The influence of differing hunting practices on the relative abundance of mammals in two rainforest areas of the Western Ghats, India

H.N. Kumara and Mewa Singh

Abstract We assessed the distribution and relative abundance of mammals in two rainforest areas, Brahmagiri-Makut and Sirsi-Honnavara, of the Western Ghats, southern India, from November 2001 to April 2002. Both direct (daytime and night-time wildlife sightings through 'recky' walks) and indirect (wildlife signs and local information) methods were employed. A total of 34–35 species, of which we recorded 31–32, are known from the two areas; 14 are in one of the IUCN Red List threatened categories and six are endemic to India. Ecological factors account for the distribution and relative abundance of only three species (Nilgiri langur *Semnopithecus johnii*, lion-tailed macaque *Macaca silenus* and Asiatic elephant *Elephas maximus*). Ten other large species of mammals were more common in Sirsi-Honnavara than in Brahmagiri-Makut, whereas most of nine smaller species were generally more common in Brahmagiri-Makut. These differences can be attributed to different hunting practices rather than to ecological or biogeographical factors. In Brahmagiri-Makut the mainly daytime hunting using guns has the greatest impact on large diurnal mammals, whereas in Sirsi-Honnavara the mostly night-time hunting with traps, and avoidance of primates, has a greater effect on small nocturnal mammals. Brahmagiri-Makut is one of the few areas in the Western Ghats where all of the primate species of southern India can still be found, but the area does not receive any official protection. In Sirsi-Honnavara encroachment of agriculture is a regular practice, and the remaining forests exist only as a network of narrow strips.

Keywords Hunting practices, India, langur, mammals, rainforest, Western Ghats.

This paper contains supplementary material that can only be found online at http://journals.cambridge.org

Introduction

Increasing human populations, especially in tropical countries, have caused loss of potential habitats and lead to species extinctions (Pimm & Raven, 2000) and uneven and clumped species' distributions (Myers *et al.*, 2000). Anthropogenic processes such as hunting have also resulted in the decline of many wildlife species (Diamond, 1989; Madhusudan & Karanth, 2002). One area that has been particularly affected by human population growth and hunting is the Western Ghats mountain range, which runs parallel to the west coast of south India, passing through six states, and harbours a great variety of animal species; it has been recognized as a hot spot of biodiversity (Myers *et al.*, 2000). The Western Ghats also have the highest human population density of all hotspots (Cincotta *et al.*, 2000).

Ramesh (2001) classified the ecological zones of the Western Ghats as Wet Evergreen Forests, Dry Evergreen Climax Forests and Deciduous Climax Forests. Most of the ecological studies in the Western Ghats have described the ecology, distribution and behaviour of individual species, but only a few studies have dealt with broader issues. Madhusudan & Karanth (2002) discussed local hunting of large mammals in Kudremukh and Nagarahole, two protected areas in the state of Karnataka. Other studies have included habitat fragmentation and its impact on small mammals and primates (Kumar *et al.*, 1995; Umapathy & Kumar, 2000), the lion-tailed macaque *Macaca silenus* (Singh *et al.*, 2002), small carnivores (Rai & Kumar, 1993; Ashraf *et al.*, 1995; Yoganand & Kumar, 1995; Mudappa, 2001), the flying squirrels *Petaurista petaurista* and *Petinomys fuscocapillus* (Kurup, 1989; Ashraf *et al.*, 1993), and mammals of a wildlife sanctuary in Tamil Nadu (Kumar *et al.*, 2002). Two earlier studies on distribution of mammals in the state of Karnataka (Prasad *et al.*, 1975; Karanth, 1986) were based largely on secondary information.

Of the total 78,387 km^2 of the Western Ghats, 17,613 km^2 (20%) falls within protected areas (Johnsingh, 1986). Because most studies have been conducted in and around these protected areas, little information is available on mammalian ecology in other areas. In the

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present study two regions of rainforest of the Western Ghats where official protection status of the forest and the culture and lifestyle of people differ were selected. We describe the diversity, distribution and relative abundance of mammals in these two areas, and evaluate the impact of different hunting practices. Our focus is on larger mammals in particular because their size and visibility makes them more susceptible to human pressures (Robinson & Redford, 1986; Arita *et al.*, 1990) and they are more likely to lead to human-animal conflict.

