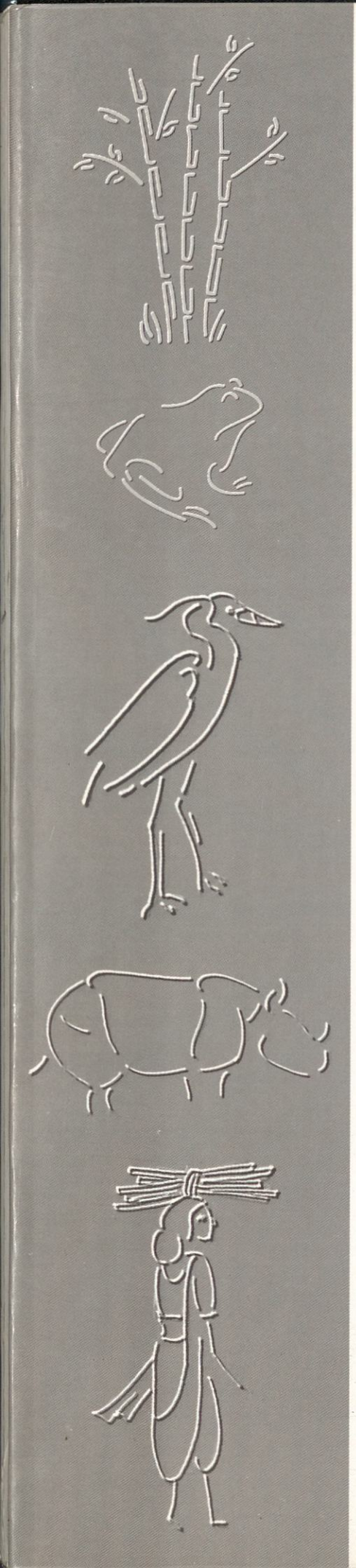

WILDLIFE CONSERVATION, RESEARCH, AND MANAGEMENT

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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WILDLIFE CONSERVATION, RESEARCH, AND MANAGEMENT

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PREFACE

As the human population continues to increase and wilderness areas continue to dwindle the opportunities for research, conservation, and management of wilderness resources in the future will decline. A major change in the attitude of the societies from their consumptive lifestyles to a more harmonious coexistence with nature is urgently needed. Until this happens, it would be essential to safeguard the remnants of the wilderness resources with the zeal of a missionary. To achieve effective conservation, it would be essential to consolidate and use existing knowledge of species, ecosystem functions, conservation strategies and socio-economies in an integrated manner for optimal returns.

Generating reliable scientific knowledge is a time consuming process for which conservation actions can seldom wait. Thus, conservation action essentially is based on best information available today. Practitioners of conservation in developing countries rarely have ready access to expensive journals where most of this information is available. Our attempt here was to invite prominent wildlife biologists, managers, and socio-economists to contribute relevant research and management related articles and case studies to compile them into a single multidisciplinary publication thereby increasing their accessibility to practitioners of conservation. Commemorating fifty years of India's Independence (1998), we at WII organized a National Seminar on Wildlife Conservation, Research and Management to take stock of progress made in wildlife science and conservation practice. Studies ranging from national history of single species, to understanding ecosystem processes, and finally the integrated conservation practice of involving various stakeholders, incorporating socio-economic aspects, are all included in this publication. The peer review process of invited manuscripts and delays in funding support delayed the publication of the proceedings for several years. We are grateful to all the authors of the various articles for revising their contributions incorporating the peers concerns. We also thank all the authors for patiently bearing the painfully long delay in the publication of their work.

We thank Mr. Gyanesh Chhibber who worked on the typescript and layout of the manuscript and revised the several drafts keeping track of them over several years. We thank Shri P.R. Sinha, Director, Wildlife Institute of India for providing the funding needed for this publication.

RESOURCE AVAILABILITY AND UTILIZATION IN THE FORESTS SURROUNDING THE MIGRATORY VILLAGES OF UTTARKASHI, GARHWAL HIMALAYA

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Abstract: Incompatible landuse practices such as expansion of agriculture on steeper slopes, uncontrolled livestock grazing and extensive logging and lopping for fuelwood and fodder have been the principal causes for the degradation of Himalayan forests. We quantified the availability of forest biomass, current levels of pressure on the forests and possible consequences on high altitude forests in Saura- Belak area (1700-3400m) located in upper catchment of river Bhagirathi, Garhwal Himalaya. Structure, composition and standing biomass of woody vegetation were quantified along the altitudinal and human use gradient. Patterns of fuel wood and fodder extraction by the migratory as well as settled villagers were assessed based on structured questionnaires and direct observations. The study reveals that there is a spatio-temporal variation in the resource extraction. The standing biomass of preferred woody species at low altitude villages and summer settlements (*chhans*) were 140.68±26.91 t/ha and 477.46±31.8 t/ha respectively. Average fuel wood consumption per household at permanent villages was 14.65±0.78 kg/day whereas consumption per *chhan* at temporary settlements was 36.42±3.35 kg/day. There was a limited choice of fuel wood and fodder species at higher altitude. Higher per capita consumption of fuel wood per *chhan* located near timberline suggests that current practice of migration to high altitudes may not be sustainable in the long run. The 'nibble effect' at lower altitude seems to be leading to increase in distance between forests and village . Both these processes might result in decline of the relatively undisturbed forest at middle elevation which has maximum available biomass and regeneration capacity. Implications of the biomass utilization patterns and migratory lifestyle of locals on the conservation values of high altitude forests are discussed in the paper.

WILDLIFE CONSERVATION, RESEARCH & MANAGEMENT : 1-7

Key words: degradation, fuelwood, landuse, lopping, temperate forests, transhumance.

The climax forests of the Western Himalaya are characterised by the dominance of one or the other species of oak (*Quercus spp.*) These forests are not only intricately associated with hydrological balance but also form the life support system for its inhabitants including human beings and wild fauna (Singh and Singh 1992). The sustainability of this resource base depends greatly on the productivity and resilience of these forest and the actions of the local inhabitants. Excessive resource use and faulty landuse practices by the people are said to be cause of ecosystem degradation and imbalance in the resource availability. However, local people alone can not be blamed every time for these degradational trends (Ives and Messerli 1989, Guha 1989). In fact, many sectors in the Himalaya represent a good harmony between man and nature. Relatively low population densities and traditional lifestyle have helped in the retention of adequate forest cover and natural resources in this area (Metz 1990). Natural calamaties and "mountain syndrome" which prohibits the rapid growth, maturity and reproductive efficiency of the vegetation and rapid change in socio-economic and landuse patterns are the real causes of environmental degradation in this region (Singh 1983, Khanka 1993, Fox 1994, Singh 1996, Duffield et al. 1998). One of the common traditional landuse practices in the western Himalaya has been nomadic pastoralism. This system represented an example of spatio-temporal resource use which is gradually transforming to nuclear transhumance (Farooquee 1992). This transformation is leading to simultaneous resource use at permanent as well as temporary settlements creating large "blanks" in the forests (Moench and Bandhyopadhya 1986, Singh and Singh 1991). In this paper we present a case study from Garhwal Himalaya which deals with the past and current land use practices and resource utilization patterns by the local people and their conservation implications. The broad objectives of this study were: i) to quantify availability of biomass (fodder and fuelwood) along the human use gradients, ii) preparation of seasonal calendar of the various activities of villagers, iii) comparison of biomass consumption by locals at their permanent and temporary settlements (*Chhans*).

STUDY AREA

The tract between village Saura to Belak (a sub-alpine area), which covers an area of approximately 27 km^2 in the upper catchment of river Bhagirathi in district Uttarkashi, was selected for the study. The area lies on the north facing slope with an altitudinal gradient of 1700-3600m. The major vegetation types of the study area are Himalayan Moist Temperate Forest, Himalayan Dry Temperate Forest, Subalpine Forest and Alpine scrub (Champion and Seth 1968). There are one resident and three migratory villages dependent

on these forests for their basic requirements of fuel, fodder and leaf-litter. Broad landuse categories of the area include permanent settlements, irrigated and rainfed agricultural fields, scrub vegetation, mixed broad leaf forests, sub-alpine oak-fir forest, temporary settlements and alpine meadows locally known as "*chhans*" and "*bugyals*" respectively. A perennial rivulet called Saura Gaad drains the area and forms a tributary to river Bhagirathi. Pilgrims and locals used to follow Gangotri-Belak-Budhakedar-Kedarnath trek until Gangotri road was opened in 1962. Even today, locals, trekkers and some pilgrims follow the same trek. The migratory graziers (*Gujjars*), pilgrims and trekkers use forest resources exclusively during summer and rainy seasons whereas the locals depend on the forest resources throughout the year for their basic needs.

METHODS

The present study was undertaken during July 1996 to January 1998. Vegetation parameters were quantified in one hectare plots (n=62) marked at an interval of 100m elevation using 10x10m quadrats (n=10) (Misra 1968). Data was collected on species diversity, number of individuals of woody plants, their GBH, height and canopy cover. Diversity and above ground biomass of the three sites were calculated using Shannon & Wiener diversity index (Magurran 1988) and regression equation : $\ln Y = a + b \ln X$, where Y= dry weight of the component X= DBH (cm), a= Y intercept and b= slope or regression coefficient (Singh and Singh 1992, Adhikari et al. 1995) respectively.

A door to door survey was conducted in the four villages (n=229) of the study area to ilicit information on socio-economic status, land use and resource use pattern. Structured questionnaires (Patton 1981, Clarke 1986) were used to interview members of the each household. Based on the initial survey, households were stratified and 20% of the households (n=44) in each strata were selected randomly for monthly monitoring. There were seven cattle camps (*kharaks*) of which four were selected for the present study. In these four cattle camps, there were a total of 80 *chhans* of which 34 *chhans* were selected randomly for estimating biomass use. Parameters selected for biomass estimation included weight, composition and phenology of the fodder fed and weight and size (length and circumference at base, CAB) of the fuelwood burnt. One sheep equivalent was defined as one livestock unit (Singh et al. 1988). In the rapid survey of the area different trails were given scores for various disturbance parameters. Later based on these scores the trails were stratified as near village, near *chhan* and least disturbed sites. In each trail belt transects (n=60) of 30x 5m were marked at a distance of 150m to assess biotic pressures following Sale and Berkmuller (1988). These belts were monitored on a monthly basis and parameters such as number and GBH of cut & lopped trees and evidences of grazing signs and wild animals were noted.

Four entry and exit points to villages were monitored regularly to record information on removal of biomass resources. Number of headloads of forest produce coming to villages were counted and weighed at each entry point.

RESULTS

Socio-economic aspects

There were 229 families in the study area of which 160 were migratory. A general profile of the area prepared based on door to door survey revealed that the study area had a total human population of 1495. Average family size was of 6.11 ± 0.04 with a male to female ratio of 1: 1.16. Of the total population, 27.42% was literate. More than 60% of the population belonged to Garhwali Rajputs, just two families of Nepali labourers were found in village Syaba. No tribal population was found in the villages of study area. Primary occupation of the people was based on agricultural activity (85.59%). Around 10% of the families in village Saura had service and business based occupation besides agriculture. The average per capita annual income ranged between Rs 873.33 to Rs 1249.52. One of the reason of this unusually low income could be the resistance on the part of the people to declare their real income.

Livestock (n=1268, where n is number of livestock) was kept basically for draught power and manure. Livestock comprised mainly of buffaloes, cows, oxen and mules. Very few families own sheep and goats now. Of a total of 987.812 ha of land holding in all four villages, village Saari had maximum land holding of 483.663 ha and Saura had least land holding of 133.76 ha. Just 1.15% (11.36 ha) of land at the lowest elevation village was irrigated. All other land was rain-fed. Cropping patterns differed with season. In kharif season (April-November) irrigated land was devoted to paddy cultivation whereas in rainfed land, cultivation of potato has increased (406.44±175.85 Q/Yr/village). Approximately three fields (*dogaddas*) (40X50m) per year were added after clearing the forested abandoned land (pers. observ). Few other crops like French bean (42.78± 14.71 Q/Yr/village) and pulses were also grown. Interviews with the locals revealed that, 96.51% (n=221) families used to grow indigeneous crops such as amaranth (*Amranthus* sp,), millet (*Oplismenus frumentaceus* Linn.), kodu or finger millet (*Eleusine coracona* Linn.), cheena (*Panicum miliaceum* Linn.), phaphara or buck wheat (*Fagopyrum tataricum* Goertn.) and bhatt (*Glycine soja* Sieb.) in the last decade. The cultivation of amaranth (195.92 ± 19.44 Q/Yr/village), rain-fed paddy (83.19 ± 7.14 Q/Yr/village) and others (32.01 ± 4.99 Q/Yr/village) showed a decline. Just 48.47% (n=111) households now cultivate these crops that too in a minor proportion.

Table - 1: Density, Biomass, Regeneration and Diversity of Preferred species at three sites

Species	Density (no/ha)			Biomass (t/ha)			Regeneration (no/ha)			Diversity (H')		
	V	C	LD	V	C	LD	V	C	LD	V	C	LD
Cedrus deodara	*97.04*	*NA*	*8.12*	*58.02*	*NA*	*1.9*	*NA*	*NA*	*NA*	*1.9*	*1.1*	*1.6*
Pinus roxburghii	57.06	NA	NA	53.41	NA	NA	NA	NA	NA			
Quercus leucotrichophora	63.6	NA	93.25	22.9	NA	33.25	71.62	NA	7.85			
Lyonia ovalifolia	50.4	NA	34	6.2	NA	4.2	37.74	NA	0.7			
Rhododendron arboreum	6.6	14	54.75	7.1	1.8	7.9	24.11	26.6	98.14			
Litsea umbrosa	29.1	NA	8.75	2.6	NA	0.4	NA	NA	NA			
Symplocos chinensis	7	1	21	0.3	0.04	0.65	NA	NA	NA			
Aesculus indica	0.2	1	55.12	0.04	1.5	78.3	NA	0	NA			
Quercus floribunda	0.34	5	122	0.12	5.4	141.3	0	0	118.96			
Abies pindrow	NA	78	50.75	NA	NA	64.11	NA	NA	NA			
Ilex dipyrena	NA	1	11.5	NA	0.04	0.6	NA	0	NA			
Quercus semecarpifolia	NA	297	16.75	NA	371	32.9	NA	19.99	15.71			
Juglans regia	NA	NA	21	NA	NA	12.32	NA	NA	NA			
Total	**311.34**	**397**	**496.9**	**140.68**	**477.48**	**377.73**	**133.47**	**46.59**	**241.36**			

V=Near village site, C=Near chhan site, LD=least disturbed site, NA=Not available

The seasonal calendar of various activities showed that villagers were involved in two types of interrelated activities *viz.*, extraction of biomass from forests and agricultural activities. Three villages follow a seasonal migration to *chhans* with their livestock. The availability of fresh grass at higher elevation during summer, less use of animals for agricultural purposes when all the cropping work has been finished force locals (one or two members per family) to migrate to *chhans* with their livestock. Villagers had to depend on forest for their basic needs of fuel, fodder, leaf-litter and Non Timber Forest Products (NTFPs). There was a seasonal variation in the composition of various resources extracted from the forest. Firewood being the major source of fuel was extracted throughout the year whereas lopping for leaf fodder mostly occurred during months of February-May and leaf-litter was collected during winter season when cattle were kept in the sheds. Extraction of bamboo (*Arundinaria falcata*) culms occurred in the month of April-July when it was needed for supporting French bean seedlings .

Resource availability

The density (individuals/hectare) of preferred (for fuelwood and fodder) woody species was minimum near village (311.34±11.44) and maximum in least disturbed site (496.99±10.37). Diversity (H') of woody species was maximum (1.9) in forests surrounding the villages and minimum near *chhans* (1.1). The available aboveground woody biomass of preferred species was maximum near *chhans* (477.48±52.25 t/ha) whereas minimum near village (140.68±7.14 t/ha) (table-1).

Resource use

Fuelwood and fodder are the primary non-agricultural products necessary for the livelihood of locals. There was a spatio-temporal variation in fuelwood and fodder extraction. At villages, fuelwood was either cut directly from the forest or dead wood of any kind was collected. Approximately 45% households also used dried twigs for fuel gathered as a by-product of leaf fodder. Fuelwood consumption at permanent settlements varied significantly with the season (1-way ANOVA, F-value= 7.16, $p<0.001$, n=4). It was maximum during winter (20.18±0.44 kg/day/h.hold) and least in the summer (9.86± 0.83kg/day/h.hold). Whereas at *chhans* the fuelwood consumption was restricted between April-September, but due to low temperature at higher elevations fuelwood burnt was quite high as compared to villages (figure-1). Also a significant difference in the size (length and circumference at base) of the fuelwood burnt at two settlements (table-2) was found.

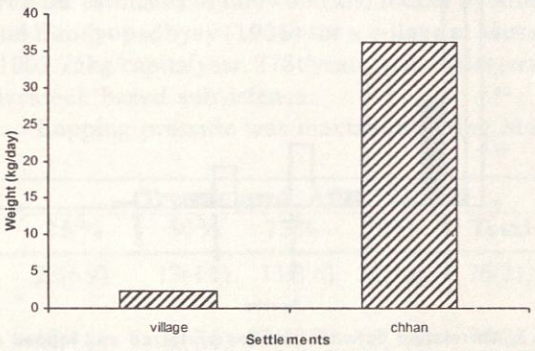

Fig - 1. Per capita fuelwood consumption at two settlements in rainy season

Table-2: Variation in CAB and Length of fuelwood consumed at two settlements

Location	CAB*(cm)	Length (cm)
Village (n=4)	14.93 ± 0.7	83.78 ± 3.45
Chhan (n=4)	25.77 ± 3.68	315.5 ± 66.54
	16.30 ± 2.1	91.45 ± 6.07

*Circumference at base, ±=SE

At village medium sized branches from full canopy trees were mainly lopped whereas at *chhans*, along with one or two thick branch, few loads of medium size branches was burnt. The composition of fuelwood species too varied at the two settlements. At village, there was a choice of species available as fuelwood whereas at *chhans*, where *Quercus semecarpifolia-Abies* forms the timberline, the choice was limited and thus due to its burning and heating quality *Q.semecarpifolia* was preferred (figure-2 & 3)

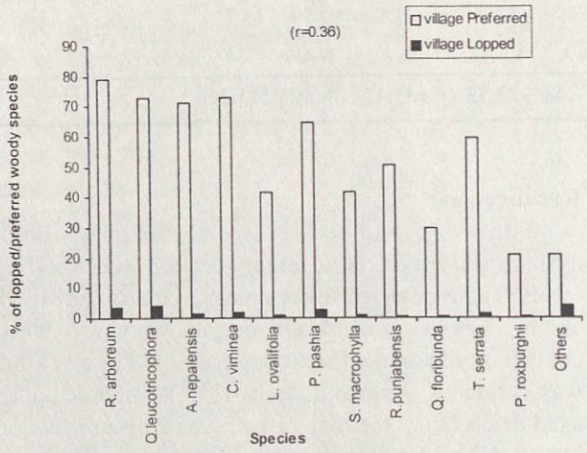

Fig - 2. Correlation between species preferred and lopped at village

At permanent villages where most of the livestock remained from Oct.-April, they were strictly stall fed during the periods of snowfall otherwise stall feeding

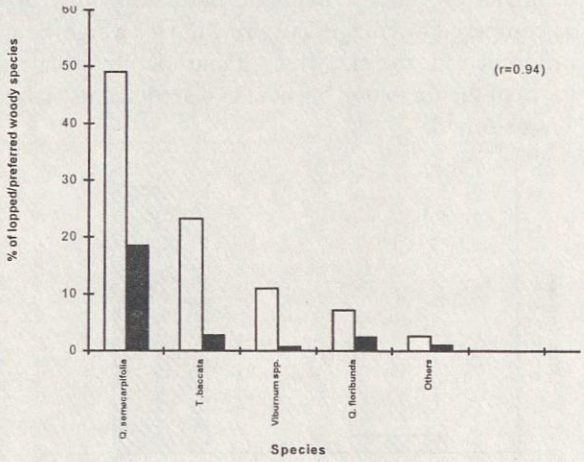

Fig - 3. Correlation between species preferred and lopped at chhan

was accompanied with grazing. Fodder demands were basically fulfilled through leaf fodder, agricultural by-products and grass fodder (green and dried). There was a seasonal variation in the type of fodder fed. Agricultural by-products constituted the major feed in winters while leaf fodder lopped from nearby forest was fed during summer (table-3). At *chhans*, most of the time animals were grazed. Stall-feeding was needed for calves and milch cows during night. This greatly reduced the demand (7.91±0.66 kg/day/l.u). Consumption of leaf fodder per livestock unit varied significantly at two settlements in rainy season (figure-4). Species preferred as leaf fodder at *chhans* was of *Q.semecarpifolia* followed by *Thamnocalamus sp.* and *Q.floribunda* .

Table-3: Seasonal variation in fodder composition at village

Fodder Type (kg/l.u*/day)	Summer	Rainy	Winter
Leaf fodder	11.81 ± 2.8	1.94 ± 1.04	5.54 ± 1.25
Agriculture by-product	0.9 ± 0.42	4.13 ± 1.7	9.49 ± 1
Grass fodder	1.7 ± 0.59	0.39 ± 0.16	5.36 ± 0.62

*l.u= animal unit, ±=SE

Assessment of biotic pressure

During the initial survey (Oct. 1996), a total of 1004 woody plants representing 40 species were recorded

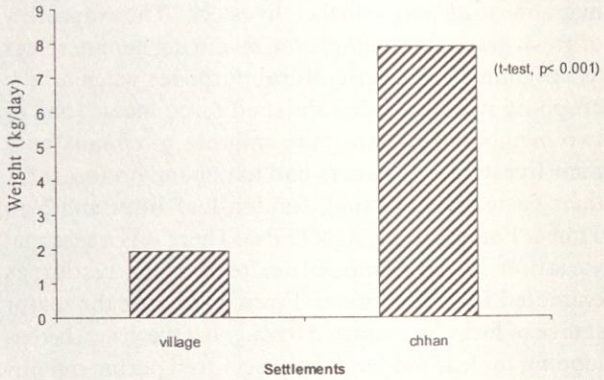

Fig - 4. Leaf fodder consumption at two settlements expressed as per livestock unit

in the sixty belt transects. Of the total trees, 35.96% were found near village, 28.98% near *chhans* and 35.06% in least disturbed sites (table-4). Near village, of the total 31 species, 54.84% were preferred as fuelwood, 9.68% as leaf fodder and 22.58% as both whereas near *chhans* of the total 14 species, 42.86% were preferred as fuelwood, 7.14% as leaf fodder and 28.57% as both (table-5). During initial survey cut signs near village were seen on 63.29% of trees, near *chhans* on 16.46% trees and in the least disturbed site on 20.25% of trees. By December 1997, of the total trees 21.05% were found cut near village and 25.42% near *chhans* with different percentage of cut signs (table-6). There was a spatio-temporal variation in resource extraction at the two

Table-4: Number of marked trees and species at three sites

Location	Total Trees	No. of Species
Near Village site	361(35.96)	31
Near Chhan site	291(28.98)	14
Least disturbed Site	352(35.06)	21
Total	**1004 (100)**	**40**

values in () indicate % of total

Table-5 : Use of different species at two Sites

Location	Total species	Fuelwood	Leaf fodder	Both
Near Village	31	17(54.84)	03(9.68)	07(22.58)
Near Chhan	14	06(42.86)	01(7.14)	04(28.57)

values in () indicate % of total

settlements. At village the biomass was extracted maximum during winter season (11.36%) whereas maximum biomass extraction near *chhans* was during rainy season (22.34%) of the total extraction (figure-5). A positive correlation was found between fuelwood species burnt and species lopped near two settlements. The most intensively lopped tree was banj oak (*Quercus leucotrichophora*) near village and kharsu oak (*Q.semecarpifolia*) near *chhans* (figure –2 & 3).

DISCUSSION

Transformation in the traditional lifestyle due to changing socio-economic conditions also leads to change in resource use pattern. In the present study area we had observed a clearcut shift from traditional subsistence based agriculture to cultivation of cash crops such as potato, French bean and cucumber. The indigenous crops were helpful in maintaining agro-ecosystem besides being the source of good fodder for livestock (Negi 1994). Composition of livestock has also changed since past two decades. Earlier, of a total number of 2343 livestock of which more than 50% composed of sheep and goat (Anon. 1969-70) but now more than 60% of the livestock is composed of cattle. This might put pressure on the forests for more leaf and grass fodder needs. Observations of the present study showed that new agricultural fields are coming up at a rate of approximately 3 fields/year for the cultivation of cash crops at the cost of abandoned land and forests. This might lead to receding forest boundaries as has been visualised in other parts of

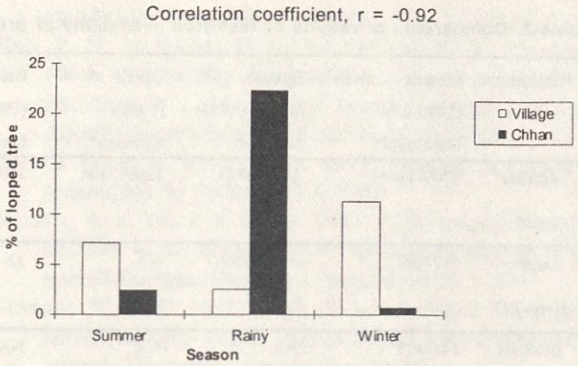

Fig - 5. Spatio-temporal variation in resource extraction

Himalaya (Moench and Bandhyopadyay 1986).

Data on availability of biomass and density of species revealed that the available biomass, density of trees and regeneration of most intensively lopped *Quercus spp.* near village was quite low whereas diversity was high. The reason for this could be coming up of secondary species under lopped oak canopy. At *chhans*, higher biomass of *Q. Semecarpifolia* which was most intensively lopped was observed due to old trees still standing and contributing large amount of biomass. However, data on regeneration revealed low number of saplings and seedlings per hectare near *chhans*. This could be due to climatic conditions and also germination failure of seedlings of *Q. semecarpifolia* under its own canopy (Troup 1921). A comparative account of results of present study with various other studies is mentioned in table-7. It was found from study that lowest (1700-2200m) and highest zone (>2700m) forests are under maximum pressure as these forests are utilized by locals.

According to Rai and Chakrabarti (1996) average per capita annual consumption of fuelwood in U.P. hills comes out to be 652 kg. Estimates of the present study for fuel wood (876kg/capita/year) and fodder (3.31t/a.u/year) consumed at the village level are comparable with other studies done at Nepal (829kg/capita/year) (Schmidt-Vogt 1990) and Sikkim (3.59t/cow/year) (Sundriyal and Sharma 1996). This could be due to similar altitudinal range and pattern of resource use. But the results of present study do not compare with the estimates of fuelwood and fodder by Moench and Bandyopadhyay (1986) for a village at Mussorie (1003.75kg/capita/year, 278t/year) where villagers had livestock based subsistence.

Lopping pressure was maximum during March-

Table-6:Lopping intensity of trees marked at two sites

Location	Total Trees	Initially Lopped	Trees lopped After* Oct.96				
			25%	50%	75%	100%	Total
Near village site	361(100)	150	25(6.9)	17(4.7)	13(3.6)	21(5.8)	76(21.1)
Near chhan site	291(100)	39	12(4.1)	22(7.6)	37(12.7)	03(1.0)	74(25.4)

* represent different lopping percentages, values in () represent % of the total

Table-7 :Comparison of results of resource availability of present study with various other studies

Parameter	Present study (1996-97) Uttarkashi*	Saxena & Singh (1982) Kumaun	Upreti *et al* (1985) Kumaun*	Rao *et al* (1990) Meghalaya*	Adhikari *et al* (1995) Kumaun	Singh *et al* (1995) Corbett N.P	Sundriyal & Sharma (1996) Sikkim*	Metz (1997) Nepal
Altitude (m)	1700-3400	1200-2523	1200-2400	1500-1955	2300-2650	250-1100	1350-2550	2400-2900
Density (trees/ha)	312-497	420-1300	NA	12-453.3	280-480	180-860	536-756	408-650
Biomass (t/ha)	141-478	NA	NA	NA	502-590	NA	385-683	NA
Regenera-tion (no./ha)	47-241	NA	NA	4-892	20-300	90-8591	1267-6726	624-72000
Diversity (H')	1.1-1.9	0-2.95	0.52-2.58	0.6-1	NA	1.8-3.6	3.7-4.6	7-13
Remarks	High diversity, low standing biomass & lack of regeneration at disturbed sites (lower elevation	Comparable to the present study because of maximum tree diversity & least regeneration at lowest elevation & maximum at mid-elevation	Comparable to the present study because of poor regeneration at lower altitude disturbed site	Regeneration of secondary species at disturbed sites is comparable to present study whereas higher species diversity at undisturbed site does not conform with present study	Standing biomass & density of timberline species is comparable to present study	Species composition & diversity different due to altitude variation	High species diversity & lack of regeneration of canopy species in disturbed sites. Higher biomass due to abundance of big trees is also comparable.	Higher tree & sapling density at little disturbed temperate forests compared to the present study.

