattern were observed in the Mysore Slender Loris population at Malapatti (Radhakrishna & Kumara 2010), where the gestation period was 5.3 months, and the inter-birth interval was nine months. Further, as against the promiscuous mating at Ayyalur, the females at Malapatti encouraged the residence of a single male. Births recorded in January, May, June, and July at Malapatti differed from the pattern at Ayyalur. Infant parking and weaning at Malapatti occurred at the age of six weeks and 118 days, respectively. High loris density and low resource abundance at Malapatti compared to Ayyalur probably account for these differences in reproductive biology at these different habitats. In the Slender Loris population at KMTR, Kar Gupta (2007) reported 12 births during the study period of February 2002 and May 2003, with six birth occurring in August–October and the other six in April–May. Comparing the studies of Radhakrishna (2001), Kar Gupta (2007), and Radhakrishna & Kumara (2010), it appears that the reproductive patterns of the Slender Loris vary in different habitat types and different populations, which indicates need of further research covering a variety of habitats and regions. Further still, no systematic long-term data are available on birth patterns in the Malabar Slender Loris from any of its distributional ranges.

There has been a general assumption that the mating systems in primarily solitary species are simple and opportunistic. Poindexter & Nekaris (2020) categorised the social organization of Lorisiformes into three groups, viz., promiscuous, monogamous, and multi-female/single-male, and concluded that lorisids have the dispersed family group social organization. Kar Gupta (2007) observed a fairly complex mating system in the Slender Loris males in KMTR. She identified three types

of males: Roamer, Settler paired with a female, and Settler unpaired. Roamers had home ranges overlapping with other males and several females, and had a mean number of 23.33 sleeping sites. A Paired Settler had a smaller range with a mean number of 11 sleeping sites and paired male and female slept together. Unpaired Settlers had overlapping ranges and a mean number of eight sleeping sites. Settled males were in better habitats with higher arthropod abundance than Roamers. Paired Settler males had larger testes than other males suggesting a role for sperm competition and mate guarding. Kar Gupta opined that this kind of pair living with polygyny and sperm competition elements is an unusual breeding system in primates, and it also suggests that the social organisation of Slender Loris is far more complex than previously thought. Kar Gupta suggested carrying out more research on female social interactions, specifically on roaming males' social interactions with females.

Mother-Infant Interactions and Infant Development

Observations in the laboratory maintained Slender Lorises show that the mother shows intense attachment to the new born infant (Swayamprabha & Kadam 1980). However, when infants were separated from their mothers for two weeks and then presented to the females again, there was no mutual recognition between mothers and offspring, and females became indiscriminate, and any infant settled with any lactating female when several were caged together. However, this behaviour of females was never observed in free-ranging lorises where a female never cared for infant of another female (Nekaris 2003; Radhakrishna & Singh 2004b). Nekaris (2003) and Radhakrishna & Singh (2004b) have reported the development of loris infants in their natural environments in the Ayyalur forests. Young infants spent about 43 % of their time inactive. The neonates had their eyes closed and were carried unsupported by the mothers for the first three weeks after birth. Mothers carrying infants were regularly attended to and groomed by males. 'Parking' began when an infant was three weeks old, where the mother would 'park' her infant at the sleeping place at dusk and retrieve it at dawn. Infants were more social than adults. However, a primiparous mother parked her twin infants as early as two weeks and began to park them in different trees at four weeks. On many occasions, subadult and adult males visited and socially interacted with the parked infants when their mothers were away. Twins interacted socially more with each other than with their mothers. The weaning of the infant begins when it is about four months old and lasts about a month. The mother first refuses to carry the infant and then stops joining it to sleep. As the infants grow, time spent with related conspecifics decreases and with non-related individuals increases. Females attain their first estrus at 9–10 months of age, after which they either start moving in areas more than their mothers' range or just disappear from their natal range. We recommend further systematic research to see what happens to dispersed individuals. Do the males become wanderers for specific periods of their age? How do the subadult, now adult, females establish their new territories? As it is difficult to know when a subadult would disperse and follow a dispersing individual, the study would require radio-collaring several subadult males and females to track their movements.