Study area

The study was carried out in Brahmagiri-Makut in southern Karnataka and Sirsi-Honnavara in northern Karnataka (Fig. 1, Table 1). In Brahmagiri-Makut the habitats are *shola* grasslands (narrow patches within the rainforest) at higher altitudes and evergreen and semi-evergreen forests at medium and lower altitudes. The distribution of *Cullenia exarillata*, a dominant tree in the wet evergreen forests at medium elevations throughout

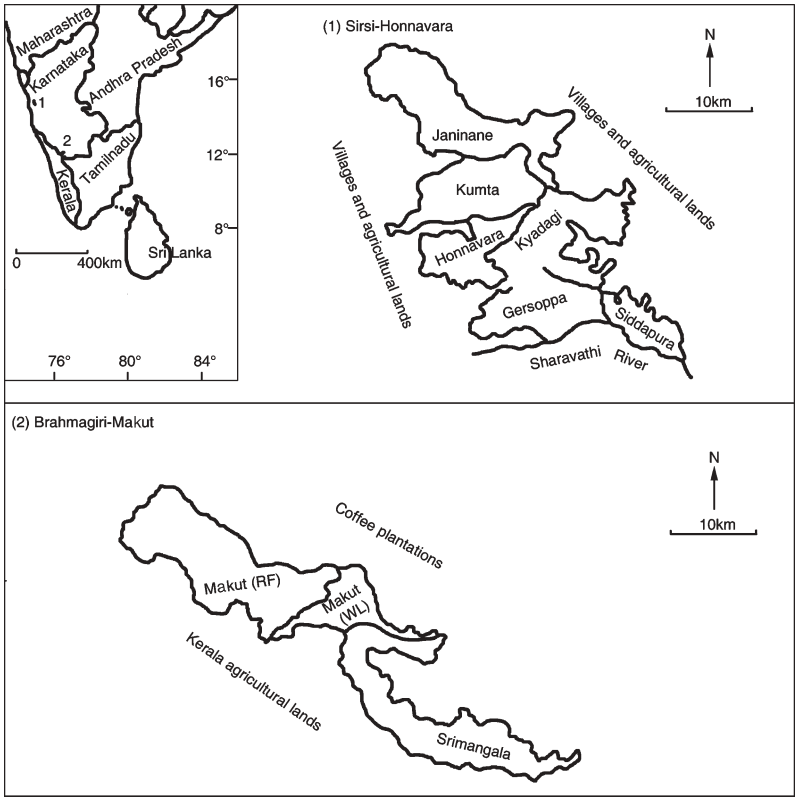

Fig. 1 Southern India, indicating the location of the two study areas of Sirsi-Honnavara (1) and Brahmagiri-Makut (2) in the state of Karnataka; the detail of each area indicates the location of the Forest and Wildlife Ranges (see Table 1).

Table 1 Summary of geographical, climate and administrative features of the two study areas of Brahmagiri-Makut and Sirsi-Honnavara (see Fig. 1).

	Brahmagiri-Makut	Sirsi-Honnavara
Area (km^2)	306	200
Altitude range (m)	60–1,600	200–800
Temperature range (°C)	5–32	15–35
Total annual rainfall (mm)	Up to 6,000	Up to 5,000
Vegetation types[1]	*Mesua ferrea – Palaquim ellipticum*	*Persea macrantha-Diospyros* spp.- *Holigarna* spp.
Names of Administrative Ranges	Srimangala & Makut Forest Ranges, Makut Wildlife Range[3]	Sirsi Divison: Janmane, Kyadagi & Siddapura Forest Ranges. Honnavara Division: Kumta, Honnavara & Gersoppa Forest Ranges[2]

[1]Pascal (1988).
[2]A Forest Range is an area of 50–100 km^2 administered by a Forest Range Officer within a larger area such as a Forest Division.
[3]A Wildlife Range is an area of forest reserved for wildlife and within which no forestry activities are permitted.

