



Status of *Macaca silenus* in the Kudremukh Forest Complex, Karnataka, India

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Abstract We assessed the population status of endangered lion-tailed macaques (*Macaca silenus*) in the rain forests of Kudremukh Forest complex (Kudremukh National Park, Someshwara Wildlife Sanctuary and Mookambika Wildlife Sanctuary), Western Ghats, Karnataka in January 2007. We performed a census of 20 groups in Kudremukh NP, 4 groups in Someshwara WS, and 6 groups in Mookambika WS. We estimated the population size as *ca.* 451 individuals in the 3 parks. The forests of Kudremukh NP and Someshwara WS are continuous, and the present finding of 24 groups in a single continuous forest confirms the existence of another significant population of lion-tailed macaques.

Keywords Kudremukh National Park · lion-tailed macaque · Mookambika Wildlife Sanctuary · Someshwara Wildlife Sanctuary · Western Ghats

Introduction

The rain forests of the Western Ghats are extremely rich in arboreal fauna, due to their canopy contiguity and the availability of a variety of fruit-bearing trees throughout the year. The most conspicuous of the arboreal mammals are several species of nonhuman primates including lion-tailed macaques (*Macaca silenus*), bonnet macaques (*M. radiata*), Nilgiri langurs (*Semnopithecus johnii*), and Hanuman langurs (*S. entellus*). Whereas lion-tailed macaques and Nilgiri langurs are

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endemic to the Western Ghats, the other 2 species are widespread throughout southern India.

Lion-tailed macaques range through 3 southern Indian states: Karnataka, Tamil Nadu, and Kerala. Because of its highly selective feeding habits, limited range of occupancy (*ca.* 2500 km²), delayed sexual maturity, long interbirth intervals, low population turnover, and a small remaining wild population, the species is classified as endangered (IUCN 2003). The effect of habitat loss, fragmentation, and hunting has been most drastic on lion-tailed macaques (Karanth 1992; Krishnamurthy and Kiester 1998). Though lion-tailed macaques are considered endangered, comprehensive information on surviving numbers in the fragmented rain forests is not readily available.

Ali (1985), Easa *et al.* (1997), Green and Minkowski (1977), Karanth (1992), Kumar (1995), Kurup (1978), and Molur *et al.* (2003) reported a few estimates, most of which are based on sporadic visits to different parts of lion-tailed macaque range or on short surveys in a few pockets. Green and Minkowski (1977) projected the number of surviving wild lion-tailed macaques to be *ca.* 600 individuals, whereas Kurup (1978) and Ali (1985) later estimated the entire population to consist of 825 (in 55 groups) and 915 individuals (in 61 groups), respectively. However, Joseph (1985) believed that there were 635–735 individuals in the State of Kerala alone, whereas later estimates were *ca.* 475–594 (Government of Kerala 1993) and 1216 (Easa *et al.* 1997). In Karnataka, Karanth (1985) estimated 2000–3000 lion-tailed macaques, distributed in *ca.* 200 groups, in Kerala on the basis of secondary information, but Kumar (1988) questioned the finding on the basis of his long-term study on the ecology of the species. Karanth (1992) later reported a population of *ca.* 1000–2000 individuals in Karnataka. Unfortunately, no such state-level estimates are available from Tamil Nadu. Based on the collective opinion of several experts during a population assessment exercise, Kumar (1995) estimated 3500–4000 lion-tailed macaques for the entire Western Ghats, a number later placed at *ca.* 3500 in a similar exercise (Molur *et al.* 2003). Molur *et al.* (2003) believed the individuals comprise 49 subpopulations isolated in rain forest fragments scattered over 8 locations.

Nevertheless, the surveys contribute significantly to understanding the status of each population; important information is thus available on the macaque populations of the Indra Gandhi Wildlife Sanctuary (Singh *et al.* 2002); Silent Valley National Park (Joseph and Ramachandra 1998); Sringeri forest range (Singh *et al.* 2000); Brahmagiri-Makut and Sirsi-Honnavaara areas (Kumara and Singh 2004a); the Kudremukh National Park, Someshwara Wildlife Sanctuary, and Mookambika Wildlife Sanctuary (Vasudevan *et al.* 2006); and the Talakaveri Wildlife Sanctuary, Pushpagiri-Subramanya including Pushpagiri Wildlife Sanctuary, and Sharavathi-Gersoppa including Sharavathi Valley Wildlife Sanctuary (Kumara 2007; Kumara and Sinha *in press*). However, the population status of the species as a whole continues to be elusive over most of its range. Karanth (1992), while outlining the conservation prospects for the Western Ghats, emphasized the importance of lion-tailed macaques as a flagship species of the rapidly declining rain forests of this biodiversity hotspot. We provide the findings from recent surveys on the status of lion-tailed macaques in Kudremukh Forest complex (Kudremukh National Park, Someshwara Wildlife Sanctuary, and Mookambika Wildlife Sanctuary) in the State of Karnataka.