*** studies carried along altitudinal /disturbance gradient**

June near village and during May-September near *chhans*. This might affect regeneration of oaks as this is the time when flowering and pollination take place on the new shoots (Troup 1921). Repeated lopping also leads to 'bushy' form of the severely lopped trees and increased growth of thorny and unpalatable species (Upreti et al. 1985, Moench and Bandhyopadhyay 1986, Singh and Singh 1991).

Present practice of nuclear transhumance increases the biomass consumption as the resources are simultaneously used at two settlements. Overall per capita consumption of fuelwood which should otherwise decrease during summer and rainy season, remains same or even increases due to firewood burnt at the *chhans*. Studies of Metz (1990) and Schmidt-Vogt (1990) which are comparable to the present study also reveals that fuel wood consumption at the temporary settlements (*kharaks)* is greatest due to round the clock burning of fuelwood to keep the place warm.

In traditional transhumance rarely were two settlements occupied at the same season. This helped in sustainable use of the resources. Most of the people had pastoralism as the main basis of livelihood whereas agriculture was just subsistence based. Van panchayats, weed management, mixed cropping and shifting cultivation were few practices which had their own value from conservation point of view (Guha 1989).

From the present study it can be concluded that in the near future unavailability of preferred woody species for fuelwood and fodder around villages is likely to force people to disperse to relatively undisturbed mid elevation forests. Increased human activities at the timberline due to increasing number of trekking parties, besides summer migration of locals and *Gujjars* (nomadic tribe) will lead to an increase of new *chhans* and hotels. These activities will ultimately result in degradation of camping sites along with increased fuelwood and fodder demand. Thus increased human activities at lower and higher elevation forests, is likely to further shrink relatively undisturbed mid elevation forest.

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METAPOPULATION DYNAMICS AND LANDSCAPE EFFECTS IN SMALL MAMMAL POPULATIONS OF MONTANE ECOSYSTEMS IN SOUTHERN INDIA

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Abstract : Small mammal populations of montane ecosystems of the Nilgiris in southern India were studied. Natural and man-made habitats were sampled using 0.45-ha, 0.49-ha and 1-ha plots from January, 1994 to September, 1996. Small mammals were live-trapped using standard Sherman traps; animals were captured, marked and released. Vegetation structure was sampled at all the sites. There are eight species of small mammals, including six rodents and two shrews, in the *sholas* and two species of small mammals in the grassland. *Rattus rattus* is dominant in the *sholas* while *Millardia meltada* is the only rodent found in the grassland. While these two species are mutually exclusive in the natural ecosystems, they coexist on plantations. Forest small mammals were never captured in the grassland. Further, synchrony in small mammal population fluctuations was higher in contiguous patches than in patches separated by grassland. Hence the grassland seems to act as a barrier to movement of forest small mammals. Small mammal communities differed in composition between *sholas* and adjacent plantations. However, the population structure of *Rattus rattus* was not significantly different between *sholas*, *shola*-plantation edges and plantations (*Eucalpytus globulus* and *Acacia spp.*), though densities varied considerably. Though the within-site synchrony was high in contiguous patches, synchrony between adjacent *shola* and plantation populations was very low. It is clear that the *shola*-grassland and *shola*-plantation systems are very different landscapes for small mammal populations. Edge permeability and connectivity between similar landscape elements differ significantly between the two systems. Metapopulation effects are likely to play an important role in the long term persistence of rare species in *shola*-grassland ecosystems. On the other hand, habitat quality of different kinds of plantations is likely to be a major factor in influencing small mammal populations in *sholas* in *shola*-plantation ecosystems. Differences in landscape effects could lead to differences in predator-prey dynamics. An understanding of the system would also facilitate conservation efforts by outlining specific management strategies in different landscapes.

WILDLIFE CONSERVATION, RESEARCH & MANAGEMENT :8-12

Key Words: Connectivity, persistence, *Rattus rattus*, synchrony.

INTRODUCTION

The island biogeography framework (MacArthur and Wilson 1967) has been extended to insular groups of animals (Brown 1971, Lomolino et al. 1989) to study theoretical aspects of diversity, community structure, and populations dynamics. The theory is also being increasingly used in conservation biology in fields such as population viability analysis (Shaffer and Sampson 1985) and in refuge design (for review, see Shafer 1990) Islands have hence served as 'natural laboratories' for studying theories and testing hypotheses in ecology (Diamond 1975). However, the rules of refuge design have not rested solidly on the island biogeography theory, and much of the population biology that has been studied under this framework may actually come under the realm of metapopulation dynamics (Hanski and Simberloff 1997). Populations must maintain critical population sizes to avoid extinction in forest fragments (Shaffer 1981, Shaffer and Sampson 1985), and the persistence of small populations in fragmented forests is of much interest in this context. Metapopulation dynamics offers a framework in which the presence and absence of one or more species can be modeled in a landscape comprising several patches in a matrix.

The montane ecosystems of the Nilgiris provide an ideal natural system in which to study these processes, as they are composed of patches of montane evergreen forests in a matrix of grassland. It is also interesting to study the impact of changes in the ecosystem : the replacement of grasslands with plantations has altered the characteristics of the landscape such as edge permeability and connectivity between patches. This is bound to have an impact on the population dynamics of small mammals and may have consequences for predators that depend largely on rodents for prey.

METHODS

STUDY AREA

The higher altitudes of the Nilgiris -located between 11°10' - 11°30' N and 76°25' - 77°00' E in southern India- have a montane ecosystem, comprising of patches of stunted evergreen forest (locally known as '*shola*') surrounded by grasslands. In the Nilgiris, most grasslands and much of the forest has been replaced by exotic wattle (*Acacia spp.*), pine (*Pinus roxburghii*), tea (*Camellia sinensis*) and bluegum (*Eucalyptus globulus*). The *shola* patches, usually 1-10 ha in size, have a sharply defined ecotone with the grasslands, which is maintained by frost and fire.

The natural vegetation has remained relatively undisturbed in the Upper Bhavani region, at the southwest corner of the Nilgiris, a part of the Mukurthi National Park (74 km^2) in Tamilnadu state. Thaishola (601 ha), twelve kilometres from Upper Bhavani, is

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the largest *shola* patch in the Nilgiris plateau. Both these areas, on the western slopes of the Nilgiris, receive 1500 - 2000 mm of annual rainfall, mostly between June and November.

Five patches, ranging in size from 2 ha to 60 ha, in Upper Bhavani and a single large patch in Thaishola were sampled using 0.49-ha and 1-ha plots. Species removal experiments at two of these plots provided information on immigration of small mammal into patches. *Sholas*, grasslands and plantations- tea, wattle, eucalyptus and pine- were sampled using 0.45-ha plots. (See Shanker 1998, Shanker and Sukumar 1998, for details of sampling). (Table 1).

SAMPLING PROCEDURE

Traps were placed at intervals of 10 metres so that each 0.49-ha plot consisted of 49 permanently marked trap stations, in a square grid of 7 × 7 traps (the 1-ha plots had 100 trap stations, in a 10 × 10 configuration). A standard Sherman live trap (22.9 × 7.6 × 8.9 cm) was placed on the ground at each station, close to a tree, log, or any other appropriate runway. The traps were baited with grated coconut and rice. The plots were run for five consecutive nights during January-October 1994 and for three consecutive nights after that until September 1996. All trapped animals were identified, ear-punched, sexed, weighed, measured and released. The traps were checked once daily between 0800 hrs and 1200 hrs.

HABITAT SAMPLING

Seven habitat variables that were considered important were sampled in every plot at each trap site (modified from Duesser and Shugart 1978).

1) Canopy cover- a qualitative estimate on a scale of 0-4
2) Ground cover: a qualitative estimate on a scale of 0-4
3) Woody stem density: a classification of the density of woody stems (> 1 cm dbh) within a radius of one metre around the trap site on a scale of 0-3
4) Tree density: a classification of the density of trees (> 10 cm dbh) within a radius of five metres around the trap site on a scale of 0-3
5) Canopy height.

DATA ANALYSIS

The following variables were analysed:

I. Population characteristics of *Rattus rattus* and *Millardia meltada*:

1) Density (Minimum Number Alive/ha)
2) Proportion of juveniles, sub-adults, adults and adult females
3) Biomass per ha
4) Mean weight of adults (males, females)

II. Community structure

5) Densities of *Rattus rattus, Millardia meltada* and *Suncus montanus*

RESULTS

SPECIES COMPOSITION IN VARIOUS HABITATS

A total of 9 species were trapped, of which there were 8 species in *sholas*, 3 species in the grassland, 3 species in wattle, eucalyptus, and pine plantations and 4 species in tea plantations. *Rattus rattus* was the dominant species in the *shola*, comprising 60.9 % of total density, while *Millardia meltada* was the dominant species in the grassland. *Suncus montanus*, a shrew, was the only species captured in both habitats. *Rattus rattus* and *Millardia meltada* coexisted in the plantations. The other common species in the *sholas* included *Mus famulus* and *Suncus dayi*.

RELATIVE ABUNDANCE IN VARIOUS HABITATS

The total density and biomass of small mammals was highest in the old and middle-aged wattle stands (Table 2). While *Rattus rattus* accounted for the bulk of the density and biomass in the former, *Millardia meltada* was the dominant species in the latter. *Sholas*

Table 1 : Trapping effort and habitat characteristics of the habitat types sampled in the Upper Nilgiris

Habitat	Plots	Sessions	Trap-nights	Canopy cover	Grass	Woody stems	Tree density	Height (m)
Grassland	3	3	405	open	High	None	none	
Wattle- young	3	6	810	open	medium	High	none	3.2
Wattle- middle-aged	1	4	540	medium	high	high	medium	4.1
Wattle- old	3	9	1800	closed	low	medium	high	9.9
Shola (all plots)	11	85	~20000	closed	low	high	medium	11.5
Bluegum	2	6	810	open	low	low	medium	5.3
Tea	2	3	335	open	low	medium	none	
Pine	3	10	1350	closed	none	none	low	10.9

Table 2: Density (MNA/ha) and biomass (gms/ha) of the three common species in various habitats and total density and biomass of all small mammals trapped in these habitats.

Plot	*Rattus rattus*		*Millardia meltada*		*Suncus montanus*		Total	
	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass
Grass	0	0	9.6	490.6	1.4	31.1	11.1	521.7
Wattle - young	0	0	6.6	328.9	2.2	65.1	8.8	394.0
Wattle -mid	5.0	382.4	25.5	1330.3	4.4	107.7	34.9	1820.4
Wattle -old	16.6	1627.2	8.3	456.5	4.3	99.2	30.7	2296.2
Shola	11.9	1171.2	0	0	4.0	87.0	17.3	1277.8
Shola -all	13.4	1280.6	0	0	4.3	104.1	20.7	1453.6
Bluegum	4.0	312.2	7.7	380.7	2.5	62.1	14.4	755.1
Tea	8.4	796.3	2.0	136.0	0.7	17.7	15.4	1019.0
Pine	4.0	394.9	2.6	140.3	2.0	52.3	8.8	605.3

had intermediate densities and biomass, while grasslands had relatively low density and biomass. The density and biomass of the dominant species in some plantations were substantially higher than in the natural habitats. The density of *Millardia meltada* was significantly higher in middle-aged wattle stands than grasslands (Mann Whitney $p < 0.05$), while the density of *Rattus rattus* was significantly higher in old wattle plantations than *sholas* (Mann Whitney $p < 0.05$).

In the natural habitat (*shola* and grassland), Rattus *rattus* and *Millardia meltada* are mutually exclusive. While the former is trapped in the *shola* forest patches, the latter was the only rodent trapped in the grassland. An analysis of wattle stands of different ages shows that *Millardia* dominates young stands (grass-like habitat), while *Rattus* dominates the older stands (forest-like habitat) (Tables 1 and 2).

Rattus rattus attained a maximum density of 34.4 animals/ha and biomass of 3247 gms/ha in November in an old wattle plantation. Millardia peaked at 31.01 animals/ha (1558.4 gms/ha) in June in a middle-aged wattle plantation.

DEMOGRAPHY IN VARIOUS HABITATS

The population characteristics of the three species varied substantially in the three habitats. *Rattus rattus* age structure in the old wattle plantations most resembled *sholas* in terms of average proportions of juveniles, sub-adults and adults. Pine and tea plantations had particularly high proportions of adults, while middle-aged wattle plantations had a high proportion of juveniles, but no sub-adults. (Fig. 1)

A *SHOLA*-GRASSLAND ECOTONE

Sampling of *shola* and grassland edges showed that *Millardia meltada* was never trapped in the forest and the forest rodents were never trapped in the grassland. This was true to the point that a species would never be trapped even one metre into the other habitat.

In a series of removal experiments, all *Rattus rattus* individuals were removed from two small *shola* plots: *Millardia meltada* did not enter these patches. The first individuals of *Rattus rattus* were trapped two to three weeks after the removal and several individuals, including a marked individual from an adjoining patch, were trapped at one of the these plots three months after the removal.

A *SHOLA*-BLUEGUM COMPARISON

The density of *Millardia meltada* was highest in the bluegum habitat and lower in the edge, while it was completely absent from *sholas*. *Suncus montanus* had similar densities in all habitats. The density of *Rattus rattus* was marginally higher in *shola* and edge habitats than in the bluegum (Fig. 2). The age structure of *Rattus rattus* was very similar in all habitats, but there was a trend towards an increase in mean weight

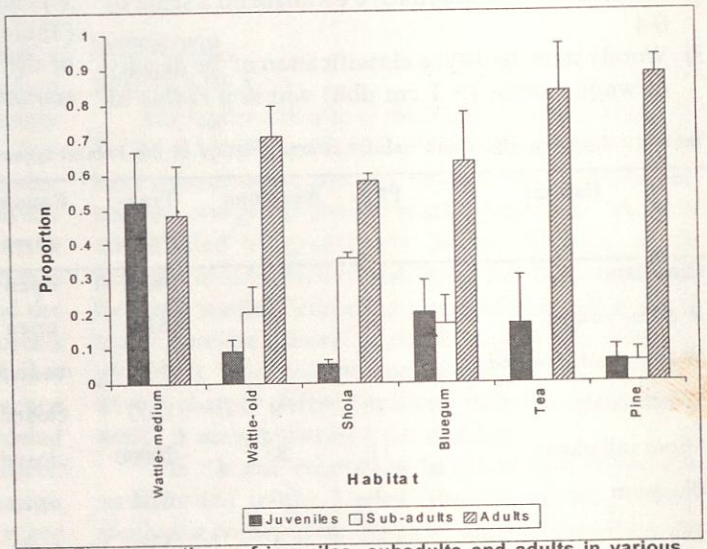

Fig 1: The proportions of juveniles, subadults and adults in various habitats in the Nilgiris. The age structure in the old wattle plantations resembles the *sholas* most closely.

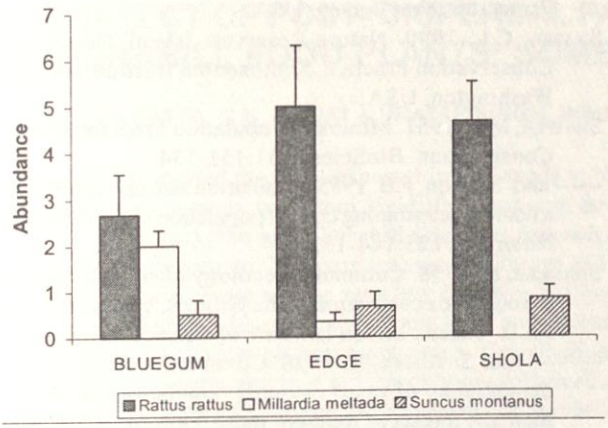

Fig 2 : The abundance of *Millardia meltada* was highest in bluegum and lower in edge, while it was absent from the *shola* habitat. *Suncus montanus* was found at similar densities in all three habitats. *Rattus rattus* densities were higher in the *shola* and the edge than in the bluegum.

of adult male *Rattus rattus* in the edge than in the other two habitats.

There was a trend towards increased proportion of adults at the edge and in the *shola*, compared to the bluegum. There was also a trend towards increased weight of adult males at the edge and in the *shola*. However, none of the age structure variables showed any significant difference between the three habitats. Since the sample was small, the trends suggest that further data collection is necessary before anything can be concluded about *shola*-bluegum ecotones.

DISCUSSION

There seems to be little doubt that the grassland acts as a barrier to the movement of forest rodent species, and the population dynamics within these forest patches are somewhat isolated. This is reflected in synchrony in population fluctuations between these patches which is significantly higher in contiguous patches than in fragments separated by grassland (Shanker and Sukumar 1999). If one examines the conditions for a population to have classical metapopulation dynamics (as defined by Hanski, 1997), small mammals in these montane ecosystems satisfy all the conditions. The suitable habitat occurs in discrete patches, the largest populations have a substantial risk of extinction (except perhaps *Rattus rattus*), the habitat patches are close enough to permit recolonisation and local populations are asynchronous. The removal experiments on *Rattus rattus* showed that patches are recolonised by individuals from other patches. While rare species frequently went extinct in each of the patches, their populations persisted in the landscape. This clearly indicates that metapopulation effects were acting on these populations.

When one examines the *shola*-plantation landscape as compared with *shola*-grassland natural landscape, there are several differences. Firstly, since forest small mammals were captured in the plantations, they can obviously use these plantations as corridors to move between patches. Hence the connectivity between patches is much higher in *shola*-plantation habitats. Further, *shola* and grassland species were captured at *shola*-plantation edges. Hence, edge permeability is also much higher in *shola*-plantation habitats.

The average age structure of *Rattus rattus* populations over a year appears to be different for the different habitats. It is different for different stages of the same plantation species (wattle). Further, there appears to be little or no synchrony between the populations either in terms of abundance or in terms of breeding, despite the fact that plantations are contiguous habitat (Shanker and Sukumar 1999). One could therefore expect the dynamics of small mammal populations in *shola*-plantation landscapes to be substantially different from *shola*-grassland systems.

It is important also to note the increase in densities of *Millardia meltada* in middle-aged wattle plantations and of *Rattus rattus* in old wattle plantations. The forest department has been following a policy of replacing grassland with wattle for commercial purposes over the last 50 years and substantial areas of the Upper Nilgiris and other areas in the western Ghats have already been covered with plantations. While it may not be possible to reclaim this land, one can take into consideration the use of these habitats by different groups of animals and accordingly devise appropriate management policies. If wattle stands are clearcut every few years, they are not good habitat for any of the rodent species. However, older wattle stands are suitable habitat for both forest and grassland species of rodents. Hence, a policy of periodically harvesting wattle without clearing it completely would provide commercial benefit while supporting a small mammal community at the same time. This could be of tremendous importance for small carnivore and avian predators that depend on these species for their food.

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THE EFFECT OF POST- DISPERSAL FACTORS ON REGENERATION SUCCESS OF HORNBILL FOOD PLANTS: SOME PRELIMINARY EVIDENCE

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Abstract : We studied the post-dispersal loss of seeds to invertebrate and vertebrate seed predators of several hornbill-dispersed plant species in Pakhui Wildlife Sanctuary, Arunachal Pradesh. Six food species of the wreathed hornbill (*Aceros undulatus*), the great hornbill (*Buceros bicornis*) and possibly of the Oriental pied hornbill (*Anthracoceros albirostris*) belonging to the Myristicaceae, Meliaceae and Annonaceae families were studied. The adult densities of the tree species varied from rare or very low (< 1 tree per ha) to common or very high (> 30 trees per ha). This was also reflected in seedling densities under nest trees and perches with a preponderance of seedlings of a few species while others were rare despite all being dispersed. Germination experiments showed that hornbill-regurgitated seeds of all species remain viable and in a few cases show enhanced germination. This suggested that post-dispersal factors were likely to cause differential regeneration success of hornbill food plants and possibly subsequent adult densities. We then asked if rodent removal or insect infestation of seeds could explain this differential regeneration. We found that seeds of the rarer species were subjected to greater damage due to both rodent gnawing and insect infestation whereas rodents did not attack the commonest species at all. There seemed to be a weak inverse relationship between measured levels of seed predation and the adult densities of the plant species. Though seedling densities were positively correlated to proportion in the diet and hence regurgitated and deposited, seed predation by rodents seems to be an important negative factor in their establishment as seedlings. Besides post-dispersal seed predation, the life-history characteristics of the plant species and a host of external factors may also contribute to differing density, but the evidence suggests that rodent seed predation negatively affects regeneration of two of the food plant species examined.

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Key Words: fruigivory, hornbills, regeneration, rodents, seedling, seed dispersal, seed predation.

INTRODUCTION

Dispersal by animals is chancy and serendipitous. Unlike other plant-animal interactions such as mutualistic plant-pollinator systems, the benefits of dispersal are not foolproof. The plant offers a reward to the disperser but cannot be sure that its seeds are being dispersed successfully (i.e. germinating and surviving to establish into adults). However, most studies that focus on the effectiveness of animal species as dispersers rarely examine the post-dispersal factors that affect germination success, seedling recruitment and ultimate adult tree densities. Studies on dispersal generally focus on the quantity removed and hence deposited but rarely look at the locations and pattern of seed deposition and the subsequent fate of seeds (Howe & Smallwood 1982). For instance, a dispersal agent depositing seeds in small piles or scattering seeds singly is presumably better than one putting many in a few piles. Ultimately, the effectiveness of dispersers would also depend on other factors that operate after dispersal. These in turn would reflect in seedling and adult tree densities. Post-dispersal seed predation by rodents and invertebrates has been implicated as one important factor by several studies (Coates-Estrada and Estrada 1988, Sánchez-Cordero and Martínez-Gallardo 1998, Shepherd and Chapman 1998).

As part of a study on several aspects of hornbill ecology in the tropical forests of Arunachal Pradesh, we are examining the role played by hornbills as dispersers. In this paper, we first report the disparity between adult tree densities of 6 hornbill food species. In addition, observations of rodent-gnawed seeds under nest trees and very low seedling density of some food plant species, led to the question that given the fact that hornbills are feeding on the fruits of all these species and they are all being dispersed, why are some species more common than others? Could it be related to seed predation that has been found to be an important post-dispersal factor in other studies? A plethora of other factors could also be responsible for the variability. For instance, seedling density could be simply reflecting proportions in the diet of hornbills. Inter and intra-specific competition between seedlings of species, inhibition of germination, specialized microhabitat factors for successful germination, and herbivory are other likely factors. A complex interplay of several factors could be responsible at different stages of the life history. Here, we first present evidence of seed dispersal by 2 species of hornbills (the Great hornbill (*Buceros bicornis*) and the Wreathed hornbill (*Aceros undulatus*) and then examine whether differential levels of post-dispersal seed predation by rodents and invertebrates could be one factor responsible for variable seedling and adult tree density of six hornbill food plants consumed during the breeding season.

The study was conducted from April to mid-June 1998 during the breeding season of the hornbills. The breeding season starts by the end of March with female incarceration in nest cavities and lasts till the end of July when the chicks fledge.

STUDY SITE

The study was carried out in Pakhui Wildlife Sanctuary (WLS) (92°7.5'E to 92°22'E longitude and 26°53.7'N to 27°16.2'N latitude) in the state of Arunachal Pradesh, North-east India. Pakhui covers an area of 862 km^2 and is bounded to the north and west by the river Bhareli, to the east by the Pakke river and to the south by the Nameri National Park and reserve forests in the state of Assam. A number of small rivers and perennial streams of the Bhareli and Pakke rivers, both of which join the Brahmaputra river, drain the sanctuary. The area lies in the foothills of the Himalaya and the terrain is undulating and hilly. The altitude ranges from 200 m to about 1500 m above sea level. The area has a subtropical climate with cold weather from November to February. Both the south-west (May to August) and north-east (December to January) monsoons are prevalent here. The average annual rainfall is 2500mm.

The general vegetation type has been described as tropical semi-evergreen (Champion & Seth, 1968). The vegetation is dense with a high diversity and density of woody lianas and climbers. A total of 234 plant species (angiosperms) were recorded with a high representation of species from the Euphorbiaceae and Lauraceae families (Datta & Goyal, *in prep.*). The emergent species are *Tetrameles nudiflora*, *Ailanthus grandiflora* and *Altingia excelsa* (Singh, 1991). The forest types include tropical semi-evergreen forests along lower plains and foothills dominated by *Terminalia myriocarpa*, *Ailanthus grandis* and *Duabanga grandiflora* (Singh, 1991). Moist areas near streams have a profuse growth of bamboo, canebrakes and palms. Along the larger perennial streams, there are shingle beds with patches of tall grassland, which give way to lowland moist forests with *Dillenia indica* and *Talauma hodgsonii*.

The intensive study site (*c.*20 km^2) is located near the south-eastern boundary of the sanctuary near Seijusa village (on the west bank of the Pakke river) with an elevation ranging from about 200 to 700 m above sea level. All the nest/roost/perch trees of hornbills were located within this intensive study site.

METHODS

Germination experiments

Germination experiments were carried out using regurgitated seeds of 11 hornbill food species collected under hornbill nest/roost/perch trees and fallen seeds (controls) from under fruiting trees for each of the species. Five of the species tested are consumed during the non-breeding season. Both fallen and regurgitated seeds were planted in homogenized soil in exposed seedbeds near the forest edge in a fenced enclosure and monitored till germination. Germination experiments were terminated after 3 months. The number of germinated seedlings was counted. Germination success of regurgitated *vs* fallen seeds were compared using chi-square tests for some species.

Seed dispersal & seedling densities

Seedling density of hornbill food species was compared between plots laid directly below nest holes and behind nest holes (controls). If seeds deposited by hornbills do germinate and establish as seedlings, this would give evidence for effective dispersal. All seedlings were identified and counted in 2-m radius plots both in front of the hole and behind the hole. Seedling plots were also laid at random locations and seedling density of hornbill food species compared with seedling density at nest trees.

All seedlings, lianas, climbers, shrubs were enumerated under 4 hornbill nest trees (separately at the front and back of the cavity) and 2 roost/perch trees in 2-m radius circular plots. Mean seedling density of each species was obtained from pooling the data from all the 10 plots. Since the bulk of the seeds regurgitated by the female fall in front of the nest, it was expected that seedling density of hornbill food plants would be higher in front of the hole.

Adult tree density

Adult tree density of the 6 food plant species was obtained from 11 randomly located permanent plots of 0.25 ha each, covering a total area of 2.75 ha. All trees ≥ 30 cm GBH had been enumerated and marked earlier for monitoring phenology of trees in this forest.

Breeding season diet

To calculate proportions of each species in the diet, regurgitated seeds dropped under 10 nest trees were counted periodically. The bulk of the seeds found under the nest tree are obviously deposited by the incarcerated female and subsequently her chick. Some proportion of seeds are also regurgitated and dropped by the male while perching on the nest tree during a feeding visit. The seeds of all non-fig fruit species are regurgitated intact by hornbills, therefore it was possible to determine the exact numbers of fruits of each of these species consumed by the nesting hornbills during the study period. The six food species that were examined are *Polyalthia simiarum* (Annonaceae), *Horsfieldia kingii* (Myristicaceae), *Dysoxylum binectariferum*, *Chisocheton paniculates*, *Amoora wallichi* and *Aglaia* sp. (Meliaceae).

Seed predation

To examine whether seed predation levels was a factor in low seedling and adult densities of some of these species, seeds of these species were collected and placed in clumps under one wreathed hornbill nest tree (*Tetrameles nudiflora*) and their fate monitored

over two months. The number of seeds damaged due to predation by rodents and invertebrate predators were counted as well as those remaining intact. Rodent damage to seeds is easily noted, since seeds are thoroughly chewed up into small pieces or gnawed partly where the incisor marks are clearly visible. Invertebrate damage is usually due to the holes bored through the seeds by the larvae of beetles. Seeds of only four species were used, *viz. Polyalthia simiarum*, *Dysoxylum binectariferum*, *Horsfieldia kingii*, and *Aglaia* sp. Very few ripe fruits of the other two species, *Amoora wallichii* and *Chisocheton paniculates* were available during the study period, therefore the fate of a few seeds of these species could be monitored only for two weeks.

Additional data on levels of seed predation were obtained by checking the middens of 6 other wreathed hornbill nest trees and 3 great hornbill nest trees periodically (every 10-15 days). The proportion of damaged to undamaged seeds was quantified here.

The proportion of damaged seeds was calculated. Chi-square tests were also used to determine if levels of seed predation were significantly different between species. One of the assumptions of the chi-square test is independence of samples. This assumption is violated here since each seed was treated as a single sample. But since the comparison was to test for differential seed predation between species the use of the test is not completely inappropriate. All seeds of the species to be examined were placed in the same location therefore if rodents or invertebrates selectively feed on seeds of some species the differences would show up even using a chi-square test. In the future, a more rigorous experimental design is being setup where a clump of seeds would be treated as a sample with several replicates at different places.

