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Population Status of the Endangered Lion-tailed Macaque *Macaca silenus* in Kalakad-Mundanthurai Tiger Reserve, Western Ghats, India

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Abstract: The lion-tailed macaque, endemic to the evergreen forests of the Western Ghats in southern India, is endangered. Over the last two decades surveys have documented population declines in a number of areas. There still exists a huge gap, however, in our knowledge of this macaque's status at many sites. It is imperative to identify and conserve existing populations in contiguous, large and undisturbed forests. We present the results of a first complete population survey carried out in the Kalakad-Mundanthurai Tiger Reserve (KMTR) in the Agasthyamalai landscape; an area that has not been surveyed for two decades. We found a population of at least 462 lion-tailed macaques in 30 groups. The mean group size was 15.4 individuals per group, and the adult sex ratio was 3.5 females/male. The forest of the KMTR is connected with forest reserves in the states of Tamilnadu and Kerala, and it is probable that the lion-tailed macaque population of KMTR is likewise contiguous. Measures must be taken at a landscape level for the long-term conservation of the species; the status of the populations in the neighboring sites need to be assessed, and priority should be given to adequate protection for the Agasthyamalai sub-population as a whole.

Key Words: lion-tailed macaque, southern Western Ghats, primate surveys, habitat connectivity, Agasthyamalai landscape

Introduction

Primates are among the most imperiled of the mammals (Ceballos and Brown 1995; Schipper *et al*. 2008), with many species occurring in regions of high human density (Harcourt and Parks 2003). Habitat loss and hunting have been the major causes for the population declines of many primate species (Chapman and Peres 2001; Mittermeier *et al*. 2009); many survive in just fragments of their former contiguous habitat, often as small and isolated populations (Mittermeier and Cheney 1987). These threats exacerbate extirpation risks in primate species, especially those with life history traits associated with slow reproductive rates and a limited capacity for population recovery (Isaac and Cowlishaw 2004; Purvis *et al*. 2000). The long-term survival of some primates may hinge on just a few remaining habitats large enough to maintain viable populations (Chapman and Peres 2001; Zeigler *et al*. 2010).

The lion-tailed macaque, *Macaca silenus* (Linnaeus, 1758), is endemic to the Western Ghats in southern India, and is Endangered (Kumar *et al.* 2008). It is a habitat specialist, restricted to the evergreen forests of the Ghats (Singh *et al*. 1997). Being primarily frugivorous with a narrow dietary niche, it requires a perennial fruit availability (Kumar 1987; Sushma and Singh 2006). Its life history traits are typical of a primate adapted to a stable environment, rendering it vulnerable to changes in habitat and to hunting (Kumar 1987). Forest connectivity is important for the dispersal of adult males, as is evident from the unnaturally high proportion of adult males in fragments that lack connectivity (Umapathy and Kumar 2000a).

The geographical area of occupancy of the lion-tailed macaque is less than 2,500 km². It extends from a few kilometers north of the Sharavati River (14°N) in Karnataka (Karanth 1985; Kumara and Singh 2004) to the Agasthyamalai hills (8°N) at the southern tip of the Western Ghats (Green and Minkowski 1977). Presently, it is believed that about 3,500 lion-tailed macaques survive in 49 sub-populations across eight locations (Molur *et al.* 2003). Many of these sub-populations are restricted to fragments that are small and isolated (Singh *et al.* 2002). There are four known sites in its entire range that hold large populations in relatively large forests (Singh *et al.* 2009): (1) Sirsi and Honnavara Forest Divisions in Karnataka (Kumara and Singh 2004); (2) Kudremukh National Park and the adjoining sanctuaries (Kumara and

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Singh 2008); (3) Silent Valley National Park (Ramachandran and Joseph 2001); and (4) the Kalakad-Mundanthurai Tiger Reserve (KMTR). While there have been surveys undertaken in the recent past in the first three of these sites, there has been none in the KMTR. Because of the large extent of forest, Molur *et al.* (2003) identified it as a site with the potential of harboring a significant population of lion-tailed macaques. Along with adjoining forests, the KMTR forms the southernmost limit of the macaque's geographic range—the Agasthyamalai landscape. It is also a distinct sub-population with tenuous connectivity at the Shencottah gap (9°) that has a railway line and a national highway passing through it, and is densely populated, with a large number of homesteads and small landholdings (Gangadharan *et al.* 2011). There is unlikely to be connectivity for these macaques across this gap. KMTR is thus deemed to play an important role for lion-tailed macaque conservation in the Agasthyamalai landscape.