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the Western Ghats (Pascal, 1988; Ramesh, 2001) ends just to the south of Brahmagiri-Makut. Although there is no human habitation within the forests of Brahmagiri-Makut, the forest boundary is densely populated. Eleven communities, or castes, live on the eastern border. More than 80% of the population are Kodavas (a land-owning warrior community) and 5–7% are forest-dwelling tribes. Christian and Muslim communities dominate the western border. The people frequently come into conflict with authorities over resource use (Machaiah, pers. comm.).

The forest type of Sirsi-Honnavara constitutes the northern limit of the evergreen forests of the plains and low elevations of south India (Pascal, 1988). Villages are scattered throughout these forests, and to document patterns of land use we selected seven villages from the Kyadagi Forest Range. These villages were Suthlamane, Talkeri, Nirgod, Kodigadde, Dhanmavu, Hukkali, and Kaunsale, with a total area of 4,857 ha. The agricultural land was 345 ha and the forest area was 4,224 ha, amounting to 7% and 87% of the total area respectively. At least 596 houses with a population of *c.* 2,047 were scattered throughout the forest. Approximately 82% of the total population of the region belonged to three communities, or castes; the Nayaka, Vokkaliga Gowda and Harijana. They were the major hunting communities. Muslims, Christians and some nomadic tribes such as Hakki Koramaru and Beduvavaru also hunt in the region.

Methods

The study was conducted in Brahmagiri-Makut from November 2001 to January 2002, and in Sirsi-Honnavara during February–April 2002. We made 'recky walks' (Walsh & White, 2000) at 0.8 km h^{-1} on both pre-existing trails and new routes, with a pedometer used to record distance walked. During 41 and 44 days of walks in Brahmagiri-Makut and Sirsi-Honnavara the average distance covered per day was 6.4 km ($\pm$ SD 2.5) and 4.5 km ($\pm$ SD 2.2), respectively. All mammal species sighted were noted, and when necessary sufficient time was spent to determine group size. The number of traps and hunters encountered was noted. Because both study areas contain rainforest and we anticipated that similar mammal species would be encountered in both areas, we assumed that differences in visibility or detectability between the two areas would not bias observations significantly. The encounter rate (i.e. animals km^{-1}) was used as the relative abundance of a species. Night-time walks were also made in the same areas, using spotlights, and the relative abundance of species sighted was estimated as the number of individuals sighted per spotlight-hour (Kemper, 1988). The total distances walked during daytime were 238 and 198 km, and the spotlight hours during night-time walks were 27 and 46 in Brahmagiri-Makut and Sirsi-Honnavara, respectively. Additional information on the presence and absence of mammal species was gathered from forest staff, local inhabitants, footprints, faecal deposits, calls, kills, foraging and roosting signs. A list of mammal species in the two areas was compiled from our survey data, from earlier published records (Prater, 1993), and local information.

Interviews (Appendix 1) were employed to record hunting technique, hunting intensity, hunters' prey choice, and influence of socio-cultural factors on hunting practices. Multiple responses were permitted to a single question (Madhusudan & Karanth, 2002). Because most people avoided filling the questionnaire, we talked with them to obtain the required information, and later filled in the questionnaire. We interviewed 42 forest personnel and nine local informants in Brahmagiri-Makut, and 32 hunters in Sirsi-Honnavara. Not all items in the questionnaire could be filled for all individuals, as some information was not divulged. Information on number of guns in the villages around Brahmagiri-Makut was obtained from the local Police Department and Karnataka Forest Department, and in Sirsi-Honnavara from interviews. Because the data collected through interviews was incomplete, it could not be presented in a systematic form or analysed statistically, and we therefore present it in summary form. In Sirsi-Honnavara, Karnataka Forest Department and Karnataka Revenue Department provided information on land use patterns, forest encroachment for agricultural purposes, and village populations.