Methods

Study Sites

Kudremukh Forest complex (Fig. 1), in the central Western Ghats, includes the Kudremukh National Park (KNP), Someshwara Wildlife Sanctuary (SWS), and

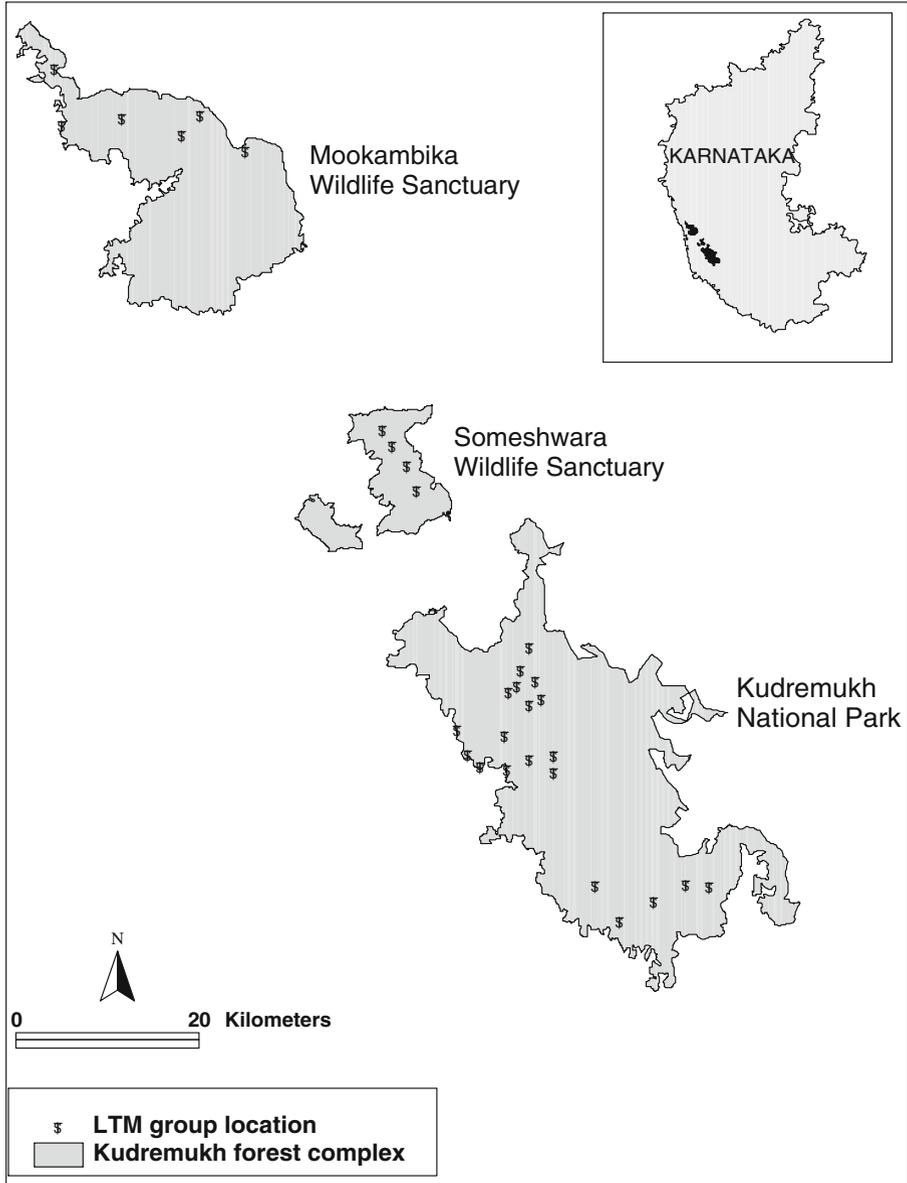


Fig. 1 Group locations of lion-tailed macaques in Kudremukh National Park, Someshwara Wildlife Sanctuary, and Mookambika Wildlife Sanctuary.

