

quickly mastered and easy to teach to other investigators. It did, however, rely upon skillful tracheostomy and subsequent skin suturing by the operator. No complications were noted in our study.

With our modification of the traditional technique, endotracheal intubation in rats could be safely performed with high success rate, which makes it highly suitable for basic cardiovascular research. Our intubation method requires no special equipment, needs little training to master and thus far has not been seen to be associated with any complications.

Distribution, abundance and conservation of primates in the Highway Mountains of Western Ghats, Tamil Nadu, India and conservation prospects for lion-tailed macaques

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In the present study, we surveyed the primate species in the Highway Mountains of Tamil Nadu, India. Five primate species, including Nilgiri langur, Hanuman langur, bonnet macaque, lion-tailed macaque and slender loris were recorded in the region. Coffee and cardamom plantations in the hill system still hold the population of endangered lion-tailed macaque and Nilgiri langur. However, tea plantations act as a barrier for the movement of primate groups between the forest patches. The disturbance in the hill system and its consequence may be a reason for the increased group size of lion-tailed macaques. The inclusion of the lion-tailed macaque occurring areas to the newly declared Megamalai Wildlife Sanctuary in the Highway Mountains is recommended.

Keywords: Distribution, Highway mountains, lion-tailed macaque, Megamalai, primates.

THE forests of the Western Ghats harbour a large number of flora and fauna. Due to its high biodiversity, the hill system has been recognized as one of the global biodiversity hotspots¹. Nevertheless because of high human density² and high anthropogenic pressure, the rate of forest loss is alarming and these forests are considered to be one of the world's most endangered forests³. Developmental activities such as construction of dams, roads and power lines, converting the forests for commercial plantations such as coffee, tea and eucalyptus, and exploitation of trees for decades to cater to the wood industry led to a sharp decline of forest cover and resulted in fragmentation^{4,5}. As a consequence of this, populations of many species have become fragmented. In addition, hunting of wild animals by humans has resulted in local extinction of some species^{6,7}. Nevertheless, protected area network was created during 1972 to conserve the flora and fauna of the country (Wildlife Protection Act 1972, ref. 8). Although some parts of the Western Ghats were declared as

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protected areas, many potential forest regions were left out due to lack of baseline data. The Highway Mountains in the southern Western Ghats is one such area lacking baseline data on mammals except for few five decade old occurrence records. Wroughton⁹ identified 25 mammals and later Hutton¹⁰ reported 56 mammals including certain range restricted and threatened species such as lion-tailed macaque *Macaca silenus*, Nilgiri tahr *Hemitragus hylocrius*, Nilgiri langur *Semnopithecus johnii*, Salim Ali fruit bat *Latidens salimali* and Nilgiri marten *Martes gwatkinsii*. All the five species of primates known from the Western Ghats are reported in Hutton's survey of the Highways.

Highways of the southern Western Ghats have remnant evergreen forests that have been severely fragmented and overexploited to raise economic crops such as tea, coffee, cardamom, etc. Nevertheless, it forms a crucial wildlife refuge that spurs north to the Periyar Tiger Reserve (PTR) and connects the Grizzled Squirrel Wildlife Sanctuary (GSWS) of Srivilliputhur in the east¹¹. Yet, detailed data on any aspect of mammals are not available for this hill system. We present here findings from a survey of primates in the evergreen forests and adjoining dry disturbed forests in the Highways and discuss the conservation value of the hill system.

Highways (~490 sq. km) is located in Theni district of Tamil Nadu, and lies between 9°30'N to 9°50'N and

77°10'E to 78°30'E (Figure 1). The elevation ranges from 300 to 2016 m above msl. The average rainfall ranges from 700 mm in the foothills to over 2500 mm in the higher reaches¹². The forest types^{13,14} include shola forests and grasslands at high altitude, evergreen and semi-evergreen forests at slopes and plateau (i.e. 108.44 sq. km), moist deciduous forests and its degraded stages (i.e. 103.38 sq. km) deciduous forests towards the edge on eastern side (i.e. 228.73 sq. km) and plantations and commercial croplands of tea, coffee and cardamom (i.e. 49.78 sq. km). The commercial crops that are grown in the region are coffee, tea, cardamom, clove, cashew and silk cotton.

The survey was done in the evergreen forests and its adjoining dry forests for the diurnal primates focusing mainly on the endangered lion-tailed macaque. A large proportion of the dry forests was not covered in the survey. We also surveyed the commercial plantations of coffee, tea and cardamom at higher altitude. However, all the forest types in the entire hill system were surveyed during the night for slender loris.