Effect of distance and season

Seeds of one species, *Dysoxylum binectariferum* were placed at two locations, near the nest tree and > 100 m away to determine if there are higher levels of seed predation near the nest where there is already a concentrated seed rain and clumping which may be more visible to predators.

To determine whether there were differences in levels of seed predation during different times in the breeding season, data were analyzed separately for April (hot, dry) and May-June (rainy).

Data analysis

Simple descriptive statistics and non-parametric tests were used. While the data on proportions of each species in the diet and levels of seed predation are from the 1998 breeding season, it should be mentioned that seedling densities in the sampled plots are as a result of previous years' deposition by hornbills. Therefore, the implicit assumption is that there is little variation in seed rain between years at nest trees. Though this assumption seems reasonable, it is likely to be incorrect, as there is variability in fruit abundance and intake by hornbills between years (Datta, *unpubl. data*). In the 1999 breeding season, seed rain at individual nest trees would be monitored and the fate of the seeds, number of seedlings establishing at the end and the causes of mortality would be determined.

RESULTS

Food plant species of hornbills : a description (Kanjilal *et al.* 1934, Grierson and Long 1984).

Polyalthia simiarum (Annonaceae) (32.4 trees per ha ± S.E. 6.28)

Evergreen trees generally 15-20 m in height, with a straight bole and thin horizontal branches. The fruit is an ellipsoid berry/drupe, turning from green to orange-red to blue-black on ripening gradually narrowed to a stalk 3-4cm long, the seeds are ovoid, grooved and transversely ribbed. The species is fairly common in upper Assam, but very common in lower Assam. The fruiting period is reported to be from May-June. In the study area, apart from the main fruiting peak from May to July, individuals with ripe fruits were noted from December to February. There seems to be two fruiting periods in this species.

Dysoxylum binectariferum (Meliaceae) (5.09 trees per ha ± S.E. 5.34)

These are medium-sized evergreen trees generally 12-15 m in height. The capsules are globose, orange-yellow, 4-5 celled, seeds are green to yellow in color, heart-shaped, covered by an edible shiny black aril. The main fruiting peak is from April to June. Fruits take a long time to ripen and the capsules dehisce on ripening.

Chisocheton paniculates (Meliaceae) (21.1 trees per ha ± S.E. 1.53)

These are evergreen trees about 12 m in height. The fruit is a 2-5 celled globose capsule, pinkish-red. The glossy dark black/chestnut-colored seed is partly surrounded on top by orange-white arillode. The main fruiting is from mid-May to June.

Horsfieldia kingii (Myristicaceae) (0.36 tree per ha ± S.E. 0.36)

These are evergreen trees, generally 10-12 m in height. The branches are usually crowded on top of the trunk and somewhat horizontal. Fruiting is reported to be in June. The fruits dehisce on ripening. The fruit and seed are edible and used as a substitute for betelnut. The cream-colored ovoid seed is covered by a fleshy yellow aril. The main fruiting peak was noted to be in April in the study area.

Aglaia sp. (Meliaceae) (1.82 tree per ha ± S.E. 0.83)

These are medium sized evergreen trees from 10 to 15 m in height. This species seems to have a localized distribution near moist areas. The capsular globose pinkish fruits are covered by an orange-red aril, ovoid brownish seed with wavy lines. The main fruiting peak is from March to April.

Amoora wallichii (Meliaceae) (11.27 trees per ha ± S.E. 4.06)

The trees are large, up to 20 m in height. The fruit is capsular and broadly pyriform (3-4 celled, 2-3 seeded) with an orange-red fleshy edible aril, the seeds are maroon to dark brown and kidney-shaped. The main fruiting peak is reported from August to September. In the study area, ripe fruits were available from June till August.

Adult tree density

Adult tree density of hornbill food plants varied from rare (< 1 tree per ha) for *Horsfieldi kingii* to common (> 30 trees per ha) for *Polyalthia simiarum* (Table 1). Apart from *H.kingii,* two other food plant species were relatively rare (< 5 trees per ha), while one species *Amoora wallichi* was moderately common and two were common.

Seedling density (under nest/roost/perch trees)

Seedling densities of the food plants were highly variable and did not vary consistently with adult tree density for all species (Table 1). It should be mentioned here that while adult tree densities were determined from randomly placed plots, seedling density of the food plants here only refers to seedlings enumerated under hornbill nests/roosts/perches. Apart from the seedling density of *P.simiarum* which was highest (1.23/m²) and that of *H.kingii*, which was low (0.02/m²), seedling density and adult tree density were not correlated (Spearman's $r_s = 0.37$, $p = 0.2$ (one-tailed), $n = 6$). Seedling density of *Dysoxylum binectariferum* was high (0.9/m²) though it is relatively rare as an adult tree.

Seedling density of hornbill food plants was significantly higher in front of the nest cavity (10.12/m² ± S.E. 2.18) when compared to that behind the nest cavity (8.65/m² ± S.E. 1.93), (Wilcoxon- matched pairs signed rank test, $p < 0.05$, one-tailed, $n = 4$). There was no difference in seedling density of non-food plants between the front and back of the cavity.

Germination experiments

Food plant species consumed during both the breeding and non-breeding species were used for the germination experiments. The germination success of hornbill-regurgitated seeds of the 6 food plant species varied from 13.33% to 66.66%. The germination success of all the species is shown in Table 2. Regurgitated *P.simiarum* seeds had a significantly higher germination success compared to that of fallen seeds ($\chi^2 = 5.6$, df =1, n =28, $p < 0.05$). Seeds of *D. binectariferum* showed no difference in germination success between treatments. Sample sizes were too low for statistical comparisons for the other 4 species. The germination successes of 5 other species that ripen and are consumed during the non-breeding season (September to February) were also tested. Three of these species showed significant differences in germination success between regurgitated and fallen seeds ($\chi^2 = 4.01$ for *Livistonia jenkinsii*, df =1, n = 33, $\chi^2 = 14.31$ for *Pygeum acuminatum*, df =1, n = 132, $\chi^2 = 5.04$ for *Beilshmedia* sp.2, df =1, n = 17, $p < 0.05$), while in two other species, there was no significant difference.

Table 1. Seedling and adult tree density of 6 hornbill food plants

SPECIES	Seedling density (m²) ± S.E.	Adult tree density (ha) ± S.E.
P. simiarum	1.23 ± 0.29	32.36 ± 6.27
D. binectariferum	0.98 ± 0.23	5.09 ± 5.34
Aglaia sp.	0.31 ± 0.12	1.82 ± 0.83
C. paniculates	0.071 ± 0.03	21.09 ± 1.53
H. kingii	0.016 ± 0.016	0.36 ± 0.36
A. wallichii	0	11.27 ± 4.06

For adult tree density, n = 11 plots of 0.25 ha each (total area sampled = 2.75 ha)

Seedling density, n = 10 plots of 2 m radius (total area sampled = 125.7 m²)

Breeding season diet

A total of 3384 regurgitated seeds were counted under the 10 nest trees to characterize diet during the study period from the first week of April to the first week of June. *P.simiarum*, the most common species was the major species in the diet (45.59%), followed by *D. binectariferum* (30.46%). The rare species, *H. kingii* formed 4.8% of the diet. Most ripe fruits of *A. wallichi* and *C. paniculates* become available later in the season and formed only 10% of the diet together till the end of the study period.

Table 2. Germination success of regurgitated and fallen (control) seeds of 11 hornbill food plants

Species	Regurgitated	Fallen
Amoora wallichi	58.69%, n=46	----------
Aglaia sp.	13.33%, n=45	----------
Chisocheton paniculates	32.5%, n=40	20%, n=9
Dysoxylum binectariferum	66.66%, n=36	60%, n=15
Horsfieldia kingii	47.62%, n=21	----------
Polyalthia simiarum	61.03%, n=77	42.85%, n=14
Actinodaphnne obovata	80.64%, n=27	74.07%, n=31
Beilshmedia sp. 1	60%, n=10	66.66%, n=9
Beilshmedia sp. 2	62.5%, n=8	11.11%, n=9
Livistonia jenkinsii	66.66%, n=18	33.33%, n=15
Pygeum acuminatum	80.24%, n=81	66.66%, n=51

SEED PREDATION

Rodent seed predation was observed on two species. The level of rodent seed predation on the rare species, *H. kingii* was very high (88%, n = 18), while *D. binectariferum*, a relatively rare species also suffered seed predation (42.35%, n = 85). Rodent seed predators did not attack the most common species (*P. simiarum*) but about 38% of seeds (n = 79) were bored with small holes by beetle larvae. But even seeds bored with larvae, often germinate successfully. At one count under a nest tree, while 87% of *P. simiarum* seeds with holes were viable, forty percent of seeds had germinated despite being bored with holes, n = 210 (Datta, unpubl. data). Very limited seed predation was noted in another rare species, an *Aglaia* sp., n = 15).

Although, there seemed to be a weak inverse relationship between both seedling density and adult tree density and measured levels of seed predation, it was not significant (Spearman's r = -0.4, p = 0.3 (one-tailed), n = 4) (Figure 1). Seedling density of food plant species was positively correlated with the proportion in the diet (Spearman's r = 0.77, p < 0.05 (one-tailed), n = 6).

Chi-square tests showed that the most rare species (*H. kingii*) suffered a significantly greater seed predation than the most common species (*P. simiarum*), (χ^2=15.24, df=1, p < 0.05, n = 97). There was significantly greater predation on *D. binectariferum* compared to that on *P. simiarum* (χ^2 = 12.88, df=1, p < 0.05, n = 103).

Differences in seed predation levels – near & far

Eighty percent of *D. binectariferum* seeds were lost due to seed predation under the nest tree, while only 26.7 % were lost at a location 100m away from the nest tree. There were a significantly greater number of seeds lost under the tree compared to further away (χ^2= 13.72, df=1, p < 0.05, n = 55)

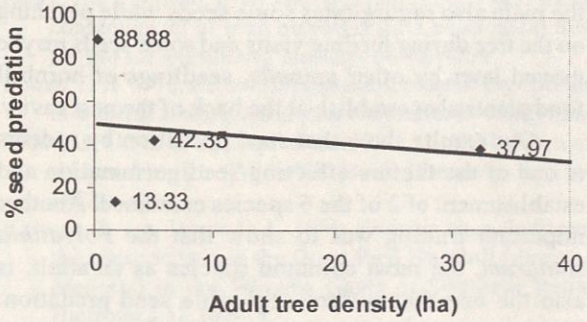
Proportion of seeds damaged to undamaged

Under a few nest trees monitored every 2 weeks, rodent damage was relatively lower. Rodents chewed up 15% of *H.kingii* seeds, while 25.2% seeds of *D. binectariferum* suffered damage due to rodents, beetles or rot. On the other hand, 99% of seeds of *P.simiarum,* the most common species, were intact, of which about 24% were germinating. Ninety-five percent of *Aglaia* seeds, a rare species was intact, of which 16.1% were germinating. None of the *H.kingii* and only 6.4% of the *D. binectariferum* was germinating.

Effect of season on seed predation by rodents

Seeds of *D. binectarierum* suffered heavier predation in April (hot, dry season) (26.5%), while in May-June (rainy season) only 15.8% were lost. The percentage loss was significantly greater in April than in May (χ^2 = 8.87, df=1, p < 0.05, n = 620).

Fig.1. Inverse relationship between levels of post-dispersal seed predation on 4 hornbill-dispersed species and their adult tree densities (Spearman's r_s = -0.4, n = 4, p = 0.3, one-tailed test)



Seed removal experiments

Seeds of several species placed together were monitored for about 57 and 44 days. In both sets, *H.kingii* were completely destroyed by the end of the month, while 80% of *D.binectariferum* seeds were lost by the end of the month.

All *H.kingii* seeds (n =16) and 80% of *D. binectariferum* (n = 40) were lost to rodents. Though 71% of *P.simiarum* seeds were partly damaged (beetle larvae holes), they were not eaten by rodents.

DISCUSSION

For any understanding of the phenomenon of seed dispersal, it is important to determine the fate of seeds after the dispersal event, since a multitude of factors affect seed germination and seedling establishment (Dirzo & Dominguez 1986). This is also important for discerning the factors underlying the adult distribution and abundance patterns of the plant species.

Hornbills have been found to be important seed dispersers of species belonging to the Meliaceae, Myristicaceae, Annonaceae and Lauraceae in a number of studies in South-east Asia (Leighton & Leighton 1983, Becker & Wong 1985, Poonswad *et al.* 1983, 1987, Kinnaird 1998). In fact, some authors have speculated based on the large fruit sizes of many of the capsular fruits of Meliaceae and Myristicaceae that hornbills maybe the sole dispersers since most other birds cannot swallow them intact (Leighton & Leighton 1983, Becker & Wong 1985, Kannan & James 1999). Wheelwright (1985) found that frugivores face constraints imposed by gape size limitations. He found that plants with large fruits attracted fewer bird species than those with smaller fruits.

Hornbills swallow the fruits whole and regurgitate the seeds intact after the pulp or aril is processed in the proximal gut. The germination experiments conducted show that most regurgitated seeds germinate, and in several cases, passage through the hornbill's gut enhances germination. Evidence for dispersal by hornbills is further provided by the higher seedling

density of the food plants in front of the nest cavity (where the bulk of the seeds fall after regurgitation by the female) than at the back of the cavity. But since the male also regurgitates some seeds while perching on the tree during feeding visits and some seeds maybe moved later by other animals, seedlings of hornbill food plants also establish at the back of the nest cavity.

Our results show that seed predation by rodents is one of the factors affecting seed germination and establishment of 2 of the 6 species examined. Another important finding was to show that the *Polyalthia simiarum,* the most common species as an adult, is also the one that suffers negligible seed predation. Though beetle larvae attack seeds of this species, observations show that seeds with a few holes are still viable and germinate.

The pattern of seed deposition by hornbills in the breeding season is concentrated around the nest tree and therefore there is a high density of seeds. The chances of discovery are higher and the situation mimics that under the crowns of fruiting trees where many studies have found density-dependent mortality because of seed predators, herbivory and/or alleopathy (Janzen 1970, Connell 1971, Clark & Clark 1984, Becker & Wong 1985). In our study, we found higher seed predation near the nest tree than 100m away. Horvitz & Schemske (1994) found that post-dispersal predation was low (c. 6%) and that invertebrates and pathogens cause much less mortality than larger post-dispersal predators. Louda (1989) found that predators selectively chose larger seeds. On the other hand, Forget *et al.* (1994) found low occurrence of seeds gnawed by rodents and concluded that seed removal in rodent-dispersed species is not a good estimator of seed predation rather of seed dispersal. Howe *et al.* (1985) found that insects and mammals killed 99.2% of seeds under fruiting trees. But seeds that are dispersed > 20m by large birds such as toucans and guans have a greater advantage for germination and seedling survival.

Though the data was limited, there seemed to be higher seed predation in the hot dry period of the study when fewer fruit species were available. Forget *et al.* (1994) also found there were differences in seeds gnawed and cached over months. He found the most intense seed predation when there was low availability of fruits in the forest.

The weak inverse relationship between levels of seed predation and both adult tree density and seedling density and the relatively higher levels of seed predation on the two less common species seem to suggest that seed predation is one of the factors affecting ultimate adult tree density at least for some species. But seed predation cannot be the only factor explaining the variability in seedling and adult tree density. Four species were used in this correlation, but one species, *Aglaia* (negligible seed predation, but rare) seems to have a localized distribution near moist areas and may require specialized microhabitat factors to establish and seed predation may not be an important negative factor.

In the germination experiments (exposed site), this species had the lowest germination percentage, but 8 of 10 seeds planted under closed canopy in the forest germinated successfully. Local factors at individual nest sites such as microhabitat conditions, variability in rodent seed predation also contribute to the differential regeneration success of food plants. *D.binectariferum*, suffers moderate levels of seed predation, but has a high seedling density and is relatively rare as an adult. In this species, herbivory by caterpillars on seedlings seems to be a factor causing mortality (Datta, unpubl. data) and thus may play a role in contributing to lower adult tree density.

The positive correlation between seedling density and the proportion in the diet also indicates that to some extent seedling density reflects amounts eaten, regurgitated and deposited by hornbills. The most common species *Polyalthia*, interestingly also has two fruiting peaks in the year and consequently some fruits of this species are available throughout the year. The fruits are drupes and smaller in size (*c.* 2 cm) and easier to access and swallow by other bird or mammal species. On the other hand, the two rare species are large-sized capsular fruits and fruiting peaks are not as extended. These factors could also contribute to the differences in adult tree density.

It is important to realize that though many factors are responsible for plant distribution and abundance patterns and ideally a multivariate analysis investigating the role of all these in explaining individual species abundance patterns is needed, the purpose of this paper was to highlight the fact that at least for some species, rodent seed predation plays a negative role in seedling recruitment, especially under nest trees where the high density of deposited seeds leads to greater detectability.

In a recent paper, Sánchez-Cordero and Martínez-Gallardo (1998) even concluded that differential seedling regeneration resulting from rodent food choices partly determines long-term floristic composition in a Mexican rainforest. Given the prevalence of seed predation, the contention here is that in the absence of seed dispersers (since seeds are scattered over a wider area and some proportion would escape predation by rodents), the survival of rare species would be negatively affected.

This paper presented some preliminary data on the role of factors such as seed predation on the fate of hornbill-dispersed seeds and possibly on their adult tree densities. More rigorous and intensive sampling is being carried out for a further understanding of the ideas and questions raised here.

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RAPID ASSESSMENT OF REEF RESPONSES TO ELEVATED SEA-WATER TEMPERATURES CAUSED BY THE EL NIÑO SOUTHERN OSCILLATION (ENSO) CURRENT SYSTEM IN INDIAN WATERS

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Abstract : The El Niño Southern Oscillation (ENSO), the warm water ocean current system that develops off the west coast of South America, elevating global ocean temperatures has, in the past, influenced the ecology of near-shore marine ecosystems, particularly coral reefs. Elevated Sea Surface Temperatures (SSTs), higher than 1°C above the seasonal average, can result in widespread bleaching events in scleractinian corals and other coelenterates with symbiotic photosynthetic algae. Recovery from this bleaching depends on the intensity of the ENSO event, and local conditions. This study assessed the extent of bleaching in three reef regions in the country using rapid assessment methods. Data on substrate composition and coral genera were collected along 10m point intercept transects, and in $1m^2$ quadrats. SST anomalies and duration was established using NOAASST maps. The survey shows that bleaching had occurred in all reef regions studied. The reefs of the Gulf of Kutch showed an average of 10.7% coral affected by the bleaching, with only 1.9% coral cover completely bleached, the rest of it showing heat stress by loss of pigmentation. No apparent bleaching-related mortality of coral was observed in the Gulf of Kutch. In contrast the lagoon reefs of Lakshadweep, and the reefs of Mannar were severely influenced by the bleaching event; some 81.8% of the total coral cover was affected in Lakshadweep, and 89.2% in Mannar. Bleaching-related mortality was high in both these reefs (25.7% in the Lakshadweep, 23 % in Mannar), and a large proportion of coral still did not show signs of recovery. Several instances of bleached soft coral and sea anemones were also noted. I present the potential implications of this mass bleaching event on the sustained conservation and management of Indian reef systems. I outline the possible ecological and socio-economic fall-outs of this mortality, and stress the need for strict, sustained reef monitoring. This is essential to keep track of further mortality, recovery of coral, and to detect any far-reaching changes to the functioning of the reef.

WILDLIFE CONSERVATION, RESEARCH & MANAGEMENT : 20-27

INTRODUCTION

Disturbance ecologists have, for several years been both concerned and fascinated with large-scale disturbance events that frequently affect coral reefs (Glynn 1993, Connell 1997). Storms and unusually prolonged low tide events, *Acanthaster planci* outbreaks, white-band disease (WBD) plagues of coral, and seawater temperature elevation, all threaten coral and the reefs they inhabit. These events are showing both, that the reefs of the world are under severe threat, but also that they are surprisingly resilient to disturbance, and can recover from mass die-outs, with time, and intelligent management.

The El Niño **:** The El Niño Southern Oscillation (ENSO) of 1997-1998 created a near pan-tropical band of warm water, that is, till today affecting ocean systems around the world. While the El Niño always brings in its wake a spate of global climatic changes, and an inevitable host of ecological and economic disasters, the present event is perhaps the most severe in recorded history, and has already been implicated as the causative agent for the drought in the Philippines, the failure of rains in Indonesia, where forests continue to be devastated by fire, and in the torrential rains in North-America and parts of Africa. Perhaps the most direct impact of the ENSO however, is on marine and coastal ecosystems. Reports from locations around the tropics point to a developing global catastrophe for coral reef ecosystems of the world.

Bleaching **:** The most significant and noticeable result of temperature elevation in reef waters is a phenomenon known as bleaching, which is a rapid loss of pigmentation of coral, leading to a complete whitening of the colony. Bleaching is a generalised stress response of scleractinian coral, caused by the expulsion of the photosynthetic symbiont zooxanthallae by the polyp, or by a severe reduction in the photosynthetic activity of resident zooxanthallae (Kleppel *et al.* 1989). Zooxanthallae lend the coral its characteristic colour, and its expulsion in large numbers, reveals the true white colour of the coral polyp. Bleached coral regain photosynthetic algae when conditions improve, but if the stress is severe and prolonged, the coral often dies because of prolonged bleaching, and other secondary stresses (Brown 1997).

Causes of Bleaching **:** Elevated sea-water temperatures are perhaps the most important and widely reported cause of coral bleaching (Glynn 1993, Brown and Suharsono 1990), and it is often a normal, non-lethal response to seasonal variation in water temperatures (Gates 1990). Increased irradiance, reduced salinity, bacterial infection and decreased water temperatures have also been known to cause coral bleaching (Brown and Suharsono 1990, Kushmaro *et al.* 1996).

Mass Bleaching **:** Mass bleaching was first observed on the coral reefs of the Pacific in 1984 (Glynn 1991), and has since been noticed as a common

† This work was funded by the Wildlife Conservation Society, India Chapter

phenomenon in reefs across the tropics. It appears to be well correlated with changes in Sea Surface Temperatures (SST's), and, in El Niño years, the frequency of bleaching events in coral reefs increase dramatically (Glynn and D'Croz 1990, Williams and Bunkley Williams 1990). The current ENSO has seen initial reports of coral bleaching and mortality from reefs in East Africa to the islands of the Pacific, and several programmes to monitor recovery and further mortality have already been set up.

Indian coral reefs have not received the same attention because of the lack of field researchers in coral reefs of the country. Reefs in India occur in patchy locations around the country; major reef areas exist in the Gulf of Kutch, the Lakshadweep, Mannar, and the Andaman and Nicobars. Coral presence and reef formation has also been reported in scattered locations along the west and east coasts of India (Bakus 1994, Pillai 1996). This survey was conducted to rapidly assess the impact of the current El Niño system on some of the coral reefs of India, to provide a minimum baseline from which further monitoring can be done. The survey was conducted on several islands of the Gulf of Kutch, the Lakshadweep and the Gulf of Mannar. The survey assessed bleaching related stress to corals, and quantified the amount of coral mortality already caused by the ocean warming.

STUDY AREAS

The Gulf of Kutch **:** Some 42 islands dot the southern lip of the Gulf of Kutch (Figure 1). The reefs that fringe these islands are atypical fringing reef formations, and are found primarily in the vast intertidal region of the Kutch. Coral survives in shallow tidal pools within the vast intertidal flats that characterise this coastline. Coral cover and diversity is low and patchy (Arthur 1995). Several of these reefs are recovering from large-scale coral mining practised in the past. This region forms part of the Gulf of Kutch Marine Park and Sanctuary, but the anthropogenic pressures on this group of islands continues to be high (Patel 1985). Several polluting industries fringe the coastline, and development continues unabated, sometimes directly affecting reef areas, as in the case of the oil refineries that build their receiving pipelines through the reef. The survey was conducted in the reefs of Pirotan, Meetha Chusna, Ajad, and in Betu, a submerged reef close to Ajad. The islands were sampled between the 28th of April, 1998 and the 9th of May, 1998.

The Lakshadweep Islands **:** In the Western Indian Ocean, the Lakshadweep and Minicoy group of coral atolls (Figure 2), along with the Maldives and Chagos are an important biogeographic link for coral reefs. The archipelago comprises some 27 islands, ten of which are inhabited. The total land area of these islands is 32 km^2, and has among the highest population densities in the country (1922 people/km^2, Thangal 1994). The reefs enclose the islands in extensive lagoons and protect them from storm damage and other ravages of the sea. Diversity is high, and the islands share much of their fauna with the reefs of the Maldives, with some faunal affinity to the reefs of mainland India (Sheppard 1987). The onset of the monsoon and some particularly inclement weather in the open sea, made work possible only in the lagoon reefs of the Lakshadweep. The survey was conducted in the lagoons of Kavaratti and Kadmat between the 9th and 19th of June, 1998

The Gulf of Mannar and Palk Bay **:** The islands of the Gulf of Mannar and Palk Bay are a series of shallow fringing uninhabited islands (Figure 3). The reef fauna is linked closely to Sri Lankan coral reefs. The south-eastern coast of India is heavily populated, and the dependence of local communities on marine resource is heavy. A high density of trawlers and boats ply these waters and the seas in this region appear to have a high nutrient influx. The reefs are are also mined illegally from many areas, adding to the pressures on the reefs of this coast (Bakus 1994, Pillai 1996). Bleaching surveys were conducted on the islands of Manauli Putti, Shingle, and Pumarichan in the Gulf of Mannar between the 7th and the 11th of July 1998.

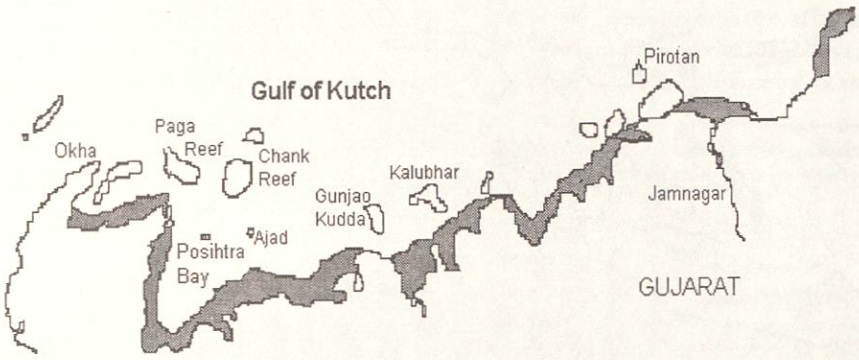


Fig.-1 The southern Gulf of Kutch, Gujarat, India. The extensive grey areas represent mudflats and degraded mangroves.

METHODS

The purpose of this study was to rapidly assess reef responses to seawater temperature elevation. Several weeks had already past since SST anomalies had been noticed in these waters, and it was crucial to get all information with rapidity, to ensure that confounding factors did not invade in the analysis of the impact. Much mortality had already

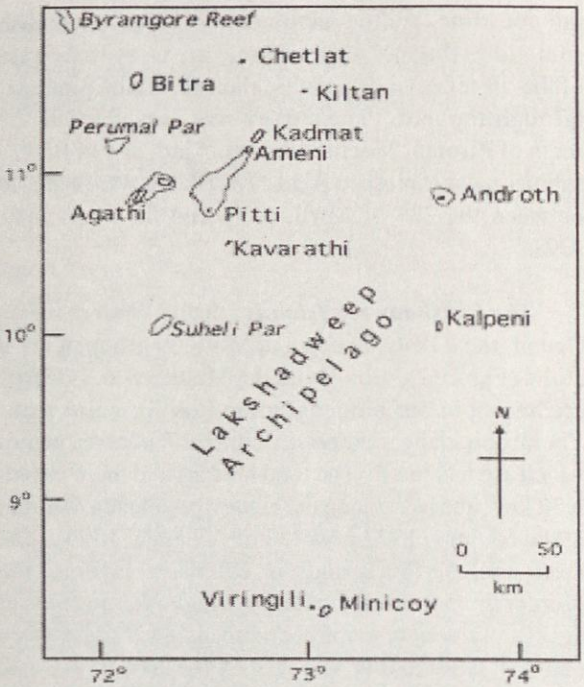


Fig.- 2. The islands of the Lakshadweep and Minicoy Archipelago, Indian Ocean

occurred in most reefs, and it becomes difficult to determine the cause of mortality accurately after a time.

The core of the sampling strategy was the Point Intercept Transect. This consists of a ten-metre line laid out along the substratum, data collected along this line as the number of 10-cm points intercepted by each benthic component under the line. Data was collected on coral at the genus and lifeform level. For a detailed description of the lifeform classification method, see English *et al.* (1997). Coral affected by bleaching were classified in three ways:

Pale **:** The colony shows pale pigmentation. This is caused either by a partial loss of zooxanthallae or the lowering of photosynthetic content in the available zooxanthallae. With the snapshot nature of this sampling, it is impossible to determine whether the coral was bleached in the past and is now recovering, or is heading towards a more severe bleaching. In either case though, it is a sign of significant stress.