Mookambika Wildlife Sanctuary (MWS). KNP is in the District of Dakshina Kannada and Chikmagalur, whereas SWS and MWS are in the Udupi District. The physical features and the location points are in Table I. The Kudremukh Forest complex is between 13°01'–13°29'N and 75°01'–75°25'E. All 3 parks receive *ca.* 4000 mm of rainfall annually. Elevation varies from 20 to 1892 m asl, the highest point being the Kudremukh Peak (1892 m) in the south of KNP. The forest types include high-altitude grassland with shola forests, evergreen and semi-evergreen forests on slopes and plateaux of the hills, and deciduous forests toward the edge of the park. Few areas with open grasslands were converted into plantations of *Acacia auriculiformis*. KNP has 4 ranges, *viz.* Karkala, Kerekatte, Kudremukh, and Belthangdi, and SWS and MWS have 1 range each, *i.e.*, Someshwara and Kollur, respectively.

Census

Because lion-tailed macaques occur in low numbers in the wild and are highly restricted to narrow strips of rain forest in the Western Ghats, estimation of their density via line transect survey or distance sampling requires an enormous effort. Laying transect lines is often not possible over much of the range of the species. Researchers have therefore widely adopted the total count method (NRC 1981) to estimate populations of such rare and patchily distributed species (White and Edwards 2000; Whitesides *et al.* 1988).

One can achieve the total count of the groups via 2 approaches. In the first, 2 or 3 people conduct repeated walks in the same region and confirm the group location and identity. Usually researchers identify the groups based on repeated group counts and their consistency and further by recording the location of the group at each sighting, which helps to differentiate one group from the other. However, the method demands enormous amounts of time and energy. Researchers have widely adopted the total count method with little modification for lion-tailed macaque surveys in different regions including the Anaimalai Hills and Sringeri Forest range (Singh *et al.* 2000, 2002), Silent Valley National Park (Joseph and Ramachandran 1998), and the Brahmagiri-Makut and Sirsi-Honnava areas (Kumara and Singh 2004a).

The second approach is via walks by many trained people in a selected grid or the selected region and repetition of ≥ 3 walks. We adopted this sweep sampling method with modifications. Because the effort is intensive, the accuracy of the information is expected to be high. Because all the study areas harbored tropical rain forests, we

Table I Physical features of the study sites

Protected area	Latitude-longitude	Ranges	Area (km ²)	Rainfall (mm)	Elevational range (m asl)
Kudremukh NP	13°01'00"–13°29'17"N, 75°00'55"–75°25'00"E	Karkala, Kerekatte, Kudremukh, Belthangdi	600.32	4064	134–1892
Someshwara WS	13°27'54"–13°30'54"N, 74°56'09"–74°59'45"E	Someshwara	88.40	4000	75–870
Mookambika WS	13°41'24"–13°58'48"N, 74°39'58"–74°55'54"E	Kollur	247.00	4000	20–1343

assumed that neither visibility nor detectability would affect observations or bias the data significantly.

We trained 8–10 forest department personnel and research fellows along with a few local people regarding the survey methods. We selected the latter based on previous association with the forest department and also on their knowledge of lion-tailed macaque presence in different ranges of the parks. We trained them to walk in the forest to obtain the best sightings of lion-tailed macaques, while maintaining interindividual distances; to differentiate lion-tailed macaques from other primates; to count the individuals in the group (group count); and to record and to store the global positioning system (GPS) readings. After the rigorous training for 3 d, we conducted the survey in all 3 parks —KNP, SWS, and MWS— from January 8, 2007 to January 22, 2007.

We first pooled the data from the published literature mainly from Karanth (1985) and unpublished archive records, and also collected secondary data for the sightings in the last 5 yr from the local people and the department personnel, and identified the suitable available habitat. We obtained the possible area for lion-tailed macaques in each of the parks from the information, which also helped us to select specific areas for the survey. The trained persons made consecutive walks in each fixed area for 3 d via established trails or fixed directions through undisturbed forests. During each walk, 2 or 3 people walked parallel to each other 100 m apart. We conducted walks between 0600 h and 1100 h, and after sighting a macaque group, spent sufficient time to obtain a proper count of individuals and a GPS location. Because lion-tailed macaques are canopy-dwellers and we found it difficult to record their age-sex classes during the short period surveys, we did not document the demography of the groups or attempt to assess the viability of the population.