Results

Mammal species

Of the 34–35 species listed known from the two areas (Appendix 2), 31–32 were recorded during this study (only local information is available for the two species of otter that potentially occur in the area, and we are unable to determine whether one or both of the species are present). On the Red List (IUCN, 2003) 14 of these 35 species are in one of the threatened categories (one Critically Endangered, three Endangered, 10 Vulnerable), three are categorized as Lower Risk: near threatened and one as Data Deficient. Six of the recorded species are endemic to India (Appendix 2). Although we did not record the occurrence of the rusty spotted cat *Felis rubiginosa*, fishing cat *Felis viverrina* and Malabar civet *Viverricula megaspila*, they were previously known from both areas (Prater, 1993; Rai & Kumar, 1993; Yogananda & Kumar, 1995). Leopard cat *Prionailurus bengalensis*, Travancore

flying squirrel *Petinomys fuscocapillus* and Nilgiri marten *Martes gwatkinsi* were recorded only in Brahmagiri-Makut. Lion-tailed macaque *Macaca silenus* was present in all Forest Ranges except Janmane and Kumta in Sirsi-Honnavara; only a lone male has been sighted in recent years in Brahmagiri-Makut. Nilgiri langur *Semnopithecus johnii* was found only in Srimangala in Brahmagiri-Makut. Tiger *Panthera tigris*, leopard *P. pardus*, dhole *Cuon alpinus* and jackal *Canis aureus* were the predominant larger carnivores found in the study areas. Sloth bear *Melursus ursinus* signs were not observed in either Makut Forest Range or Makut Wildlife Range but were recorded in other Ranges. Elephant *Elephas maximus* was absent from Sirsi-Honnavara but occurred in all Ranges of Brahmagiri-Makut. The other mammals listed in Appendix 2 were found in all Forest Ranges of both study areas.

Relative abundance of mammals

The encounter rates of most of the 10 larger species of mammals, sighted during the day, were higher in Sirsi-Honnavara than in Brahmagiri-Makut, whereas most of the nine smaller species of mammals, spotted during the night, were generally more common in Brahmagiri-Makut. The overall daytime encounter rate of the five arboreal mammal species seen in Brahmagiri-Makut and Sirsi-Honnavara was 2.22 and 18.52 km^{-1}, respectively (Table 2), and significantly higher ($z = 27.93$, $P = 0.01$) in Sirsi-Honnavara. The overall daytime encounter rate of the five herbivorous terrestrial mammal species seen was 0.187 km^{-1} in Sirsi-Honnavara, which was significantly higher ($z = 3.02$, $P = 0.01$) than the rate of 0.088 km^{-1} in Brahmagiri-Makut (Table 2). A relatively low number of four small carnivorous mammal species were seen during night-time walks (Table 3), and the number

Table 2 Number and number per km of arboreal and terrestrial herbivorous mammals seen during daytime walks in Brahmagiri-Makut (238 km) and Sirsi-Honnavara (198 km).

	Brahmagiri-Makut		Sirsi-Honnavara	
Species	No.	No. km^{-1}	No.	No. km^{-1}
Arboreal				
Hanuman langur *Semnopithecus entellus*	137	0.576	1,784	9.010
Nilgiri langur *Semnopithecus johnii*	39	0.164	0	
Bonnet macaque *Macavca radiata*	285	1.197	1,045	5.278
Lion-tailed macaque *Macaca silenus*	18	0.076	790	3.990
Indian giant squirrel *Ratufa indica*	49	0.206	48	0.242
Total	528	2.218	3,667	18.520
Terrestrial herbivores				
Sambar *Cervus unicolor*	11	0.046	6	0.030
Wild pig *Sus scrofa*	7	0.029	24	0.121
Indian spotted chevrotain *Tragulus meminna*	1	0.004	3	0.015
Indian muntjac *Muntiacus muntjak*	1	0.004	4	0.020
Gaur *Bos frontalis*	1	0.004	0	
Total	21	0.088	37	0.186

Table 3 Number and number per spotlight hour of small carnivorous and other small mammals encountered during night-time walks in Brahmagiri-Makut (27 spotlight hours) and Sirsi-Honnavara (46 spotlight hours).