Only two reports on the population of lion-tailed macaques in the KMTR were available prior to the present survey. The earliest survey reported 14 groups with 145 individuals (Green and Minkowski 1977). This was followed by a rapid survey that reported 15 groups with 159 individuals (Hohmann and Sunderraj 1990). Both surveys were based on local knowledge and restricted to just parts of the reserve.

During 2008–2009, we carried out a survey to assess the population status of lion-tailed macaques in the KMTR. In this paper we report our findings and discuss the importance of this sub-population for the conservation of the lion-tailed macaque.

Methods

Study site

The Kalakad-Mundanthurai Tiger Reserve (89,500 ha) is situated at the southernmost end of the Western Ghats on the eastern slopes, 8°25'–8°53'N and 77°15'–77°35'E (Fig. 1). Elevation ranges from 100 m to 1866 m above sea level. This region receives rainfall during the south-west monsoon (June–August) and the north-east monsoon (October–December). Mean annual rainfall is about 3,000 mm.

Forest types in the KMTR range from west-coast, tropical evergreen to semi-evergreen, moist mixed-deciduous, and dry mixed-deciduous, to thorn forest (Champion and Seth 1968). The prime lion-tailed macaque habitat there is wet evergreen forest, which covers about 20,000 ha and is mostly undisturbed (Giriraj *et al*. 2008). There are 28 human enclaves in the reserve. They include Electricity Board settlements and commercial plantations of tea, coconut, clove and cardamom (Ali and Pai 2001). While most plantations are abandoned, two are still functional and are situated in the middle of the Reserve, one of them a tea estate, covering an area of about 3,400 ha. There are also a few scattered human enclaves (Ali and Pai, 2001). Many of the abandoned plantations were acquired by the Reserve in 1995 and allowed to regenerate into forest (Ali and Pai 2001). The KMTR, along with other adjoining parks and reserves in Kerala and Tamil Nadu, form the Agasthyamalai landscape, which has some of the least fragmented forest stretches in the southern Western Ghats.

Data collection

In order to cover the study area systematically, we overlaid a grid of 2.23 × 2.23 km cells on the vegetation map of KMTR using ArcView Version 3.2 (Environmental Systems Research Institute, Inc. California). We chose this cell size since it approximately equals the average home range size of a lion-tailed macaque group in the study area (about 500 ha; Green and Minkowski 1977). We selected all cells that contained evergreen forest; the habitat of the lion-tailed macaque. We sampled 40 of 83 selected cells, covering 200 km², using the existing network of trails and animal paths. The remaining cells were inaccessible due to rough terrain or impenetrable reed brakes. Given limited resources and time, we did not attempt to cut transects. The average length of the trail walked in each cell was 2.72 km (SD ± 1.02). We used temporal replicates (four consecutive days) to survey each cell, but due to logistic constraints this was not possible for all. We surveyed 23 cells for four days each, eight cells for three days each, two cells for two days each and seven cells were surveyed on just one day. We uploaded the cell locations using DNR GARMIN software (version 5.04) into a handheld GPS (Garmin eTrex VistaHCX), which helped us locate the cells on ground. All surveys were carried out between 0700 h and 1600 h. Each survey was carried out by two people, at least one of them an experienced observer (biologist/trained volunteer). All volunteers were given prior training. All survey teams included one forest-dweller who was familiar with the study area and its fauna. This was done to ensure that the detectability of lion-tailed macaques in the surveys was high and uniform across the cells. Each team walked at a pace of about 1 km/h, scanning the canopy and stopping every few minutes, at intervals of about 30 m, to listen for calls. Three other diurnal arboreal mammals share the habitat with the lion-tailed macaque: the Nilgiri langur (*Semnopithecus johnii*), the bonnet macaque (*Macaca radiata*), and the Indian giant squirrel (*Ratufa indica*). Calls of these species are very different from those of lion-tailed macaques, and hence easily distinguishable. When the team heard a call or detected movement in the canopy away from the trail, the team took a few minutes to leave the trail in order to observe the species. This ensured that there were no false detections. On sighting lion-tailed macaques, we recorded (i) the location using GPS, (ii) the number of individuals, and (iii) date and time. Most of the groups we encountered were not habituated and therefore did not allow observers to follow them in close proximity. Given the rugged terrain and shyness of the groups, it was not always possible to follow the groups to obtain a count. Due to the large group spread typical of lion-tailed macaques (over about 150 m; Kumar 1987), the team counted only when the group made a coordinated movement across a gap in the canopy. There are often stragglers in groups, so we waited for at least 15 minutes after the group had moved to