Social Behaviour

Radhakrishna & Singh (2002c) published the first detailed account of social behaviour of the Mysore Slender Loris in its wild habitats. Lorises spend only about 7 % of their time on social activities. The main social interactions include sleeping together, grooming, courtship and mating, agonistic interactions, and social communication. The large sleeping groups of 2–6 individuals include a female and her present and previous offspring and an adult male. Such a sleeping group is temporary and is found chiefly when a female is in oestrus. The other types of sleeping groups are mother and infant, adult male and adult female, and siblings. About 98 % of the social interactions are affiliative, and only about 2 % are agonistic. Mother-infant, siblings, adult male-female, juvenile-adult and subadult-adult accounted for 39.1, 28.7, 8.6, 14.7, and 8.8 per cent respectively of the total affiliative social interactions. Of the 31 agonistic encounters observed, 18 occurred when an adult female rejected advances by a male for sexual contact. Four agonistic interactions between females occurred when another female tried to enter the home range of a female. Most of the agonistic interactions between males occurred during copulations and at boundaries of home ranges. Emigration, which correlated with sexual maturity, was observed in three females and five males from their maternal ranges. Immigration recorded for four adult males into ranges of females resulted in sleeping associations with resident females. The immigrant males first started to play and sleep with the present offspring before making approaches to the female. This behaviour appears to be a strategy used by the males to appease and attract females. Social communication included urine-marking and vocalisations. Urine-marking may serve as a territorial

signal in both sexes and a signal to indicate the oestrus status of a female as males, on some occasions, showed excitement after sniffing the substratum with female urine. Urine handwashing was also often observed. The vocalisations included whistle and chitter used mostly by adults during agonistic interactions and territorial warning calls, growl used in aggressive encounters, zic used by infant to attract mother's attention, and krik used by males as appeasement calls to females. A scream heard only once was probably indicative of fear. Nekaris (2006) in the same population reported that males were more social than female and interacted with both sexes. On the other hand, females rarely interacted intra-sexually, and associated commonly with males. Although active social interactions were nocturnal, contact associations continued even during the day. Significant differences from the above features of social behaviour were observed in the Mysore Slender Loris population at Malapatti (Radhakrishna & Kumara 2010), where affiliative and agonistic interactions were 53 % and 47 %, respectively. Most of the affiliative interactions were among kin, with some between an adult male and a female and her offspring. Female territoriality accounted for most (46.3 %) of the agonistic interactions, with 14.8 % between adult females and males when females rejected the male advances. The sleeping group pattern at Malapatti was about the same as at Ayyalur. Higher loris density and probably lesser resource abundance at Malapatti than at Ayyalur are the probable reasons for a higher degree of agonistic behaviours at Malapatti. These observations further point out that these behaviours in loris need to be studied in several different habitats with differences in population and resource abundance. Radhakrishna (2004) concluded that "the slender loris appears to be the archetype of a solitary primate species, with most of the intraspecific social interactions occurring in biological contexts like reproduction and parental investment" (p. 80). However, the possibility of adult male-adult female, adult male-juvenile, and sibling associations exists beyond biological contexts, which can be revealed only by further long-term studies on identified individuals.

THREATS AND CONSERVATION

Both Mysore Slender Loris (Kumara et al. 2020a) and Malabar Slender Loris (Kumara et al. 2020b) have been listed as 'Near Threatened' on the IUCN Red List of Threatened Species. However, lorises are facing severe threats to their survival in some areas of their distribution. In the past, when there were no institutional animal ethics committees and strict wildlife protection laws, there was an indiscriminate use of Slender Lorises in laboratory researches. For example, for one study on male reproductive organs (Ramakrishna & Prasad 1967), 151 wild lorises were captured outside Bengaluru city and autopsied within hours in the laboratory. In many places in their habitats, electric wires are running through the habitats of the Slender Loris. The height of the electric poles is about the same where most loris movement and foraging takes place. As a result, lorises accidentally touch live wires and die of electrocution. Such cases have been observed in several areas. In places where lorises occur in agricultural lands and roadside vegetation, they often have to cross the roads by walk as the canopies on the two sides of these roads and paths are not contiguous. Because of their odd and clumsy walks and freezing in response to intense vehicular lights, they often get run over by motor vehicles and bicycles. Such roadkills of lorises are reported from many regions. In some areas, local hunters consider the sighting of a loris a bad omen and often kill them. The body parts, especially the eyes, are used by people in some areas as traditional folk medicines and cultural practices (Radhakrishna & Singh 2002; Dittus et al. 2020). In some regions of Karnataka, lorises are considered harbingers of misfortune and are killed on sight (Kumara et al. 2006). Traditional use of lorises is an important component in treating different illnesses, making love potions, and treating eye problems with loris tears in Tamil Nadu (Kanagavel et al. 2013). There are superstitions that an unmarried woman in the community will remain unmarried for the rest of her life on sighting a Slender Loris; hence lorises are killed by men on sight (Kanagavel et al. 2013). These practices can be controlled through strict implementation of wildlife protection laws and public education and awareness at the same time. Unlike many other primates such as macaques and langurs, which often negatively interact with humans, Slender Lorises have little to no conflict with people either for habitats or for resources. Based on the available field studies, there is a requirement for three conservation management practices for lorises. First, there are several large areas where Slender Lorises are present in good abundance, but these regions do not have proper legal status for wildlife conservation; for example, the reserved forests in Tumkur, Karnataka, and Ayyalur, Tamil Nadu. If not elevating the status of such areas to the level of PAs, at least the regions could be declared as 'loris reserves' as a first step, which could provide legal protection for these animals. Second, some regions have substantial loris populations, but tree

