Technical Report

Impact of local hunting on abundance of large mammals in three protected areas of the Western Ghats, Karnataka

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Contents

Abstract

The Western Ghats mountain ranges run parallel to west coast in south India is one of the hotspot of the world biodiversity. Though many protected areas have been established along the Ghats, the base line information include occurrence of any wildlife, their status, the threats, significance of the park and required managements are not available on most of the parks. The present study undertook between January 2006 and February 2007 with the objectives to record the occurrence of mammals, their distribution and abundance, hunting practice and its impact on large mammals in Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary and Sharavathi Valley Wildlife Sanctuary in the state of Karnataka, India. A total of 24 species were sighted and 31 species were confirmed during the study. The rare sight records includes Malabar slender loris and brown palm civets in all the study sites, Travancore flying squirrels in PWS and SVWS, tiger in SVWS and Nilgiri marten TWS. Since all the parks are in the Western Ghats mountain system with evergreen forests, due to continuous canopy the food resource available to arboreal mammals was more than the terrestrial mammals, hence in all the study parks the relative abundance of arboreal mammals was very high than the terrestrial mammals. The present findings show the hunting is the driving force in causing uneven distribution and local extinction of the species in all the study sites. Both gun hunting and trap hunting is prevalent in all the study parks. The wide varieties of traps are used in trap hunting. The checklist of the hunting techniques used in the study parks, and its description are documented. The lion-tailed macaques are in sharp decline in all the parks due to hunting, and now no viable population exists in any of the parks. This finding highlights the importance of the recently discovered viable population of the lion-tailed macaques in the Sirsi- Honnavara, and the recommendation was made to upgrade this area as protected area. Further study requires to prepare the conservation profile and management plan to develop the reserve forests of Sirsi-Honnavara as conservation reserve for lion-tailed macaque.

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1. General Introduction, Study sites and Methods

Virtually all students of the extinction process agree that biological diversity is in the midst of its sixth great crisis, this time precipitated entirely by man.

Edward O. Wilson

Introduction

The Western Ghats

The Western Ghats hill ranges harbour many endemic and threatened species hence it has been recognized as one of the biodiversity hotspots of the world. The Western Ghats stand eighth position among the biodiversity hotspots (Myers et al., 2000). According to one estimation Western Ghats hills spans c. 78,387 km^2 at parallel to the west coast of south India passing through six states (Johnsingh, 1986) and 20% of it falls within protected areas (Fig. 1.1). The state Karnataka alone has nine protected areas with c. 2,841 km^2 in the range of rain forests of Western Ghats that includes two national parks i.e. Kudremukh National Park and Anshi National Park, and seven sanctuaries i.e. Brahmagiri Wildlife Sanctuary, Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary, Someshwara Wildlife Sanctuary, Mookambika Wildlife Sanctuary, Sharavathi Valley Wildlife Sanctuary and Dandeli Wildlife Sanctuary. The rare mammals of the Western Ghats include lion-tailed macaque *Macaca silenus*, Nilgiri langur *Semnopithecus johnii*, Nilgiri *tahr Hemitragus hylocrius*, Nilgiri marten *Martes gwatkinsii*, brown mongoose *Herpestes fuscus*, brown palm civet *Paradoxurus jerdoni*, Malabar civet *Viverricula civettina* and Travancore flying squirrel *Petinomys fuscocapillus*.

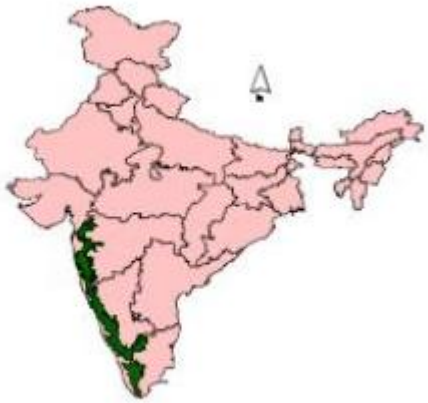

Fig 1.1 Map showing the Western Ghats in India

A century ago the hill ranges of the Western Ghats attracted thousands of people from the plains due to three major reasons commercial plantations, water and timber (Chandran, 1997; Congreve, 1938). Earlier days it was thought that the rainforest trees were very soft and does not have any timber value in the market, but the climate is suitable for many commercial crops like coffee and tea, thus the trees were cut and such commercial crops were introduced, further this also created a mass employment. Over the period conversion of the forest in to commercial plantation increased. During the middle of the 19th century even the soft wood of the rain forest also got attention by matchwood industries, and large forest patches were leased out for the timber extraction for those industries. This has resulted in indiscriminate exploitation of the rainforest trees to supply for such industries. Further the high rainfall in the hills brought many hydroelectric power projects to the hills. Collectively all these commercial and developmental activities brought thousands of people to these hills, and gradually most of them settled in the hills, further the dependency on the forests by these people also increased. Hence the Western Ghats hill ranges have the highest human population density of all the hotspots in the world (Cincotta et al., 2000). As a consequence of this the loss of virgin forest and fragmentation was accelerated in later part of the 19th century and resulted in the large extant of the rainforest into fragmented and remain tiny thread in most of the region. The increase in the human density, access to the arms and forest increased the indiscriminate hunting in the entire Western Ghats hill ranges.

Hunting

Although many parks have been notified for their protection, they continue to face serious threats; local hunting being the one most important. Hunting has existed in the Western Ghats since historical times (Chandran, 1997), accelerated in the 19th century and it continues to persist (Madhusudan and Karanth, 2002; Kumara and Singh, 2004a) undermining all conservation efforts. Quantification of loss of wildlife due to local hunting is not available for any course of the time. Local hunting is carried by a large number of people, and it targets a wide variety of species. The biological impacts of hunting are poorly understood (Madhusudan and Karanth, 2002). Also found that due to various reasons, no information was available with the forest officials on occurrence and status of any mammals in most of the protected areas of the Western Ghats, and they are unaware of the pressure created by local hunting.

I have initiated to document such baseline data on occurrence, status and distribution of mammals in several forest ranges of Western Ghats. (Kumara, 2005; Kumara and Singh 2004ab; Kumara et al, 2006; Kumara and Singh, in press) including

Brahmagiri Wildlife Sanctuary. However I paid more attention to outside the protected area during my earlier studies, later I realized even lacking in scientific documentation in most of the protected areas of the Western Ghats.

However the major surveys on mammals in Western Ghats include: mammal survey in Karnataka (Prasad et al., 1978), elephants (Nair and Gadgil, 1978; Nath and Sukumar, 1998), lion-tailed macaques in Karnataka (Karanth, 1985; Singh et al., 2000), small carnivores in Kalkad-Mundanthurai Tiger Reserve (Mudappa, 2002), mammals in Indira Gandhi Wildlife Sanctuary (Kumar et al., 2000; Kumar et al., 1995; Mishra and Johnsingh, 1998; Singh et al., 1997,2002), Nilgiri langur and lion-tailed macaques in Tamil Nadu (Hohmann and Sunderraj, 1990), primates in Silent Valley National Park (Ramachandran and Joseph, 2001) and brown palm civets in Western Ghats (Rajamani et al., 2002). Despite the large number of studies in the Western Ghats, most of the protected areas remain unexplored for mammals, since the studies were short period and one time study; further focused on single species at one or few locations. Hence the comparative data is lacking from most of the region of the Western Ghats. With this background the present effort was made to establish baseline data on occurrence and conservation status of mammals and also hunting practice and related consequence on them in Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary and Sharavathi Valley Wildlife Sanctuary.

Project Initiation and People Participation

The study was initiated during the January2006 with the financial support from Rufford Foundation, UK and with the official approve by the Karnataka forest department. Forest department and the parks mangers supported the fieldwork by providing the logistic and personnel support. The department personnel were also involved in the field surveys. And during the different phase of the fieldwork, fifteen people from local NGO were trained to help in the field work, while doing this the message on different aspects of conservation of wildlife was conveyed. The people participatory programs are more effective than the classroom workshops in making the people to understand the situations, hence during the fieldwork local volunteers and the department personnel were used. Since researchers alone cannot do the active conservation, this type of training and revealing the data to local people help in future conservation activity and to develop awareness among local people.

Objectives of the Project

1. Assess the occurrence and status of large mammals in three parks of the Western Ghats.
2. Assess the effect of local hunting practices on large mammals in these parks

Study Sites

The details of the different study sites are provided in Table 1.1 Talakaveri Wildlife Sanctuary (TWS) and Pushpagiri Wildlife Sanctuary (PWS) are located in the southern parts of the Western Ghats in Karnataka state, whereas the Sharavathi Valley Wildlife Sanctuary (SVWS) is located at the central part of the Western Ghats (Fig. 1.2).

Table 1.1 General features of the three protected areas (from Lal et al., 1994)

Protected Area	Lat-Long	Area	Altitude Min-max	Temperature Min-max	Mean Annual Rainfall
Talakaveri Wildlife Sanctuary (TWS)	$12^0 17'14''$-$12^0 26'38''$N, $75^0 25'23''$-$75^0 33'15''$E	105 km^2	63-1659m	15^0-35^0C	2,000mm
Pushpagiri Wildlife Sanctuary (PWS)	$12^0 29'16''$-$12^0 42'02''$N, $75^0 37'59''$-$75^0 42'37''$E	102 km^2	60-1712m	10^0-38^0C	2,000mm
Wildlife Sanctuary (SVWS)	$13^0 54'10''$-$14^0 16'31''$N, $74^0 38'32''$-$74^0 59'45''$E	431 km^2	300-1102m	8^0-33^0C	3,700mm

The forests of TWS and PWS lie between $12^0 17'14''$-$12^0 26'38''$N, $75^0 25'23''$-$75^0 33'15''$E, and $12^0 29'16''$-$12^0 42'02''$N, $75^0 37'59''$-$75^0 42'37''$E respectively in Kodagu district of the state. These two parks have been established during 1987, and the notified area of the TWS is 105 km^2 and PWS is 102 km^2.The forests are broadly classified as Medium Altitude Forest Type with Mesua ferrea-Palaquium ellipticum type of vegetation (Pascal, 1988). The TWS has a single administrative forest range, Bhagamandala. On the west of these hills lie the Mundrot Reserve Forest (RF) range and agricultural villages of the state of Kerala, while on the east are coffee (*coffea arabica/robusta*) and cardamom (*Elettaria cardamom*) plantations. The sanctuaries are bound on the north and south by wet evergreen forests and grassy mountain slopes of different reserve forest ranges. There are eleven enclosures in these two sanctuaries, including cardamom or coffee plantations, with a population of a few thousands of people. The PWS also has a single administrative forest range, Sampaja, and is also surrounded by reserve forests – Subramanya RF on the west, Sakaleshpur RF and Yesalur RF on the north and cardamom and coffee plantations and villages on the east. There are a few enclosures of cardamom/coffee plantations in this sanctuary as well.