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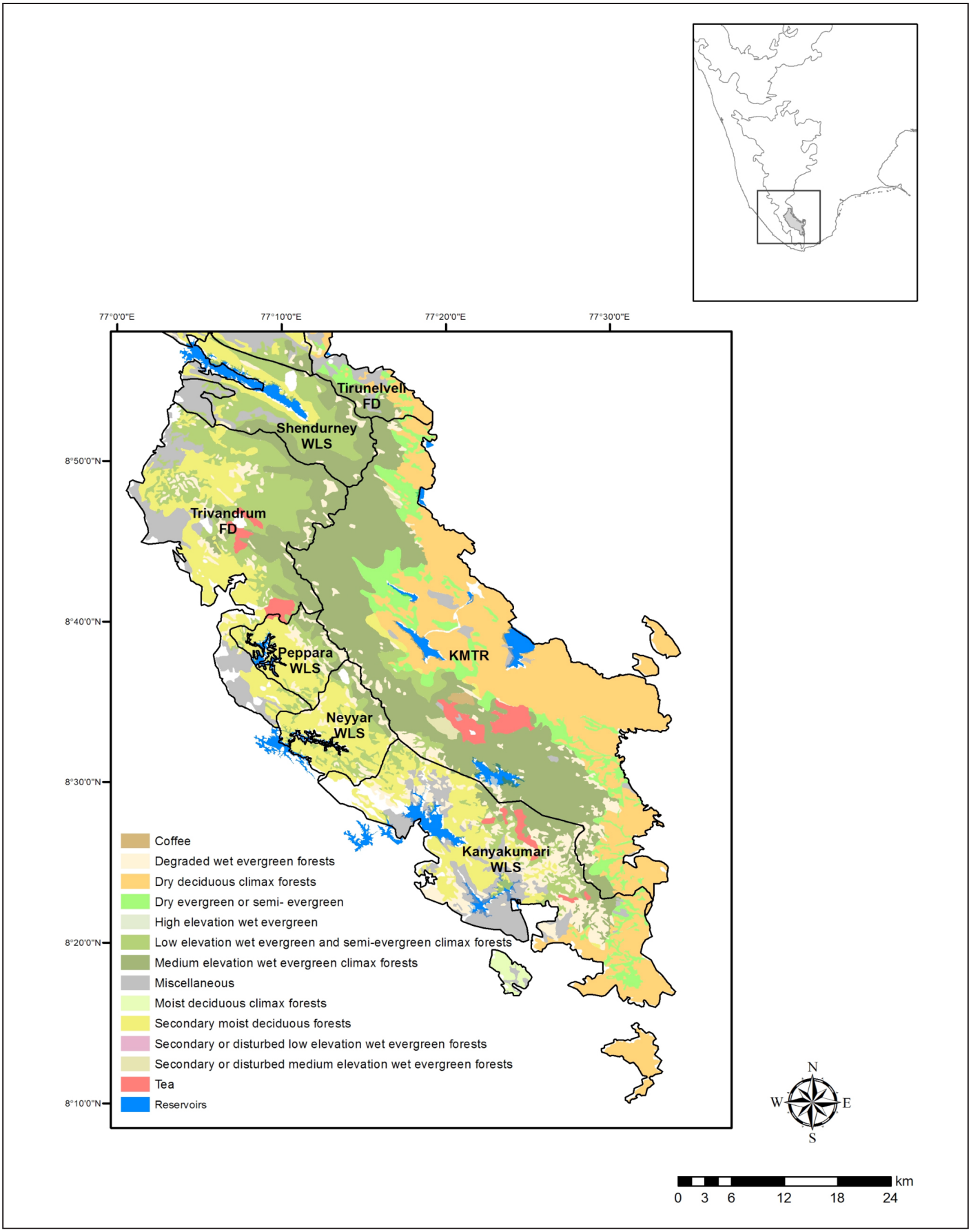


Figure 1. Map showing the Agasthyamalai landscape consisting of the Kalakad-Mundanthurai Tiger Reserve (KMTR) and adjoining areas and different vegetation types in the landscape. Inset map shows Western Ghats with the study area (KMTR) at the southern tip of India (Vegetation map attribution: B. R. Ramesh, D. De Franceschi and J.-P. Pascal, French Institute Pondicherry, downloaded from http://thewesternghats.indiabiodiversity.org).