Bleached **:** The colony shows a brilliant white appearance, though the coral is not yet dead. Even completely bleached coral will have some zooxanthallae, but the density within each polyp will be severely reduced. If conditions remain stressful, these bleached coral often die.

Dead **:** Coral exposed to extensive bleaching eventually die because of bacterial infections and other stresses. Sediment rejection rates decrease, and an accumulation of sediment on the coral prompts the growth of turf algae that form a thin mat over the coral. Since this turf grows very quickly, it is often difficult to separate old coral death from post-bleaching mortality. To be conservative I classified coral in this category only if the layer of sediment and algae was visibly thin, and some traces of the bleached coral beneath could be seen. This provides an under-representation of the amount of coral death caused by bleaching, but it protects against doomsday prophesying. Data on other substrate components (fleshy and coralline algae, sessile invertebrates, seagrass, and all abiotic components) were recorded along the transect. If other organisms showed signs of bleaching stress, this was also recorded.

In the Gulf of Kutch, the waters were too turbid to sample with transect methods because the waters clouded up within a few minutes of sampling. In these reefs, I estimated benthic cover in $1m^2$ quadrats at every alternate metre along a 30m line. Data on the size and condition of each coral colony within the quadrat was estimated. Data was then pooled for each 30m line for analysis. Though data is not strictly comparable with the data from the Lakshadweep and Mannar, it represents the field condition fairly accurately, and I present the data together. Data were analysed as proportions and frequencies along the transect line. Single factor ANOVA's were used for comparisons between reef areas, after arcsine transforming the data to correct for normality.

Tracking the Anomaly **:** Sea Surface Temperatures

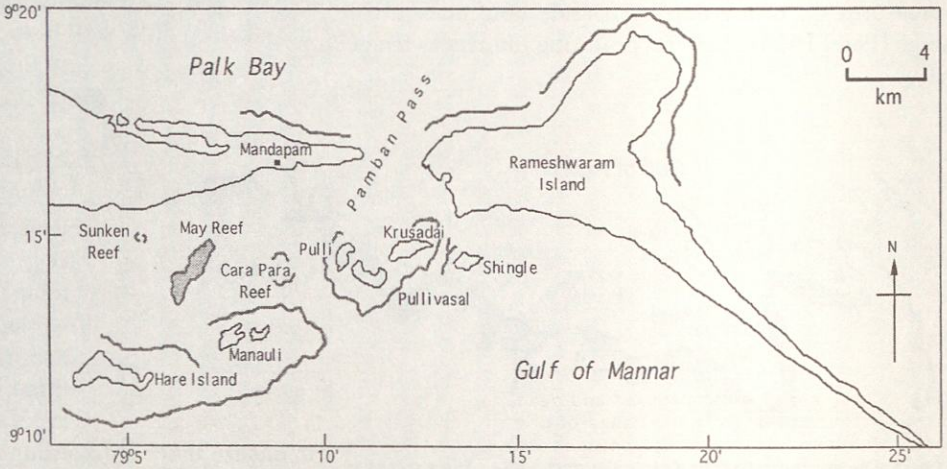


Fig.- 3. The islnds of the Gulf of Mannar and Palk Bay

Table 1. Percent composition of reef benthic substrate in the Gulf of Kutch, Lakshadweep and Gulf of Mannar. The Gulf of Kutch data was collected using multiple 1m² quadrats. The Lakshadweep and Mannar data were collected along 10m point intercept transects. ANOVA's were done on arc-sine transformed values of percentage data at a 95% confidence limit.

	Gulf of Kutch (n=7)		Lakshadweep (n=34)		Gulf of Mannar (n=30)		ANOVA	
	Mean	SEM	Mean	SEM	Mean	SEM	F	P
Coral Cover	11.7	3.22	37.2	1.99	33.6	3.21	**8.20**	*<0.01*
Turfed Coral	41.4	4.55	21.4	2.16	32.0	2.73	**8.14**	*<0.01*
Coralline & Calcerous Algae	5.1	1.76	14.9	1.02	10.3	1.02	**4.01**	*0.02*
Fleshy Algae	15.5	3.31	0.0	0.00	5.7	1.91	**14.23**	*<0.01*
Seagrass	0.01	0.01	0.2	0.21	--	--	0.53	*0.59*
Other Invertebrates	7.6	3.07	0.4	0.15	0.5	0.19	**24.13**	*<0.01*
Sand	18.8	2.97	18.9	2.55	11.0	2.89	2.31	*0.11*
Rubble	--	--	7.0	1.23	6.9	1.77	3.32	*0.11*

(SSTs) greater than 1°C above the seasonal average are sufficient to cause significant bleaching in most coral (Brown 1997). Using satellite data, it is possible to record changes in regional waters of 0.25°C and above (Gleeson and Strong 1995). I used twice-weekly NOAA/NESDIS SST maps of the Indian Ocean (accessed from the NOAA website <http:\\www.noaa.gov>) to determine anomalous temperatures in Indian reef waters. I considered anomalous temperatures of 1°C or higher to be potential conditions for bleaching to occur (Brown 1997), and calculated the approximate number of days the reefs in the region had been subjected to this temperature anomaly.

RESULTS

The intertidal reefs of the Gulf of Kutch are characterised by sparse coral cover, 11.7% on average (Table 1). Old dead coral covered with turf and mud dominates the reef. Several species of macroalgae also contribute to the benthic community here, *Ulva*, *Sargassum, Caulerpa, Padina,* among the most common genera. Coral genera are limited; this study recorded 11 genera of coral, restricted to massive and encrusting forms, dominated by *Favites*, *Porites* and *Platygyra*.

In contrast the lagoon reefs of the Lakshadweep, had a much higher coral cover, and about 14.9% coralline algal cover. Eighteen genera of coral were recorded in Kavaratti and Kadmat lagoons, *Porites*, branching *Acropora* and *Pavona* being the most abundant (Table 2).

The shallow reefs of the Gulf of Mannar had 33.6% coral cover, and a large proportion of old dead and turfed coral (32%). *Montipora*, tabular *Acropora* and *Porites* were the most dominant of the 12 genera recorded used extensively for shell, algae, and sea cucumber collection. Corals in Mannar reefs.

Single factor ANOVA's carried out on substrate cover show significant differences in the coral cover, turfed coral, coralline and filamentous algae, fleshy macroalgae, and sedentary invertebrates (Table 1). These differences are largely due to the substrate cover values encountered in the Gulf of Kutch. The reefs of Lakshadweep and Mannar are much more similar in their substrate composition, reflecting the basic structural differences between the reefs of the Kutch (shallow intertidal) and the reefs of Lakshadweep and Mannar (deeper lagoonal and fringing structures).

Bleached coral was encountered in all reefs surveyed. The Lakshadweep and Mannar reefs were most severely affected by the bleaching; more than 80% of the coral cover in the Lakshadweep, and nearly 90% of the coral in the Gulf of Mannar showed signs of bleaching stress (Table 3). Between 30 and 40 percent of the coral in these reefs were severely bleached, and more than 20% dead in bleaching related stress, in both reef areas.

	Anomaly Days	Pale (%)	Bleached (%)	Dead (%)	Total Affected
Kutch	0	8.81	1.92	0	***10.73***
Lakshadweep	78	26.0	30.09	25.71	***81.80***
Mannar	99	24.98	41.26	23.00	***89.24***

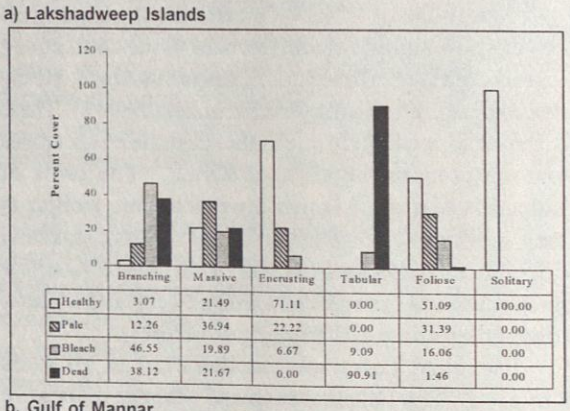
Table 2. Percent cover of stressed and dead coral recorded in the reefs of Kutch, Lakshadweep, and Mannar. Only coral where the cause of death could unambiguously be assigned to bleaching were included in the Dead Coral category, so as not to overestimate the impact of the bleaching. The anomaly days represent the approximate number of days the studied reef had been exposed to SST's of higher than 1°C, prior to the dates of sampling.

The reefs of the Gulf of Kutch in contrast, seemed to be much less severely affected than the other reef areas. No obvious bleaching related death was observed in the seven reefs surveyed, and only 1.92% of the coral was bleached severely.

The differences in bleaching correlate well with the number of SST anomaly days recorded on satellite imagery, before the survey dates (Table 3). The Gulf of Kutch was sampled before abnormal mean SSTs were noticed in the gulf. In contrast the reefs of Lakshadweep had already experienced at least 78 days of elevated temperatures before this sampling, and the Gulf of Mannar, at least 99 days, temperatures rising to as much as 3°C above seasonal averages.

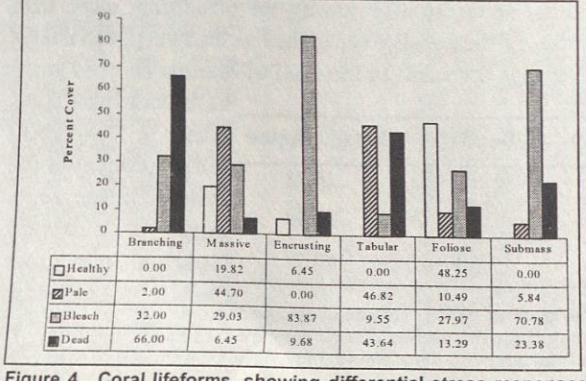
Coral lifeforms showed a differential response to coral bleaching in Lakshadweep and the Gulf of Mannar (Figure 4). While solitary Fungiids appeared indifferent to the rise in temperatures, Tabular, Branching and Massive corals were significantly affected by the bleaching in both reef areas. Encrusting coral show conflicting responses in both reef areas, being largely unaffected in the Lakshadweep (71.1% healthy coral), but severely bleached in the Gulf of Mannar (6.5% healthy coral). Part of the reason for this difference is that the encrusting coral in the Gulf of Mannar was monogenerically *Montipora*, which appeared to be badly affected by the bleaching in both reef areas. Several genera showed encrusting lifeforms in the Lakshadweep Islands, dominated by *Pavona*, which appeared largely unaffected by the anomalous temperatures.

a) Lakshadweep Islands



	Branching	Massive	Encrusting	Tabular	Foliose	Solitary
Healthy	3.07	21.49	71.11	0.00	51.09	100.00
Pale	12.26	36.94	22.22	0.00	31.39	0.00
Bleach	46.55	19.89	6.67	9.09	16.06	0.00
Dead	38.12	21.67	0.00	90.91	1.46	0.00

b. Gulf of Mannar



	Branching	Massive	Encrusting	Tabular	Foliose	Submass
Healthy	0.00	19.82	6.45	0.00	48.25	0.00
Pale	2.00	44.70	0.00	46.82	10.49	5.84
Bleach	32.00	29.03	83.87	9.55	27.97	70.78
Dead	66.00	6.45	9.68	43.64	13.29	23.38

Figure 4. Coral lifeforms, showing differential stress responses to bleaching.

Table 3. Percent composition of coral genera in the Lakshadweep, Gulf of Mannar and Gulf of Kutch.

Genus	Lakshadweep	Gulf of Mannar	Gulf of Kutch
Branching *Acropora*	12.41	6.82	--
Tabular *Acropora*	0.90	22.02	--
Astreopora	1.15	--	1.77
Cyphastrea	2.71	0.31	2.04
Favia	--	5.03	4.74
Favites	1.45	0.91	24.59
Fungia	0.24	--	--
Galaxea	0.46	--	--
Gardinerorseris	0.76	--	--
Goniastrea	0.41	0.42	--
Goniopora	0.15	--	12.77
Hydnophora	--	0.84	1.23
Leptastrea	0.71	--	--
Millepora	1.48	--	--
Montipora	4.31	35.77	2.64
Mycedium	0.08	--	--
Pavona	10.94	--	--
Platygyra	0.46	--	18.03
Pocillopora	1.44	3.55	--
Porites	57.95	14.51	23.91
Stylophora	1.99	--	--
Symphyllia	--	0.33	5.27
Turbinaria	--	9.47	3.02

DISCUSSION

The present survey indicates that the reefs studied are all undergoing bleaching stress, related to sea-surface temperature rise caused by the 1997-1998 El Niño. The Lakshadweep and Mannar reefs have been most severely affected, with large-scale mortality in both reef areas. It is difficult to determine from a rapid study if the coral died directly as a result of bleaching, or were killed by secondary stresses. In all probability, the observed death was a result of synergistically acting disturbances – heavy bleaching reducing the coral's ability to reject sediment build up, and resist the growth of turf algae (Glynn 1993, Brown 1997). The Southwest monsoons could also have played a significant role in making waters more turbid, increasing suspended sediment levels in the water.

The bleaching reported appears to be correlated with rises in ocean temperature. Both, the duration, as well as the intensity of this rise contributes to the bleaching event. Satellite imagery gives a good overview of temperature conditions over a large area of the ocean, and is very useful in tracking changes in temperature over time. Ground truthing has shown that the smallest change the satellite can record is a 0.25°C rise in temperature, and the maximum error of this measurement may be as high as 0.5°C (Gleeson and Strong 1995). However, in the absence of continuous and reliable

field data from reefs in India, the NOAA/NESDIS images are still the most useful and accurate means of gaining a comprehensive picture of the El Niño anomaly in Indian seas.

Levels of bleaching stress encountered correlate well with the number of days these reef areas were exposed to abnormal temperatures. It is important to note that abnormal temperatures continued to persist for at least four weeks after the survey dates. This survey, carried out while anomalous temperature conditions were still active, does not reflect the full extent of the damage caused by the bleaching event. From initial reports of subsequent observations on the reef, it is apparent that the reefs have deteriorated further, and that bleaching conditions are extremely widespread in these reef areas (Jason Rubens, pers. comm.).

The causal mechanisms of coral bleaching are not fully understood, nor conclusively proved (Glynn 1993). The evidence for seawater temperature rise being chiefly responsible for bleaching is largely circumstantial, and it is not possible to discount the influence of other stressing agent in the bleaching and death of the corals in these areas. Both the Gulf of Mannar and Lakshadweep have problems of high nutrient contents in their waters, besides a hosts of other anthropogenic disturbances (Bakus 1994, Pillai 1996). High levels of nutrients and bacterial infections have both been implicated as causal agents in coral bleaching (Glynn 1993, Kushmaro *et al.* 1996), and may facilitate the proliferation of fleshy algae, and coral bioeroders (Cuet *et al.* 1988, Hallock 1988, Eakin 1992, Gabric and Bell 1993). These stresses however are chronic, and are not likely to cause sudden intense mass bleaching as reported here. They could still be important agents of coral stress, lowering the disease-resistance of the coral, and exacerbating mortality in bleached coral.

The Gulf of Kutch, in contrast with the other reef areas surveyed, did not seem to be as badly affected by the bleaching, with 10.7% of the coral showing signs of bleaching. Very little obvious mortality could be ascribed to bleaching, and it is possible to suggest, that the bleaching encountered in the Gulf of Kutch was normal, related to a seasonal rise in ocean temperatures, before the onset of the monsoon. Temperatures in the intertidal reefs of the Gulf of Kutch commonly rise to as high as 36°C, and higher in reef areas during summer (Arthur 1995), and it is conceivable that coral species here are adapted to such seasonal temperature fluctuations (Gates 1990). It has also been suggested that for such high-latitude reef locations, bleaching may not be as significant a disturbance, since wide temperature variations are common at these latitudes (Cook *et al.* 1990). However, SST anomalies were not recorded in the Kutch waters till after the present survey was conducted, and it is possible that the sampling picked up only the start of a bleaching event in the Gulf of Kutch. A study conducted in 1995, estimating benthic cover in the Gulf of Kutch, reported between 1.2% and 1.4% of the coral bleached in the summer months before the monsoons (Arthur 1995), indicating that the bleaching reported in this survey is considerably higher than normal summer bleaching. Even below bleaching thresholds, elevated temperatures have significant impacts on coral health, retarding coral growth and reproduction (Jokiel and Coles 1990).

Implications for Conservation :

It is difficult to predict how Indian reefs will respond to a large-scale die-out of coral without a reliable baseline, and with no sustained monitoring in any reef area in the country. Mass bleaching of this intensity has not been reported before from Indian reefs in previous El Niño years. From studies done elsewhere, it has been shown that reefs subjected to large-scale bleaching disturbances, may take 5 to 10 years to recover (Brown and Suharsono 1990, Connell 1997). Individual colonies may take up to five months to recover from bleaching (Bunkley Williams *et al.* 1991), and several species may go locally extinct in the process (Glynn and de Weerdt 1991). Bleached coral suffer from lowered growth rates, and their reproduction potential is also severely affected (Goreau and Macfarlane 1990, Szmant and Gassman 1990). This could mean a considerable retardation in reef production. Brown and Suharsono (Brown and Suharsono 1990) demonstrate that five years after a major bleaching event, only 50% of the coral cover had recovered.

More subtle community changes are also likely to occur in bleached reefs. (Eakin 1992) reports increases in urchin densities in mass-bleached reefs, leading to the potential of further coral death through spine abrasion and erosion. Fleshy algae, potential competitors of coral, are also benefited by this coral death, and, presumably by shading the coral, can retard coral growth (Sheppard 1988). The effects of bleaching on other reef organisms, such as fish has not been well studied. Several species of fish and invertebrates, dependent on coral for shelter, camouflage and food will be the most badly affected, while several herbivorous fish, could likely see population increases in the wake of large-scale coral death (Eakin *et al.* 1989). Omnivorous fish numbers have been shown to rise opportunistically with coral bleaching, as previously well-hidden invertebrates were exposed. Whether these translate into more permanent changes in reef communities has not yet been demonstrated. Lowered coral resistance could also increase coral bioeroder numbers, considered one of the primary factors controlling post-bleach recovery in coral (Scott *et al.* 1988).

The mass bleaching of coral may portend a global disaster in the making, but it will most profoundly

affect people at a more regional scale. Local communities are dependent on these reefs for their livelihood, supporting artizanal and bait fishery, as a source of ornamental products, and cheap construction material. Mass bleaching and its subsequent fallouts could spell a major problem for these reef based cottage industries and sustenance fishery. Major reef destruction for tiny atoll islands like the Lakshadweep, could be disastrous, increasing coastal erosion, and leaving them unprotected from storms and cyclones. Tourism in reef areas is also likely to decline, as the aesthetic experience of the reef that attracts the tourist, is replaced by dead remnant reefscapes.

While anomalous SST-induced bleaching was perhaps the primary cause of death implicated in this study, much mortality was most likely a result of anthropogenic stresses such as nutrient enrichment and sedimentation, working synergistically with elevated temperatures (Brown 1997). This points to a much longer-term problem of rational coral reef management for Indian reefs. Marine conservation has not had a long history in India, and many terrestrial paradigms still dominate the management of marine reserves. Very little active management has actually been carried out in Indian waters – managers content with establishing areas of no-use (National Parks) and restricted use (Sanctuaries). This simplistic planning is both difficult to implement in the field, and does not tackle the much larger issues of reef decline that more often than not, have their roots far outside these 'protected' areas. The stresses that affect coral reefs most significantly today are insidious in nature, and, without constant *in situ* monitoring, it is impossible to track gradual changes in coral reef health. This basic knowledge is crucial if rational and planned management has to be effected in Indian reef waters, with clearly defined conservation goals, and reef-sensitive approaches to management.

Monitoring programmes and research :

In the absence of long-term monitoring of coral reefs, and the sparse information available on Indian coral reefs, it is difficult to make well-supported quantitative statements about the effect of the current bleaching event on the coral reefs of the country. This survey suffers naturally from the lack of a reliable baseline in time, with which to compare cover values for coral and other benthic components. In isolation, it may be a misleading snapshot of the health of the reef. What is apparent however, is that, at the time of the survey, large-scale coral stress and death was occurring, coincident with an anomalous rise in ocean temperatures. Within three months of the anomaly, between 80 and 90% of the coral was bleached or dead in the Lakshadweep and Mannar. It is imperative that a sustained monitoring of the reefs be initiated in the wake of this bleaching event. This is important to track recovery in reef areas, and to keep a pulse on any changes in reef community structure that could take place. Several easily applicable techniques for reef monitoring have been developed (English *et al.* 1997), which require moderate amounts of training. The Lakshadweep Island administration for instance has begun a programme of instituting posts of Honorary Environment Wardens, engaging local youth in environmental awareness programmes. Working in tandem with a local dive operation, some of these wardens are being equipped with diving skills, so that they can be effectively used in monitoring programmes. Initiatives like this are extremely promising, and could point to a new paradigm of community involvement in marine conservation in India.

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STATUS AND DISTRIBUTION OF PHEASANTS IN WESTERN ARUNACHAL PRADESH, EASTERN HIMALAYA, INDIA

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Abstract : This paper presents the information collected on the distribution and status of pheasants in four districts of western Arunachal Pradesh. Our efforts were concentrated mainly in the higher and interior areas along the Great Himalayan Range, and particularly in the East Kameng and Lower Subansiri districts (Dafla hills), where surveys for pheasants had not been carried out earlier. Interesting information on the distribution patterns of pheasants mainly of those belonging to the genus *Lophophorus* and *Tragopan* was obtained. Here we report the discovery of the new pheasant taxon belonging to the genus *Lophophorus*. We also identified new localities for the presence of Satyr tragopan *Tragopan satyra*. Threats to pheasants in the surveyed districts were found to be mainly due to hunting.

WILDLIFE CONSERVATION, RESEARCH & MANAGEMENT : 28-34

Key words: Arunachal Pradesh, dafla hills, distribution, eastern Himalaya, new pheasant taxon (*Lophophorus species*), pheasants.

In recent years, studies on wildlife have been carried out in many parts of the Himalaya. However, very few studies have been conducted in the Eastern Himalaya, mainly due to its remoteness, difficult terrain, and adverse climatic conditions. This is evident in the case of studies on pheasants here. Most published information on galliforms here is based on natural history observations, which are more than 40 years old (Kaul et al. 1995). Few surveys for pheasants have been carried out recently. These surveys have provided some information on the presence or probable absence of pheasants and status of their habitats (Katti et al. 1990, Kaul and Ahmed 1993, Kaul et al. 1995). However, large gaps in the information on the distribution and status of most pheasant species continue to exist.

Arunachal Pradesh located in the Eastern Himalaya has the highest concentration of pheasant species within the Indian subcontinent. Ten out of the 17 species of pheasants found in India occur here, including the endangered Sclater's monal *Lophophorus sclateri* and Blyth's tragopan *Tragopan blythii*. The Himalaya and their associated cold deserts have evidently served as an effective barrier to the northward expansion of pheasants (Johnsgard 1986). And their center of dispersion is believed to be the mountains of the Eastern Himalaya and of Western China (Delacour 1977). Perhaps, this is the reason as to why there is a high concentration of pheasant species in Arunachal Pradesh.

Our main objectives of this study were to survey new localities for the presence/absence of pheasants and in turn identify distribution patterns. We also aimed at assessing the status of the habitats and threats to pheasants in the surveyed localities. Special emphasis was given to the distribution of the endangered *L. sclateri* and *T. blythii*. Both the species are stated endangered mainly due to the lack of information available on them (McGowan and Garson 1995).

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STUDY AREA

We conducted surveys in four districts of western Arunachal Pradesh viz., Tawang, West Kameng, East Kameng and Lower Subansiri between February 1998 to May 1998 and September 1998 to November 1998. An important criterion for selecting these districts for survey was that the distribution ranges of the pheasants specifically the tragopans, monals and blood pheasants either end or begin here. And since this study aimed at identifying the exact distributional limits of these pheasants it became necessary to choose the above districts for the survey. Apart from this, our surveys were concentrated in the higher and interior areas along the Great Himalayan Range particularly, in the East Kameng and Lower Subansiri districts, where surveys for pheasants had never been carried out before. Two protected areas Eagle Nest Wildlife Sanctuary and Pakhui Wildlife Sanctuary were also surveyed. The localities visited in the four districts during the survey are shown in Figure1.

METHODS

Information from local people played a crucial role in carrying out this survey. We conducted interviews with the local people at each locality and trekked to different areas in search of pheasants. On reaching a locality, village-heads, local hunters and other knowledgeable people were consulted and information on galliforms, pheasants in particular, was obtained. Pictures of pheasants were shown to them for identification. Skins and feathers of pheasants kept with the locals were also examined. In all 32 localities were visited in the four districts surveyed. Field data were collected over 47 days during the survey period. Treks along existing trails were the only means possible to get direct sightings as well as indirect evidences of pheasants. The trails were monitored only once since large areas of ground had to be covered. Moreover, in most cases due to the remoteness of the area it was

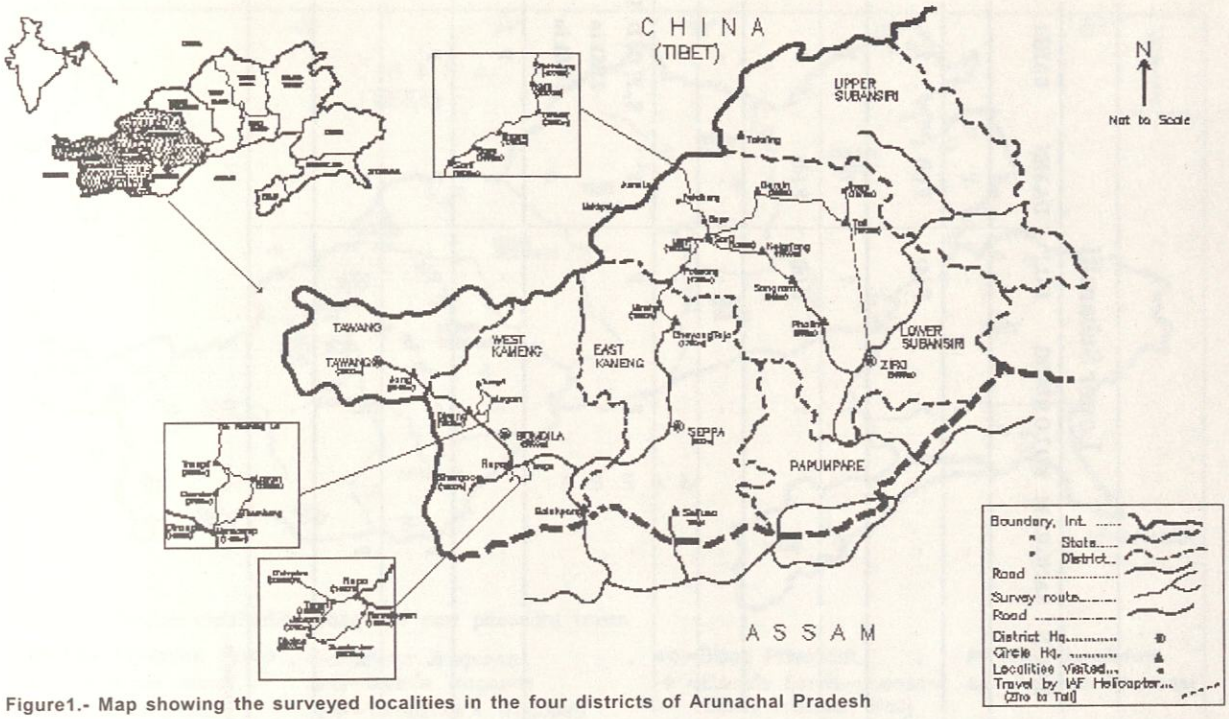

Figure1.- Map showing the surveyed localities in the four districts of Arunachal Pradesh

not logistically feasible to conduct regular monitoring of each trail. No special methods were employed to collect information on indirect evidences of pheasants such as calls, feathers, tracks and droppings. The above were obtained or searched for only along the trails during the treks. On few occasions while camping in pheasant habitats random search for tracks and droppings of pheasants was done. With experience it was possible to distinguish the pheasants up to the genus level by looking at the shape and size of the droppings and tracks. Hunters and loggers camps encountered along the trails were also searched for feathers of pheasants or remains of kill. Play back of recorded pheasant calls in order to obtain vocal responses from tragopans could only be done in the Eagle Nest Wildlife Sanctuary.

Since, after few trials the play back equipment failed and this method had to be abandoned. Information on status of pheasants in the surveyed localities was largely based on the discussions with the locals.

RESULTS

This study produced interesting information on the distribution patterns of pheasants in the districts surveyed, particularly of those belonging to the genus *Lophophorus* and *Tragopan*. Both direct and indirect evidences of pheasants obtained from the surveyed localities are given in Table 1. All records of the pheasants form this study as well as from earlier studies are shown in Figure 2.