The forests of SVWS lie between 13$_0$54′10″-14$_0$16′31″ N, 74$_0$38′32″-74$_0$59′45″ E in the district of Shimoga. This has been established during 1972 and the notified area of the sanctuary is c.431 km^2. The area receive mean annual rainfall of 3700mm and the forests of the sanctuary are broadly classified as Low Altitude Rainforest Type with Persea macrantha-Diospyros spp- Holigarna spp type of vegetation (Pascal, 1988). A number of villages (>120, with >20,000 people) and large areas under cultivation of commercial crops, including areca nut (*Areca catechu*) and paddy (*Oryza sativa*), are scattered inside the sanctuary.

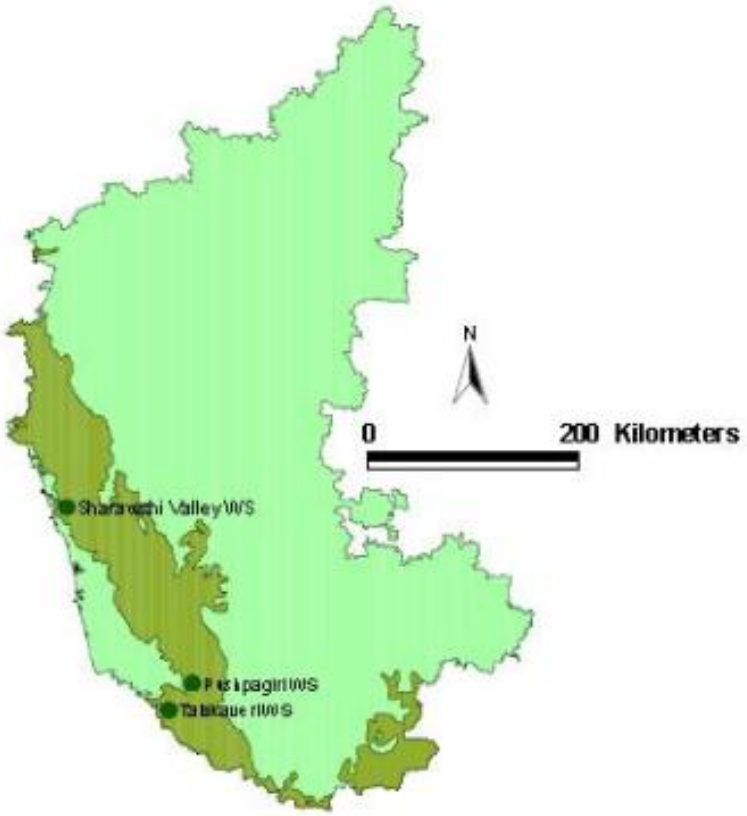

Fig. 1.2 Karnataka map showing the study sites

Table 1.2 The mammals expected to occur in Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary and Sharavathi Valley Wildlife Sanctuary based on nominal distribution of the species (Except the species belongs to order Chiroptera and small rodents)

Order	Family	Scientific name	Common name
Primates	Loridae	*Loris lydekkerianus*	Slender Loris
	Cercopithecidae	*Macaca radiata*	Bonnet Macaque
		Macaca silenus	Lion-tailed macaque
		Semnopithecus entellus	Hanuman Langur
Carnivora	Felidae	*Felis chaus*	Jungle Cat
		Prionailurus bengalensis	Leopard Cat
		Panthera pardus	Leopard
		Panthera tigris	Tiger
	Canidae	*Canis aureus*	Golden Jackal
		Canis alpinus	Indian Wild Dog
	Viverridae	*Viverra civettina*	Malabar Civet
		Viverricula indica	Small Indian Civet
		Paradoxurus hermaphroditus	Asian Palm Civet
		Paradoxurus jerdoni	Brown Palm Civet
	Herpestidae	*Herpestes brachyurus*	Brown Mongoose
		Herpestes edwardsii	Grey Mongoose
		Herpestes vitticollis	Stripe-necked Mongoose
	Mustelidae	*Amblonyx cinereus*	Oriental small-clawed Otter
		Lutra lutra	Common Otter
		Lutrogale perspicillata	Smooth-coated Otter
		Martes gwatkinsi	Nilgiri Marten
	Ursidae	*Melursus ursinus*	Sloth Bear
	Hyaenidae	*Hyaena hyaena*	Striped Hyena
Rodentia	Scuridae	*Ratufa indica*	Indian Giant Squirrel
		Petaurista philippensis	Giant Flying Squirrel
		Petinomys fuscocapillus Travancore	Flying Squirrel
		Hystricidae Hystrix indica	Indian Porcupine
Pholidota	Manidae	*Manis crassicaudata*	Indian Pangolin
Lagomorpha	Leporidae	*Lepus nigricollis*	Indian Hare
Proboscidea	Elephantidae	*Elephas maximus*	Asian Elephant
Artiodactyla	Suidae	*Sus scrofa*	Wild Pig
	Tragulidae	*Moschiola meminna*	Indian Chevrotain
	Cervidae	*Axis axis*	Spotted Deer
		Cervus unicolor	Sambar
		Muntiacus muntjak	Indian Muntjac
	Bovidae	*Bos gaurus*	Gaur

Mammal Species

Considering the nominal distribution based on unpublished archive records, literature and Prater (1986), a total of 36 species of large mammals were expected including slender loris and Travancore flying squirrel in the study sites (Table 1.2), Among them 13 species are listed in globally threatened species list i.e. one species is critically endangered, three species are endangered, eight species are vulnerable and one species is listed as data deficient. However even the nominal distribution of some species were not clear e. g. distribution or sight records of striped hyena from Western Ghats is not available. Further although three species of otters exists in the state, but species level possible distribution is not available. The local people were also unable to distinguish the otter in two different species however they provided the information only on occurrence of the otter as such. In the report also no attempt was made to distinguish them as separate species.

Methods

Since the terrain of the study sites are undulating with many perennial streams and narrow slopes, which did not allow making a straight line and walk to assess the density of the animals. In recent years the forest department officially made a few lines, which are roughly straight and had enough distance covering all the possible terrain and habitat types. However the lines were not enough straight to adapt the distance method to estimate the density, hence no attempt was made to estimate the absolute density. On the other hand the same lines were used to assess the mammal abundance. The lines were walked between 06.00am to 11.30am and 03.00pm to06.30pm, and the same lines were repeated a minimum of three times and up to five times. The total effort put in the study areas are provided in the Table 1.3. The results from this are presented with standard error of the mean, and they are compared using appropriate statistical tests like one way ANOVA and two sample z–test. Some of the same lines and the existing trails were used for the night walks, however the walks on the same lines could not be repeated due to official restrictions and problem of access to remote areas of the forests, hence the results are provided as number animal per kilometre without the standard deviation or standard error of mean. However since the large effort, the results from this method provide the comparative status of the nocturnal animals. And since the same researchers walked in all the study sites, and further the habitat type, canopy heights and vegetation types are similar between the sites, and hence we expected the equal rate of error in the sightings between the sites, thus the results are compared between the sites.

Since lion-tailed macaques live in low density, the regular line transect method did not give any result, hence the sweep sampling or modified total count method was adopted to know how many groups are in the given area. The details of the method adopted to assess of lion-tailed macaques and the findings are provided in Appendix 1. The adjacent forest ranges of PWS and SVWS were also surveyed for the lion-tailed macaque.

Many local hunters and villagers were informally interviewed to understand their life style, hunting practice, agriculture, their interaction with the forest etc. Many attempts were made to stay in the local village and understand them and also used many such active and ex-hunters as field assistants. This gave an ample of opportunity to interact with them and understand the different faces of the local hunting. The attempt was made to record the information while interacting with them on structured questioner, but many of them have resisted in giving the response to our questions. Hence the questioner was not directly used to enter the information, but later the information was organized properly according to the subjects and questions. Hence the most of the information on hunting is provided as descriptive in this report.

Table 1.3 Sampling efforts in Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary and Sharavathi Valley Wildlife Sanctuary

Protected Area	No. trails	Total day walk (km)	Total sweep sampling walk (km)	Total night walk (km)
Talakaveri Wildlife Sanctuary (TWS)	15	302.2	95.2	77
Pushpagiri Wildlife Sanctuary (PWS)	13	184.0	82.8	57
Reserve forest around Pushpagiri Wildlife Sanctuary	-	-	103.2	100
Sharavathi Valley Wildlife Sanctuary (SVWS)	18	186.8	125.0	69
Total	46	673.0	406.2	303

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2. Mammals of Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary and Sharavathi Valley Wildlife Sanctuary

Results

Occurrence of mammals

During the study occurrence of 31 species of mammals was confirmed and 24 species were sighted, however this differed between the parks (Table 2.1). In TWS 26 species were confirmed and 15 species were sighted, in PWS 23 species were confirmed and 18 species were sighted, and 27 species were confirmed and 20species were sighted in SVWS.

Except the lion-tailed macaque in PWS, all the three parks had four species of primates which includes slender loris *Loris lydekkerianus,* Hanuman langur *Semnopithecus entellus,* lion-tailed macaque *Macaca silenus* and bonnet macaque *Macaca radiata*. Although three species of large carnivores i.e. tiger *Panthera tigris*, leopard *Panthera pardus*, dholes *Canis alpinus* exists in all the parks, only tiger was sighted twice in SVWS. Compare to large carnivore species more number of small carnivore species were sighted in all the parks, and Nilgiri martin *Martes gwatkinsii* was sighted in TWS. Although local ex-hunters were able to differentiate the Malabar civet *Viverra civettina* from small Indian civet *Viverricula indica* at western foot hills of the PWS and SVWS there were no recent records available on the existence of the species hence the occurrence of the Malabar civet could not be confirmed in any of the parks. No evidence was available on existence of the sloth bear *Melursus ursinus* in TWS and PWS, and further no reports were available on sighting of the bear in last four decades. However one bear was sighted and recovered secondary signs like droppings in the entire park and it was evident that the occurrence of good population in SVWS. Elephants *Elephas maximus* were sighted in TWS and PWS, but no evidence for the occurrence was available in SVWS. Gaur *Bos gaurus*, Sambar *Cervus unicolor*, Indian muntjac *Muntiacus muntjak* and Indian spotted chevrotain *Moschiola meminna* were the more common terrestrial herbivore species in all the parks. Spotted deer *Axis axis* was found only in SVWS, and no reports were available on past existence in other two parks in the last four decades. Indian giant squirrel *Ratufa indica* and giant flying squirrel *Petaurista philippensis* were sighted in all the parks, where Travancore flying squirrel *Petinomys fuscocapillus* was sighted only in PWS and SVWS. All other species have been found in all the parks.