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Table 1. Group structure of lion-tailed macaque groups in the Kalakad-Mundanthurai Tiger Reserve.

Group	Size	Adult male	Adult female	Subadult	Juveniles	Infants	Immature	Unidentified
Sengaltheri CE	10	1	5	0	1	2	3	1
Oothu	22	2	9	0	10	1	11	0
Peyar	16	2	7	0	4	1	5	2
Knapp's hut	20	2	7	1	5	5	10	0
8th mile	12	1	5	0	4	2	6	0
Valayar CE	14	2	5	3	3	1	4	0
Manimutthar	13	2	4	1	2	2	4	2
Total	107	12	42	5	29	14	43	5
Mean		1.71	6	0.71	4.14	2	6.14	

ensure that all the individuals were counted. The survey was then resumed from the spot from where the team deviated. Whenever we failed to get a full group count, we revisited these cells to locate the groups again. Information on group composition was recorded only when we were certain that all the animals in group were identified unambiguously. Only two researchers who had prior experience of studying lion-tailed macaques were involved in collecting information on group composition. We followed Kumar (1987), using body size and morphological features to distinguish individuals of different age-sex categories. In order to arrive at the number of groups and avoid double counts, we adopted the method described in Kumara and Singh (2008). We counted any two detections of LTM in a survey as distinct groups if they occurred >1.3 km apart, or <1.3 km but <1 h apart. We arrived at a minimum number of groups by pooling all identified in this way, along with incidental sightings that did not violate the criteria laid down for the survey. The field surveys were carried out between October 2008 and September 2009.

Results

The total length of the trails used for sampling was 108.7 km, and the total sampling effort, including replicates, was 347.5 km. The estimation of sampling effort did not include the distance traveled away from the trail while following monkeys. We saw lion-tailed macaques 48 times during our survey. Mean encounter rate was 0.14 groups/km (SE ± 0.02). They were found at elevations ranging from 370 m to 1300 m above sea level.

We were able to distinguish 30 groups of lion-tailed macaques (Fig. 2). However, secondary information from reliable sources (such as other researchers working in the reserve) revealed the presence of four other groups. We also saw solitary adult males on three occasions in different areas of the reserve. We obtained group size information from 15 of the groups (see Appendix). The mean group size was 15.4 individuals (SD ± 3.24; 95% CI 13.04–17.75). We estimate a minimum number of 462 individuals in 200 km². The group composition for seven groups is shown in Table 1. The mean numbers of males and females per group were 1.71 and 6, respectively. Overall, the adult male–adult female sex ratio was 3.5 females per male. The adult female–immature ratio was 1:1.02, and the adult female–infant ratio was 1:0.3 (Table 2).

Table 2. Age-sex ratios of lion-tailed macaque groups in the Kalakad-Mundanthurai Tiger Reserve.

Age-Sex	Number of individuals	Ratio
Adult ♂ : Adult ♀	12 : 42	1: 3.5
Adult ♀ : Immature	42 : 43	1: 1.02
Adult ♀: Infant	42 : 14	1: 0.33