Laying transect lines is often not possible over much of the forested areas of the mountains. Considering the total area to be surveyed (108.44 sq. km of evergreen forests and adjoining degraded moist deciduous forests, dry forests and plantations of about 70 sq. km), the total area was divided into seven segments of about 25 sq. km. We trained forest department personnel, research students and few local people in the survey methods. The survey was conducted during 21–25 January 2009, which involved simultaneous walks in selected segments (five persons for each segment) by maintaining the inter-individual distance of 100–200 m. A total of 204 km was walked between 0600 and 1400 h on predetermined routes. During the walk, after sighting a primate group, 5–10 min were spent to obtain a proper count of individuals and coordinates were recorded. The data on group composition of all the primate species was collected for a span of 10 days.

The major goal of the survey was to assess the status of the lion-tailed macaque in the Highways. Previous studies have documented the home range of a single group to be about 5 sq. km (refs 15–18). Hence, we considered each group that was sighted within a range of 1.5 km radius from the other group as same, unless the two groups were sighted in a short span of time and the group identity of each was confirmed as different. The inter-group distance was extracted with GIS.

Meanwhile, the survey was also carried out between 1900 and 2400 h for slender loris. The night survey was done by walk on pre-existing trails at a speed of 0.5 km/h, and the total distance walked was 62 km. While walking, we flashed light on the sides and recorded the distance walked. Slender loris *Loris lydekkerianus* was differentiated from other animals by its orange-red reflection of eyes to the light, which is very different from the

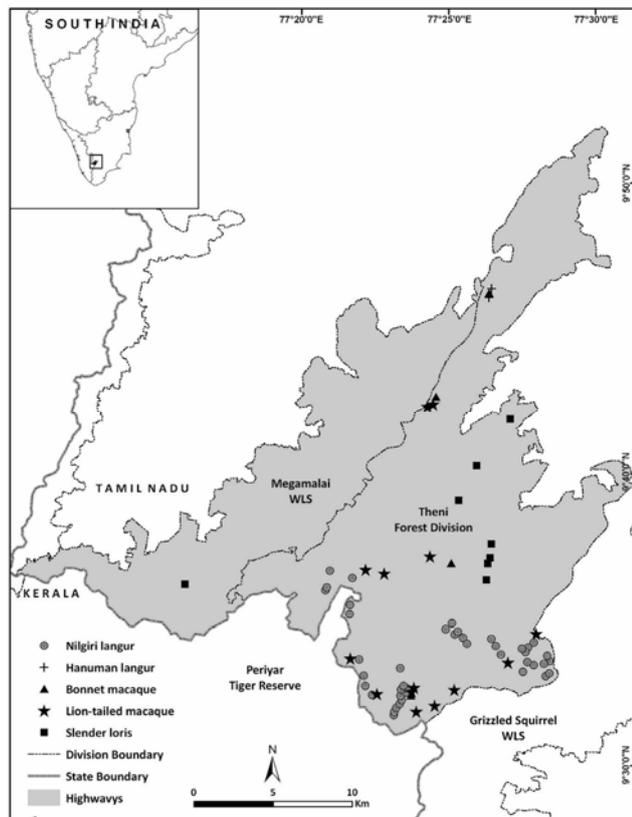


Figure 1. Map showing the sightings of primates in Highway Mountains.

Table 1. Encounter rate and group size of the primates in Highway Mountains. Effort during the day was 204 km of walk (for diurnal primates) and night was 62 km of walk (for nocturnal primates)

Species	Encounter rate			Group size	
	No. of groups sighted	Groups/km	N	Minimum–Maximum	Mean group size (SD)
Diurnal primates					
Nilgiri langur	61	0.30	11	3–11	6.00 (± 2.62)
Hanuman langur	2	0.01	2	10–12	11.00 (± 1.41)
Bonnet macaque	18	0.09	5	6–28	17.20 (± 8.41)
Lion-tailed macaque	15	0.07	8	7–55	33.25 (± 18.78)
Nocturnal primate					
Slender loris	8*	0.13**	–	–	–

*Number of individuals; **Number of individuals/km; N, Number of groups with group size data.

Table 2. Mean number of different age–sex individuals in the groups and age–sex ratios of the primate groups in Highway Mountains

Age, sex	Nilgiri langur	Hanuman langur	Lion-tailed macaque
Adult ♂	1.17	1.15	1.75
Sub-adult ♂	0.33	1.00	1.25
Adult ♀	2.17	3.50	7.00
Sub-adult ♀	0.66	1.00	1.00
Juvenile	1.00	2.50	6.75
Infant	1.17	1.50	2.00
Adult ♂ : Adult ♀	1 : 1.9	1 : 2.3	1 : 3.9
Adult : Immature	1 : 0.9	1 : 1.2	1 : 1.3
Adult ♀ : Infant	1 : 1.5	1 : 1.7	1 : 0.3

eye reflections of other nocturnal animals^{19–21}. If there was ever any doubt regarding the identity of a species, we walked to the animal and confirmed its identity. For each sighting, number of individuals, forest type and coordinates were recorded.