Distribution

Though all the study sites had a variation in altitude, rainfall and vegetation type, nevertheless many of the species occurred in the entire range of the parks, however few species have shown habitat specific and restricted distribution pattern, those species are emphasized and the distribution are provided e.g., slender loris, lion-tailed macaque, Travancore flying squirrel, sloth bear, spotted deer, brown palm civet *Paradoxurus jerdoni*, Asian palm civet *Paradoxurus hermaphroditus*.

Slender loris was sighted in different altitude gradients but found largely in medium to low canopy vegetation, wet scrub forests and highly disturbed vegetation, than the tall evergreen forests. Lion-tailed macaques were restricted to tall evergreen forests and ridge of the Ghats to western slopes in SVWS, where in TWS since the tall evergreen forests were wide at the ridge, and lion-tailed macaques were found at such locations, however they were restricted to the western slopes of the park.

Table 2.1 Occurrence of mammals in Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary and Sharavathi Valley Wildlife Sanctuary (National status as provided in Indian Wildlife Protection Act 1972 and IUCN red list as downloaded on January 2005)

Common name	Status in IUCN red list	National status	Evidences$	Occurrence of mammals*		
				TWS	PWS	SVWS
Slender Loris	VU	I	1	+	+	+
Bonnet Macaque			1	+	+	+
Lion-tailed macaque	EN	I	1	+	-	+
Hanuman Langur			1	+	+	+
Jungle Cat		II	1, 6	?	+	+
Leopard Cat		I	1, 6	+	+	+
Leopard		I	2, 5, 6	+	?	+
Tiger	EN	I	1, 2, 6	+	?	+
Golden Jackal			1,2, 6	+	+	+
Indian Wild Dog	VU	I	2, 6	+	+	+
Malabar Civet	CR	I		?	?	?
Small Indian Civet		II	6	+	?	+
Asian Palm Civet		II	1,6	+	+	+
Brown Palm Civet	VU	II	1, 2, 6	+	+	+
Brown Mongoose	DD			?	?	?
Grey Mongoose			1, 6	+	+	+
Stripe-necked Mongoose			1	+	?	?
Otter Species			6	+	+	+
Nilgiri Marten	VU	II	1,6	+	?	?
Sloth Bear	VU	I	1	-	-	+
Indian Giant Squirrel	VU		1	+	+	+
Giant Flying Squirrel			1	+	+	+
Travancore Flying Squirrel	VU		1	?	+	+
Indian Crested Porcupine			1,2, 3, 4	+	+	+
Indian Pangolin			3, 4, 6	+	+	+
Indian Hare			1	+	+	+
Asian Elephant	EN	I	1,2, 5	+	+	-
Wild Pig			1, 2, 5	+	+	+
Indian Spotted Chevrotain			1, 2	+	+	+
Spotted Deer			1	-	-	+
Sambar			1	+	+	+
Indian Muntjac			1	+	+	+
Gaur	VU	I	1, 2	+	+	+

* +: Occur (+ sighting, +secondary data); -: Absent; ?: No information

$ 1: Sighted; 2: Fecal deposit; 3: Body parts; 4: Denning/roosting site; 5: Foot prints; 6: people and other evidence

Though the sightings of Travancore flying squirrel was very few but all the sightings were at the western foothills of the Ghats or a little above in the slope up to 400m asl. The data from secondary sources also provided the same distribution pattern of the squirrel in PWS and SVWS. Sloth bears were restricted to ridge and higher elevation slopes with more rocky patches of the SVWS. Asian palm civets were commonly sighted in secondary forests, moist deciduous forests, deciduous forests, and plantations, where brown palm civets were

highly restricted to rainforests of all the altitudes. Spotted deer's have been found only in eastern plains from the ridge of the Ghats where the forests are open secondary forests.

Relative abundance of mammals in TWS

Table 2.2 Relative abundance of mammals in Talakaveri Wildlife Sanctuary during the day walk

Species	No. of sightings	Total no. of animals sighted	No. animals seen/km (SE)
Arboreal mammals			
Hanuman langur	3	9	0.02 (±0.015)
Bonnet macaque	23	111	0.35 (±0.087)
Lion-tailed macaque	2	5	0.01 (±0.013)
Indian giant squirrel	68	120	0.37 (±0.058)
Total	96	245	0.78 (±0.110)
Terrestrial mammals			
Elephant	1	9	0.02 (±0.015)
Sambar	4	4	0.01 (±0.006)
Indian muntjac	2	2	0.006 (±0.005)
Wild pig	1	1	0.004 (±0.004)
Stripe-necked mongoose	2	3	0.01 (±0.008)
Total	10	19	0.03 (±0.012)

Through the day walk nine species were sighted in 106 encounters, during this a total of 264 animals were sighted (Table 2.2). The nine species includes four arboreal mammals and five terrestrial mammals, though the relative abundance of arboreal mammals (0.78 ±0.110) was more than ($z= 6.6678$, $p< .000$) the relative abundance of terrestrial mammals (0.03 ±0.012), further the relative abundance differed ($F_{3,232} = 13.972$, $p< .000$) among the arboreal mammals i.e. the relative abundance of bonnet macaque (0.35 ±0.087) and Indian giant squirrel (0.37 ±0.058) was more than the Hanuman langur (0.02 ±0.015) and Lion-tailed macaque (0.01 ±0.013). The relative abundance among the terrestrial mammals remained very low.

A total of 43 animals belongs to six species were encountered during the night walks (Table 2.3), among them three species were small carnivores, two species were arboreal mammals and one species was other mammals (chevrotain). The relative abundance of arboreal mammals (0.44) was higher than the small carnivores (0.09) and other mammals (0.03). Among arboreal mammals the relative abundance of slender loris (0.21) and giant flying squirrel (0.23) remained more or less same.

Table 2.3 Relative abundance of mammals in Talakaveri Wildlife Sanctuary during night walks

Species	No. animals seen	No. animals seen/km
Small carnivores		
Leopard cat	2	0.03
Asian palm civet	4	0.05
Nilgiri marten	1	0.01
Total	7	0.09
Arboreal mammals		
Slender loris	16	0.21
Giant flying squirrel	18	0.23
Total	34	0.44
Other mammals		
Indian spotted chevrotain	2	0.03
Total	2	0.03
Grand Total	43	0.56

Relative abundance of mammals in PWS

A total of 82 animals belongs to seven species were sighted in 29 encounters during the day walk (Table 2.4). The seven species includes three species of arboreal mammals and four species of terrestrial mammals, however the relative abundance of arboreal mammals (0.31 $\pm$0.099) was more than ($z = 2.6467$, $p < .004$) the relative abundance of terrestrial mammals (0.04 $\pm$0.015), and further the relative abundance among the terrestrial mammals were also remained low. Among the arboreal mammals the relative abundance of bonnet macaque (0.19 $\pm$0.087) was more than the Indian giant squirrel (0.08 □}0.021) and Hanuman langur (0.02 $\pm$0.024).

Table 2.4 Relative abundance of mammals in the Pushpagiri Wildlife Sanctuary during the day walk

Species	No. of sightings	Total no. of animals sighted	No. animals seen/km (SE)
Arboreal mammals			
Hanuman langur	1	3	0.02 ($\pm$0.024)
Bonnet macaque	6	49	0.19 ($\pm$0.087)
Indian giant squirrel	15	17	0.08 ($\pm$0.021)
Total	22	69	0.31 ($\pm$0.99)
Terrestrial mammals			
Elephant	2	8	0.04 ($\pm$0.011)
Sambar	2	2	0.01 ($\pm$0.007)
Indian muntjac	2	2	0.01 ($\pm$0.011)
Indian grey mongoose	1	1	0.004 ($\pm$0.004)
Total	7	13	0.04 ($\pm$0.015)

A total of 21 animals belongs to eight species were sighted during the night walks (Table 2.5), which provide the overall encounter rate of 0.65 animals per kilometre. The eight species includes four species of small carnivores and three species of arboreal mammals and one other mammal (chevrotain). The relative abundance of arboreal mammals (0.46) was more than the small carnivores (0.16) and other mammals (0.04), further among the arboreal mammals the highest relative abundance was slender loris (0.28) and which is followed by giant flying squirrel (0.14) and Travancore flying squirrel (0.04).

Table 2.5 Relative abundance of mammals in Pushpagiri Wildlife Sanctuary during night walks

Species	No. animals seen	No. animals seen/km
Small carnivores		
Jungle cat	1	0.02
Leopard cat	1	0.02
Asian palm civet	4	0.07
Brown palm civet	3	0.05
Total	9	0.16
Arboreal mammals		
Slender loris	16	0.28
Giant flying squirrel	8	0.14
Travancore flying squirrel	2	0.04
Total	26	0.46
Other mammals		
Indian spotted chevrotain	2	0.04
Total	2	0.04
Grand Total	47	0.82

Relative abundance of mammals in SVWS

A total of 1,332 animals belongs to ten species were sighted in 550 encounters during the day walk (Table 2.6). The ten species includes four arboreal mammals and six terrestrial mammals, and the relative abundance of arboreal mammals (7.19 $\pm$0.471) was more than ($z = 14.6389$, $p < .000$) the terrestrial mammals (0.24 $\pm$0.056). Among terrestrial mammals the relative abundance of Indian muntjac (0.11 $\pm$0.03) was more than the others. The relative abundance was also differed among the arboreal mammals ($F_{3,224} = 67.503$, $p < .000$) where the highest relative abundance was Hanuman langur (4.52 $\pm$0.38) and is followed by Indian giant squirrel (1.54 $\pm$0.117).

A total of 50 animals belongs to eight species including two unidentified small carnivores were sighted during the night walk (Table 2.7), which provides an overall relative abundance of 0.87 animals per kilometre. However the relative abundance of arboreal mammals (0.59) was higher than the small carnivores (0.22) and the other mammals include chevrotain and porcupine *Hystrix indica* (0.06), among arboreal mammals the slender loris (0.35) was more than the giant flying squirrel (0.23) and Travancore flying squirrel (0.01).