	Brahmagiri-Makut		Sirsi-Honnavara	
Species	No.	No. h^{-1}	No.	No. h^{-1}
Small carnivores				
Brown palm civet *Paradoxurus jerdoni*	4	0.148	4	0.087
Asian palm civet *Paradoxurus hermaphroditus*	2	0.074	2	0.043
Small Indian civet *Viverricula indica*	1	0.037	0	
Leopard cat *Prionailurus bengalensis*	1	0.037	0	
Total	8	0.296	6	0.130
Other small mammals				
Travancore flying squirrel *Petinomys fuscocapillus*	5	0.185	0	
Giant flying squirrel *Petaurista petaurista*	15	0.555	30	0.652
Slender loris *Loris tardigradus*	11	0.407	15	0.326
Indian spotted chevrotain *Tragulus meminna*	6	0.222	0	
Indian crested porcupine *Hystrix indica*	1	0.037	1	0.022
Total	38	1.407	46	1.000

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sighted per spotlight hour was not significantly different between the two areas ($z = 1.73$, $P > 0.05$). However, the number of five other species of small mammals seen per spotlight hour in Brahmagiri-Makut (1.4 spotlight h^{-1}) was significantly higher ($z = 3.91$, $P = 0.01$) than in Sirsi-Honnavara (1.0 spotlight h^{-1}) (Table 3). Evidence for the other 13 species of mammals (Appendix 2) came from indirect signs.

Hunting practices

Most families on the eastern and western borders of Brahmagiri-Makut owned licenced and unlicenced guns, respectively, which were used for hunting (Table 4). Large mammals were generally hunted in preference to small mammals. Hunting was for both illegal commercial purposes and personal consumption. On the western border, because of beliefs in medicine based on the use of animal parts, especially primates, a lion-tailed macaque fetched 4,000–5,000 rupees (US $90–100), a Nilgiri langur *c*. 3,000 rupees and a Hanuman langur *c*. 200 rupees per kg. There were no religious inhibitions against the hunting of any species, which mainly took place during the daytime when larger mammals could be easily seen.

In Sirsi-Honnavara, in addition to the use of guns, various traps designed for certain species were used for hunting (Table 4). We saw a total of 37 traps (0.18 traps km^{-1}). Most animals hunted or trapped were small mammals. Hunting of primates was mostly avoided, for religious reasons (as a monkey is accorded a godlike status), except by Beduvavaru, a nomadic tribe that occasionally visit the forest. Farmers of the Vokkaliga Gowda caste did not hunt flying squirrels, and the Hakki Koramaru tribe caught mainly small terrestrial mammals.

Discussion

The southerly Brahmagiri-Makut is a conspicuous ecotone in the Western Ghats because it is at the southernmost range of forests dominated by *Cullenia*, whereas the northerly Sirsi-Honnavara is at the northern edge of climax tropical rainforests (Pascal, 1988). The northernmost range of the Nilgiri langur, which is widespread in the southern areas of the Western Ghats, where it is sympatric with lion-tailed macaque and occasionally with bonnet macaque (Singh *et al.*, 1997; Ramachandran & Joseph, 2001), is at the Brahmagiri-Makut ecotone. The northernmost range of the lion-tailed macaque is at Sirsi-Honnavara, coincident with the northernmost range of dipterocarpous forests.

Two species of flying squirrels have been reported to occur in the Western Ghats. Whereas the large brown flying squirrel *Petaurista petaurista philippensis* occurs throughout peninsular India, the small Travancore flying squirrel *Petinomys fuscocapillus fuscocapillus* is restricted to the Western Ghats (Prater, 1993). The distribution of this species is poorly known but our sightings were only in wet and humid forests at 60–200 m altitude on the western slopes of Brahmagiri-Makut. Previously the species has been seen in coconut groves of coastal Kerala (Kurup, 1989) and in the Indira Gandhi Wildlife Sanctuary in Tamil Nadu. The encounter rate of the Travancore flying squirrel indicates that there is probably a relatively healthy population of this species in Brahmagiri-Makut.

Table 4 Summary of the information obtained from interviews (Appendix 1; see text for details) about hunting practices in Brahmagiri-Makut and Sirsi-Honnavara.