Genus *Lophophorus*

A new pheasant taxon belonging to this genus was discovered from the Sarli locality of Lower Subansiri district. During the first part of the survey, from February 98 to May 98 evidences in the form of four complete set of tail feathers of this pheasant were obtained, suggesting the occurrence of a probable new pheasant taxon in the Sarli area (Kumar and Singh 1998). The rectrices along with the upper tail coverts examined were flat and square shaped. The terminal half of each rectrix was completely white, lacking the chestnut, which is characteristic of *L. sclateri*. The feathers were also unlike those of the Himalayan monal *L. impejanus* in which the entire rectrices are cinnamon in color. Along with the tail feathers, few body feathers characteristic of this genus were also obtained.

A subsequent visit to the Sarli locality during September to November 1998, to ascertain the above finding, led to the confirmation of the presence of this new pheasant taxon. The new pheasant taxon was sighted on nine occasions (5 males, 13 females, 1 subadult? in total) around a camp called Pakdhung (approx. 93°7′E 28°5′N), located close to the Indo-Chinese border in the Sarli circle area. All the sightings were in the alpine meadow zone between 3900m to 4200m altitudes. Evidences of the new pheasant taxon obtained during the survey are given in Table 2.

No evidences for the presence of *L. sclateri* were obtained from the districts surveyed. And interestingly we did not find any evidence for the presence of *L. impejanus* from the Lower Subansiri and East Kameng districts. Only the local people in Tawang district and in Dirang, West Kameng district recognized *L. impejanus*. Further east, the local people neither recognized *L. impejanus* or *L. sclateri*. They only knew about the presence of the new pheasant taxon known to them as "*Thade* or *Pede*".

Table 1. Evidences of pheasants in the surveyed localities of the four districts of western Arunachal Pradesh.

SPECIES	Tawang		West Kameng				East Kameng		Lower Subansiri					
	TAWANG	JANG	EAGLE NEST WLS	RUPA	SHERGAON	DIRANG	PAKHUI WLS	CHYANG - TAJO	PALIN	SANGRAM	KOLORIANG	TALI	DAMIN	SARLI
BLOOD PHEASANT	R	R, F	-	-	-	F	-	P	-	-	-	-	P	P
SATYR TRAGOPAN	R	P	S, F, C, D, T	F, D	P	F(d),G Skin	-	F (d)	-	-	?	F (d)	F (d)	?
BLYTH'S TRAGOPAN	?	?	?	?	P	?	-	?	-	-	?	?	?	?
TEMMINCK'S TRAGOPAN	?	?	?	?	?	F(d), G Skin	-	F (d)	-	-	?	F (d)	F (d)	?
HIMALAYAN MONAL	R	R	-	-	-	R	-	-	-	-	-	-	-	-
SCLATER'S MONAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NEW MONAL	?	P	-	-	-	P	-	F, D, T	-	-	P	F	F	S, F, C, D, T 2ESkin 1GSkin
ELWES'S EARED-PHEASANT	?	?	-	-	-	?	-	-	-	-	-	-	-	P
BLACK-BREASTED KALIJ	P	P	R, F	F	P	F	R	P	P	P	P	P	P	P
RED JUNGLEFOWL	-	-	-	-	-	-	C	-	P	P	P	C	?	-
GREY PEACOCK PHEASANT	-	-	R	-	-	-	C	-	-	-	-	-	-	-

S - Seen, C - Call heard, D- Droppings, F - Feathers, F (d) – Feather of Tragopan,but species doubtful, T - Tracks or digging signs, R - Reported in literature, ? - Unknown, P - Based on local information, probably present.

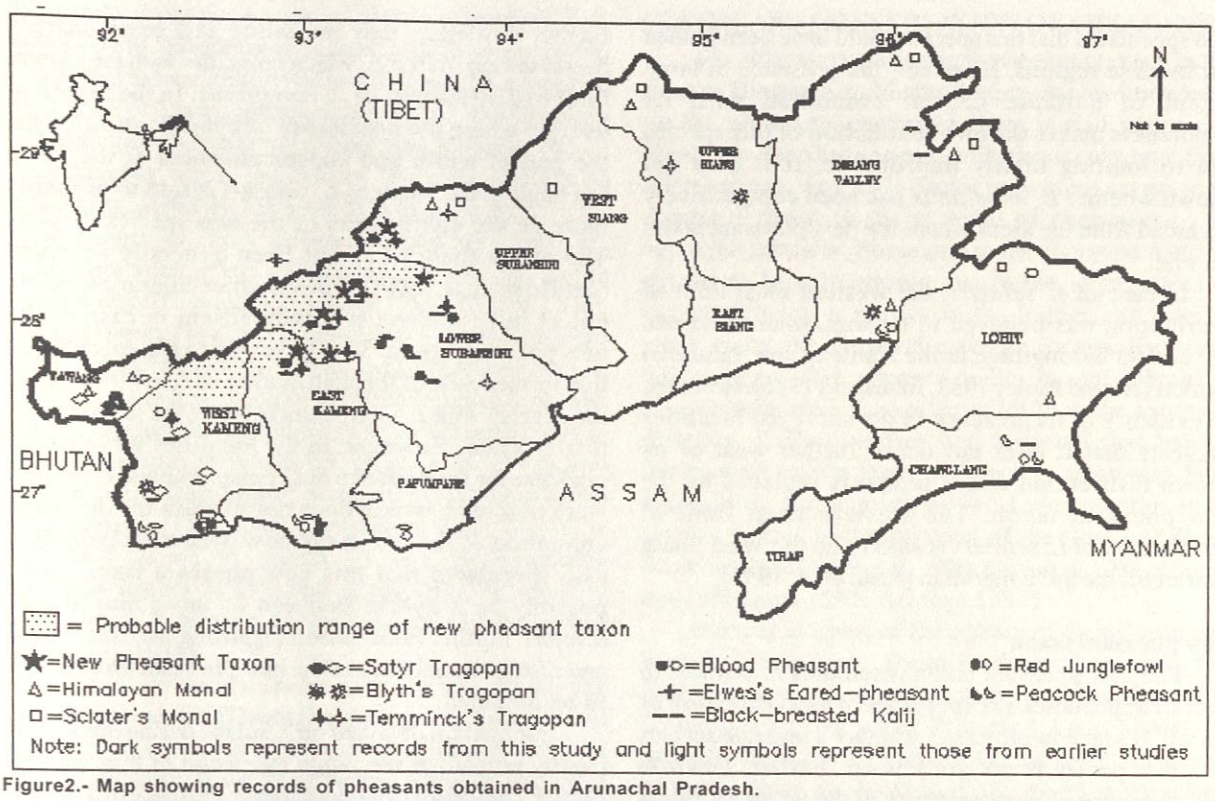

Figure2.- Map showing records of pheasants obtained in Arunachal Pradesh.

Genus *Tragopan*

A new locality for the presence of *T. satyra* was identified during this survey. Four sightings of a tragopan were had in the Eagle Nest WLS. Two males and one female tragopan were seen, and one was heard calling. The female tragopan and the calling bird could not be assigned to the species. The males were identified as that of *T. satyra*. Evidences in the form of local information for the presence *of T. blythii* was obtained only from the Shergaon locality of West Kameng district. A very old skin of a male tragopan of an unknown species was seen with the locals at Dirang. Feathers of tragopans (species unknown) were also observed with the locals in the Lower Subansiri and East Kameng districts.

Genus *Ithaginis*

Feathers of Blood pheasant *Ithaginis cruentus* were seen in the Sarli circle, Lower Subansiri district. The local people there described this bird as having a black gorget and reddish breast, which is similar to the description of the Mishmi Blood pheasant *I. c. kuseri*. Tail feathers of the other subspecies Tibetan Blood pheasant *I. c. tibetanus* were obtained in Dirang, West Kameng district and in Jang, Tawang district.

Other Pheasants

Information from local people suggesting the probable occurrence of the endangered Tibetan Eared-Pheasant *Crossoptilon harmani* across the border was obtained only from the Sarli circle. Since our surveys were mainly concentrated in the higher and interiors areas, not much information on the pheasants occurring in the lower areas could be obtained. Feathers of both male and female Black-breasted Kalij *Lophura leucomelanous lathami* killed recently were seen in the Rupa Valley and also from the Eagle Nest WLS. The local people in all the localities visited, readily recognized this species. Calls of both the Red Junglefowl *Gallus gallus* and Grey Peacock pheasant *Polyplectron bicalcaratum* were heard regularly in the Pakhui WLS. Red Junglefowl was once heard calling at 300m along the river Kamala, in Lower Subansiri district.

DISCUSSION

Pheasant Distribution

Confirmed evidence for the presence of *L. impejanus* within the state has been obtained only from few localities in the Tawang district in the west and in the Dibang valley in the east (Katti et al. 1992, Singh 1994, Kaul et al. 1995). And so far, no confirmed evidence of its presence between the above-mentioned localities exists. Though, this species is believed to occur all along the Himalayan range across the state. Information collected on the presence/absence of *L. impejanus* during this survey suggests a probable gap in its distribution range within the state. It is suspected that the distribution of *L. impejanus* might have been contiguous in the past, but to some climatic or stochastic factors and subsequent local extinction in places, may have led to the gap in its present distribution. It is

also speculated that this species could have been hunted out in these regions. However, the presence of large extent of suitable habitat combined with its remoteness makes the local extinction of this species due to hunting highly improbable. It is also not known whether *L. impejanus* has been competitively excluded from the areas where the new pheasant taxon occurs.

In case of *L. sclateri*, the western most limit of distribution was believed to be somewhere between 92° and 93°E longitude in the Kameng and Subansiri districts (Ali and Ripley 1983, Johnsgard 1986). However, no evidence of its presence in the surveyed localities suggests that it does not occur further west of its known distribution and is probably replaced by the new pheasant taxon. The western most limit of distribution of *L. sclateri* is said to be the West Siang district till the 94°E meridian (Kaul et al. 1995).

New pheasant taxon

The new pheasant taxon resembles *L. sclateri* in overall appearance except for the white coloration of the tail. It's taxonomic status, whether a separate species or a subspecies is not yet known. Earlier, Davison (1974) proposed an eastern race of the Sclater's monal *L. s. orientalis* from Myanmar based mainly on the much narrower white tail band in males than in the birds further west of its range. Davison (1978) provided further evidence that the white tail band sharply decreased east of 97°E, which coincides with the eastern limit of distribution of *L. impejanus*. In the region of overlap where the possibility of hybridization exists, the greater width and conspicuousness of the white tail band in the western *L. sclateri* is said to probably increase the distinctness of the two species display. The above theory has not been generally accepted (del Hoyo et al. 1994). The chestnut coloration on the tail as in *L. sclateri* is totally absent in case of the new pheasant taxon. This gave rise to the speculation that further west of the distribution of *L. sclateri* where the overlap with *L. impejanus* is more, the tail becomes totally white. However, in the localities surveyed no evidence for the presence of *L. impejanus* and *L. sclateri* were obtained, which does not explain for the white coloration of the tail in the new pheasant taxon. It is also speculated that this new pheasant taxon could possibly be a hybrid between *L. impejanus* and *L. sclateri*. Further information regarding the exact status and distributional limit of the new pheasant taxon needs to be obtained.

Information obtained on *T. satyra* during this survey clearly points out the range extension of this species. Earlier, confirmed evidences for the presence of *T. satyra* in Arunachal Pradesh was obtained only from the Tawang district (Singh 1994, Kaul et al. 1995). An unidentified species of tragopan was also reported from the Eagle Nest WLS. (Athreya and Karthikeyan 1995). Feathers of a tragopan species obtained in parts of Lower Subansiri and East Kameng districts appear to be that of *T. temminckii*. This species has been recently reported form the Dirang area of West Kameng district suggesting extension of its distribution range (Singh 1998). Earlier, this species was reported only till the Lower Subansiri district (Singh 1994), its presence further west was not known. Ali and Ripley (1983) believed the Subansiri-Manas watershed (somewhere between the 92° to 94°E long.) to be the dividing line between the two species. The findings from this study suggest that the two species possibly overlap in their distribution in the West Kameng district. More surveys around the Dirang area need to be carried out to confirm this.

Evidences in the form of local information of the endangered *T. blythii* obtained during the study from the Shergaon locality, which lies close to Bhutan, suggests that

Table 2. List of the sightings of the new monal.

	Date	Time	Altitude	Individuals seen	Remarks
1	17th October	5:30 a.m	4100m	1 male	Calling from a ridge top
2	"	5:40 a.m	4050m	1 male + 3 female	Flushed.
3	"	6:15 a.m	4100m	1 male + 1 female	Flushed.
4	"	6:30 a.m	4000m	1 male	Flushed.
5	"	7:50 a.m	3950m	2 female + 1 subadult?	The bird that appeared like a subadult had completely white tail like the male but the body plumage was like the female.
6	"	9:15 a.m	4100m	1 male + 2 female	Observed feeding.
7	18th October	7:30 a.m	4200m	1 female	Calling.
8	"	8:30 a.m	4000m	1 female	Observed standing on rock outcrop.
9	19th October	7:30 a.m	3950m	3 female	Flushed. They were feeding on underground tuber of Cobra lily (*Arisaema sp.*)

this could probably be the western subspecies *T. b. molesworthi*. Earlier, a specimen of *T. b. molesworthi* is reported to have been collected at Dengan La (approx. 91°1′E 27°11′) in the Sherchokpa country, 30 miles north of Odalaguri in Assam (Ludlow and Kinnear 1937). This locality when located on the map is close to Kalaktang, about 20 km west of Shergaon as the crow flies (Figure 2). This subspecies has been reported only from some parts of Eastern Bhutan and South Eastern Tibet (Biswas 1968, Cheng 1987, Ali et al. 1996). Ali and Ripley (1983) presumed that *T. b. molesworthi* extended from Eastern Bhutan east to Mishmi hills in Arunachal Pradesh north of the Brahmaputra. The only other evidence of *T. blythii* (subspecies unknown) in the state is from Mehao WLS. (Kaul et al. 1995), and more recently from Upper Siang district (Pratap Singh *pers.comm.*). The other subspecies *T. b. blythii* is believed to occur south of the Brahmaputra (Ali and Ripley 1983), and is reported to occur in significant numbers in Nagaland and Mizoram (Kaul et al. 1995).

Based on the evidence collected so far on the two subspecies of Blood pheasant *I .c. tibetanus* and *I. c. kuseri*, we believe that they probably overlap in their distribution somewhere between the 92° and 93°E meridians. That is between east of Dirang in West Kameng district and west of Sarli, Lower Subansiri district; see Figure 2. The Mishmi subspecies *I. c. kuseri* is reported to occur east of the subspecies tibetanus from 92° and 93° meridians; in the Abor and Mishmi hills of Siang and Lohit districts, in Myanmar, and in some parts of China (Ali and Ripley 1983, Johnsgard 1986, McGowan and Garson 1995). Unconfirmed reports of this subspecies have been obtained in the Dibang Valley WLS, Kamalang WLS, and Namdapha NP (Kaul et al. 1995) and recently recorded at Para in Lohit district (Pratap Singh *pers.comm.*). During recent surveys, confirmed evidence of the presence of the Tibetan subspecies was obtained in the Tawang district (Singh 1991, Kaul et al. 1995).

Only few local people in the Sarli circle of Lower Subansiri district, who regularly go for trade across the border to Tibet, recognized *C. harmani* and described a locality "Lajoli" where this species occurred. In most of the surveyed localities the locals confused this species with *L. l. lathami*. The western limit of distribution of *C. harmani* is reported to be the basin of Subansiri, north of the main range, from longitude 92°30′ eastwards (Ludlow and Kinnear 1944). It is not known as to whether this species occurs within the Indian limits. However, further surveys around the Sarli area could provide some information regarding this species. Both *L. l. lathami* and *G. gallus* based on local information appear to be well distributed through out the districts surveyed, occurring in both primary as well as secondary forests.

STATUS AND CONSERVATION OF PHEASANTS

The discovery of the new pheasant taxon, in the Eastern Himalaya highlights the fact that our knowledge on the pheasants occurring there is still very poor. Based on the discussions with the locals and from observations, no single factor at present seems to be a serious threat to the survival of pheasants in the surveyed districts. Pheasants in the surveyed districts appear to be safe mainly due to the large extent of habitat left intact mostly in the higher and interior areas along the Great Himalayan Range. However, hunting probably appears to be the only threat to pheasants as well as to other wildlife in the surveyed districts. Earlier studies had reported that habitat destruction in the form of logging, slash and burn agriculture, and hunting by local communities to be serious threats to the survival of the flora and fauna occurring there (Katti et al. 1990, Kaul et al. 1995, Athreya and Johnsingh 1995, Athreya 1997).

Hunting is a part of the culture of the tribes living here and in practice would be difficult to curb. The first step towards conservation of pheasants could be through setting up of Protected Areas (PA's). At present, there are 13 PA's in Arunachal Pradesh and of these, three are located in the districts surveyed. Only few of these PA's cover the higher reaches above 3000m and most pheasants occupy habitats mainly above 2000m. Within the districts surveyed, there is no protected area that includes areas in and along the Great Himalayan range. Some of the areas important for pheasants are also the regular haunts of endangered species like the Takin *Budorcus taxicolor*, Musk deer *Moschus chrysogaster*, Red Panda *Ailurus fulgens*. Moreover, very few or no human settlements in the higher and interior areas were observed in the surveyed districts. Most of the surveyed localities in the four districts were under the category of Unclassed State Forests. Therefore, declaring a PA particularly, in the Lower Subansiri and East Kameng districts could help ensure the survival of the new pheasant taxon. This could in turn help in the conservation of other wildlife in the area.

Many areas in Arunachal Pradesh remain unexplored. Baseline information such as presence/ absence of pheasants is lacking in many areas. Therefore, more extensive surveys need to be taken up to clearly chalk out distribution patterns of pheasants, which could help in their conservation.

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CONSERVATION STATUS OF MOUNTAIN UNGULATES IN GREAT HIMALAYAN NATIONAL PARK, HIMACHAL PRADESH

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Abstract : Conservation status of three mountain ungulates viz., goral (Nemorhaedus goral), Himalayan musk deer (Moschus chrysogaster) and Himalayan tahr (Hemitragus jemlahicus) were studied in Tirthan Valley of Great Himalayan National Park (GHNP), Himachal Pradesh from January 1996 to June 1998. In total, 396 sightings of goral, 42 sightings of musk deer and 64 sightings of Himalayan tahr were obtained during the study period. Goral encounter rates (± SE) and density estimates (± SE) in four monitoring transects ranged from 0.45 ± 0.15 to 2.57 ± 0.59 / km walk and 3.70 ± 1.31 to 26.85 ± 4.19 / km² respectively. Goral density estimates varied between transects (Kruskal-Wallis Test, $c^2 = 18.03$, d.f. = 2, $p < 0.05$) and between seasons (K-W Test, $c^2 = 5.83$, d.f. = 2, $p < 0.05$), but not between years. It also differed significantly between areas with different levels of human disturbances (Mann-Witney U Test, U = 1920.0, $p < 0.01$); more disturbed areas had relatively low density. Based on silent drive counts, musk deer density estimates (± SE) were 3.55 ± 0.20 / km² in Gumtharao (less disturbed, n = 5) and 1.14 ± 1.71 / km² in Dhela (more disturbed, n = 5). Himalayan tahr density estimates (± SE) based on scan counts ranged from 1.15 ± 0.62 to 4.53 ± 1.71 / km². Goral (n = 226) were mostly sighted between 2200 m to 2600 m (74% sightings) elevation, south and south-eastern aspects (80%) and in 41 - 60° slope categories (73%). Musk deer (n = 31) were sighted only in subalpine forest and alpine scrub above 3200 m and were mostly encountered in eastern aspects (53%) and in moderate slope categories (21 - 40°, 55%). Himalayan tahr (n = 64) were encountered in steep areas (> 60° slope, 77%) above 2800 m on the southern, southeastern and southwestern aspects (86%) with low tree cover. Potential threats to these ungulates have been identified and conservation implications and management strategies have been discussed.

WILDLIFE CONSERVATION, RESEARCH & MANAGEMENT : 35-39

Key Words : conservation, density, encounter rate, habitat use, mountain ungulate, threats.

Mountain ungulates are an important component of the Himalayan ecosystem as they form the prey of the endangered high altitude predators. Of the 31 species of ungulates reported in India, 19 species (61%) belonging to four families Equidae, Moshidae, Cervidae and Bovidae occur in the Himalaya (Bhatnagar, 1993). Scientific information on Himalayan ungulates is still lacking and the presence/absence of many species in different parts of this region is yet to be known. With the exception of a few long term studies (Green 1985, Kattel 1989, Chundawat 1992, Sathyakumar 1994, Bhatnagar 1997 & Manjrekar 1997), all other information on Himalayan ungulates is based on short term studies (Mishra 1993 & Pendharkar 1993) and status surveys (Schallar 1977, Gaston et al. 1981, Gaston et al. 1983, Fox et al. 1988, Cavallini 1990, Gaston & Garson 1992, Sathyakumar 1993 and Lovari & Apollonio 1994).

In the state of Himachal Pradesh, 8 species of ungulates are present of which seven occur in Great Himalayan National Park. They are goral (*Nemorhaedus goral*), Musk deer (*Moschus chrysogaster*), Himalayan tahr (*Hemitragus jemlahicus*), barking deer (*Muntiacis muntjak*), serow (*Nemorhaedus sumatraensis*), Himalayan ibex (*Capra ibex*) & blue sheep (*Pseudois nayaur*). The virtual absence of tracks & droppings of barking deer & serow in the area suggests that these species were not an important component of the ungulate community in the area. Except for ibex (Bhatnagar 1997 & Manjrekar 1997), no long-term studies were done in the state for any other species (Vinod et al. 1997). Present study focuses on goral, musk deer and Himalayan tahr which occupies the middle altitudes (between 2000-4000 m), which is also highly used by local people. Here we report the abundance, habitat use and conservation issues of these species.

STUDY AREA AND METHODS

This study was conducted in the Tirthan Valley of Great Himalayan National Park, Himachal Pradesh, India. The Park is located at the junction of two great faunal realms, Palaearctic to the north and Oriental to the south (MacKinon et al. 1986). The intensive study area forms the southwest part of the Great Himalayan National Park (Fig.1). Altitude of the area ranged from 1344 m to 6246 m above msl. The climate is typical of the front ranges in the Himalaya. Precipitation is moderate over most of the year and abundant during summer season (July-September). Snowfall is common in winter through out the area. The mean minimum and maximum temperature recorded in the intensive study area were –3.5°C (during January) and 31.1°C (during June).

The plant community in the area is representative of temperate, sub-alpine and alpine regions. At least 31 mammals were reported in the area. The common leopard (*Panthera pardus),* snow Leopard (*Panthera uncia)* and red fox (*Vulpes vulpes)* were major mammalian predators. A more detailed description of the study area is given by Vinod et al. (1997).

Four transects namely Kharongcha-Rolla (KHRO), Rolla-Shilt (ROSH), Rolla-Basu (ROBA) and Chalocha-

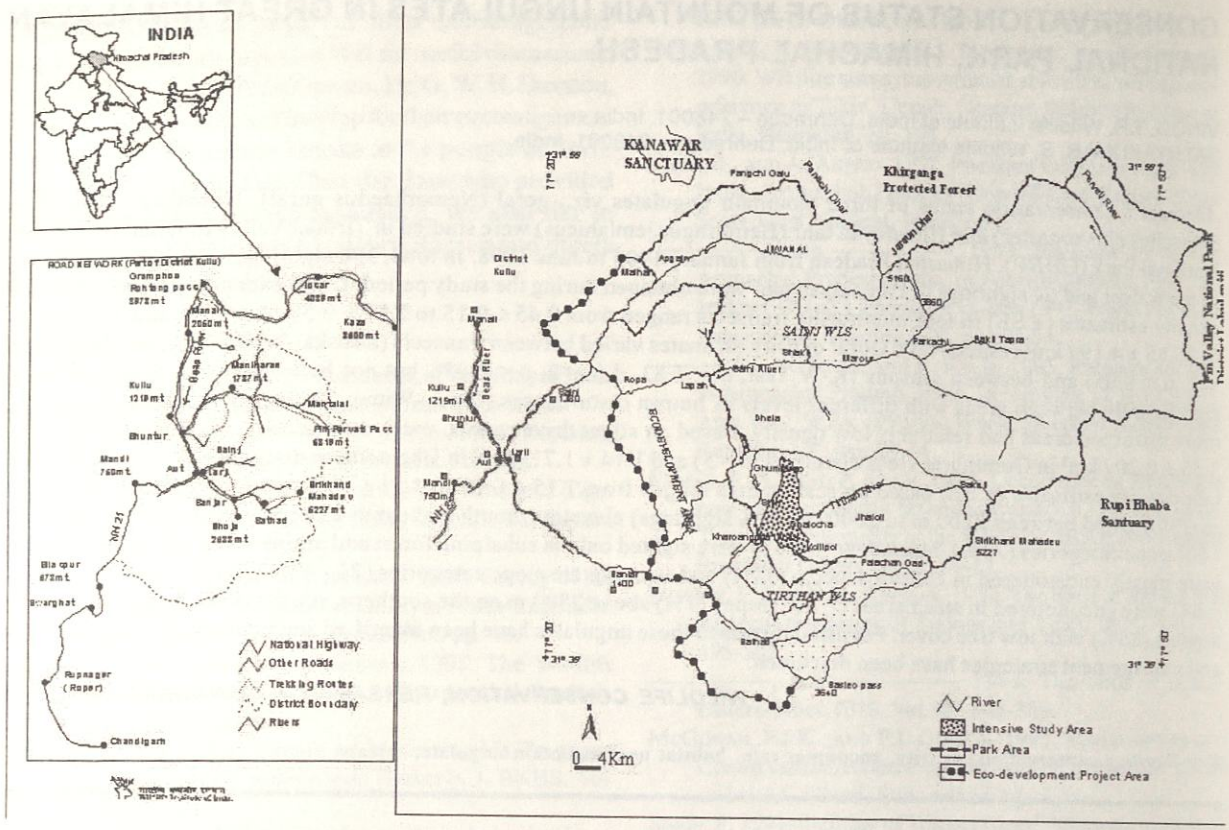

Fig.1. Map of the Great Himalayan National Park showing intensive study area.

Nara (CLNA), each 2.2-km were walked twice a month from January 1996 to June 1998. All transects were walked between 06.00 and 09.00 h. Four vantagepoints were also regularly scanned with 8x31 binocular and 15-25x spotting scope. Data on number of animals, sighting distance and angle, activity and sex of the animals were recorded for every sighting. Silent drive counts as described by Green (1985) were carried out at two known musk deer areas to estimate the musk deer density.

Data on use of various habitat and vegetation parameters namely altitude, aspect, slope, tree cover, shrub cover and grass cover were recorded for all sightings by transect walks, scanning and systematic searches in different habitats. All factors were recorded within a circular plot of radius 10-m. The encounter rates and density estimates animals were calculated for every transect walk. The following formulae were applied to the data.

Encounter Rate = n/L, where n and L are the number of animals sighted and the length of transect walked. Density = n/2Lr, where n = number of animals sighted, L = length of transect and r = mean sighting distance. Density estimates using silent drive count and scan methods were calculated as D = n/A, where n = the number of animals counted/seen and A = the area covered/scanned.

Two-tailed Mann-Whitney U (M-W U) test and Kruskal-Wallis (K-W) test with 95% confidence limits were performed using SPSS/PC statistical computer package to detect any difference in encounter rates or density estimates in different areas, between seasons, between years and with the human disturbance to habitat. Zar (1984) was followed during statistical treatmentof data.

RESULTS

A total of 396 sightings of goral, 42 sightings of musk deer and 64 sightings of Himalayan tahr were obtained during the study period. Goral encounter rates and density estimates in four monitoring transects ranged from 0.45±0.15 to 2.57±0.59/km walk and 3.7±1.31 to 26.85±4.19/km^2 respectively (Table 1&2). Goral density estimates varied significantly between transects (Kruskal Wallis Test, c^2=18.03, df=3, p<0.05) and between seasons (Kruskal Wallis Test, c^2=5.83, df=2, p<0.05), but not between years. Density estimates were higher during winter compared to other seasons. The density estimates also differed significantly between areas with different levels of human disturbances, (Mann Witney U Test, U=1920.0, p<0.01), more disturbed areas had relatively low density (Table 3). The musk deer density estimates based on silent drive counts were 3.55±0.20/km^2 in Gumtharao (less disturbed, n=5) and 1.14±0.49/km^2 in

Table 1. Seasonal Encounter Rates (#/km walk ± SE) for Goral in the Study Area (January 1996 - June 1998).

Transect Name	Winter (n=12)	Spring (n=16)	Autumn (n=8)
KHRO	0.45 ± 0.15	0.60 ± 0.18	0.91 ± 0.22
ROSH	1.36 ± 0.19	1.22 ± 0.30	1.08 ± 0.20
ROBA	1.70 ± 0.29	1.19 ± 0.26	0.64 ± 0.23
CLNA	2.57 ± 0.59	1.65 ± 0.48	0.85 ± 0.21
Overall	1.52 ± 0.20 (n=48)	1.17 ± 0.16 (n=64)	0.87 ± 0.11 (n=32)

Table 2. Seasonal Density estimates (#/km² ± SE) for Goral in the Study Area (January 1996-November 1998).