Table 2.6 Relative abundance of mammals in the Sharavathi Valley Wildlife Sanctuary during the day walk

Species	No. of sightings	Total no. of animals sighted	No. animals seen/km (SE)
Arboreal mammals			
Hanuman langur	243	835	4.52 (±0.380)
Bonnet macaque	31	147	0.91 (±0.241)
Lion-tailed macaque	7	23	0.12 (±0.057)
Indian giant squirrel	238	287	1.54 (±0.117)
Total	519	1292	7.19 (±0.471)
Terrestrial mammals			
Gaur	1	1	0.004 (±0.004)
Sambar	9	13	0.05 (±0.020)
Spotted deer	4	6	0.05 (±0.026)
Indian muntjac	15	17	0.11 (±0.030)
Wild pig	1	2	0.01 (±0.012)
Indian grey mongoose	1	1	0.005 (±0.005)
Total			

Table 2.7 Relative abundance of mammals in Sharavathi Valley Wildlife Sanctuary during night walks

Species	No. animals seen	No. animals seen/km
Small carnivores		
Leopard cat	5	0.07
Asian palm civet	3	0.04
Brown palm civet	5	0.07
Unidentified small carnivores	2	0.03
Total	15	0.22
Arboreal mammals		
Slender loris	24	0.35
Giant flying squirrel	16	0.23
Travancore flying squirrel	1	0.01
Total	41	0.59
Other mammals		
Indian spotted chevrotain	3	0.04
Indian crested porcupine	1	0.01
Total	4	0.06
Grand Total	60	0.87

Discussion

The present study documents the existence of large proportion of a species in the protected areas, and also discuss the distribution and relative abundance of them in the parks. Since mammals with various habits are surveyed at same time, though little, nevertheless the information on some species was able to gather. In Western Ghats of Karnataka, except the survey on lion-tailed macaques (Karanth, 1985; Kumara and Singh, 2004b) and brown palm civet (Rajamani et al., 2002) there are no other status report on any other mammals available. Recently, Karanth et al. (2001) documented the occurrence of large mammals in Kudremukh National Park, in Karnataka. Hence the current sight records of several species are a significant contribution in understanding of their present range of distribution, habitat they occur and the required conservation value. I discuss the species accounts which shows a specific pattern or rare sight records in this section.

Though small carnivores are difficult animals to survey due to their small size and elusive habits, a total of eight species were sighted include jungle cat *Felis chaus*, leopard cat *Prionailurus bengalensis*, small Indian civet, brown palm civet, Asian palm civet, stripe-necked mongoose *Herpestes vitticollis*, Indian gray mongoose *Herpestes edwardsii* and Nilgiri marten. Among them brown palm civet and Nilgiri marten are endemic species to the Western Ghats. In Karnataka, though the local people had the occasional sightings of the Nilgiri marten, there were no authentic sight records in the last two decades therefore the present sighting in TWS confirms the existence in some regions of the Ghats.

Nair and Gadgil (1975) reported the elephants during 1960s in SVWS. Over the period the elephants have disappeared from the park. Similarly from the north of the sanctuary i.e. between Sharavathi and Aghanashini rivers also the elephants have disappeared in recent years (Kumara and Singh 2005b). The probable reasons could be developmental activities like dam, road and increased number of human enclaves, made them completely isolation from the main population, and probably resulted in biased sex ratios over a period and in turn on breeding efficiency. Further, gradual elimination of the individuals drove into local extinction. Due to this local extinction created a long gap between the northern population in Dandeli and Yellapura with the southern population in Kalasa. However, TWS and PWS have elephant's population, since the population is continuous between TWS, PWS and the potential site for the elephants 'Rajiv Gandhi National Park', and the regular movement of the elephants is very frequent between these three parks. Bears have a high capability to adapt for various habitats from rain forest of the Western Ghats to the high temperature, dry rocky outcrops in the plains, even interviews with the old people, active and ex-hunters, yet no evidence could be obtained for the absence or no sightings of bears in TWS and PWS.

Travancore flying squirrel is one of the small flying squirrel, expected to found in some parts of the Western Ghats. The species was rediscovered from Kerala during 1960s by Kurup (1989) after 70 years of gap from previous sighting, and again there was no sight record for another couple of decades. Ashraf et al. (1993) reported the species during 1990s, and Umapathy (1998) reported the species from Indira Gandhi Wildlife Sanctuary in Tamil Nadu. Karanth (1986) also mentions presence of the squirrel, but there were no sight records available. Hence there were no sight records of the species from the state until the recent sightings from Makut Reserve forests (Kumara and Singh, 2005a), and the present sightings from PWS and SVWS are the added records on the species in the state. Further all the sightings including earlier ones (Kumara and Singh, in press), are all from western foot hills and slopes of the Ghats, which is a high rain fall and humid area. Though the complete distribution pattern of the species could not be established due to a small sampling effort and few sightings, nevertheless these sight records provide the evidence for the habitat selection by the species and also for the future studies.

Slender loris in south India has two sub species, one Loris *lydekkerianus lydekkerianus* is a drier form and another one is Loris *lydekkerianus malabaricus* is a wet form. Loris *lydekkerianus malabaricus* is also called Malabar slender loris, Malabar slender loris found in rain forest of the Western Ghats (Kumara et al., 2006). During the present study whenever the lorises were in close proximity, the subspecies of loris was confirmed at each site. The lorises sighted in TWS, PWS and SVWS were Malabar slender loris. Though it appears lorises occupies various altitudes and forest types, they were found in less number in tall trees, and further throughout the range they were thinly populated, probably this is due to continuous habitat and trees with large girth.

The higher relative abundance of the arboreal mammals than the terrestrial mammals can be attributed to the differences in the resource availability and terrain. Since the major forests of the Western Ghats are tall tree evergreen forests, and due to continuous canopy in the forest the light penetration is comparatively less than the deciduous forests, or open scrub forests, which results in more litter than the grass (Pascal, 1988). Only at crest of the hill system has a grassy meadow, thus the amount of grass availability to large number of herbivores may be poor, and this could be the reason for the number of herbivore species and their relative abundance was much lesser than the arboreal mammals. On the other hand high abundance of arboreal mammals was expected, due to availability of the resource throughout the year, however, except the loris all other animals varied in abundance, the probable reason could be the human intervention. Madhusudan and Karanth (2002) have shown the hunting as the main threat for the survival of the species in the forests of Western Ghats, and also mentioned the hunting as a prime driving force causing the variation in animal abundance in the country, Kumara and Singh (2004) provide enough evidence for the hunting driven sharp decline of several species in the forests of Western Ghats. Hence, among all the factors the hunting is a principal force for the high variation in abundance of mammals in a short course of time between the sites (see Chapter 3), and also driven some of the animals in to local extinction (Appendix 1).

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3. People and Hunting practice in Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary and Sharavathi Valley Wildlife Sanctuary

Observations

People and pressure

Talakaveri Wildlife Sanctuary and Pushpagiri Wildlife Sanctuary: TWS and PWS are situated in 'Kodagu' district in the state of Karnataka. Most people in this district mainly belong to a few ethnic communities i.e. Kodava, Arebhashe gowda, Bhants, Kudiya, Phaniya and Nayaka. Large number of Christians, who migrated from Malabar part of the Kerala and are called as Malabar Christians, apart from Muslims who hailed from Kerala became permanent settler. Kodagu district is known for production of popular commercial crops such as coffee, pepper, and cardamom. Prior to the notification of TWS, these crops were grown in estates and situated as an enclave of plantations in the amidst of the TWS sanctuary in the Western Ghats part of India, , However many of these estates were abandoned during 2000 Currently, the TWS includes few cardamom and pepper plantations. On the other hand, PWS has few human encroachments such as settlements and agriculture lands in the fringes of sanctuary. There are big plantations crops exist. However, Due to timber extraction, estate work, honey culture and MFP collection both the sanctuaries had very high movement of the people for long period of time in during last century, further though the surrounding areas of the sanctuaries had much lesser livestock holding, there was a little grazing pressure on the protected areas.

Sharavathi Valley Wildlife Sanctuary: On the other hand the SVWS has high density of people with 10,305 people living in 2,192 houses in 26 villages in the protected area the human density in the SVWS is 34 people km2. The main ethnic communities in the sanctuary were Nayaka, Brahmin, Jain, Marathi, Gondaru, Asalaru, Bovi, Ediga and Malabar Christians. The main occupation of the people in the region was agriculture, in small holdings of lands, and they also work as labourers in the other agriculture lands on daily wages. The major crops in the region are paddy, areca nuts and sugar cane. Prior to 1980, the sanctuary had very few Malabar Christians, due to the inception of legalizing the encroached lands between 1980 and 1985, many of them settled inside the sanctuary, currently there are 98 families with 455 people residing in the sanctuary. The sanctuary also has 123 families with about 693 Marathi people, these people also migrant to the region during early 19th century. When these Malabar Christians started agriculture in the sanctuary they have introduced lavancha grass (*Vetiveria ziznoides*). The oil extracted from the root of this grass is supplied to perfume industries and has been considered as one of the important commercial crop. This has triggered many local people to gradually start cultivation of lavancha grass. At present there are more than 300 acres of lavancha grown inside the SVWS. The livestock density in the sanctuary was 43 animals per square kilometre, and the fodder for all these animals are from nearby forests.

Guns in and around the study sites

In TWS and PWS, since from the colonial period, Kodava people have been known as warriors and accorded the right to have guns, even during the post independence period it has been retained as status symbol. The other community people include Arebhashe gowda and Malabar Christians are also known to own licensed or unlicensed guns. In the TWS and PWS >55% of the families are known to possess to have guns. In SVWS, the usage of gun was less for a long period and the number of guns in the region were also few until late 1970s. In the later period large number of land owners started to procure locally crafted

guns. Now most of the Malabar Christians and some of the Marathi people in the sanctuary own the unlicensed guns. Ten villages were randomly selected for investigating possessing licensed and unlicensed guns. It is found among the total families in the ten villages, 12% of the families had guns, and also found that nearly of the 26 guns possessed by the people only five were licensed guns.