The study confirms the presence of all five primates, viz. Nilgiri langur, Hanuman langur *S. priam*, bonnet macaque *M. radiata*, lion-tailed macaque and slender loris in the Highway Mountains. The subspecies of slender loris in the hill system was confirmed to be *L. lydekkerianus lydekkerianus*. Bonnet macaque being a habitat generalist species showed a wider distribution and was found in all the forest types. Nilgiri langur was restricted to evergreen and moist deciduous forests, lion-tailed macaques were confined to high and medium elevation evergreen forests and coffee plantations, and Hanuman langur and slender loris were confined to dry forests. Population of Nilgiri langur was discontinuous towards north and absent in certain forest patches. Further, Nilgiri langur and lion-tailed macaques were not recorded from western slopes of the hills.

Table 1 summarizes the number of groups or individuals seen, encounter rate and group sizes for each species. The encounter rate of Nilgiri langur was higher than other primates. Complete count of the group size could be obtained only for few groups for each species. Nevertheless we were able to obtain group sizes of all the lion-tailed macaque groups. Mean group sizes of Nilgiri langur, Hanuman langur, bonnet macaque and lion-tailed

macaque were 6.00 ± 2.62 , 11.00 ± 1.41 , 17.20 ± 8.41 and 33.25 ± 18.78 respectively. The group size of lion-tailed macaque varied between 7 and 55. The slender loris is mostly solitary and all the sightings were of single individuals. The group composition and age–sex ratio of Nilgiri langur, Hanuman langur and lion-tailed macaque are summarized in Table 2. The groups of these species were multi-male and multi-female. We could not get the group composition of bonnet macaque since they did not permit proximity. The average age–sex ratio of the Nilgiri langur, Hanuman langur and lion-tailed macaque groups was 1.9, 2.3 and 3.9 adult female per adult male, 1.5, 1.7 and 0.3 infants per adult female and 0.9, 1.2 and 1.3 immature per adults respectively.

Considering the location details of each group of lion-tailed macaque and their group size during the survey, a separate effort was made for collecting the group characteristics, i.e. size and age–sex of each group. In addition to this, the data on location of groups with size, repeated counts and sightings helped to differentiate the groups from each other. Although the number of groups encountered during the survey was 15, we could establish a minimum number of groups in the hills as eight with about 266 animals (Table 3). All the groups sighted were associated or found amidst private estates.

Highway Mountains has a wide array of forest types due to high variation in altitude and rainfall. Drastic bioclimatic changes caused by the steep environmental cline create very restricted habitats and niches²². The vegetation gradient of Highway Mountains ranges from dry scrub forests in the foothills (low rainfall and more dry months) to montane shola at higher altitude where the rainfall is high. Although the rainfall in the Highway Mountains is low and the dry months are high and not typical enough to hold typical evergreen vegetation, the occult precipitation because of the massive elevation gradient is speculated to compensate it²³. Hence, the mountains still hold the remaining fine evergreen forests (isolated amidst dry plains), especially the high elevation montane forests which is indeed the top-most endangered vegetation type in the Western Ghats²⁴. The forest mosaic thus available (even after large-scale commercial conversions into non-forest

Table 3. Estimated lion-tailed macaque groups and their group size in Highway Mountains

Area	Coordinates	Altitude (m asl)	Group size
Vellimalai estate I	9°32'43.8"N, 77°23'45.9"E	1014	34
Vellimalai estate II	9°32'36.7"N, 77°23'45.8"E	1061	55
Engineering estate	9°36'24.6"N, 77°22'50.6"E	1263	28
Ananda estate	9°32'37.4"N, 77°22'37.4"E	1417	10
Palanikumar estate	9°31'54.7"N, 77°24'31.4"E	1180	50
Egan jaga	9°32'30.7"N, 77°22'36.3"E	1404	28
Kardana estate I	9°41'32.8"N, 77°23'48.2"E	1204	7
Kardana estate II	9°41'19.6"N, 77°24'02.6"E	1421	54
Total			266