Transect Name	Winter (n=12)	Spring (n=16)	Autumn (n=8)
KHRO	3.69±1.31	5.96±1.88	3.28±2.04
ROSH	16.90±2.77	13.20±3.80	12.16±3.10
ROBA	26.85±4.19	14.14±2.99	10.25±2.85
CLNA	23.40±5.22	17.99±6.15	13.11±2.56
Overall	17.59±2.27 (n=48)	12.82±2.04 (n=64)	9.70±1.33 (n=32)

Table 3. Goral abundance Vs. disturbances in GHNP (1996-98)

Levels of disturbance	Encounter rate	Density
More disturbed (n=72)	0.92±0.10	10.20±1.32
Less disturbed (n=72)	1.52±0.18	17.42±2.08

Table 4. Density estimates of Himalayan tahr in GHNP (total count) during 1996-98.

Area	Spring	Autumn
Gumtharao-pari	4.53±1.71	3.15±1.26
Nara-Chidor	2.48±0.70	1.15±0.62
Overall	**2.97±0.56**	

Dhela (more disturbed, n=5). The Himalayan tahr density estimates based on scan counts ranged from 1.15±0.62 to 4.53±1.71/km² (Table 4).

The use of habitat factors and vegetation cover by goral, musk deer and Himalayan tahr were shown in Table 5&6. Goral (n=226) were encountered mostly in the middle and lower altitude forests. Most of the sightings (74%) were between 2200 and 2600 m elevation in south and southeastern aspects (80%) with 41-600 slope categories (73%). They used low tree cover, shrub cover and moderate grass cover. Musk deer were sighted only in sub-alpine forest and alpine scrub above 3200 m and were mostly encountered in eastern aspects (53%) and in moderate slope categories (21-400, 55%). They used mainly low tree cover and grass cover but high shrub cover. Himalayan tahr (n=64) were encountered in upper temperate, sub-alpine and alpine habitats, above 2800 m mainly on steep areas (>600 slope, 77%) in southern, southeastern and southwestern aspects (86%). They used low tree cover, shrub cover and moderate grass cover.

DISCUSSION

The abundance estimates for goral, musk deer and Himalayan tahr were low when compared with estimates from Kedarnath Wildlife Sanctuary (Sathyakumar 1994) and other PA's of Western Himalaya. The goral abundance in the area was higher during winter and there was a decreasing trend from winter to autumn. This is because, during winter the animal tend to concentrate in snow free areas. During spring the animal could be dispersed to more snow free areas. Low visibility during autumn might be a reason for further decline in the encounter rate. The higher encounter rate and density estimates in less disturbed areas suggested that goral do respond negatively to disturbances.

The musk deer densities are lower than the estimates of Green 1985 (3.2/km²) and Sathyakumar 1994 (3.7/km²) in Kedarnath Wildlife Sanctuary. Intensive poaching in the area is a major reason for the decline in musk deer population. The highest density was observed in Gumtharao area, which is less disturbed compared to other areas.

Scanning was found to be the only suitable method for estimating the density of Himalayan tahr. Tahr populations in the Park were highly affected by poaching and habitat degradation. The result of the present study indicates that tahr also do respond negatively to human activities. The density estimates were very low compared to the estimates of Kedarnath Wildlife Sanctuary (25.7/km², Sathyakumar 1994) and Langtang National Park (5 to 46/km², Green 1978).

The major threats to these ungulates are from snaring, livestock grazing, medicinal herbs and guchhii (*Morchella* sp.) collection. About 500 snares were detected and removed from the goral and tahr habitats of the study area during 1997 with the help of front line staff of GHNP. The mean snare density of musk deer habitats in the area during 1996-98 was 5.8 snares/

Table 5. Use of habitat factors by ungulates in GHNP.

Habitat factors	More utilized		
	Goral (n=226)	Musk deer (n=31)	Himalayan tahr (n=64)
Altitude (m)	2200-2600	3200-3600	3200-3600
Aspect	S, SE	E	S,SE,SW
Slope (°)	41-60	21-40	>60

Table 6. Use of vegetation cover by ungulates in GHNP

Vegetation Cover	More utilized		
	Goral (n=226)	Musk deer (n=31)	Himalayan tahr (n=64)
Tree cover (%)	0-20	<10	<10
Shrub cover (%)	1-20	31-60	<10
Grass cover (%)	11-40	0-20	21-40

km2. About 22000 sheep and goats (23 groups) enter the Park every year out of which ca. 7200 (8 groups) used the intensive study area for about 120 days.

The graziers used six of the seven identified musk deer habitats in the area and consumed ca. 7720-kg fuel wood every year. At least 960 herb collectors (120-160 groups) enter the study area every year and their average duration of stay was 12 days/group. They also used the six identified musk deer habitats and consumed ca.13520 kg fuel wood per year. Each year ca.18.3±1.6 guchhii collectors /day enter the study area. The collection period coincides with the birth season of goral and the collectors traverse every inch of the habitat in search of guchhii. The domestic dogs accompanying the collectors used to chase the animals frequently.

The first and most important step in the mitigation of these threats is the speedy settlement of 'rights' of local people and final notification of the Park. The camping and fuel wood consumption of livestock graziers and herb collectors in the critical musk deer habitats should be regulated. There is an urgent need for regular patrolling of the area by Park staff and removal of snares at frequent intervals. All the entry and exit points should be thoroughly monitored to check illegal activities. The conservation of these animals does not succeed unless local people around the Park are taken into consideration. There is a need to improve the economic status of these people by providing alternative income sources. Finally awareness should be created among these people about the importance of conservation.

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SEASONAL CHANGES IN FOOD HABITS OF THE ASIATIC LION AND LEOPARD IN THE GIR PROTECTED AREA

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Abstract : The Asiatic lion (*Panthera leo persica*) and the leopard (*P. pardus*) coexist at high densities in the Gir Protected Area (PA). The feeding niche of both the cats was studied by Singh *et al.* (1999). Seasonal variations in diet of both the cats along with other remarkable changes in the food habits were recorded during the study. The study was carried out by analysing hair samples of prey remains from 332 lion scats and 366 leopard scats collected from the Sanctuary as well as the National Park during summer, winter and monsoon of 1996-97. The study depicts the overall picture that a lion preys mainly on domestic livestock like buffalo and cow and wild animals such as chital (*Axis axis*), sambar (*Cervus unicolor*), nilgai (*Boselaphus tragocamalus*) whereas a leopard preys up on chital, langur (*Presbyties entellus*), other small mammals and domestic livestock. Seasonal variation in food preference of lion shows that the chital was highly fed on throughout the year but during monsoon the buffalo, chital and cattle were almost equally taken; whereas in case of leopard chital was most preyed upon throughout the year; which is followed by langur during winter and summer (15.27%, 15.75% respectively), and langur was replaced by domestic livestock (17.64%) during the monsoon. The scats of both the cats collected from the National Park contained remains solely of the wild prey. This study shows that the infiltration of the domestic livestock in the Sanctuary during monsoon reflects in the food habits of both the cats.

WILDLIFE CONSERVATION, RESEARCH & MANAGEMENT : 40-43

Key words: Asiatic lion, Food habits, Gir forest, Leopard, Scat analysis.

INTRODUCTION

The Gir is known all over the World as the last home of the Asiatic lion (*Panthera leo persica*) and it has the highest concentration of top carnivores namely lions and leopards (*P. pardus*). It would be interesting to study the food habits of both the sympatric cat species in the Gir. To fulfill this objective the scat analysis, one of the method to study the food habits of carnivores has been done throughout the year as a part of the research and monitoring work undertaken by the Wildlife Division, Sasan (Gir).

Scat analysis has been widely used to study the food habits of the carnivores (Joslin 1973; Johnsingh 1983; Norton *et al.* 1986). A method of knowing the food of the cats is through the collection of their faeces containing undigested material like hair, with the help of which the prey species could be identified (Singh *et al.* 1999). A study of mammalian hair structure could be used for investigating the food and feeding habits of carnivores.

Typical hair structure has three layers of keratin viz. central core or medulla; cortex surrounding the medulla; and cuticle, an outer most layer. All the three layers are composed of dead cells and the shape, size and relative thickness of these three layers are of great importance in hair identification (Brunner and Coman 1974).

Koppikar and Sabnis (1975) have identified hairs of 21 mammalian species through characteristics of their cuticular and medullary pattern. Rajaram and Menon (1985) studied the surface structure and cross section of hairs of some Indian mammals using the Scanning Electron Microscope. The details of hair identification are given by Brunner and Coman (1974).

Mukherjee *et al.* (1994) studied the prey items based on hair remains in the scat of the free ranging Asiatic lion, they analysed 30 scats to estimate the lions' diet. Singh *et al.* (1999) analysed 58 scats of lion and 102 scats of leopard collected from the Gir Protected Area. The studies mentioned above were confined to shorter period of year compared to the present study which was carried out on an annual basis so that complied information of diet and food preference may form a base line data which can be utilized for permanent monitoring purposes in future.

STUDY AREA

The Gir PA is situated between 20°40' N and 21°50' N latitude and 70°50' E and 71°50' E longitude, and it spreads over 1412.13 sq. km with dry deciduous forest. There are many forests adjoining the PA, which are almost contiguous with the present Sanctuary. These pockets are of varying sizes. In total about 470 sq. km area is available at present, which though is a part of the lion habitat but is not included in the Sanctuary.

Gir has tropical monsoon climate with three distinct seasons namely, summer, monsoon and winter. The temperature drops to about 10° C in winter and is as high as 43° C in summer. The average rainfall is 1000 mm in the western area and 600mm in the eastern area.

The Gir is dry deciduous Teak forest in the western part and Savannah type Acacia forest in the eastern part (Singh and Kamboj, 1995). There are more than 400 species of plants found in Gir forest and it harbours

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32 species of mammals, 300 species of birds, 33 species of reptiles and more than 300 species of insects (Anonymous 1996).

The main carnivores of the Gir are the Asiatic lion (*P. leo persica*), Leopard (*P. pardus*), Jungle cat (*Felis chaus*), Striped hyaena (*Hyaena hyaena*), Jackal (*Canis aurius*), Civet cat (*Viverricula indica*), Ratel (*Mellivora capensis*) etc. and the main herbivores are the Chital (*Axis axis*), Samber (*Cervus unicolor*), Blue bull (*Boselaphus tragocamalus*), Four horned antelope (*Tracerus quadricornis*), Chinkara (*Gazella gazella*), Wild boar (*Sus scrofa*), Common langur (*Presbyties entellus*), Porcupine (*Hystrix indica*), etc. A Small population of Black buck (*Antelope cervicapra*) is also found in the adjoining area of Gir.

Apart from the wildlife, the Maldharis living in the forest keep livestock which includes about 10,000 cattle (Buffalo and Cow) and goat, sheep and camel in small numbers. The wild herbivores numbering 38,221 and the livestock are the chief prey base for about 304 lions and 268 leopards in the Gir Protected Area as per 1995 census (Singh and Kamboj, 1995). Another 4,250 livestock owned by inhabitants of forest settlements also graze in the Sanctuary area.

METHODOLOGY

Scat collection and identification

A Total of 332 scats of lion and 366 of leopard were collected starting from September 1996 to August 1997 from different areas covering entire Gir Protected Area. Identified scats were collected in the polythene bags and were tagged with information on collection site and date. Since the scats as well as pugmarks are fresh in the morning it is easy to identify to which animal the scat belongs. So, the scats were collected during mostly during morning hours.

The scat of leopard is usually with pointed tips and smaller in size compared to that of lion. It could be further conformed by looking at the pugmarks as well as scratches of a leopard found nearby a scat.

Analysis of the scat

Each scat was washed thoroughly with hot water; and the hair and other prey remains like bones, hooves, quills, feathers, plant materials etc. were separated and washed again, packed separately in polythene bags and marked with the collection details.

Ten hair were picked randomly from a sample foı the study. Hair imprints were made as described by Keogh (1983) to see the scale patterns and scale margin structure. Cross sections of each hair were taken using pith and blade, sections passed through alcohol-xylene series and mounted in DPX for permanent preservation. The imprints and cross sections of the hair were observed under the microscope and compared with the reference collection for prey identification.

Table-1. Scat contents of lion and leopard showing one or more then one prey species

No. of Scats	1 prey species	2 prey species	3 prey species	Total
Lion	307	25	00	**332**
Leopard	320	37	09	**366**

Photographs of the cross sections were taken at 40X magnification. The measurements of the hair diameter were taken by micrometer.

RESULT

Total 332 scats of lion and 366 scats of leopard were analyzed. Most scats of both the cats had remains on one prey species, some lion scats had remains of two prey species while some leopard scats had remains of a maximum of three prey species (Table 1). The study shows that a lion preys mainly on domestic livestock like buffalo and cow and wild animals such as chital, sambar and nilgai whereas a leopard preys up on chital, langur, other small mammals , domestic livestock and stray animals like dog.

Seasonal variation in food preference of lion shows that the chital was highly fed on throughout the year but during monsoon the buffalo, chital and cattle were almost equally taken; whereas in case of leopard chital was most preyed upon throughout the year; which is followed by langur during winter and summer (15.27%, 15.75% respectively), and langur was replaced by domestic livestock (17.64%) during the monsoon. The scats of both the cats collected from the National Park contained remains solely of the wild prey. This study shows that the infiltration of the domestic livestock in the Sanctuary during monsoon reflects in the food habits of both the cats. Analysis of majority of scats (16 out of 17 scats of leopard and 19 out of 21 scats of lion) collected from the National Park shows the wild prey only.

DISCUSSION

The Gir PA has the highest concentration of top carnivores i.e. Asiatic lion and leopard in the country. The food preference of lion and leopard varies with change in seasons. The top ranking prey animal in case of both the cats is the chital (23.20% and 27.74% in the diet of lion and leopard respectively). The chital population has shown a dramatic increase from about 4,100 in 1970 to 32,061 In 1995. This is likely due to more availability of fodder resulting from reduced biotic pressure of the cattle gazers in the PA. According to Joslin (1973) livestock contributed 78% of the food of lion, Sinha (1987) reported that 52% of the scats he analysed contained wild prey remains, Chellam (1993) found (65%) wild prey in the food of Asiatic lion. The increase in Chital number might have decreased the competition for the food between lion and leopard.

Table 2 Seasonal variation in food habits of lions in Gir PA expressed as percent occurrence of prey in lion scat.

No.	Prey Animals	Winter (n=108)	Summer (n=113)	Monsoon (n=111)	Annual Total % (n= 332)
1	Chital	24.07	23.89	21.26	23.20
2	Sambar	12.04	15.93	07.21	11.75
3	Wild boar	07.41	08.85	07.21	07.80
4	Blue bull	09.26	15.93	09.00	11.40
5	Other wild prey	12.04	07.08	07.21	08.75
6	Buffalo	11.11	12.93	23.42	16.85
7	Cow	13.88	11.27	19.82	15.70
8	Other live stock	04.63	04.42	03.60	04.20

In case of lion the second ranking prey is the domestic livestock namely Buffalo (16.85%) and Cow (15.70%). It seems that for a lion, domestic livestock like buffalo, cow, camel, goat, etc. are more easy to prey upon than the other wild animals. Further a kill of an adult buffalo or a cow also provides sufficient meal for a pride.

Whereas leopard being smaller in size, usually kill smaller prey below 100 kg of body weight. Leopard preys upon arboreal animals like langur (14.28%), peafowl (6.37%) and civet(4.60%). Porcupine (7.40%), hare (4.59%) and feral dog (4.59%) also contribute to the leopard's diet.

Striking variation in food habits has been seen during monsoon; in case of leopard predation on livestock is increased up to 17.46% from 9.58%. In case of lion also the highest livestock depredation was seen during monsoon (46.84%); while during summer 71.68% of food contributed by the wild prey. During summer the water holes become restricted and wild animals like sambar, which prefers hilly terrain, has to come down for water; further the visibility of forest during summer also plays an important role in the predation of wild prey. So wild ungulates like sambar, chital, chinkara, four horned antelope (*Tetracerus quadricornis*) become more vulnerable for predation during summer. Infiltration of the domestic livestock from neighbor-ing villages for grazing recorded more during monsoon and post monsoon.

As mentioned above the Gir has the highest concentration of the top carnivores but both the great cats survive in Gir by the feeding niche differentiation. Though the most preferred prey for both the cats viz. lion and leopard is chital but leopard's predation on langur and other small animals like porcupine, peafowl, civet (4.60%), Feral dog (4.59%) and other wild prey (12.06%) contributes a significant portion of the leopards' diet, whereas on the other hand, the lion also prefers to take domestic livestock. Generally lions prefer the bigger prey due to it gregarious living behaviour and they require more food for fulfilling the requirement of a whole pride. So, by such feeding habits both the big cats of Gir avoid competition for the food. The only overlapping prey is Chital due to it s higher number in the PA.

Moreover scats of both the cats collected from the National Park area during summer contain chiefly the wild prey remains; this shows that if livestock is not available to a lion and leopard they can prey upon the wild ungulates.

The study shows that as wild prey densities increases and cattle densities decreases at the outside of Gir PA, large carnivores of Gir are switching to consumption of more wild prey; a healthy sign for a protected area. It also shows the change in feeding habits of lion from the time of Joslin (1971) who reported livestock 78% consumption in the food of lion. That is also due to very low population of wild ungulates in early '80s than what is found now a days.

Further the translocation of Maldhari Nesses from the Gir PA to outside the PA also have reduced biotic pressure and thus the availability of wild prey per lion has become higher (125.9) then the past (53.5) (Singh, 1997).

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Table-3. Seasonal variation in food habits of leopards expressed as percent occurrence of prey in the scat collected from the Gir PA.

No.	Prey Animals	Winter (n=137)	Summer (n=95)	Monsoon (n=134)	Annual Total % (n=366)
1	Chital	27.77	23.29	22.54	27.74
2	Common langur	15.27	15.75	10.78	14.28
3	Porcupine	06.94	05.85	08.82	07.40
4	Peafowl	04.17	06.16	09.80	06.37
5	Sambar	05.55	08.47	06.68	05.87
6	Hare	06.25	03.42	03.92	04.59
7	Civet	05.55	02.05	06.86	04.60
8	Feral Dog	03.77	07.53	02.94	04.59
9	Domestic livestock	11.80	09.58	17.64	12.50
10	Other wild prey	11.80	15.06	10.06	12.06

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RECENT DECLINE IN THE PHEASANT POPULATIONS IN GREAT HIMALAYAN NATIONAL PARK, WESTERN HIMALAYA: CONSERVATION IMPLICATIONS

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Abstract : We assessed the changes in the pheasant populations in Tirthan valley of Great Himalayan National Park (GHNP) during 1996 to 1998. To index himalayan monal (*Lophophorus impejanus*) population, 6 trails were walked twice a month to obtain encounter rates (# / km) with birds seen or heard flushing nearby. For koklass (*Pucrasia macrolopha*), we counted dawn calling sites from two points each on 5 trails during April and May when calling is maximal. The resulting index value for monal in winter (December-March) on three trails and koklass calling in five trails were used to indicate population trends. Mean (± SE) encounter rates for monal were 8.0 ± 1.6 / km in 1996 and 4.9 ± 0.8 / km in 1998 indicating a decline over just two years. For koklass, our index declined from 3.1 ± 0.2 calling sites / calling station in 1997 to 2.5 ± 0.2 in 1998, again representing a decrease in one year. Encounters on trails for the threatened western tragopan (*Tragopan melanocephalus*) were too few (0.6/km in 1996: 0.3/km in 1998) to allow meaningful statistical analysis, but the trend also suggest a decline over two years. Present results have been compared with previous studies and possible reasons for the apparent decline are discussed. The need for immediate action towards conservation has been stressed.

WILDLIFE CONSERVATION, RESEARCH & MANAGEMENT : 44-49

Key words : conservation, decline, encounter rate, mushroom, pheasants, population trend.

Effective management and conservation of any wildlife species requires detailed knowledge on population structure and dynamics. Estimating populations for free ranging vertebrates has usually been difficult and is subject to considerable amount of errors. This is mainly attributed to inherent variation in the distribution and behavior of animals, compounded with inaccessibility of terrain that does not permit adequate sampling. Recording population trends for a species is of greater help than just knowing how many individuals of the species are present in a given area. Population trends can be detected by undertaking biological monitoring protocols, which are careful and periodical evaluations of selected parameter(s)/ phenomenon to assist in detecting the spatio-temporal changes.

It is a means of viewing the subject on a long-term and obtaining information on select aspects such as its status, distribution, habits and ecology (Woodburn 1993). Decrease in population of a species indicates unfavourable condition effected by some biotic/abiotic factors and should invoke immediate management intervention to protect the species from deteriorating further. Several extant species are faced with unlimited number of human induced threats, which has resulted in restricted or shrinking distribution. Pheasants are by no means exception to this ever-increasing persistent problem. This kind of situation, where these species are forced into isolated pockets, makes them vulnerable to extinction. The rate of extinction becomes even faster when the species comes under direct persecution by the local human population (Primack 1993).

Pheasants belong to avian order 'Galliformes' and family 'Phasianidae'. Interestingly, of the 51 species of pheasants that occur in the world, 50 of them are Asian in origin. The lone exception is of the Congo peafowl (*Afropavo congensis*) which is found in Zaire of southern Africa (Delacour 1977). Though they occur in relatively least-studied terrestrial environment(s), pheasants are among the most seriously impacted of all major groups of birds due to human exploitation and habitat destruction (Johnsgard 1986). A total of 29 species (57%) of the entire group are listed as rare, endangered or vulnerable in the Mace-Lande threat category, provided by the IUCN Pheasant Specialist Group (PSG) (McGowan and Garson 1995). The pheasants, throughout the western Himalaya, have long been under severe pressure due to hunting and poaching (Gaston *et.al.* 1983). These, along with large-scale habitat destruction for various developmental purposes, have caused the decline of this remarkable group of birds (Ali 1981 and McGowan & Gillman 1997). However, there are still few areas that are relatively undisturbed and support substantial populations of pheasants. The Great Himalayan National Park (GHNP) is one such area, which offers suitable habitat for five of the 17 species that occur in India viz. western tragopan (*Tragopan melanocephalus*), himalayan monal (*Lophophorus impejanus*), koklass (*Pucrasia macrolopha*), cheer (*Catreus wallichii*) and kalij (*Lophura leucomelanos*). These pheasant species are listed under Schedule I in the Indian Wildlife (Protection) Act, 1972 (Anon 1972), and the IUCN considers the western tragopan as Vulnerable, which reflects the threat perception of national and international conservationists on these birds. The GHNP in India and Machiara National Park in Pakistan are the only two National Parks in the world that support a viable population of the endangered western tragopan (Collar & Andrew, 1988). GHNP also falls under the globally

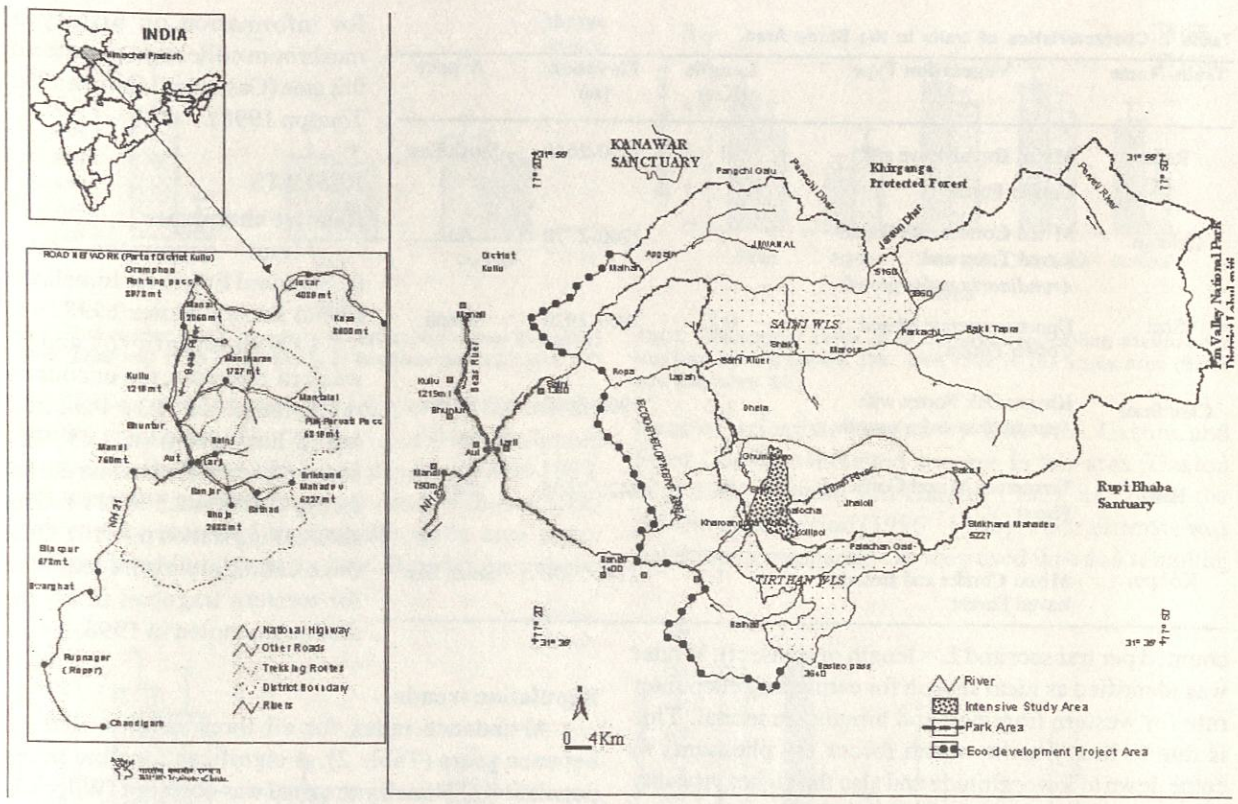

Fig.1. Map of the Great Himalayan National Park showing intensive study area.

important 'Endemic Bird Areas' designated by the International Council for Bird Preservation (Anon, 1992). With the increase in human population, dependency on park resources by the local people has also increased (Kumar *et al.* 1997). Due to increase in the National and International market demand, morel mushroom (*Morchella esculenta*, locally called 'Gucchhi') has become a commercially exploitable commodity by the local people (Tandon 1998). This has resulted in intense combing of the entire forested area by the local people. This mushroom grows between 1500m to 4000m in lower and upper temperate conifer and mixed broad-leaved forests during spring season. Incidentally, the pheasants are found to be breeding in these habitats and therefore, the extraction of mushroom is likely to have negative impact on the pheasants as the extraction coincides with the breeding season. A study on Brown-eared pheasant in China has confirmed that mushroom collectors reduced breeding success to a large extent (Zhang Zheng-wang 1995). This paper appraises the changes in the population of three pheasant species (viz. Western tragopan, Himalayan monal and Koklass) and discusses the pressures of mushroom collection on breeding pheasant in the GHNP.

STUDY AREA AND METHODS

The Great Himalayan National Park (31° 33' 00" N to 31° 56' 56" N, 77° 17' 15" E to 77° 52' 05" E) is situated in Kullu District of Himachal Pradesh, India (Fig. 1). The study area extends over 1,171 km^2 and comprises the GHNP (765 km^2), Sainj Sanctuary (90 km^2), Tirthan Sanctuary (61 km^2) and the buffer zone (or ecodevelopment area) (255 km^2). The GHNP is located at the junction of two faunal realms, viz. Palaearctic in the north and Oriental in the south and supports rich biological diversity of both biogeographic elements (MacKinon *et al.* 1986). The altitude of this area ranges from 1,344m to 6,246m above mean sea level. The climate is typical of front ranges in the Western Himalaya. The plant communities are representatives of the temperate, sub-alpine and alpine regions which include oak and coniferous forests, high altitude mixed forests and sub-alpine and alpine pastures. Five forest types of Champion and Seth's (1968) classification have been reported from the Park by Gaston and Garson (1992) viz., 1. subtropical pine forest, 2. himalayan moist temperate forest, 3. sub alpine forest dominated by birch and fir species, 4. moist sub alpine scrub and 5. dry alpine scrub.

A 16 km^2 area was identified for intensive study (Fig. 1) in Tirthan valley based on initial surveys and the area was stratified into six different vegetation types (Table 1). Within the study area, 70 percent of the trails traversing through potential pheasant habitats were sampled. Six trails ranging from 0.7 km to 1.2 km were walked twice a month systematically to estimate relative abundance. Abundance index was calculated using encounter rate (n/L, where n = number of birds

Table 1. Characteristics of trails in the Study Area.