Table 3.1 Hunting aspects in Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary and Sharavathi Valley Wildlife Sanctuary

Common name	Hunting Motivation@	Main Hunting Technique&
Slender Loris	f	B
Bonnet Macaque	a, b	A, C
Lion-tailed macaque	a, c	C
Hanuman Langur	a, c	C, D
Leopard Cat	g	C
Leopard	d	E
Tiger	d	E
Small Indian Civet	a, c	C, F
Common Palm Civet	a, g	C, F
Brown Palm Civet	a	C, F
Gray Mongoose	a	F
Otter species	a	D
Nilgiri Marten	a, e	C, F
Indian Giant Squirrel	a	C
Giant Flying Squirrel	a	C
Travancore Flying Squirrel	a	C
Indian Crested Porcupine	a, b	C, G, H
Indian Pangolin	a	C, G, H
Indian Hare	a	C, F
Wild Pig	a, b	C, F
Indian Spotted Chevrotain	a	C, F
Spotted Deer	a, b	C, F
Sambar	a, b	C, F
Indian Muntjac	a, b	C, F
Gaur	a, b	C

@ a: Meat; b: Crop damage; c: Medicinal value; d: Livestock depredation; e: Honey depredation; f: Bad omen; g: Poultry depredation

& A: Cage; B: Stick; C: Gun; D: Dog and mesh net; E: Poisoning; F: Snare/traps; G: Dig and pierce; H: Smoke

Hunting Practice

Since some aspects of hunting practices is a sensitive topic, and many of the local people or hunters were aware of the legal aspects, did not reveal the complete information. A little information was able to pull out from them after a few long interactions for couple of days. Usually people have tendency to talk about others, we used this to understand the general pattern of hunting practices exists in the parks. A total of 84 people were interviewed includes 35 people in TWS, 25 people in PWS and 24 people in SVWS, among them 18, 8 and 19 people were active hunters respectively. All the respondents from the TWS and PWS reported the intensity of hunting was very high between 1960 and 1990 and also they were on the opinion that hunting expeditions (gun hunting) have come down from 1995, due to non-availability of enough wild game for their effort. The current hunting expeditions by active hunters was estimated to be 3.04 (SD0.96) days/month, and they have perceived the number of days per month is an only 30 to 40% compare to their hunting expeditions prior to 1995. On the other hand 71% of the interviewed hunters perceived though hunting exists in the SVWS the intensity of hunting was very less till 1980s, and other hunters projected different periods include after1970 and after1985, since

the technique used was mostly trap hunting (Appendix 2) than using gun. However, in SVWS, the current hunting expeditions was estimated to be 5.84 (SD1.17) days/month, and this is several fold increase in the hunting intensity compare to hunting expeditions prior to 1980s. The hunting expeditions in TWS and PWS is significantly lesser than the SVWS ($F_{1, 43}$ =78.14, P<.000).

In TWS and PWS, all the passive and active hunters interviewed were practiced both gun hunting and trap hunting, but since they had easy access to the arms the hunting was prevalent with the guns than through traps. Since some species do not require hunting through gun different techniques are adopted to trap the animal, e.g. to kill the pangolin *Manis crassicaudata* and porcupine *Hystrix indica* from their den sites different techniques were used. In general the traps were fixed at fringes of the forests and crop fields, and targeted animals are terrestrial herbivore species, wild boars *Sus scrofa*, small mammals and birds.

About 24 species are hunted with diverse motives like wild meat for local consumption, control the crop damage, depredation on livestock and predation on poultry and bee culture, the belief in medicinal value attached to the species, and some of the species are also considered as bad omen (Table 3.1), however once the animal is killed usually such animals have been eaten. Except the elephants *Elephas maximus* , large cats, dholes *Canis alpinus* and jackal *Canis aureus*, all other terrestrial herbivore species, small carnivore species, wild boar, pangolin, porcupine, hare *Lepus nigricollis* and squirrels, of about 21 species are hunted in all the three sites for wild meat, among them seven species were hunted by considering them as pests for agriculture.

In general the most preferred animals in TWS and PWS were sambar *Cervus unicolor*, wild boar and Hanuman langur *Semnopithecus entelius*, where in SVWS the spotted deer *Axis axis* and muntjack *Muntiacus muntjak* were equally preferred and they are followed by wild boar and Hanuman langur. On the other hand the most hunted species is Hanuman langur, and is followed by Indian chevrotain *Moschiola meminna* and wild boars in all the study sites. All species of primates are hunted without any inhibition in TWS and PWS by most of the community people chiefly Kodava, Arebhashe gowda and Kudiya, where in SVWS, Nayaka, Marathi and Schedule caste people, though they hunt langurs but not preferred species and still many of them believe the langur as a 'state of god'. In SVWS, even the Brahmin and Jain community people also hunted the wild animals which comes to ride the crops includes bonnet macaque *Macaca radiata*, Hanuman langur, wild boar, sambar, spotted deer.

Among 24 people interviewed in SVWS, five were Malabar Christians, all of them revealed the high intensity of hunting (a minimum of five days per month by Malabar Christians). They also reported that they eat any moving wildlife however the most preferred animals are primates especially the lion-tailed macaques *Macaca silenus*, and followed by Hanuman langurs. The lion-tailed macaques are believed to have medicinal value since they eat vegetative materials from the higher canopy. This belief has also created a commercial value to the lion-tailed macaques in the villages of Kerala. Thus the lion-tailed macaques have been severely hunted. The impacts of hunting on lion-tailed macaques are provided in Appendix 1. Hanuman langurs were hunted more in the region as a minimum of three animals per two months per family, and also reported about 70% of the families of Malabar Christians in SVWS regularly use the Hanuman langurs. Keeping their population status and the hunting rate on Hanuman langurs, the probable number of Hanuman langurs hunted every year was estimated to be c.1, 200 langurs. Of all the hunters in TWS and PWS only two were Malabar Christians, they were reported the same as in SVWS, the highly preferred animals and also highest hunted animals are primates. Further among primates the preferred animal is lion-tailed macaque but highest hunted animal is Hanuman langurs.

In all the three parks reported the Muslim community people frequently come from nearby townships mainly to hunt gaur *Bos gaurus* , especially from Bhatkal to SVWS and from nearby towns in Kerala to TWS and PWS. Usually they come to the sanctuary up to 15-20 people in many vehicles with full sophisticated arms and hunt indiscriminately and

wild meat is taken to the town. Of the interviewed hunters, 3.5% of hunters (one from PWS and two from SVWS) informed occasionally gaur, sambar and wild boar meat is catered to the local market.

Discussion

Though all the three parks having many anthropogenic pressures, nevertheless they are having good evergreen and moist deciduous forests, but the abundance of mammals varied between the parks (Chapter 2), but some of the anthropogenic intervention has caused sharp decline in number of species and their abundance. The present findings undoubtedly reveal the direct elimination of the individuals is the only major reason for the decline in abundance and uneven distribution of several species. Madhusudan and Karanth (2002) have shown the hunting as the main threat for the survival of the species in the forests of Western Ghats, and also mentioned the hunting as a prime driving force causing the variation in animal abundance in the country, Kumara and Singh (2004) provide enough evidence for the hunting driven sharp decline of several species in the forests of Western Ghats.

The present findings shows hunting is wide spread in all the studied parks, but varied in techniques used, and further reveal the variation in hunting practices between the regions due to culture, migration of the people, access to the arms, life style of the local people, etc. Indeed, such factors have influenced with in the park in changing the hunting intensity and pattern. Though gun hunting is little expensive, considering the market value of the gun and cartridge, but the success rate of hunting will be high in a short span of time. In the post independence, there was an easy access to the arms (Karanth, 1986), inversely increased the use of arms for various purposes, hunting has become one among them. And for a longer period the wild meat was considered as easy source of protein, hence the rate of hunting increased in several folds, especially gun hunting, hence the traditional hunting techniques have faded in TWS and PWS (Appendix 2). In SVWS, yet various hunting techniques are in practice, this is probably due to the late access to arms however the traditional hunting is fading out against gun hunting even in SVWS after Malabar Christians moved in.

Very often, some of the hunting practices are considered as rare ones, hence such information goes unnoticed both officially and scientifically, e.g. gaur hunting by Muslim people (Bhatkala to SVWS). Though everybody is aware of such hunting, including officials, documentation is not available and also not controlled. This is probably due to lack of arms, department personnel and higher official support in the department setup. Although such sensitive issues could not be quantified, it was able to trace out the occurrence of such hunting pressure. Certainly such aggressive hunting in short period will have drastic impact on the animal population. Local hunting is always been ignored in local management of the park. Before realizing the impact of such hunting practices many animals will be in the verge of extinction. Since already there is drastic decline in the wild habitat and wild animals, if the existing wild animals to be retained the local hunting should be restricted.

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4. Major findings and Implications for Conservation

The vegetation and its distribution directly or indirectly determine the distribution and abundance of animals. The vegetation, in-turn depends upon climate, physical features, the nature of the land, the terrain etc. Since all these parameters continue to change, the distribution of animal life on earth has always been changing. Increasing human population all over the world, especially in the tropical countries, has caused the loss of vegetation cover and potential habitats and in-turn this has resulted in an uneven distribution of animals (Myers et al., 2000). Larger mammals are more susceptible to human pressures due to their body size and visibility (Robinson and Redford, 1986; Arita et al., 1990). Western Ghats is not exceptional from this and hunting is one of the major threat causing uneven distribution and local extinction of the species (Chandran, 1997; Kumara and Singh, 2004a; Madhusudan and Karanth, 2002).

1. Prior to 1990, severe hunting in TWS and PWS has resulted in drastic decline in the abundance of large mammals include both arboreal mammals and terrestrial mammals. If any hunting continues for some more years, TWS and PWS will become empty parks. At the moment active hunting is in peak in SVWS, if the same is continued in couple of decades SVWS also follows the situation of TWS and PWS. Nevertheless, a 24 species were sighted and 31 species were confirmed during the study. The rare sight records includes Malabar slender loris *Loris lydekkerianus malabaricus* and brown palm civets *Paradoxurus jerdoni* in all the study sites, Travancore flying squirrels *Petinomys fuscocapillus* in PWS and SVWS, tiger *Panthera tigris* in SVWS and Nilgiri marten *Martes gwatkinsi* in TWS.

2. The present findings show the hunting is the driving force in causing uneven distribution and local extinction of the species in all the study sites.

3. The wide varieties of traps are used in trap hunting. The checklist of the hunting techniques used in the study parks, and its description are documented.

4. In all the study parks the relative abundance of arboreal mammals was very high than the terrestrial mammals. Since all the parks are in the Western Ghats mountain system with evergreen forests, due to continuous canopy the food resource available to arboreal mammals is more than the terrestrial mammals.