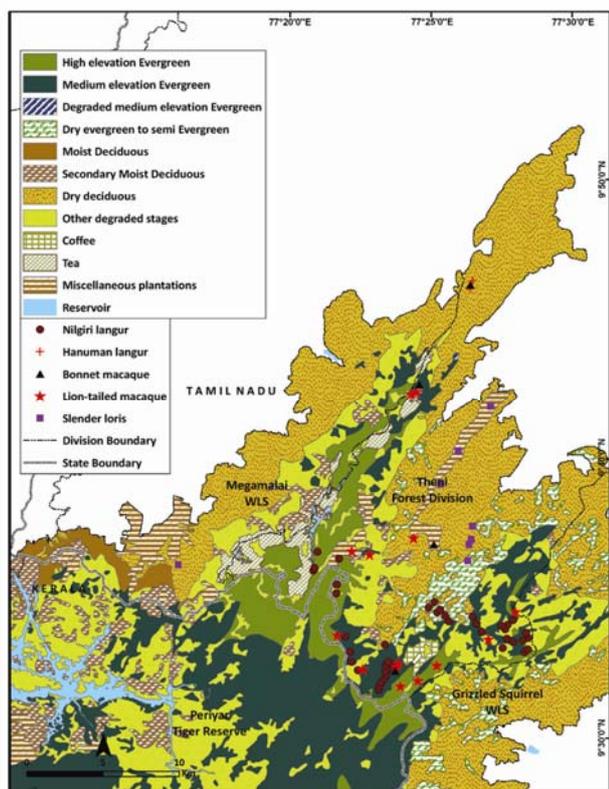


Figure 2. Vegetation map of the Highway Mountains and adjoining forest divisions showing the sightings of primates.

land-uses) enabled the mountain system to harbour all the primate species found in the Western Ghats. In the eastern side of the southern Western Ghats, Hanuman langur is restricted to dry forests whereas the Nilgiri langur is found in high altitude evergreen to moist deciduous or semi-evergreen forests. Lion-tailed macaque is highly restricted to evergreen forests. Although bonnet macaque is found in evergreen forests, it is largely restricted to low elevation gradients. Slender loris is found only in low elevation scrub or disturbed deciduous forests (e.g. Indira Gandhi Wildlife Sanctuary²⁵). The present observation of primate distribution in Highways closely follows the same pattern.

Many anthropogenic disturbances are apparent such as the commercial plantations of tea, coffee and cardamom at the cost of rainforests and the three dams built in the hills have submerged vegetation in the valleys and pla-

teaus that have created a gap for the animal movements. Yet, due to relative plasticity to adapt to varying habitat conditions, lion-tailed macaque, bonnet macaque and Nilgiri langur were found in the coffee and cardamom plantations. This has made the population of all the primate species continuous in the entire hill system except towards the western side where the tea plantation is predominant. The tea plantations act as a barrier to the west side deciduous forests and hence the populations of Nilgiri langur and lion-tailed macaque are restricted only to eastern parts of the hill. The Mysore slender loris is known to be found in drier forests of the plains and rain shadow forests of Western Ghats¹⁹⁻²¹, and the present records in the Highways confirm this.

The evergreen forests of the Highways are continuous with the adjacent forest divisions (Figure 2), i.e. PTR in Kerala in the south and GSWS in Tamil Nadu on the eastern side. We presume that the populations of all primate species would be continuous including the lion-tailed macaque. Earlier we have sighted a few groups of lion-tailed macaque in both PTR and GSWS, and hence a proper survey of especially the lion-tailed macaques is necessary in these two protected areas to understand the total population status.

The mean group size and mean age-sex ratio of all primate species were close to the average calculated for many other regions except the mean group size of the lion-tailed macaque (33.25), which is much higher than all other regions, e.g. 19.6 in the Silent Valley²⁶, 16.3 in Anaimalai Hills¹⁸ and 24.7 in Sirsi-Honnava²⁷. The lion-tailed macaque groups in the Highways are highly associated with the coffee or cardamom plantations or a portion of their home range is in the plantations. Even lion-tailed macaques in smaller fragments which were associated with the coffee plantations in Anaimalai Hills had high group size (22.83) than in the larger forest complexes (13.17)¹⁸, and the group size of one of the smallest groups is more than 80 (ref. 28). Although it is very difficult to conclude which factor has really influenced the increased group sizes; one of the common factors in both the regions is the disturbed forests which forms a habitat mosaic with high plant diversity. However, this requires a detailed study. Although the number of groups is small (8 groups), the minimum population size of 266 individuals

is very promising. Since the population is expected to be continuous with PTR and GSWS, the total population size may be much larger. However, this needs confirmation from further investigation of the status of lion-tailed macaque groups in neighbouring forests. Considering the current status of the lion-tailed macaque population in different parts of the Western Ghats (e.g. Kumara and Singh²⁹ and Kumara and Sinha³⁰ reported the decline in population size or almost local extinction of the lion-tailed macaques in different parts of the Western Ghats), the present finding of a large population therefore has high conservation value.

The population in the Highwayvys needs proper attention since the habitat of the lion-tailed macaque remains outside the protected area network. Even the recently declared Megamalai Wildlife Sanctuary in the Highwayvys (Figure 1) totally left out the habitats of lion-tailed macaques and Nilgiri langur. Further the large proportion of such habitat is under private holdings, and the official status of the forest is still considered as a 'reserve land', which raises need of urgent concern to retain the population through proper conservation and management strategy. In the near future it is necessary to provide a protected area status for this region.

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