Trails Name	Vegetation Type	Length (Km)	Elevation (m)	Aspect
Rolla	Mixed Broad-leave and Conifer Forest	1	2290-2640	South East
Dulunga	Mixed Conifer with Broad-leaved Trees and *Arundinaria* under growth	1	2700-2770	East
Shilt	Upper temperate Mixed Conifer Forest	0.7	2900-2920	South
Chordhuar	Kharsu Oak Forest with *Arundinaria* under growth	1.2	2900-3010	South
Basu	Temperate Mixed Conifer Forest	1	2420-2655	North
Koilipoi	Mixed Conifer and Broad-leaved Forest	1	2710-2870	South East

counted per transect and L = length of transect). Winter was identified as ideal season for estimating encounter rate for western tragopan and himalayan monal. This is due to heavy snow which forces the pheasants to come down to lower altitude and also the higher visibility during this period, thus enabling higher chance of sighting maximum individuals in the given area.

For species such as koklass and western tragopan which are shy and skulk under ground vegetation cover, call counts were undertaken. These species call intensively during breeding season to attract females and defend territories (Gaston *et.al.* 1980, Ramesh *et.al.* 1998). Ten calling stations were established (2 in each trail) to record dawn calls and the encounter rate was expressed as number of calling sites per unit effort per calling station. Since koklass exhibits skulking behaviour, call counts were likely to index abundance better. Western tragopan's abundance was indexed by both call count and direct sighting.

Data on number of people visiting the study area for mushroom collection was collected by monitoring the park entry point. Existing literatures were also referred for information on history of mushroom collection practice in this area (Gaston and Garson 1992, Tondon 1998).

RESULTS

Relative abundance

Mean encounter rates (± Standard Error) for himalayan monal during winter 1998, was 5.1 ± 1.0 birds/km (n= 6), and for western tragopan, the encounter rate estimate was 0.3 ± 0.5 birds/km (8 birds seen) (n = 6). Call count estimates for koklass during spring 1998 was 2.5 ± 0.21 calling sites/calling station (n = 10). Only three calling sites were recorded for western tragopan in all the stations sampled in 1998.

Population trends

Abundance index for all three species differed between years (Table 2). A significant decline in the population of Himalayan monal was observed (Wilcoxon matched pair test $P< 0.05$, n = 3) (Fig. 2) between years. Abundance estimate for Koklass also showed a significant decline ($P< 0.01$, n = 5) between the years compared (Fig.3). Statistical tests could not be performed for Western tragopan due to insufficient data. However, the reduction of sighting from 11 individuals in 1996 to six individuals in 1998 (pooled data) indicates a decline in population (see also Fig.4). Of three trails compared, there was no sighting of Western tragopan in Dulunga trail in 1998. The trend was similar in call count estimate as well. There were only three calling sites recorded in 1998 as compared to five in 1997. Spring estimate for Himalayan monal between the years 1997 and 1998 also showed a significant decline of 25% (Wilcoxon matched pair test $P< 0.05$,n = 6) (Fig.5). Overall decline per year for these pheasants were 19 percent for Himalayan monal, 23 percent for Western tragopan and 18 percent for Koklass.

Table 2. Mean encounter rate (± Standard Error) for pheasant species between years in the study area

Species (*season sampled*)	Year			Percentage decline
	1996	1997	1998	
Western tragopan (*Winter*)	0.61 ± 0.14	-	0.33 ±	23.
Himalayan monal (*Winter*)	8.0 ± 1.62	-	4.9 ± 0.80	19
Himalayan monal (*Spring*)	-	2.4 ± 0.44	1.8 ± 0.54	25
Koklass (*Spring*)	-	3.1 ± 0.21	2.52 ±	18

Mushroom collection

Of the eight Non Timber Forest Products (NTFP) under extraction in GHNP, mushroom is the most preferred one and is been collected by 60% of the local population (Fig. 6). Though the collection started in late eighties, the intensity of collection increased since early nineties.

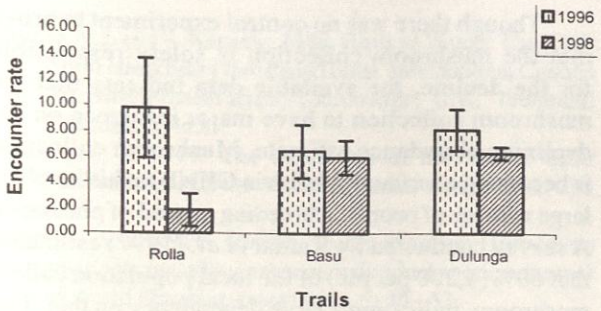

Fig.2. Encounter rates (# / km) for Himalayan monal during winter 1996 and 1998 in the study area (Error bar indicates SE)

This is evident from the increase in the market price in recent years (Fig. 7). One kg of dried mushroom was sold for Rs.900 in 1994, and it is Rs. 2500 in 1998, with constant increase at every year. Fifty to sixty people were recorded to visit the study area every day from late March to early June. Besides the people,

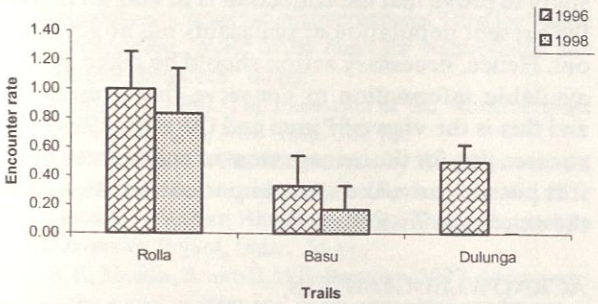

Fig.4. Encounter rates (#/km) for Western tragopan during winter 1996 and 1998 in the study area (Error bar indicates SE)

a total of 70-80 dogs entered the area along with the 'gucchii' collectors. Secondary data collected by interviewing known mushroom collectors revealed that stealing of eggs of pheasant species is taking place in GHNP. Besides this, dogs that are taken to forest were also seen involved in nest predation (N=2).

DISCUSSION

Population trend was looked at in two different time periods. One was between 1980 to 1991, when a

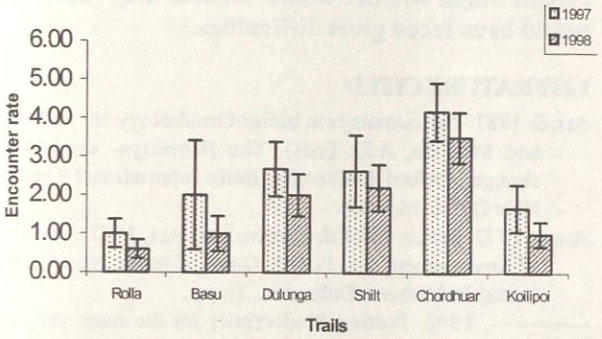

Fig.5. Encounter rates (#/km) for Himalayan monal during spring 1997 and 1998 in the study area (Error bar indicates SE)

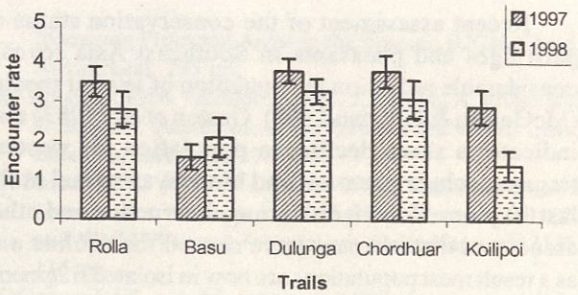

Fig.3. Encounter rates (# of calling sites/calling station) for Koklass during spring 1997 and 1998 in the study area (Error bar indicates SE)

team of scientists headed by Drs. A.J. Gaston and Peter Garson conducted surveys in this area (Gaston *et.al* 1981, Gaston and Garson 1992), and other the present study period (1996 - 1998). Their estimate was not directly comparable as they used time as a sampling

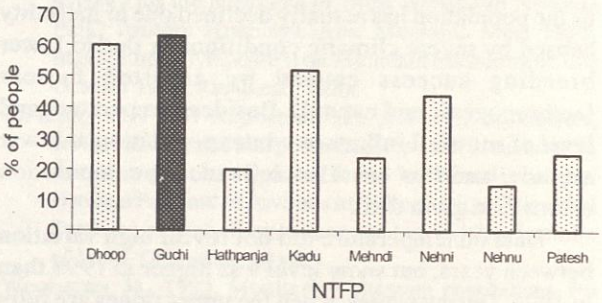

Fig.6. Non Timber Forest Products (NTFP) collection by local people in Tirthan valley of GHNP

unit while in our study distance was the sampling unit. For all these pheasants, Gaston and Garson (1992) presented a 5% decline in the population between 1980 (0.9 birds/hour search) and 1991 (0.8 birds/hour search). Our study documented an over all decline of 19 percent for Himalayan monal, 23 percent for Western tragopan and 18 percent for Koklass. The reason for the sudden decline in the pheasant population can possibly be attributed to the extreme level of disturbance caused by the uncontrolled mushroom collection practice by the local people.

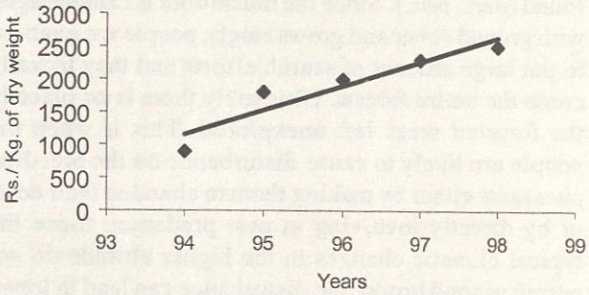

Fig.7. Trend in the rise of market price of morel mushroom (*Morchella esculenta*) from 1994 to 1998 in buffer zone of GHNP

Recent assessment of the conservation status of partridges and pheasants in Southeast Asia reveals considerable reduction in population of several species (McGowan & Gillman 1997). Gaston *et al.* (1983) also indicates a sharp decline in population for western tragopan, cheer pheasant and himalayan monal in the last 30 years. Habitat alteration, destruction and other associated disturbances have caused the decline and as a result most populations are now in isolated fragments (McGowan and Garson 1995). The causes of these vary from clear felling of forests, encroachment, excessive impact of domestic stock, human induced fire and extraction of medicinal herb and fungi. In our study, disturbances associated with the collection of mushroom seem to be the major threat to the pheasants. Gaston and Garson (1992) also observed these factors during their survey. The reasons attributed to lower encounter rates of pheasants in the second year of our study may be, either the pheasants moved to an other area or the population has actually declined due to mortality caused by severe climatic conditions or due to lower breeding success caused by assorted factors (anthropogenic and natural). Besides, temperature and level of snowfall influence winter population at lower altitude, and this can also influence the population estimate in great deal.

Data on temperature did not reveal high variation between years, but snow level was higher in 1998 than in 1996. During winter, when the upper ridges are fully snow covered, most of these pheasants migrate to lower elevation (Johnsgard 1985, McGowan 1994, Kumar 1997 and *pers. obs.*). However, the extent of concentration at lower altitude is controlled by the level of snow cover and duration of snowfall. In 1998, heavy snowfall occurred in GHNP reaching as low as 1800 m elevation and snow cover of 2 - 3 ft depth remained till March 1998. This should have ideally forced most of the pheasants to lower elevation and thus enabling more sightings. But, this was not the case in our study and indeed, the abundance index was much lower when compared to the previous year, indicating a strong decline in the population. Mortality due to natural factors such as predation etc. was ruled out since possible predators are in low abundance and no dead birds were found (*pers. obs.*). Since the mushroom is camouflaged with ground cover and grows singly, people are required to put large amount of search efforts and they literally comb the entire forests. Ultimately there is no place in the forested areas left unexplored. This is when the people are likely to cause disturbance on the breeding pheasants either by making them to abandon their nests or by directly involving in nest predation. Since the typical climatic changes in the higher altitude do not permit second brood, the disturbance can lead to lower breeding success and thus invoking concern and adequate management intervention.

Though there was no control experiment to prove that the mushroom collection is solely responsible for the decline, the available data indicate that the mushroom collection to have major influence on the declining abundance estimate. Mushroom collection is becoming a serious problem in GHNP as this involves large number of people in breeding ground of pheasants. A survey conducted by Kumar *et al.* (1997) estimated that 60% (4,200 people) of the local population collect mushroom, indicating a large dependency on this. The dependency of the local people deserves immediate attention on a priority basis to control excessive disturbance to breeding pheasants. Though this study does not provide concrete evidence to prove that mushroom collection is causing the decline of pheasant populations in GHNP, we still argue that immediate steps should be taken up to control the mushroom collection. This is because, by the time we complete a study to prove that the collection is having an impact, the present population of pheasants might get wiped out. Hence, necessary action should be taken up with available information to conserve these pheasants, and this is the view of Pimm and Curnutt (1994) who stresses that for the management of endangered birds, it is possible to make some important decisions with the existing knowledge.

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ALTITUDINAL DISTRIBUTION, RELATIVE ABUNDANCE AND HABITAT PREFERENCE OF PHEASANTS IN FORESTS OF GARHWAL HIMALAYA

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Abstract : Pheasants as a group are threatened because they are hunted for food and aesthetic value. Due to these pressures and habitat loss some species have even been become endangered. No management plans have as yet been developed for pheasants. This is likely due to lack of adequate scientific data base on their ecology and breeding biology. This paper provides information on distribution, relative abundance and habitat preference of pheasants in Kedarnath wildlife division of Garhwal Himalaya (29°26'N to 31°05'N and 78°E to 88°E). Investigations were conducted in subtropical, temperate and alpine habitats (750-3750 m). Vantage points were selected and transects were laid in different forest types at different altitudes. In the temperate study area five habitat types i.e. alpine, sub-alpine, temperate coniferous evergreen, temperate moist and temperate mixed deciduous were identified. Subtropical study area constituted pure pine, mixed pine, subtropical mixed deciduous, open scrub and crop fields habitat types. Relative abundance of pheasant population was assessed and species specific habitats identified. Sighting frequency of monal and koklas was significantly less than that of kaleej in temperate forests. Similar sighting frequency of monal and koklas indicated that the latter has also become equally endangered and ought to be enlisted like monal as Scheduled I species in Indian Wildlife Protection Act. Results indicate that monal and koklas are specialist species limited in distribution (2500-3750m) and with limited tolerance to climatic variables. Kaleej appears to be a generalist species distributed over a wide range of habitats from subtropical to temperate having adapted to almost all climatic conditions (400-2500m). Red jungle fowl was found to be exclusively subtropical (400-1200m). Results on seasonal habitat utilisation indicate a distinct ecological segregation of pheasants in these forests along the altitudinal gradient. Areas vacated by monal are occupied by koklas in summer. Habitats vacated by koklas in summer are occupied by kaleej.

WILDLIFE CONSERVATION, RESEARCH & MANAGEMENT : 50-56

Key Words : Himalaya, pheasants, Relative abundance, Habitat use, population estimates

INTRODUCTION

Pheasants constitutes an important group of birds not only because of their aesthetic and food value but also because often their disappearance is the first sign of degradation of an ecosystem. Out of 48 species described so far 47 are endemic to Asia and a great majority confined to the Himalaya. Understandably in the wake of massive deforestation in the Himalayan region their existence stands threatened, some species actually having been declared endangered. Yet no sound strategies have been evolved for the management of pheasant in Himalayan mountains the main reason being a lack of prerequisite scientific database on the status, distribution, habitat ecology, breeding and behavioural biology in their native habitats.

In the present paper results of long term extensive and intensive investigations have been reported on the distribution, relative abundance and habitat preference in temperate and subtropical forests of kedarnath wildlife division of Garhwal Himalaya.

STUDY AREA

Garhwal Himalaya with varied topography and climatic conditions support diverse habitat types and a rich fauna. With five districts Garhwal Himalaya (29° 26'N to 31° 5' N and 78° E to 88° E) spread over an area of 30,090 sq.km. (Wadia 1978) (figure 1). Altitudinaly three broad habitats can be identified, viz. subtropical (400-1200m), temperate (1200-3000) and alpine (above 3,500 m). Extensive and intensive studies (750-3750 m) were carried out over a period of three years in Kedarnath Sanctuary and Chanttikhal reserve forest of Kedarnath Wildlife Division.

Kedarnath Sanctuary (30° 25'N - 30°45' N and 78° 55'E - 79° 22'E figure 1) cover 967 sq.km. Studies were conducted in the Okhimath reserve forests. The area forms the upper catchment of Mandakini river with gentle to steep sloaps. *Quercus leucotrichophora, Q. semecarpifolia, Abies pindrow, Cupressus torulosa, Taxux baccata, Cedrus deodara, Rhododendron arboreum, R. campanulatum, Litsea sp., Barberis sp. Arundinaria sp.* etc. the dominant plant species to different vegetational storeys.

Chanttikhal reserve forest (30° 13' E to 30° 15' 02" E and 78° 52' N to 78° 56'N, 750-1200m) lies on the bank of Alakananda river cover subtropical and pine vegetation types (figure 1). In the west the reserve is bordered by a tributary of Alakananda river named Gostu gad and on the north-eastern side by Alakananda river itself. Topographically the entire area constitute hilly terrain from gentle slopes to steep slopes. *Pinus roxburghii, Rhus parviflora, Ougeinia oojeinensis,*

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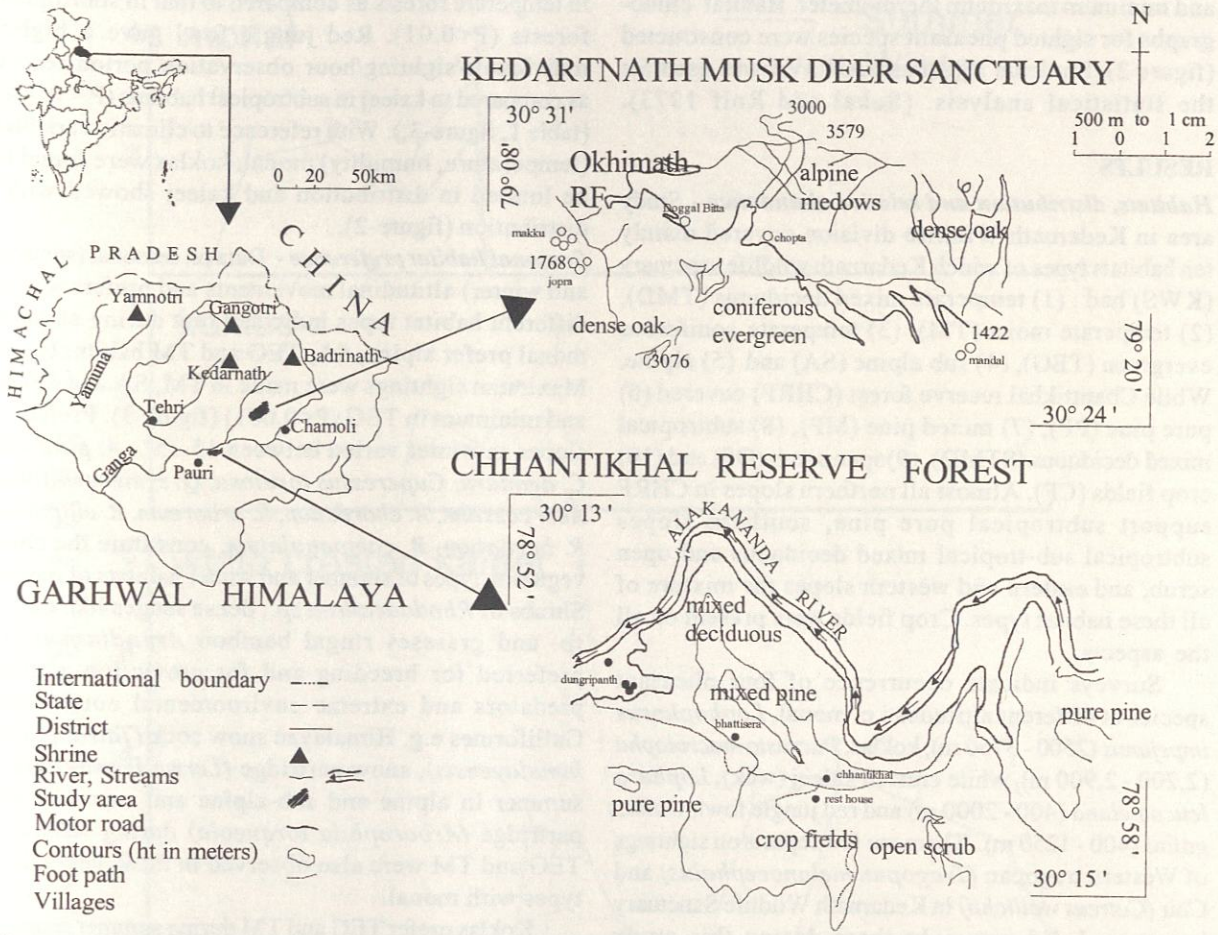

Figure -1. Map showing study sites in Garhwal Himalaya. Study site in temperate forests (1500-3750m) of Kedarnath Wildlife Sanctuary and in subtropical forests (750-1200m) of Chanttikhal Reserve in Kedarnath Wildlife Division in Garhwal Himalaya

Toona ciliata, Mangifera indica, Mallotus phillipinensis, Bauhinia variegata, Ficus bengalensis, Carrissa sp., Murrayya sp., are the dominant vegetation type of the area.

METHODS

Distribution and Relative Abundance

Seasonal observations in Kedarnath wildlife Sanctuary were made by transects (Burnhem et al 1981) of variable length covering different habitats and altitudes. In winter due to heavy snow fall in the higher reaches of the sanctuary i.e. alpine and sub-alpine and temperate evergreen habitats, transects could not walked and therefor opportunistic observations were made on the presence and absence of the pheasants by sighting, tracks and calls. Transects were walked for two hours early dawn and dusk. Sampling time was constant throughout the study period. Data collected on direct sightings, scratch marks, calls, pallets along the transects were used to workout distribution and habitat use. In the Chanttikhal reserve forest observations were made using vantage points (Jarvinen 1978) and transact walks. Twelve vantage points and six transects covering different habitats were used. Vantage points and transact walked were not habitat specific. Each vantage point and transact walked cover two to three habitat types. Vantage points were hidden elevated areas from where observations for long duration were made without disturbing the pheasants. Vantage points were also selected along the edges of the forests or crop fields. Points were visited at least half an hour before the emergence of the pheasants from their roosting grounds. Transects were not straight line because of undulating rough terrain. Paths use by grass/wood cutters were used as transects. This also helped in minimising disturbance by moving in dense habitat patches. Observations from vantage points were made only during dawn and dusk hours while transects were walked during day time also. Data collected was used for behavioural observations, activity periods and habitat use. During breeding period i.e. March to August data collected from vantage points and transact walks was compared for population estimates. Time spent on the vantage points and transects was constant i.e. two hours during dawn and dusk. Transects walked during day time data was only used for habitat use.

Abiotic factors like temperature, relative humidity were recorded in different habitat types using hygrometer

and minimum maximum thermometer. Habitat climographs for sighted pheasant species were constructed (figure 2). Students t' test and ANOVA was used for the statistical analysis. (Sokal and Rolf 1973).

RESULTS

Habitats, distribution and relative abundance - Study area in Kedarnath Wildlife division covered mainly ten habitats types of which Kedarnath wildlife sanctuary (KWS) had ; (1) temperate mixed deciduous (TMD), (2) temperate moist (TM), (3) temperate coniferous evergreen (TEG), (4) sub alpine (SA) and (5) alpine. While Chanttikhal reserve forest (CHRF) covered (6) pure pine (PP), (7) mixed pine (MP), (8) subtropical mixed deciduous (STMD), (9)open scrub (OS) and (10) crop fields (CF). Almost all northern slopes in CHRF support subtropical pure pine, southern slopes subtropical sub-tropical mixed deciduous and open scrub, and eastern and western slopes the mixture of all these habitat types. Crop fields were present on all the aspects.

Surveys indicate occurrence of four pheasant species at different altitudes i.e. monal, *Lophophorus impejanus* (2500 - 3750 m), koklas, *Pucrasia macrolopha* (2,200 - 2,900 m), white crested kaleej (wck), *Lophura leucomelana* (400 - 2000 m) and red jungle fowl, *Gallus gallus* (400 - 1250 m). There are few reports on sightings of Western tragopan *(Tragopan melanocephalus)* and Chir *(Catreus wallichii)* in Kedarnath Wildlife Sanctuary however, I did not sight them during this study (table 1).

The relative abundance of monal and koklas as indicated by number of individuals/sighting/hour observation period was almost similar (P n.s.). The number of wck/sighting/hour observation period more significantly greater as compared to that of monal (P<0.01) and koklas (P< 0.01) in temperate region of the sanctuary. The number of wck/sighting was significantly greater in temperate forests as compared to that in subtropical forests (P<0.01). Red jungle fowl gave a higher individuals/sighting/hour observation period record as compared to kaleej in subtropical habitats (P < 0.001) (table 1, figure-3,). With reference to climatic variables (temperature, humidity) monal, koklas were found to be limited in distribution and kaleej showed wider distribution (figure-2).

Table 1. Relative abundance of pheasants in Kedarnath wildlife sanctuary (30°25'-30° 45' and 78° 55'-79° 22' 1500-3750 m) and Chanttikhal reserve forest (30°13' to 30°15'02"and 78°52" to 78°56',750-1200m) of Kedarnath wildlife division of Garhwal Himalaya.

Pheasant sp.	No. of sighting	Individuals sighting/hours observation period (m ± s.e.)
Monal	76	2.47±0.20 a
Koklas	13	2.38±0.31 b
Tragopan	0	0
Chir	indirect evidences	0
Kaleej	27	5.29±0.92 c
	161	3.42±0.19 d
Red Jungle fowl	16	4.55±0.84e

One way ANOVA followed by test difference.
ANOVA F = 3.38, df = 4 ; .02<p<.05
Except monal and koklas rest all the values are significantly different.

Seasonal habitat preference - Data on seasonal (summer and winter) altitudinal movements and preference for different habitat types indicated that during summer monal prefer alpine, SA, TEG and TM habitat types. Maximum sightings were made in TM, SA and alpine and minimum in TEG (P<0.001) (figure 3). Preferred slopes in winter varied between 15-35°. *A. pindrow, C. deodara, Cuperessus torulosa, Q. semecarpifolia, Acer caesium, A. chordatum, R. arboreum, R. ellipticus, R. barbatum, R. campanulatum,* constitute the chief vegtation types of summer and winter habitats of monal. Shrubs of *Rhododendron sp.*, dense sedges like *Carex sp.* and grassses ringal bamboo *Arundianria sp.* preferred for breeding and for protection against predators and extreme environmental conditions. Galliformes e.g. Himalayan snow cock *(Tatraogallus himalayensis)*, snow partridge *(Lerwa lerwa)* during summer in alpine and sub-alpine and common hill partridge *(Arborophila torqueola)* during winter in TEG and TM were also observed in these vegetation types with monal.

Koklas prefer TEG and TM during summer months. The slope preferred in summer was 32-35°. During winter sightings were made in TMD and TM. The number of individuals/sighting greater in former than latter (p<0.01) figure 3). The slope preferred in winter was of the range 32-35°. *Q. leucotrichophora* with *Rhododendron sp., Litsea sp., Berberis sp., Arundinaria sp.*, are the chief vegetation type of the habitat inhabited. Common hill partridge was also found to frequent these habitat with koklas during summer and winter.

White crested kaleej was sighted in temperate as well as in subtropical habitat types. In temperate forests wck prefer TMD and TM during summer. Almost equal sightings were made in both the habitat (p n.s.) (table 1, figure 3). Slope preferred during summer was 30-35°. Kaleej remain in TMD during winter months. Slope range preferred during winter was 30-32°.