felling, and other habitat disturbances result in a lack of canopy contiguity. Since the lorises are anatomically incapable of jumping beyond 0.3 m (Sellers 1996), the body structure of the loris is not made for walking on the ground; canopy contiguity for easy movement of lorises in trees needs to be ensured. Third, in some areas, lorises maintain population continuity between/among scrub forest fragments through tall fences and vegetation in cultivated agricultural fields. Such areas need to be identified, and proper management practices to ensure population continuity be implemented. Most of the populations of the Mysore Slender Loris are found in forest fragments with high population density. Such fragments need additional protection.

Although indicated in the various subsections above, we specifically make the following recommendations:

· Molecular work would help in determining the extent of genetic difference between the two subspecies, and the unidentified populations.

· The survey needs to be taken up in potential areas of the distribution of Slender Loris that are not yet explored.

· The density estimation in surveyed areas with high encounter rates as potential sites would help in loris conservation.

· Behavioural studies are suggested, if possible using radio telemetry, in different habitat types, especially on the Malabar Slender Loris.

· Areas with a substantial loris population need to be prioritized to provide legal status for the conservation of loris.

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Articles

Understanding human-flying fox interactions in the Agusan Marsh Wildlife Sanctuary as basis for conservation policy interventions
– Sherryl L. Paz & Juan Carlos T. Gonzalez, Pp. 19431–19447

Argentinian odonates (dragonflies and damselflies): current and future distribution and discussion of their conservation
– A. Nava-Bolaños, D.E. Vrech, A.V. Peretti & A. Córdoba-Aguilar, Pp. 19448–19465

Communications

The diel activity pattern of small carnivores of Western Ghats, India: a case study at Nelliampathies in Kerala, India
– Devika Sanghamithra & P.O. Nameer, Pp. 19466–19474

Distribution and threats to Smooth-Coated Otters *Lutrogale perspicillata* (Mammalia: Carnivora: Mustelidae) in Shuklaphanta National Park, Nepal
– Gopi Krishna Joshi, Rajeev Joshi & Bishow Poudel, Pp. 19475–19483

Wildlife hunting practices of the Santal and Oraon communities in Rajshahi, Bangladesh
– Azizul Islam Barkat, Fahmida Tasnim Liza, Sumaiya Akter, Ashikur Rahman Shome & M. Fazle Rabbe, Pp. 19484–19491

Ethnozoological use of primates in northeastern India
– Deborah Daolagupu, Nazimur Rahman Talukdar & Parthankar Choudhury, Pp. 19492–19499

Factors influencing the flush response and flight initiation distance of three owl species in the Andaman Islands
– Shanmugavel Sureshmarimuthu, Santhanakrishnan Babu, Honnavalli Nagaraj Kumara & Nagaraj Rajeshkumar, Pp. 19500–19508

Birds of Barandabhar Corridor Forest, Chitwan, Nepal
– Saneer Lamichhane, Babu Ram Lamichhane, Kapil Pokharel, Pramod Raj Regmi, Tulasi Prasad Dahal, Santosh Bhattarai, Chiranjibi Prasad Pokheral, Pabitra Gotame, Trishna Rayamajhi, Ram Chandra Kandel & Aashish Gurung, Pp. 19509–19526

On some additions to the amphibians of Gunung Inas Forest Reserve, Kedah, Peninsular Malaysia
– Shahriza Shahrudin, Pp. 19527–19539