Because the home range of a group is *ca.* 5 km² (Green and Minkowski 1977; Kumar 1987; Umopathy 1998), we considered each group that we sighted in a radius of ≤ 1.5 km from the other group as the same, unless we sighted the 2 groups in a short span of time and confirmed that they were separate groups. We extracted the intergroup distance on a GIS platform via ArcView3.2. We compared our macaque troop locations with those of Karanth (1985).

We walked 3245 km during the sweep sampling in KNP, which includes 1075, 1269, 210, and 691 km in Karkala, Kerekatte, Kudremukh, and Belthangdi ranges, respectively, and walked 199 and 338 km in Someshwara and Kollur range, respectively.

Results

Table II contains the total number of lion-tailed macaques and groups we sighted. Using the conservative approach of 1.5-km radius as the home range of a lion-tailed macaque group, we estimated 20 groups in KNP, 4 groups in SWS, and 6 groups in Kollur range of MWS (Fig. 1). Thus our estimate of the population is 451 individuals in 30 groups in the entire Kudremukh Forest complex. Because the distance between SWS and MWS is *ca.* 20 km with no continuous forest, whereas the forests between KNP and SWS are continuous with reserve forests, we considered the lion-tailed macaques in KNP and SWS as 1 population and those in MWS as a separate population.

Table II Sightings and estimation of lion-tailed macaque groups in KNP, SWS, and MWS

Ranges	No. of km walked	No. of sightings	Total individuals sighted	Estimated groups	Total individuals sighted in estimated groups
Kudremukh NP					
Karkala	1075	8	72	5	68
Kerekatte	1269	10	216	8	169
Kudremukh	210	2	19	2	19
Belthangdi	691	6	98	5	90
Total	3245	26	405	20	346
Someshwara WS					
Someshwara	199	11	59	4	32
Mookambika WS					
Kollur	338	11	110	6	73
Total	3782	48	574	30	451

Though we could not collect the data on elevation of all the sightings of lion-tailed macaques, we obtained it for 30 of them. The number of groups in different elevational ranges are in Fig. 2. Though the groups occur from a minimum of 124 m asl to the maximum of 1400 m asl, they distribute differently at various elevations ($\chi^2=24.67$; $df=2$; $p<.01$); however, 83.3% of the sightings were between 300 m asl and 900 m asl.

The number of groups estimated in the current study is only 56.6% of the groups and 63.3% of the individuals Karanth (1985) reported in the Kudremukh complex (Table III). Except in Kerekatte and Someshwara, in all other ranges the number of estimated groups were 30–65% less than the number of groups Karanth (1985) reported.

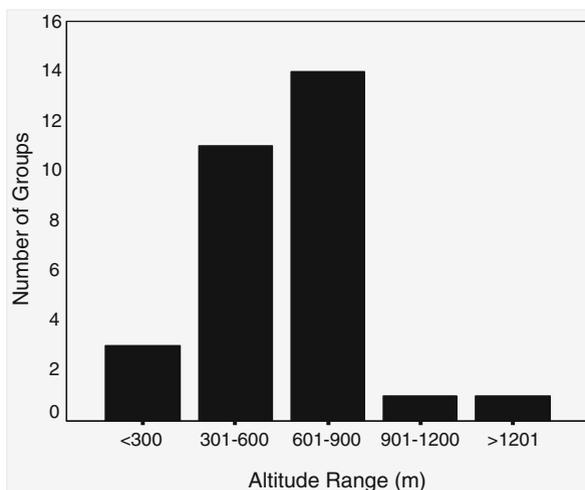
**Fig. 2** Number of lion-tailed macaque groups at different elevations in the Kudremukh Forest complex ($n=30$).

Table III Comparison of our findings with those of Karanth (1985) on the status of lion-tailed macaques in the Kudremukh forest complex

Ranges	Karanth (1985)		Current census	
	No. of groups	No. of individuals	No. of groups	No. of individuals
Kudremukh NP				
Karkala	16	211	5 (31.3)	68 (32.2)
Kerekatte	8	110	8 (100.0)	169 (153.6)
Kudremukh	5	76	2 (40.0)	19 (25.0)
Belthangdi	11	171	5 (45.5)	90 (52.6)
Total	40	568	20 (50.0)	351 (61.8)
Someshwara WS				
Someshwara	3	51	4 (133.3)	32 (62.7)
Mookambika WS				
Kollur	10	94	6 (60.0)	73 (77.7)
Total	53	713	30 (56.6)	451 (63.3)

Values in the parentheses are percentage of the current estimation versus the ones of Karanth (1985).