5. The lion-tailed macaques Macaca silenus are in sharp decline in all the parks due to hunting, and now no viable population exists in any of the parks. This finding highlights the importance of the recently discovered viable population of the lion-tailed macaques in the Sirsi-Honnavara (Kumara and Singh, 2004b). Further even in the entire Western Ghats among the known population Sirsi-Honnavara population is the only viable population. However this population exists outside the protected area thus requires proper protection and management strategy. We also recommended to upgrade the area as protected area as 'Conservation Reserve' or create the entire area as a range and join this to the existing Wildlife Sanctuary i.e. SVWS or separate 'Lion-tailed macaque Sanctuary'. The sitting Principal Chief Conservator of Forests (Wildlife) of the state has accepted the plea to do so. However this needs complete conservation profile and management plan. He has accepted to provide all the necessary support to prepare the conservation profile and management plan to develop as conservation reserve for lion-tailed macaque.

6. While doing the survey in each sanctuary, we involved many local forest personnel to make them to understand the importance of their own jurisdiction area and the threats facing.

7. Apart from this, the present study and its findings also influenced the other adjacent forest or park managers to initiate the base line data on their own jurisdictions and develop the proper management strategy. I am also invited, and involved in conducting the surveys, research and developing the management strategy. Based on this a total of five workshop was conducted for the forest personnel to train the field methodology in biodiversity documentation in three protected areas in Western Ghats.

Threats related to hunting. Apart from hunting, all the parks also face many other threats that are not listed here.

1. Gun hunting and trap hunting still persists in all the study parks.

2. Occurrence of large number licensed and un-licensed guns in and around the parks.

3. The gradual shift in hunting practice from trap to gun hunting in SVWS increases the hunting intensity.

4. Catering the wild meat for increasing demand in the nearby townships.

5. The increase in the Malabar Christians in SVWS increases the in hunting intensity.

Recommendations

1. Education and awareness among the local people is required about the legal aspects of the hunting, wrong concept of animal origin medicine, and the uniqueness of the wildlife exists in their own land and its importance.

2. The officials in local administration also require awareness about all these aspects. We found most of the ground staff in the forest department was not aware of importance of wildlife, legal aspects of the hunting and their role in practicing this. The most of the watchers never had any training on these aspects.

3. We have come across 30 to 40% of vacancies in each park. Need to increase the man power at ground level staffs. They also should be provided the proper arms

More than any developmental activities need to give an importance combat the hunting in all the parks, and also this should be incorporated in the management plan of the each sanctuary. Conservation should become a mandate of the management plan. Then only the leftover wildlife in each park will be conserved. Otherwise soon all our parks face empty forest syndrome (Redford, 1992).

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Appendix 1

Decline of lion-tailed macaque populations in the Western Ghats, India: Identification of a viable population and its conservation in Karnataka state

H. N. Kumara and Anindya Sinha

Abstract

The endangered lion-tailed macaque Macaca silenus is an endemic primate, restricted in its distribution to certain rainforest patches in the Western Ghats Mountains of south-western India. There are no proper estimate of the groups left in the wild, probably due to methodological constraints brought about by the difficult terrain and the relative rarity of the troops. Most populations of the species are, however, declining or severely fragmented, while the species has gone locally extinct in some areas. The newly discovered population of this primate in the Sirsi-Honnavara area of Karnataka state is possibly the only viable population with more than 750 individuals, but it is confined to unprotected reserve forests characterized by extensive human habitation, agricultural land and livestock reserves. We suggest the formulation of a conservation action plan to help in the development of a protected area for what is possibly the last viable population of the endangered lion-tailed macaque, endemic to the rainforests of southern India.

Introduction

The Western Ghats, a series of mountain ranges, run parallel to the western coast of south-western India, passing through six Indian states, from 21°N to 8°N (Pascal, 1988). Although human activity has been present in these hills since prehistoric times, the organized state-sponsored forestry and non-forestry activities began about 200 years ago (Chandran, 1997). Commercial plantations, tea (*Camellia thea*) and coffee (*Coffea arabica/robusta*) cultivation, construction of hydel dams and power generation have brought millions of people to these hills. As a result, wildlife habitats, especially the rainforests, have undergone drastic changes including extensive fragmentation. In most places, the rainforest fragments now stand isolated because of the gaps created by plantations of non-rainforest species and commercial crops. Despite such factors, however, the Western Ghats still harbours a remarkable diversity of plant and animal life because of which the hills have been recognized as one of eight 'hottest hotspots' of biodiversity in the world (Myers et al., 2000). It also has, ironically, the highest human population density of all the hotspots (Cincotta et al., 2000).

The rainforests 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 the lion-tailed macaque *Macaca silenus*, Nilgiri langur *Semnopithecus johnii*, bonnet macaque *M. radiata* and the Hanuman langur *S. entellus/priam*. While the lion-tailed macaque and Nilgiri langur are endemic to the Western Ghats, the other two species are widespread throughout southern India.

The lion-tailed macaque ranges through three southern Indian states: Karnataka, Tamil Nadu and Kerala. Because of its highly selective feeding habits, limited range of occupancy (about 2500 km^2), delayed sexual maturity, long inter-birth intervals, low population turnover and a small remaining wild population, this species has been classified as endangered (IUCN, 2003). The effect of habitat loss, fragmentation and hunting has been most drastic on the lion-tailed macaque (Karanth, 1992; Krishnamurthy

and Kiester, 1998). Although the lion-tailed macaque is considered endangered, comprehensive information on surviving numbers in the fragmented rainforests is not readily available; a few estimates, however, have been reported earlier (Green and Minkowski, 1977; Kurup, 1978; Ali, 1985; Karanth, 1992; Kumar, 1995; Easa et al., 1997; Molur et al., 2003). Most of these estimates are based on sporadic visits to different parts of the lion-tailed macaque range or on short surveys made in few pockets. These surveys, nevertheless, contribute significantly to understanding the status of each population; important information is thus available on the macaque populations of the Indira 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-Honnavara areas (Kumara and Singh, 2004a) and the Kudremukh National Park, Someshwara Wildlife Sanctuary and Mookambika Wildlife Sanctuary (Vasudevan et al., 2006). The population status of the species, as a whole, however, continues to be elusive over most of its range. More intensive studies thus need to be conducted to identify potentially viable populations of the species and formulate effective conservation strategies.

Karanth (1992), while outlining the conservation prospects for the Western Ghats, emphasized the importance of the lion-tailed macaque as a flagship species of the rapidly declining rainforests of this biodiversity hotspot. In this paper, we report the findings from our recent surveys on the status of the last remaining populations of lion-tailed macaques in the state of Karnataka, and also review the available information on the status of lion-tailed macaque populations in the Western Ghats to identify the potentially important populations for long-term conservation.

Study Sites

The details of the different study sites are provided in Table 1, the description of the area is provided in Chapter 1.

Table 1. The three Protected Areas in Karnataka state, India, where the present study was conducted.

Protected Area	Geographical extent	Area (km2)	Altitudinal range (m)	Temperature range (°C)	Mean Annual Rainfall
Talakaveri Wildlife Sanctuary (TWS)	12.28720-12.44390N, 75.42310-75.55420E	105	63-1659	15-35	2000mm
Pushpagiri Wildlife Sanctuary (PWS)	12.48780-12.70060N, 75.63310-75.71030	102	60-1712	10-38	2000mm
Sharavathi Valley Wildlife Sanctuary (SVWS)	13.90280-14.27530N, 74.64220-74.99580E	431	300-1102	8-33	3700mm

Methods

The study was conducted in all the three sanctuaries of TWS, PWS and SVWS from January 2005 to August 2006. As lion-tailed macaques occur in low numbers in the wild and are highly restricted to narrow strips of rainforests in the Western Ghats, estimation of their density through line transect survey or distance sampling requires an enormous effort. Laying of transect lines is often usually not possible over much of the species' range. The total count method (NRC, 1981) has thus been widely adopted 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 Ramachandra, 1998) and the Brahmagiri-Makut and Sirsi-Honnavara areas (Kumara and Singh, 2004a). We adopted the same method in the present study with some modifications.

We selected trails, which were evenly distributed in each of the study sites and represented all the representative forest types. The trails were walked repeatedly to estimate the relative abundance of all arboreal mammals, including lion-tailed macaques. It must be noted, however, that this method does not give the actual number of lion-tailed macaque groups actually present. As the macaques are confined to specific forest patches, we also collected secondary information from the local people, hunters and Forest Department personnel about their sightings of the primate in the respective study sites. Karanth (1985) provided several group locations that helped us to compare the secondary information collected on the persistence of these troops. All information collected on the sightings of the species was mapped and compared with the group localities and possible available habitat, as described in Karanth (1985), and its possible distribution range enumerated in each study region. Within each study area, we adopted the modified total count and sweep sampling methods (NRC, 1981) to determine lion-tailed macaque abundance and distribution. Two to three researchers, with two to three trained field assistants each, walked in parallel, spacing themselves 100 m from each other, and this was repeated twice in each defined region. As all the study areas harboured tropical rainforests, it was assumed that neither the 'visibility factor' nor the 'detect ability factor' would affect observations or bias the data to any significant extent. After sighting a macaque group, sufficient time was spent to obtain a proper count of individuals and a GPS reading for the location. The location site and the demographic data on the groups allowed us to distinguish between them and provide distinct names for them. Interactions and unstructured interviews with the local people provided information on hunting pressure, particularly on the macaques, in each study area.

A total of 95.2, 82.8 and 125.0 km was walked along trails during the total count method in TWS, PWS and SVWS, respectively, while 302.2, 184.0 and 186.8 km of repeated trail walk and ~480, ~426 and ~800 km of motor transects were conducted in these three sanctuaries, respectively. The repeated trail walk and motor transects were carried out in all the forested regions of the study sites, whereas the total count method was confined only to selected regions. The walks were conducted between 0700and 1130 h and between 1500 and 1830 h over the day. Irrespective of the terrain, the walking speed was maintained between 1 and 1.5 km/h.

Results

Status of the lion-tailed macaque in three protected areas

We sighted a total of nine groups of lion-tailed macaques during the survey – four groups in TWS, two groups in Pushpagiri-Subramanya and three groups in Sharavathi- Gersoppa (Table 2). All the groups were extremely shy and retreated immediately on approach; it was thus not possible to collect accurate demographic information on them in spite of repeated visits to these locations. During these observations we were able to make out highly skewed age sex ratios in all the regions.