Discussion

Conserving lion-tailed macaques will require providing protection for the habitat and populations (Singh *et al*. 2009). Gaps in our knowledge of population status at many sites and the lack of a systematic monitoring program are impediments to the *in situ* conservation of this species. Although we could not survey all of the lion-tailed macaque habitat in the KMTR, we can indicate a minimum population size of at least 30 groups with 462 individuals. This is much higher than the previous population assessments for the KMTR (Green and Minkowski, 1977; Hohmann and Sunderraj, 1990). While the methods used in the three surveys were different and cannot be compared, the higher estimate in our survey is due to enhanced effort, covering areas that had not been surveyed before. Threats faced by populations at other sites are not prevalent in the KMTR, making it singularly important for lion-tailed macaques. The Sirsi-Honnavara population is within unprotected, multiple use forests that are interspersed with fields, and faces encroachment and degradation of its habitat (Kumara and Sinha 2009). Hunting has led to population declines even in protected areas such as Kudremukh National Park (Kumara and Sinha 2009). Populations in Kerala also suffer poaching (Molur *et al.* 2003). However, habitat degradation, mainly through fire, and, to a lesser degree, degradation of forests close to human enclaves such as the tea estate are threats in the KMTR (Annamalai 2005). Nearly 16% of the evergreen forest cover has been degraded in the last 25 years in the KMTR (Giriraj *et al.* 2008). Selective logging and encroachment in the past, along with recurrent fires, have led to the proliferation of *Ochlandra* reed brakes in the gaps, preventing the regeneration of trees (Giriraj *et al*. 2008). Enhanced protection, patrolling around human enclaves and

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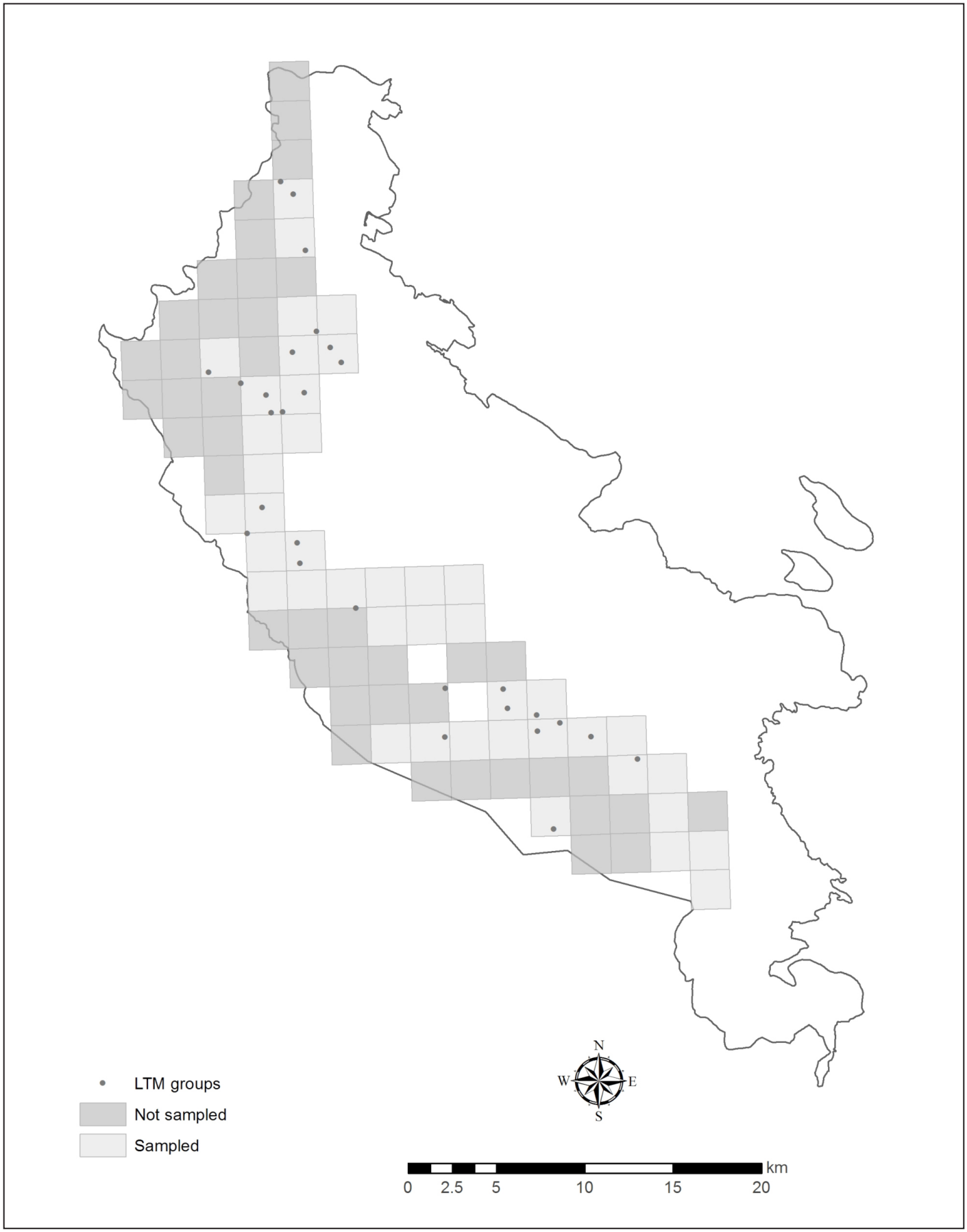