Reviews

A review of research on the distribution, ecology, behaviour, and conservation of the Slender Loris *Loris lydekkerianus* (Mammalia: Primates: Lorisidae) in India
– Mewa Singh, Mridula Singh, Honnavalli N. Kumara, Shanthala Kumar, Smitha D. Gnanaolivu & Ramamoorthy Sasi, Pp. 19540–19552

Bivalves (Mollusca: Bivalvia) in Malaysian Borneo: status and threats
– Abdulla-Al-Asif, Hadi Hamli, Abu Hena Mustafa Kamal, Mohd Hanafi Idris, Geoffery James Gerusu, Johan Ismail & Muyassar H. Abualreesh, Pp. 19553–19565

Disentangling earthworm taxonomic stumbling blocks using molecular markers
– Azhar Rashid Lone, Samrendra Singh Thakur, Nalini Tiwari, Olusola B. Sokefun & Shweta Yadav, Pp. 19566–19579

A reference of identification keys to plant-parasitic nematodes (Nematoda: Tylenchida\ Tylenchomorpha)
– Reza Ghaderi, Manouchehr Hosseinvand & Ali Eskandari, Pp. 19580–19602

Short Communications

Catalogue of herpetological specimens from Meghalaya, India at the Salim Ali Centre for Ornithology and Natural History
– S.R. Chandramouli, R.S. Naveen, S. Sureshmarimuthu, S. Babu, P.V. Karunakaran & Honnavalli N. Kumara, Pp. 19603–19610

A preliminary assessment of odonate diversity along the river Tirthan, Great Himalayan National Park Conservation Area, India with reference to the impact of climate change
– Amar Paul Singh, Kritish De, Virendra Prasad Uniyal & Sambandam Sathyakumar, Pp. 19611–19615

A checklist of orthopteran fauna (Insecta: Orthoptera) with some new records in the cold arid region of Ladakh, India
– M. Ali, M. Kamil Usmani, Hira Naz, Tajamul Hassan Baba & Mohsin Ali, Pp. 19616–19625

New distribution records of two *Begonias* to the flora of Bhutan
– Phub Gyeltshen & Sherab Jamtsho, Pp. 19626–19631

Rediscovery of *Aponogeton lakhonensis* A. Camus (Aponogetonaceae): a long-lost aquatic plant of India
– Debolina Dey, Shrirang Ramchandra Yadav & Nilakshee Devi, Pp. 19632–19635

***Glyphochloa acuminata* (Hack.) Clayton var. *laevis* (Poaceae): a new variety from central Western Ghats of Karnataka, India**
– H.U. Abhijit & Y.L. Krishnamurthy, Pp. 19636–19639

A cytomorphological investigation of three species of the genus *Sonchus* L. (Asterales: Asteraceae) from Punjab, India
– M.C. Sidhu & Rai Singh, Pp. 19640–19644

***Dryopteris lunanensis* (Dryopteridaceae) - an addition to the pteridophytic diversity of India**
– Chhandam Chanda, Christopher Roy Fraser-Jenkins & Vineet Kumar Rawat, Pp. 19645–19648

Notes

First record of Spotted Linsang *Prionodon pardicolor* (Mammalia: Carnivora: Prionodontidae) with photographic evidence in Meghalaya, India
– Papori Khatonier & Adrian Wansaindor Lyngdoh, Pp. 19649–19651

First record of the Eastern Cat Snake *Boiga gocool* (Gray, 1835) (Squamata: Colubridae) from Tripura, India
– Sumit Nath, Biswajit Singh, Chiranjib Debnath & Joydeb Majumder, Pp. 19652–19656

First record of the genus *Tibetanja* (Lepidoptera: Eupterotidae: Janinae) from India
– Alka Vaidya & H. Sankararaman, Pp. 19657–19659

***Austroborus cordillerae* (Mollusca: Gastropoda) from central Argentina: a rare, little-known land snail**
– Sandra Gordillo, Pp. 19660–19662

Intestinal coccidiosis (Apicomplexa: Eimeriidae) in a Himalayan Griffon Vulture *Gyps himalayensis*
– Vimalraj Padayatchiar Govindan, Parag Madhukar Dhakate & Ayush Uniyal, Pp. 19663–19664

Two new additions to the orchid flora of Assam, India
– Sanswrang Basumatary, Sanjib Baruah & Lal Ji Singh, Pp. 19665–19670

Wildlife art and illustration – combining black and white ink drawings with colour: some experiments in Auroville, India
– M. Eric Ramanujam & Joss Brooks, Pp. 19671–19674

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