Status in Karnataka

In Karnataka, Karanth (1985) had estimated the minimum area required by an average group of macaques and following an extensive questionnaire survey, reported the existence of 123 groups in the state. Although we feel this could have been an underestimate of the actual number of groups, the locations of the reported groups appear to be accurate. Our survey and other earlier surveys in the state have thus been compared with that of Karanth (1985). He had reported ten groups each in TWS and Pushpagiri-Subramanya, and nine groups in Sharavathi-Gersoppa. The present survey shows a 69% decline in the groups in the same regions (Table 2). The status of the lion-tailed macaque appears to be similarly threatened in other Protected Areas of the state as well. Kumara and Singh (2004a), for example, reported only a single group in Brahmagiri-Makut; this population has thus declined more than 90 % from that reported by Karanth. In contrast, however, Karanth had reported only six groups in Sirsi-Honnavara, while Kumara and Singh (2004a) later reported 32 groups from the same region. Nine groups were reported by Karanth in the Kerekatte forest range (earlier known as Sringeri) in the Kudremukh National Park and the same number of groups was confirmed during an earlier survey in 1998 (Singh et al., 2000). During a survey between 2005 and 2006, Vasudevan et al. (2006) sighted only nine groups and reported the evidence for three other groups in the Kudremukh National Park, Someshwara Wildlife Sanctuary and Mookambika Wildlife Sanctuary, from where Karanth (1985) had reported 62 groups. They, however, suspect the occurrence of more groups in this region.

Table 2. Lion-tailed macaque groups in different Protected Areas and adjacent ranges in Karnataka state, India.

Map location	**Area**	**Ranges**	**Karanth, 1985**	**Recent surveys**	
				Number of groups	**Source**
1	Brahmagiri WS	Srimangala, Makut[1]	4	0	Kumara and Singh, 2004a
2	Makut RF	Makut[1]	6	1	Kumara and Singh, 2004a
3	Talakaveri WS	Bhagamandala	10	4	This study
4	Pushpagiri WS	Sampaja[2]	1	0	This study
5	Subramanya RF	Subramanya[2]	6	1	This study
6	Yesalur RF	Yesalur[2]	1	0	This study
7	Sakaleshpur RF	Sakaleshpur[2]	2	1	This study
8	Kudremukh NP	Kerekatte	9	10	Singh et al, 2000
9	Kudremukh NP	-	44	6	Vasudevan et al., 2006
10	Mookambika WS	-	12	1	Vasudevan et al., 2006
11	Someshwara WS	-	6	2	Vasudevan et al., 2006
12	Sharavathi Valley WS	Kogar[3]	5	2	*This study*
13	Bhatkal RF	Bhatkal[3]	2	1	This study
14	Gersoppa RF	Gersoppa 1[3]	2	0	This study
15	Gersoppa RF	Gersoppa 2[4]	2	10	Kumara and Singh, 2004a
16	Siddapur RF	Siddapur[4]	2	2	Kumara and Singh, 2004a
17	Kyadagi RF	Kyadagi[4]	1	17	Kumara and Singh, 2004a
18	Honnavara RF	Honnavara[4]	0	3	Kumara and Singh, 2004a
19	Kumta RF	Kumta	1	0	Kumara and Singh, 2004a
	Total		**116**	**61**	

[1]Brahmagiri-Makut population, [2]Pushpagiri-Subrmanya population, [3]Sharavathi-Gersoppa population, [4]Sirsi-Honnavara population; WS: Wildlife Sanctuary, RF: reserve Forest, NP: National Park

Status in Western Ghats

Green and Minkowski (1977) projected the number of the surviving lion-tailed macaques in the wild to be about 600 individuals, while Kurup (1978) and Ali (1985) later estimated the entire population to consist of 825 (in 55 groups) and 915 individuals (in 61 groups), respectively. Joseph (1985), however, believed that there were 635-735 individuals in the state of Kerala alone, while later estimates reported these numbers to be approximately 475-594 (Government of Kerala, 1993) and 1,216 (Easa et al., 1997). In Karnataka Karanth (1985) estimated 2000-3000 lion-tailed macaques, distributed in approximately 200 groups, in the state on the basis of secondary information but this was questioned by Kumar (1988) on the basis of his long-term study on the ecology of the species. Karanth (1992) later reported a population of about 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 put at 3500 in a similar exercise (Molur et al., 2003). These individuals were believed to consist of 49 subpopulations isolated in rainforest fragments scattered over eight locations (Molur et al., 2003).

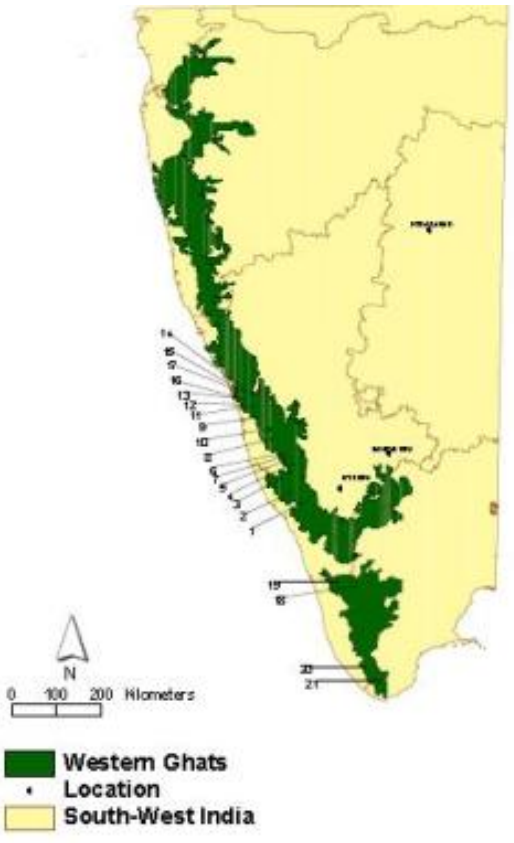

Fig. 1. The Western Ghats in South-West India showing the locations mentioned in Table 2 and Table 3

Table 3. The expected major lion-tailed macaque populations in the Western Ghats, India

Forest area	Current number of groups	Comments	Source
Kalakad- Mundanthurai Tiger Reserve, Tamil Nadu (21)*	Not known	Large tracts of ~1000 km2 of rainforest; expected to have a good population though no data are currently available	-
Indira Gandhi Wildlife Sanctuary, Tamil Nadu(18)	32	Very fragmented population, present in both protected and non-protected forests	Singh et al., 2002
Shendurney-Kulathupuzha- Peppara-Neyyar, Kerala (20)	20-25	One of the largest population in continuous forest tracts	Easa et al., 1997
Silent Valley National Park, Kerala (19)	14	Possibly a viable population	Joseph and Ramachandran, 1998
Kudremukha-Someshwara, Karnataka	6+	Large continuous forest; no proper survey, but there may be more groups	Vasudevan, et al., 2006
Mookambika-Sharavathi-Gersoppa, Karnataka	3+	Most of the groups have disappeared due to hunting (see Table 2)	This study; Vasudevan et al., 2006
Sirsi-Honnavara, Karnataka	32	Non-protected, continuous forest; a viable population	Kumara, 2005; Kumara and Singh, 2004b

*Numbers in the parenthesis is a location in the Fig.1

A viable population

Large contiguous populations of the lion-tailed macaque are expected to occur only in very few regions over the entire Western Ghats (Table 3) and the conservation status of the species is likely to differ across these sparse populations. The Kalakad- Mundanthurai Tiger Reserve in southern Tamil Nadu, for example, has large tracts of rainforest, amounting to about 1000 km2, and is believed to have a good population of the species (Molur et al., 2003) although a status survey has never been conducted there. The Indira Gandhi Wildlife Sanctuary in the Anaimalai hills of Tamil Nadu has about 32 groups of lion-tailed macaques, all of which are restricted to severely fragmented forests (Singh et al., 2002) and, hence, the future of this population is unpredictable. The Silent Valley National Park in Kerala has, however, received the attention of the entire country because of its 14 groups of lion-tailed macaques (Joseph and Ramachandran 1998). Ten groups of lion-tailed macaques were reported from the Brahmagiri Wildlife Sanctuary in the Western Ghats (Karanth, 1985); our studies have, however, revealed the virtual local extinction of this population due to extensive hunting (Kumara and Singh, 2004a,b; Kumara, 2005). We have observed similar drastic declines, sometimes leading to the loss of even 65 % of the existing groups, during our recent surveys of the TWS, PWS, SVWS and the adjacent ranges of each of these Protected Areas (Table 1; Kumara, 2006). Karanth (1985) reported a fair number of macaque troops from the Kudremukh National Park although a currently ongoing survey reveals the survival of only a few isolated groups here today (Vasudevan et al., 2006).

In the light of this dismal scenario, the large, recently discovered, population of about 32 groups of the species in the unprotected Reserve Forests of Sirsi-Honnavara in southern Karnataka possibly represents the last viable, contiguous population of the macaque in its natural habitat (Kumara and Singh, 2004a; Kumara, 2005).

Discussion

It is evident from the body of literature that now exists on the field biology of the lion-tailed macaque that although many Protected Areas have been established along the distribution range of the species in the Western Ghats mountains of south-western India, the macaques are on the decline in most of the Protected Areas of Karnataka state while its status remains relatively unknown in the other states where it is found. The practice of wildlife protection and management is also not very effective over most of the Protected Areas of the Western Ghats, possibly due to insufficient staff and a lack of vision. Information on the status, distribution and regular monitoring of the lion-tailed macaque also is thus not available over most of its distributional range, including Protected Areas, while such efforts or information are also not included in the management plans of the respective forest divisions of Karnataka state.

With the exception of theoretical studies, primate researchers have also not attempted to estimate the on-ground density of lion-tailed macaques due to the undulating terrain, their rarity in nature and methodological constraints in assessing numbers during short surveys. Vasudevan et al. (2006) attempted to estimate the population status of the macaques using trail walks within three Protected Areas in Karnataka, but failed to establish the status of the existing groups possibly due to certain methodological problems. There have, nevertheless, been a few surveys, which successfully evaluated the number of groups within particular areas by adapting the total count method. This includes the confirmation of each macaque group and enumeration of its demography by repeated exploration over relatively long time periods in the Silent Valley National Park (Joseph and Ramachandra, 1998) and Anaimalai hills (Singh et al., 2002) or repeated exploration over short periods of time with supplementary secondary information in Sringeri (Singh et al., 2000), Brahmagiri- Makut and Sirsi-Honnavara (Kumara and Singh, 2004a). We considered the latter method to be relatively robust and able to provide adequate data in short surveys, and proceeded to adapt it with some modifications during the present survey. It may, however, be necessary to standardize the method further in order to provide even more reliable data over the long term.