Figure 2. Map showing cells that were sampled, not sampled and locations of lion-tailed macaque troops in the Kalakad-Mundanthurai Tiger Reserve (KMTR), Two white cells in the middle of the map cover the tea estate in the reserve.

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along the western park boundary, and assisted regeneration of forests in some of the abandoned plantations will be a few important steps towards conservation of lion-tailed macaque and its habitat in the KMTR.

Conservation priorities for the Agasthyamalai sub-population

Frugivorous primates such as the lion-tailed macaque, which depend on patchy resources, may be particularly vulnerable to habitat disturbance (Bicknell and Peres 2010; Rode *et al.* 2006). Habitat conservation at the landscape level should be prioritized because landscape attributes and patch characteristics and quality determine the persistence of primates in forest patches (Arroyo-Rodrigues *et al*. 2007; Bicknell and Peres 2010; Umapathy and Kumar 2000b).

The KMTR population is likely to be contiguous with LTM groups in adjoining protected areas (Shendurney, Peppara and Neyyar wildlife sanctuaries) and reserved forests in Kerala as well as the Kanyakumari Wildlife Sanctuary in Tamilnadu, forming the Agasthyamalai sub-population. The current status and distribution of lion-tailed macaques in these sites are, however, not known.

The KMTR is the largest protected area in the Agasthyamalai landscape. It has retained large stretches of pristine habitat and a viable lion-tailed macaque population, giving it a key role in the long-term persistence of the species. The challenge for the conservation of the lion-tailed macaque in this landscape is to identify, monitor and restore connectivity between the KMTR and the surrounding forest reserves. This requires a larger, species-specific conservation plan to be drawn up by the two states, Kerala and Tamilnadu, targeting the entire landscape. Population assessments in the neighboring state forests need to be carried out at regular intervals, and adequate protection needs to be provided for these groups. Given the anthropogenic pressures on native forests in the Western Ghats (Davidar *et al*. 2010), habitat monitoring, using both remote sensing techniques and ground assessments, should be a priority. The prospects of conserving this endangered macaque pivots on identifying large populations, monitoring them, and providing the necessary protection.

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Appendix: Lion-tailed macaque troops and their sighting locations in the Kalakad-Mundanthurai Tiger Reserve.

No.	Group identity	Group size	Administrative Range
1.	Karupusami Koil 1	?	Kadayam
2.	Karupusami Koil 2	10	Kadayam
3.	Nondimankadu	13	Kadayam
4.	Chinnapul 1	?	Mundanthurai
5.	Udumbukal 2	?	Mundanthurai
6.	Valparai	?	Mundanthurai
7.	Kodamadi 1	?	Mundanthurai
8.	Kodamadi 2	?	Mundanthurai
9.	Valukku odai	?	Mundanthurai
10.	8th mile 2	12	Mundanthurai
11.	Knapp's hut	20	Mundanthurai
12.	Valayar CE	14	Mundanthurai
13.	Kandaparai	?	Mundanthurai
14.	Peyar	16	Mundanthurai
15.	Kannikatti	21	Mundanthurai
16.	Injikuli	?	Mundanthurai
17.	Pambar	?	Mundanthurai
18.	Mylar 1	?	Mundanthurai
19.	Mylar 2	16	Mundanthurai
20.	Thenparai 1	12	Papanasam
21.	Thenparai 2	?	Papanasam
22.	Oothu CE	22	Amb/BBTC
23.	Manimuthar 1	?	Ambasamudram
24.	Manimuthar 2	13	Ambasamudram
25.	Kakkachi 1	16	Ambasamudram
26.	Kasunguliar 1	?	Ambasamudram
27.	Kodayar	25	Kodayar
28.	Kakkachi 2	?	Kalakad
29.	Kasunguliar 3	11	Kalakad
30.	Sengaltheri CE	10	Kalakad

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