Discussion

In the distributional range of lion-tailed macaques in Karnataka, there are 7 protected areas including Brahmagiri Wildlife Sanctuary, Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary, Kudremukh National Park, Someshwara Wildlife Sanctuary, Mookambika Wildlife Sanctuary, and Sharavathi Valley Wildlife Sanctuary. Among all the protected areas, the Kudremukh Forest complex is the largest area and is also expected to have a large number of lion-tailed macaque groups. Karanth (1985) had considered the minimum area [5 km² based on Green and Minkowski (1977)] required by an average group of macaques, and after an extensive questionnaire survey, reported the existence of 123 groups there. Though we believe this could have been an underestimate or overestimate of the actual number of groups in some of the areas, the locations for the occurrence of lion-tailed macaques were accurate. Kumara and Sinha (*in press*) observed drastic declines, sometimes leading to the loss of 65% of the existing groups in Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary, and Sharavathi Valley Wildlife Sanctuary. The status of lion-tailed macaques appears to be similarly threatened in other Protected Areas of the state. For example, Kumara and Singh (2004a), reported only a single group in Brahmagiri-Makut; thus there have been >90% declines in the population since Karanth's survey in 1985. Conversely, Karanth (1985) reported only 6 groups in Sirsi-Honnava, whereas Kumara and Singh (2004a) reported 32 groups there. Karanth (1985) reported 9 groups in the Kerekatte Forest range (earlier known as Sringeri) in the Kudremukh National Park and Singh *et al.* (2000) confirmed the same number of groups during a survey in 1998.

During a survey between 2005 and 2006, Vasudevan *et al.* (2006) sighted only 7 groups and reported evidence for 3 other groups in the Kudremukh National Park, Someshwara Wildlife Sanctuary, and Mookambika Wildlife Sanctuary. However, we found problems with the efficiency of the method Vasudevan *et al.* (2006) adopted. Further, while surveying, they left out many potential sites for lion-tailed macaques in the Kudremukh Forest complex; therefore we adopted the present method to assess the same populations. The method we adopted is more robust and suitable for species like

lion-tailed macaques. However, the number of groups and individuals we estimated is much lower than the estimate Karanth (1985) reported in the Kudremukh complex (Table III). The probable reasons for our lower estimates are: 1) The number of days walked in the selected region may not be enough to locate all the groups. 2) In the areas where the hunting pressure is high, individuals may have engaged in evasive behavior that resulted in lower detection probabilities. 3) The number of groups may have declined due to hunting. 4) Because Karanth (1985) based the reported groups on secondary information and also even considered single individuals as a group, and did not verify the occurrence of groups via ground surveys, he may have overestimated the number of groups.

The rain forest habitats of lion-tailed macaques are not contiguous and most forest complexes where they occur are fragmented. Further, the status of lion-tailed macaques is not available from many regions, e.g., large tracts of rain forest in Kalakad-Mundanthurai Tiger Reserve in southern Tamil Nadu, or restricted to severely fragmented forests, e.g., Indira Gandhi Wildlife Sanctuary in the Anaimalai Hills of Tamil Nadu (Singh *et al.* 2002) or locally extinct due to extensive hunting, e.g., Brahmagiri Wildlife Sanctuary in Karnataka (Kumara 2005; Kumara and Singh 2004a) or drastic decline in the population size due to hunting, e.g., Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary, and Sharavathi Valley Wildlife Sanctuary in Karnataka (Kumara 2007; Kumara and Sinha *in press*). It is evident from the literature that very few large populations are left in nature, including 32 groups in Sirsi-Honnava (Kumara and Singh 2004a), 24 groups in Kudremukh NP-Someshwara WS, and 14 groups in Silent Valley National Park (Joseph and Ramachandran 1998). Thus the lion-tailed macaque population in Kudremukh NP-Someshwara WS is the only sizeable population among the protected areas. However, further population assessments required outside the protected areas include reserve forests ranges of Kundapura, Shankaranarayana, Byndoor and Bhatkal, which are continuous with the MWS, and south Someshwara and Megaravalli (Agumbe), which are continuous with KNP and SWS. The ranges also have a continuous rain forest and a lion-tailed macaque population (Karanth 1985), which is continuous with the population in protected areas; therefore the population size is likely to be larger. We suggest population assessment in the ranges to determine the existing population size, with continuous monitoring with the PA complex. The population of the lion-tailed macaques in the Kudremukh Forest complex might then turn out to be the largest surviving metapopulation across its known range.

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