Interviews with local people during this study has revealed severe hunting pressures on the lion-tailed macaque in all the three study regions in Karnataka, probably leading to the observed sharp decline in its population in the state. The decline and local extinction of the species has also been reported from many other parts of its range due to such hunting (Kumara and Singh, 2004a,b). We strongly feel that if hunting is not controlled, local extinction of the lion-tailed macaque can be expected from many regions of Karnataka. In addition to hunting, habitat loss and fragmentation have also resulted in severe population fragmentation and isolation of groups over much of the distribution range of the macaque (Kumar et al., 1995; Umapathy and Kumar, 2000; Singh et al., 2002). Collectively, this has resulted in a significant increase in the number of subpopulations, increase in inter-subpopulation distance, skewed sex ratios, low immature to adult ratios, and reduced male migration, all of which could lead to in viable populations, driving the species to local extinction. We would, therefore, like to propose few conservation strategies for the long-term survival of the macaque over its current distribution range, particularly in Karnataka.

In general, all the Protected Areas with lion-tailed macaque populations need to be identified, species-specific management plans developed and these plans incorporated into the overall management plan of the respective park. Annual census of all the macaque groups and individuals should be made mandatory in order to monitor population trends and to evaluate the effectiveness of the protection strategies being implemented. As hunting is the major threat to the survival of the lion-tailed macaque, particularly in Karnataka, a legislative framework needs to be strongly imposed and an adequate number of protection staff employed in order to bring down hunting pressures on the species.

Although our present survey has identified the lion-tailed macaque population in Sirsi-Honnavara (Kumara and Singh, 2004a) as one of the most viable populations left in

the wild, no other information on the feeding ecology, habitat utilization patterns and the threats to the population in this region is currently available. Without such information, management plans for the macaque cannot be effectively developed. We thus propose to begin a continuous monitoring of the Sirsi-Honnavara lion-tailed macaque population, mapping of its exact distribution and group ranging patterns, assessment of the potential threats that it faces, evaluation of the impact of the neighbouring villages and crop fields on the habitat, and delineation of boundaries for its protection as soon as possible.

It is now gradually being recognized that the rapid growth of human populations in many tropical countries have led to enormous pressure on wildlife parks in these countries, leading to a failure in the protection of their biological resources, thus often reducing them to mere 'paper parks' (Ghimire and Pimbert, 1997). An extensive analysis of data from a large number of parks in several tropical countries, however, has led Bruner et al. (2001) to conclude that many of these parks are indeed successful in managing and protecting their resource from external pressures. Likewise, Struhsaker et al. (2005) have suggested the improvement of law enforcement through greater technical and financial support to enhance proper protection of wildlife in Africa. We, therefore, believe that the development of protected areas with proper guidelines and strict law enforcement continues to be a viable way to protect threatened wildlife. Accordingly, we strongly suggest that the forests of Sirsi-Honnavara should be declared a protected area, with the establishment of a "Conservation Reserve" or a "Wildlife Sanctuary", to ensure the long-term survival of what is possibly the largest, most viable population of the lion-tailed macaque left in the wild.

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Appendix 2

Description of the Hunting Techniques used in Talakaveri Wildlife Sanctuary, Pushpagiri Wildlife Sanctuary and Sharavathi Valley Wildlife Sanctuary

Based on behaviour pattern of the species, size, food habits, etc. the hunting techniques are adopted and designed various types of traps and snares, the techniques used in all the three study sites are described in this chapter. Hunting techniques can be broadly divided as two categories one is using guns (gun hunting) and other one is without using guns (trap hunting). If large carnivore species are found regularly preying on livestock, in such situations the poison was poured on such livestock carcass to kill the predator.

Hunting with guns

This type of hunting is prevalent in all the study sites and mainly locally crafted muzzle loading gun, single barrel and double barrel guns are used for hunting. Usually the local crafted guns are used without the license from the government, which were more common in SVWS than TWS and PWS. Both during day and night hunting expedition's guns are used, if the expeditions are during the night then the spotlight to locate the animal is used while walking. The targeted animals during the day are primates, Indian giant squirrel *Ratufa indica*, sambar *Cervus unicolor*, chital *Axis axis*, wild boar *Sus scrofa*, muntjac *Muntiacus muntjak* and large birds, and during night the targeted animals are all terrestrial herbivore mammals, wild boar, civets, porcupine *Hystrix indica*, flying squirrels and black napped hare *Lepus nigricollis*. At the fringes of SVWS and PWS if the wild boar, sambar or porcupines are found using specific path specially going for crop riding, the suitable point is selected on the path and made five feet pit and gun is installed in such a way to trigger with little disturbance (trip gun). If any animal jumps on it will get killed.

Hunting techniques without using gun

These techniques involve proper understanding of habits of the species and according to that need a skill of developing the technique. The success of the trap hunting depends on many factors include the quality of the trap construction and placement of the trap. Thus the techniques used vary between the sites. I broadly classify them as the traps coupled with snares and without snares.

Traps coupled with snares

The snare preparation involves a long thin metal wire, usually break-wire of the motor cycle. The one end of the wire is made as an appropriate size ring or loops with the hitch knot and is placed at targeted place with little support, and other end of the wire is tied to strong flexible objects usually the stems and which is pulled near to the targeted place. According to the animal size and movement pattern the snares are placed and adjacent areas are blocked by fixing the many stems parallel, that acts as a barricade for the animal movement. Now animal is guided to move using the opening left where the snare loop is fixed, once the animal tried to cross this loop the loop will get released and animal gets hanged. Isolated traps are also fixed at regular animal paths and also at fences of agriculture fields. These traps are more successful in taking sambar, muntjac, spotted deer, wild boar, chevrotain *Moschiola meminna* and porcupine, occasionally small cats, civets and other small animals also get killed. The snares are also fixed without blocking the adjacent areas e.g. When the pot is fixed to the wild palm tree *Caryota urenus* to extract the juice, species like bonnet macaques *Macaca radiata*, lion-tailed macaques *Macaca silenus*, Hanuman langurs *Semnopithecus entelius*, Asian palm civets *Paradoxurus*

hermaphroditus and brown palm civets *Paradoxurus jerdoni* get attracted by this juice and they try to drink. The wire snares are openly hanged around the opening of the pot, any sneaking animal will get caught in this trap.

Multiple snare traps: If there is a path used by variety of species with varying sizes, many such snares are fixed with varying sizes in a row, and between the snares the barricade is constructed. I have come across one of this type of trap having 14 snares with 120m barricade in SVWS. In this trap animals are guided to a specific opening. The same construction was used repeatedly for a year. Of the interviewed hunters all the eight Marathi people appreciated the efficiency of this trap, and this is more popular in SVWS.

Civet trap: The nature of the trap is as described in 'traps coupled with snare', but the location of the construction differed. Usually palm civets use dead fallen trees to cross the streams and valleys and also often they defecate on such logs. The trap is constructed on such trees with proper barricade is more successful in taking the civets specially the brown palm civets.

Traps without snares

Smoking, water flushing and pitfall traps for porcupine and pangolin Manis crassicaudata: (1) The active den sites with multiple openings are identified, except the two openings, all other openings are blocked and one opening will be left for the animal to move out, and in other opening the smoke will be introduced. Usually animal inside get breathing problem and tries to escape, since all the openings are blocked animal is forced to the opening left unblocked. When the animal comes out will be killed with the hunting dogs or metal pierce weapon. (2) If the den sites are on stream or river bed and near to the water, then the water is blocked and diverted to the den site and make the water to flow inside the den and get filled. The animals comes out of the den to escape, will be killed with the hunting dog or piercing weapon. Occasionally chevrotain, monitor lizard and black napped hares are also getting killed with this method. (3) If the den has one opening, then block all the sides of the opening and allow at one side for the animal to escape with little passage. Immediate after the passage dug a big pit, but at the opening of the pit should be covered with a thin sticks and litter. Once the animal comes out of the den it will fall to the pit. (4) Otherwise the rear portion of the den is checked for the accurate location of the animal presence, and that place is dug opened, and animal will be killed with hunting dog or metal weapons. (5). If the den is having one opening, the five to six feet *Caryota urenus* stem is taken and made hollow funnel and placed the one end of the funnel to the den opening. The stem should be broader at one end and it narrows towards other end. The animal comes out of the den it has to get inside the funnel, but since the other end is very narrowed and animal cannot move further and also since the quill of the porcupine does not allow the animal to move back also. In this method only porcupine gets trapped. All these methods are widely used in SVWS, where smoking the den to kill the porcupine and pangolin is used in TWS and PWS.

Pig trap: Many stems are taken and tied each other and made a large plank, the size of the plank will be usually eight to ten feet width and length. A four feet hard pith of the *Caryota urenus* stem is taken and is penned at the selected site, in such way that stem should fall once it is disturbed. The constructed wooden plank is placed on this stem, and many large stones are placed on the plank. The stem of attracts the Wild boars, when they come to eat this entire heavy loaded plank get collapse and animals get killed. Hanuman langurs are also known to feed on this and also villagers informed deaths of many langurs in this type of traps. This type of traps is used in all the study sites.

Small mammal trap: This trap is more similar with the pig trap, but this has little variation in construction. Barricade is constructed with thin stems as a cage, in the centre of this the small stone loaded plank is placed above thin stem fixed at the middle of the cage. According to the animal targeted the baits are provided at the centre of the cage and near the thin stem or some time the baits are tied to the stem. When the animal comes to feed on the bait the thin stem will be pulled as a result the plank will get collapsed and kill the animals. This trap is commonly used at TWS and PWS to kill the mongoose, civets and jungle fowl.

Brown palm civet hunting: Usually during the rainy season brown palm civets use the abandoned nests of Indian giant squirrel for day sleep. Thin long bamboo pole will be

taken and tied a small knife to the end of the poll. While one or two persons with a hunting dog stand below the nest, one person will take this poll and climbs the tree and pierce the nest. If the animal is inside the nest it jumps out of the nest that will be caught by hunting dogs. Occasionally Indian giant squirrels also get killed. This technique is used in SVWS.

Hanuman langur hunting: Identify the targeted group and also discontinuous canopy, and drive the animals to where the canopy is not continuous. At jumping spot fix the nylon net just above the ground. Animals are forced to jump from the tree to the net, and they will get caught. This technique is wide spread in all the sites.

Guided net: A 100m long net is fixed in a shape of half circle on the ground. Few people drive the animals by beating the bushes. Animals run to the net and get caught. In this method chevrotain, black napped hare and pheasants are targeted animals. This technique is in use at SVWS.

Explosive baits: This is practiced in all the study sites, and usually explosive baits are fixed to kill the wild boars.

Capture at roosting sites: During the day time chevrotain, palm civets, flying squirrels and eggs of the birds, and during the night jungle fowl, peacock and other pheasants are captured.