Practice	Brahmagiri-Makut	Sirsi-Honnavara
Licenced guns with the predominant community (Source: Police Department)	Owned by 91% of familes (Kodava families on eastern border)	Data not available
Unlicenced guns (Source: Forest Department)	Owned by 65% of families in four villages in Kerala on the western border	Data not available
Locally made guns (Source: Interviews)	Few	Many
Guns used for hunting	Mainly personal guns	Borrowed & also personal
Traps found	2	37
Hunting strategy	Guns, rarely traps	Traps & guns
Mammals hunted	Mainly large mammals	Mainly small mammals
Encounters with hunters during this study (daytime)	7	0
Hunting time	Mainly daytime	Mainly night-time
Hunting purpose	Mainly commercial (sale of meat & for medicinal use); also for personal consumption & crop protection	For personal consumption & crop protection
Species hunted for commercial purposes	Primates, gaur, pig, sambar	None
Religious inhibitions against hunting	None	Strong for primates; selective within certain communities or castes

The discovery of this new locality for this little known species significantly enhances prospects for its conservation, and further surveys need to be carried out in the low altitude forests on the western slopes of the Western Ghats in the states of Kerala and Karnataka.

Although a small population of elephants was formerly present in Sirsi-Honnavara (Nair & Gadgil, 1978), it has now completely disappeared (Kumara & Singh, in press) and there are no areas nearby that harbour elephants. Brahmagiri-Makut is close to large belts of deciduous forests of Nagarahole National Park, which harbours a large population of elephants, and there is frequent movement of elephants between the two areas (Nath & Sukumar, 1998).

In areas relatively free of human interference the distribution and abundance of mammal species can be explained largely in terms of ecological variables. However, in human dominated landscapes, such as those of Brahmagiri-Makut and Sirsi-Honnavara, species richness and abundance are significantly influenced by anthropogenic factors. In this context one of our most important findings was the effect of hunting practices and belief systems on the relative abundance of mammals, with larger, diurnal mammals being more common in Sirsi-Honnavara and smaller, nocturnal mammals being generally more common in Brahmagiri-Makut. In the latter area the predominant communities of Kodavas, Muslims and Christians are active hunters and do not have religious inhibitions against hunting any particular species. Kodavas have been accorded the right, dating from the British colonial period, to own licenced guns. On the western border of Brahmagiri-Makut mammals are hunted both for consumption and for sale of their meat. The subsistence communities of Sirsi-Honnavara farm smallholdings in the forests. Most of the guns in this area are unlicenced and traps are widely used for hunting. Being predominantly Hindus, these communities accord a holy status to primates and do not hunt them; hunting is for personal consumption only.

In Brahmagiri-Makut indiscriminate daytime hunting using guns would have the greatest impact on large diurnal mammals as they are easily sighted, whereas in Sirsi-Honnavara night-time hunting with traps and avoidance of certain species such as primates would affect small mammals more than large mammals. Apart from the distribution pattern of the Nilgiri langur and elephants the two areas are otherwise largely comparable in habitat structure and in the composition of mammals. The difference in the relative densities of large and small mammals between the two areas is probably due to the differences in religious beliefs and hunting practices.

Karanth (1985) estimated that there were 10 groups of the Endangered lion-tailed macaque in Brahmagiri-Makut, whereas 18 years later we were only able to locate one surviving group. The Brahmagiri-Makut ecotone is one of the few areas in the Western Ghats where all of the primate species of southern India can still be found, but the area does not receive any official protection. In Sirsi-Honnavara encroachment of agriculture into the forest is a regular practice, and the remaining forests, although contiguous, now exist only as a network of narrow strips. The forest is in danger of being fragmented, as has happened in the Anaimalai Hill ranges of the southern Western Ghats (Umapathy & Kumar, 2000; Singh *et al.*, 2002). Many of the mammals of this area will then be isolated in small forest fragments.

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Appendix

The appendices for this article are available online at http://journals.cambridge.org

Biographical sketches

H.N. Kumara is studying the ecology and distribution patterns of mammals in the state of Karnataka. He has previously worked on the behaviour of non-human primates in the Western Ghats and his interests also include the conservation of threatened species.

Mewa Singh has been working on the ecology and behaviour of mammals, especially of non-human primates, for nearly three decades. He has worked on eight species of primates, mostly in their wild habitats. His primary interest is to apply behavioural data for the conservation and management of mammals, and thereby bridge the gap between behavioural and conservation biology.