Q. leucotrichophora, R. arboreum, Litsea sp., Arundinaria sp., are the dominant tree and shrubs of these habitats. Common hill partridge and Chukor partridge *(Alectoris graeca)* were also seen to share these habitats with wck during summer and winter. Subtropical forests harbour two pheasant species i.e. white crested kaleej and red jungle fowl. Kaleej was encountered in STMD, OS, MP and CF habitat types. During summer kaleej preferred STMD, OS, MP and CF habitat types. Almost equal sightings were made

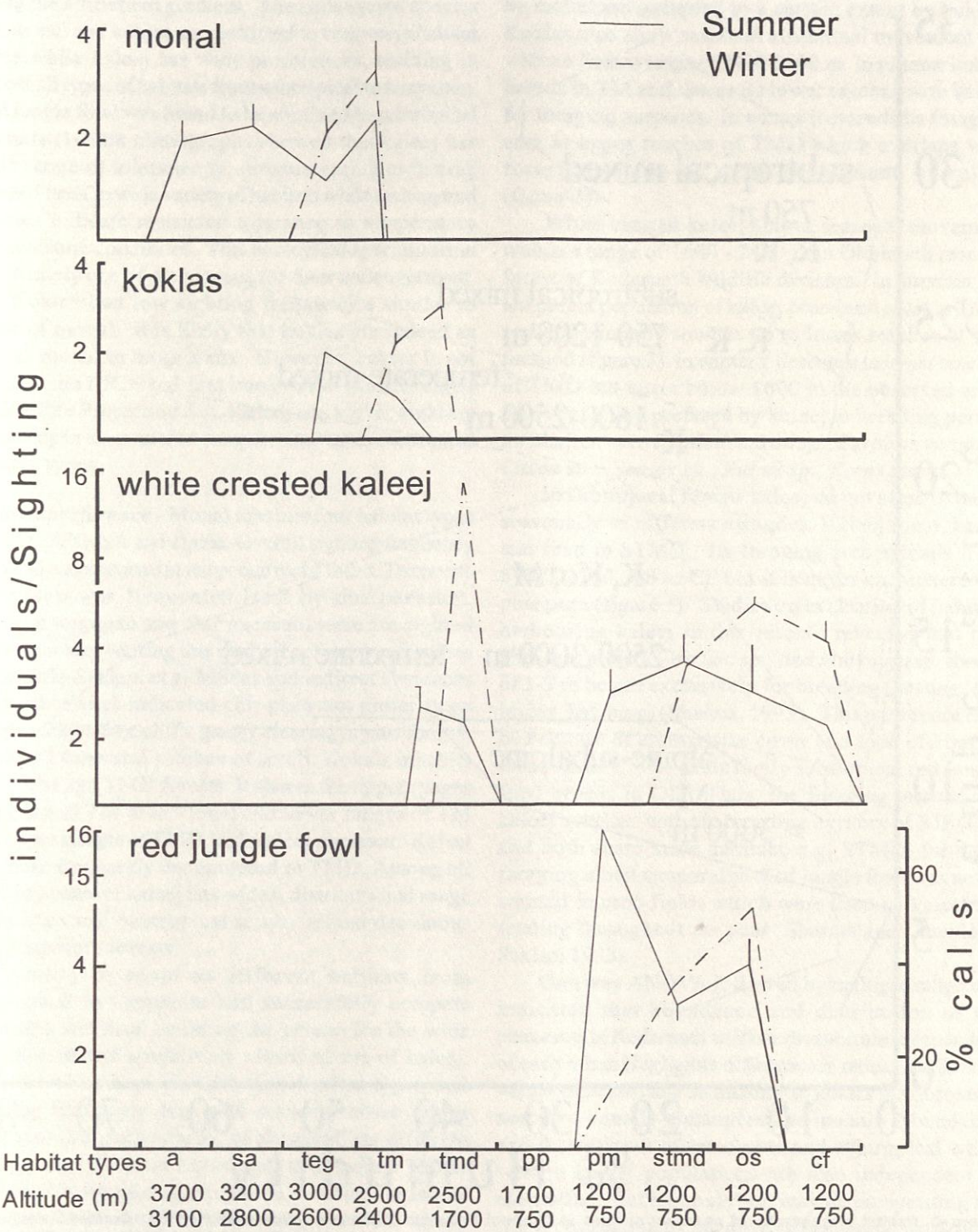

Figure -2. Altitudinal distribution and seasonal movements of pheasants in Kedarnath Wildlife Division of Garhwal Himalaya. Sightings were recorded through vantage points. Sighting data were obtained in dawn and dusk for two hours each for at least 10-15 days/month for three years. Time spent for the observations was constant throughout the study duration. In case of *rjf*

in PM, STMD and OS (Pn.s.). During summer and winter STMD, OS and CF were the habitat types preferred within a slope range of 10-30°. Overall CF and STMD were equally preferred habitats (P n.s.) whereas in OS only one sighting with maximum number of individuals was made. (table 1, figure 3).

Red jungle fowl was observed in PM, STMD and OS habitat types in summer and winter months. During summer only one sighting in PM with maximum number of individuals was made. Open scrub and STMD were equally preferred habitats (P n.s.). Slope of 10-30° was preferred. During winter only calls could be recorded.

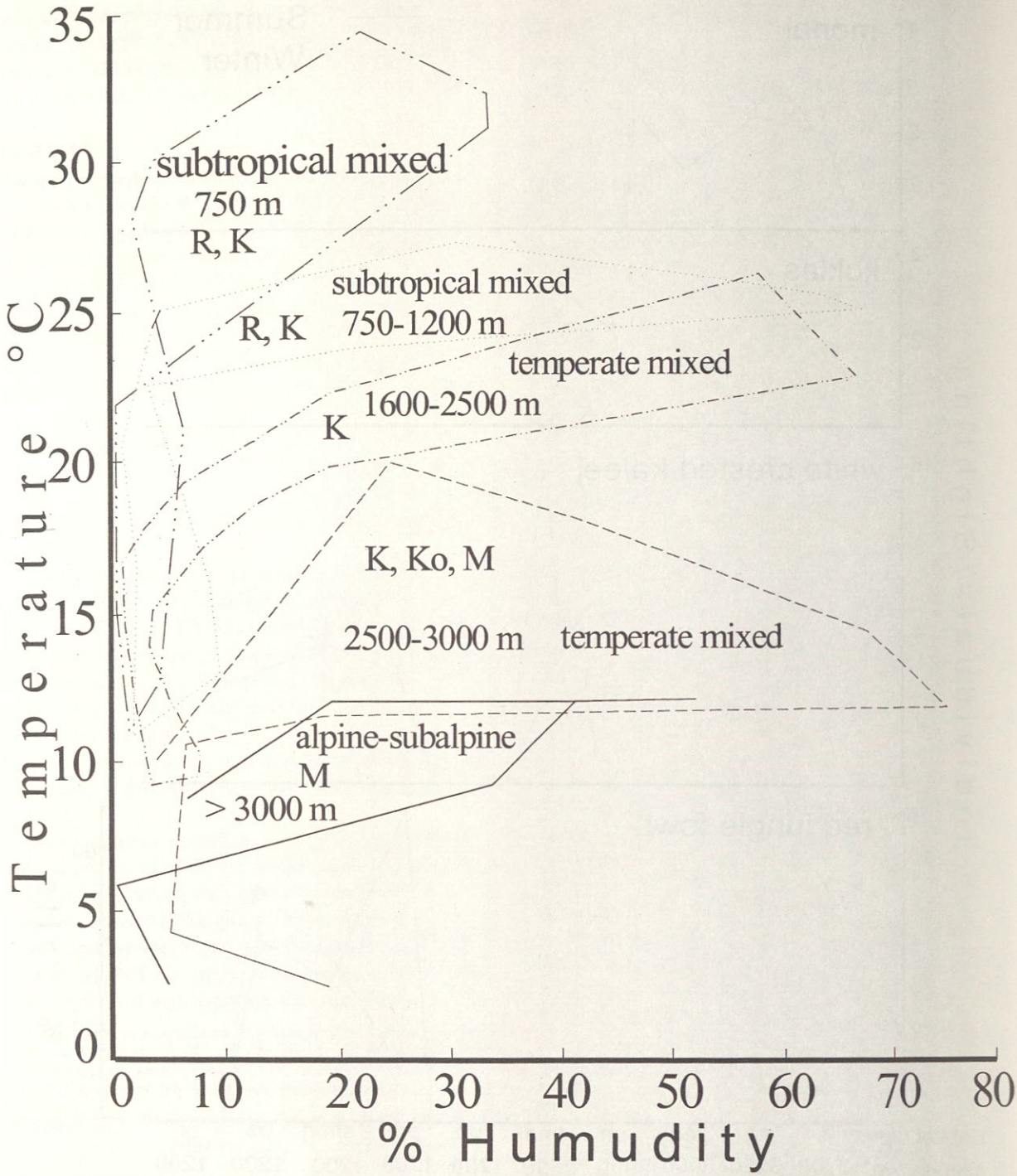

Figure -3. Habitat climographs of pheasant species in Garhwal Himalaya. M(Monal), Ko(Koklas), K (White Crested Kaleej), RJF (Red Jungle Fowl). Average temperature and humidity were accorded at each sampling interval in each habitat type. These were

Maximum calls were recorded from OS and minimum from PM (table 1, figure 3). *P. roxburghii, R. parviflora, M. phillipinensis, B. variegata, Carrissa sp., Rubus sp., Berberis sp., Arundinaria sp.*, are the dominant plant species of these habitats. Black partridge *(Francolinus francolinus)* also shares these habitats types with red jungle fowl.

DISCUSSION

Distribution and Relative Abundance

Distributional pattern of the Himalayan pheasants provides a remarkable opportunity to study ecological segregation, overlap and the influence of micro-environment thereupon. Data indicate occurrence of four pheasant species in the kedarnath wildlife division

along the altitudinal gradient. The endangered species viz. monal and koklas are restricted to temperate habitat types while kaleej has wide preferences, residing in almost all types of habitats from subtropical to temperate. Red jungle fowl was found to be confined to subtropical habitats.Habitat climographs showed that kaleej has wide range of tolerance to climatic variables having adapted itself to wide variety of habitats while endangered species indicate restricted tolerance to temperature and moisture conditions. This ecological specialisation is definitely one of the reasons for their endangerment.

Koklas had low sighting frequencies similar to those of monal. It is likely that koklas are indeed as rare as monal in these areas. However, koklas is not listed in the IUCN red data book nor in the schedule I of Wildlife Protection Act. Kaleej has higher sighting frequency in temperate as compared to that in subtropical habitat types.

Habitat preference - Monal inhabits four habitat types i.e. TM, TEG, SA and alpine. Overall sighting frequency of monal was maximal in temperate moist forest. Temperate evergreen was frequented least by this pheasant. Western tragopan and chir pheasant were not sighted in the sanctuary during this study. Earlier investigations (Chandola-Saklani et al 1988a) and indirect evidences from other sites indicated chir pheasant prefer steep slopes with broken cliffs, grassy clearing in pine forests, scattered trees and patches of scrub. Kokals inhabits TEG, TM and TMD forests. It shares the upper ranges of TEG and TM with Monal and lower ranges of TM and upper ranges of TMD with kaleej pheasant. Kaleej are more frequently encountered in TMD. Among all sighted pheasant kaleej has widest distributional range of habitats viz. subtropical scrub, mixed deciduous and temperate forests.

Ability to adapt to different habitats from subtropical to temperate and successfully compete for space and food could be the reason for the wide distribution and a relatively robust nature of kaleej. Relative abundance in different habitat types and sighting frequency data with seasonal observations indicated that each species of pheasant has different ecological requirement for breeding and feeding. Earlier studies (Chandola-Saklani 1988) indicated seasonal movements of monal between temperate sub-alpine and alpine habitats (2400-3500 m approximately). In summer alpine and sub-alpine are used for foraging, roosting and breeding purposes. A few individuals were also sighted foraging and roosting in TEG and TM. Himalayan snow cock and snow partridge also descend from their wintering grounds to alpine and sub-alpine which they share with monal for breeding, roosting and foraging. In winter monal descend to upper reaches of TEG and TM where they were seen roosting and foraging. In summer these niches left by monal are occupied to a certain extent by koklas. Koklas also show seasonal altitudinal movement but within a limited range of 2400-3000 m. In summer koklas breeds in TM and shares its lower reaches with kaleej for foraging purposes. In winter it extends its foraging area to upper reaches of TMD which overlaps with foraging niches of some populations of kaleej (figure-3).

White crested kaleej shows seasonal movement within a range of 1600 - 2400 m in Okhimath reserve forest of Kedarnath wildlife division. In summer the temperate population of kaleej breed and roost in TMD and occasionally sounter up to lower reaches of TM for food (figure 3). In winter it descends to lower reaches of TMD but never below 1600 in the observed area. The vegetation prefered by kaleej in breeding period for shelter were *Rhododendron sp., Berberis vulgaris, Litsea sp., Smilex sp., Rubus sp., Ferns etc.*

In subtropical forests kaleej do not seem to move seasonally to different altitudes. Kaleej roost, breed and feed in STMD. Its foraging area extends from STMD, PM, OS to CF but it is never encountered in pine pure (figure 3). Studies on evaluation of habitats harbouring kaleej in this reserve revealed that this pheasant prefers *Carrissa sp., and Murrayya sp.* shrubs of 1-3 m height exclusively for breeding (nesting, egg laying, hatching) (Sharma, 1993). This preference may be because of appropriate cover and food offered by these shrubs. The exclusively subtropical red jungle fowl breeds in OS. Thus, the foraging territory of kaleej overlaps with the breeding territory of RJF (OS) and both share same habitats, e.g STMD, for daily foraging albeit temporally. Red jungle fowl was never sighted in crop fields which were used by kaleej for feeding throughout the year (Sharma and Chandola-Saklani 1993).

One way ANOVA followed by multiple range test indicated that abundance and distribution of the pheasants in Kedarnath wildlife division are independent of each other. Negligible difference in monal and Koklas values indicated that abundance of koklas has decreased and now equally endangered as monal. Abundance and distribution of temperate and subtropical white crested kaleej populations are also independent of each other. Each population may be competiting for resources seasonally but are independently distributed.

Identification of preferred habitats as those highlighted above will aid in translocation programs for endangered species. These kind of information shall be extremely helpful in the identification of limiting factors of pheasant population and hence active management thereof. Pheasants are generally omnivorous and ground feeders. It seems that during the course of evolution ecological separation of pheasants in these forests has occurred along the

altitudinal gradient. This is reflected in the present day seasonal altitudinal movements and also through which pheasants avoid interspecific competition to a great extent. Along the longitudinal east-west axis of Himalaya also, a distinct environmental gradient can be recognised. As we move eastwards the environment gets more a more humid as well as warmer. This is reflected in the species content (both plants and animals) for example among Game birds Crimson horned pheasant *(Tragopan satyra)* and western tragopan *(T. melanocephala)*, koklas, chir pheasant and chukor partridge rarely ever cross river Kali (in central Nepal) over to east. Similarly, the eastern game birds are typified by greybilled tragopan *(Tragopan blythii)* and temminck's tragopan *(T. temminkii)*, mishimi monal *(Lophophorus sclateri)*, blood pheasant *(Ithaginigs cruentus)*, peacock pheasant *(Polyplectron bicalcaratum)* and assam bamboo partridge *(Francolinus francolinus melanonotus)*.

The Himalayan monal, kaleej pheasant, satyre tragopan, red jungle fowl, grey *(Francolinus pondicerianus)*, black *(F. francolinus francolinus)*, painted *(F. pictus)* and hill partidges are distributed all through from the north-western to eastern frontiers (Ali Ripley 1983). Closer examination of some of the above reveal how a vast geographical range may influence speciation.

Kaleej which has a wide altitudinal distribution also exhibit broad east-west range. Along the north-west to east environmental gradient six distinct races of kaleej can be recognised Ali and Ripley (1983). Obviously in case of kaleej desired degree of reproductive isolation has not occurred towards speciation. Once that is achieved new species of kaleej will have evolved. Monal and tragopan can already boast of two and four full fledged species respectively, distributed along the east-west gradient.

Comparative studies of the pheasants some of which are specialist e.g. endangered forms (Monal, Kokals) with restricted distribution to alpine and temperate and the generalists species like white crested kaleej pheasant with a wide distributional range would provide useful insights into the survival strategies evolved by Himalayan birds. Identification of the preferred habitats constitutes prerequisite infra-structural information for the development of adequate management plans in Himalayan forests. Further more, these will aid in translocation of pheasants to relatively richer habitats and in the designation of game reserves. Concepts of game reserves prevalent in the west is not practised in India despite the first ever game laws having been formulated in the country by Kautilya (Arthashastra 3rd Centuary B.C.). It would be an extremely practical and useful management practice for conservation and enrichment of pheasant population (since it takes into consideration human behaviour) which can now became feasible in Himalayan forests with the availability and exploitation of the kind of information provided in the present paper.

ACKNOWLEDGEMENTS

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RATES OF COLONISATION BY BIRDS AFTER AFFORESTATION : A PRELIMINARY ANALYSIS

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Abstract : Birds censuses were done in naturally regenerated and planted forest in Tamil Nadu. A species accumulation curve best fits a Weibull distribution. Bird faunas diverge initially from the original grassland fauna, and then converge towards a forest fauna. Implications for conservation are discussed.

WILDLIFE CONSERVATION, RESEARCH & MANAGEMENT : 57-59

Key words : Auroville, afforestation, India, species accumulation curves.

INTRODUCTION

The Auroville plateau in Villupuram district of Tamil Nadu, India was a wasteland when the community was started in 1968. The land was criss-crossed with ravines, and the areas surrounding these were subject to heavy soil erosion, with overgrazing taking place over most of the area. Large tracts of land had palmyra *(Borassus flabbifer)* as the only vegetation cover.

Considerable effort was expended in reforesting the plateau, and over 1500 ha have been afforested until now. In the initial years, *Acacia auriculiformis* was the main species planted. In recent years the trend has been to plant indigenous species. Over a hundred species of trees indigenous to the area have been successfully planted in past fifteen years. There are areas where natural regeneration has occurred alongside the plantations, and forests of many different ages are now extant.

This afforestation has resulted in a tremendous increase in the bird fauna. Early records prior to 1972 show a total of 25 species found, which is the same number still found on the patches of barren land. We updated the bird lists for Auroville recently and found 105 species present. The increase is linked with the variety of habitats available.

From a biological point of view, species numbers are linked to the size of areas of given habitats available. With increasing areas of habitat available the numbers of species also increase, in a logarithmic fashion. The two phenomena that operate are colonisation and extinction : in the sense that a species disappears from a patch where it was found earlier. When the extinction rate reaches the colonisation rate, an equilibrium number of species is found at a site (Wilson, 1967). In this paper we attempt to see if this equilibrium has been reached and whether there are any patterns to the bird fauna at different sites.

METHODS

Transects were established at four sites in Auroville, where large scale planting commenced at different times. There are Aranya(AR)(3 years old), Aurodam (AU)(14 years), Pichandikulam (PI)(about 20 years) and Forecomers (FO)(about 27 years). A total of eight transects at each site were done. Transects were not necessarily straight.

At each site, the area was walked in the mornings and evenings between December and April : thus winter migrants have also been recorded. A list of all the birds seen was kept, including repeat sightings. The number of birds seen was plotted against the number of species seen. When this curve became level, it was assumed that a fairly complete list of the site had been obtained. For analysis, Curve Expert 1.34 (Hyams, 1997), Excel 97 and MVSP 3.0 (KCS, 1998) were used.

RESULTS AND DISCUSSION

The number of species seen has been plotted against the age of the afforested area in Fig.1. The number keeps increasing with the age of the plantation, but it can be seen that the curve levels off. At 15 years species are being added at the rate of about one every two years; by the time the afforested areas are 30 years, the species accumulation will drop to about one species every 5 years. With species disappearing, the equilibrium number of species is estimated at around 75. As can be seen from the graph, 15 years is about the time it takes for an afforested area in this region to acquire a relatively completed bird fauna. It must be noted, though that in this preliminary analysis effects

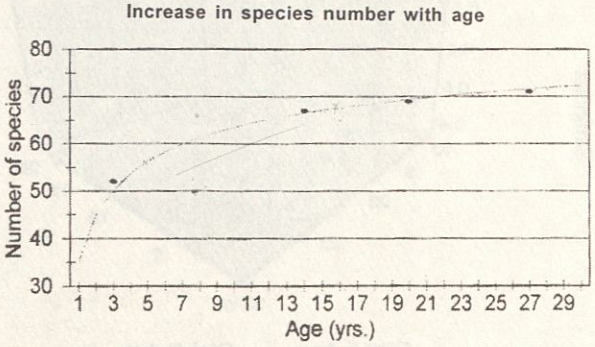

Fig.1 - Increase in species number with age of plantation. The data fit a Weibull distribution, which is plotted.

1 E-mail Comments/queries to : rauf@auroville.org.in

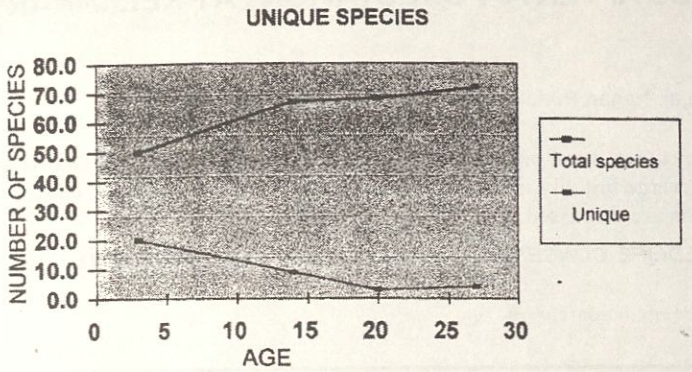

Fig.2 - The number of species found only at one site, as a function of the age of that site.

due to the size of the afforested areas have been ignored. All ecological parameters have also been ignored in this preliminary analysis.

The best fit model to the data is a Weibull distribution (Hyams, 1997), which has the desirable feature of reaching an asymptote. The equation is :

$$Y = a - be^{-cx^{\wedge}d}$$

Where Y is the number of species, x is the age of the plantation, and a,b, and d are fitted parameters. The values obtained were a=84, b=245.6, c=1.618 and d=0.186. The number of species at each site is expected to stabilise at around 84.

How similar are these bird faunas, and how does plantation age affect the types of birds found at a spot? Plot age has been plotted against the proportion of unique species (species present only in that particular plot). Fig.2 displays this graphically. Aranya, which has the lowest species richness, also has the highest proportion of unique species. A shift in the types of birds seen here compared to the other sites is noticeable. The faunas from FO, PI and AU (the three older plots) can be seen to be similar. Analysis shows that there are more species in common than would be expected by chance, which implies that the faunas appear to be converging.

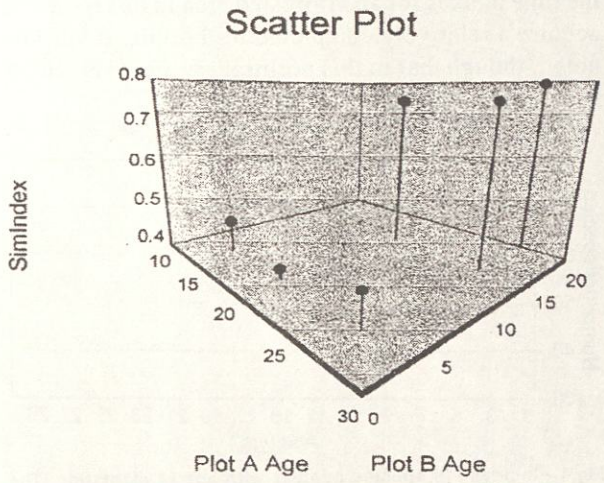

Fig.3 - The similarity between pairs of plots of different ages.

Similarity indices based on presence-absence data Calculated as : No. of species in common to both sites/Total number spp. at both sites combined) tend to strengthen the hypothesis that the bird faunas for the three older sites tend to become similar. (Fig. 3). The Aranya plot is dissimilar from the others (AU, PI an FO), while these three are very similar to each other.

Correspondence analysis was done for these plots and the results are given in Figs. 4 and 5. Factor 1 appears to represent an ecological gradient representing the shift from grassland to forest. Factor 2 appears to represent tree size. Factor 3 may be linked to overall diversity because large extents of *Acacia* monocultures were planted at Pichandukulam. These are again preliminary results and need validation by introducing ecological parameters into the analysis.

What are the actual species that appears and disappear? A look at the species that are found only at one site is instructive. Aranya has the common babbler *(Turdoides caudatus)*, Indian bustard quail *(Turnix suscitator)*, Indian jungle nightjar *(Caprimulgus indicus)*, tree pipit *(Anthus hodgsoni)*, redwinged bushlark *(Mirafra erythoptera)*, rufoustailed finchlark *(Ammomanes phoenicurus)* and white eyed buzzard *(Butaster teesa)*. As can be expected, most of these are open country species. Some of them have been noted at other places in Auroville as well, but have not been encountered in the formal surveys. The little egret *(Egretta garzetta)* is the only species recorded only at AU; the Besra sparrow hawk *(Accipiter virgatus)*, a bird of lightly wooded country, has been found both at AU and PI. The blue chat has been recorded only at PI. Finally, the birds exclusive to FO are the barn owl *(Tyto alba)*, grey quail *(Coturnix coturnix)*, jungle bush quail *(Perdicula asiatica)* and shorteared owl *(Asio flammeus)*. Apart from the last one, the others are forest birds.

CONCLUSIONS

Previous studies in plantations have shown very poor bird fauna. Khan (1980) found much lower bird diversities in tea compared to adjoining natural forest. Gandhi (pers. comm.) compared avifaunas of natural scrub near Chennai with Eucalyptus, cashew and casurina and found significantly reduced species richness in the latter three. Premdas (1990) found 44 bird species in shola patches in the Upper Planis, compared to 6 in Eucalyptus, and 7 each in wattle and peace.

In this instance, the number of species actually increased. This is because indigenous species were used, and a very large variety was also used. The results shown here are similar to those found by Shankar

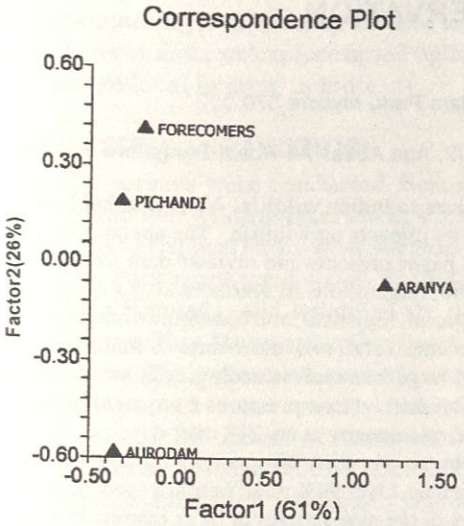

Fig.4 - Correspondence analysis for the data on the four sites, showing factors 1 and 2. Detrending has not been used.

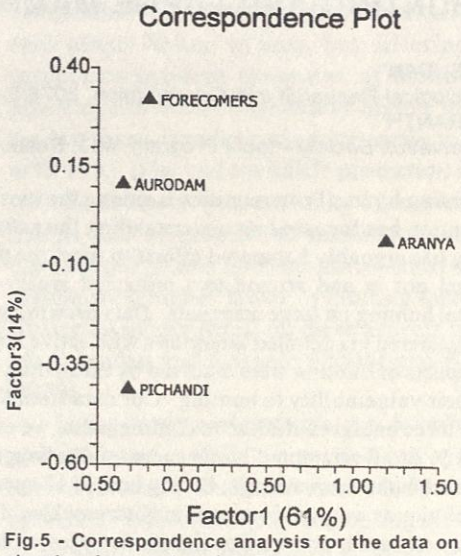

Fig.5 - Correspondence analysis for the data on the four sites, showing factors 1 and 3. Detrending has not been used.

Raman (personal communication), who found that forests regenerating after slash and burn agriculture showed a similar pattern of recovery for the avifauna, also with species richness stabilising after 15 years. If large scale afforestation is to have a positive ecological impact, then a mix of a large variety of indigenous species in necessary.

It is also worth noting that regeneration occurred naturally in places where *Borassus flabiffer* was present. Birds used to rest on these trees, and defecated seeds germinated when grazing and browsing were eliminated. A clump of vegetation would start with the *Borassus* as the nucleus and spread from there.

A similar pattern has been seen in the Nilgiris, with *Rhododendron* acting as the nucleus for shola vegetation. It is likely that each climatic and vegetation type has at least one of these "aunt" species. While there is no quantitative data to support this now, this phenomenon would well repay intensive investigation. This is because large-scale afforestation efforts could be done cheaply by using sparse plantation of these aunt species.

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LOCAL HUNTING AND LARGE MAMMAL CONSERVATION

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Abstract : Hunting by local communities is among the most widespread threats to Indian wildlife. Yet, remarkably little scientific attention has focussed on understanding the nature and extent of its impacts on wildlife. The absence of such understanding has arguably hampered efforts to meet the threat fully. This paper presents and reviews data from recent surveys carried out in and around two protected areas—Kudremukha and Nagaraholé in Karnataka—to assess the impacts of local hunting on large mammals. Data pertaining to the social, cultural, logistical, and economic dimensions of hunting were gathered via detailed interviews with active hunters, local enforcement staff and informants. Simultaneously, on-ground impacts of hunting were assessed by estimating the abundance of large mammals in ecologically similar areas differing in their vulnerability to hunting. Our data from Kudremukha established intense pressures from local hunting: in each of the three enclaves studied in Kudremukha, we estimated the hunting intensity at ca. 218 man-days per month, with some 43 % of all attempted hunts successfully bagging a large vertebrate. At least 26 species of mammals were hunted, with each hunter, on average, having hunted 18 species of large mammals. Over 90% of all hunting used guns, and traditional techniques were seldom used in Kudremukha. In Nagaraholé, six of the nine species of large mammals whose abundance we estimated, occurred at significantly lower densities in a site where enforcement capabilities were poorer, and hence, hunting pressures were correspondingly greater. Our data underscore the effectiveness of sincerely implemented preservationist programmes in consolidating the future of large mammals in a wider context of extensive local hunting.

WILDLIFE CONSERVATION, RESEARCH & MANAGEMENT : 60-67

Keywords : Hunting, human impact, India, Karnataka, large mammals, poaching, preservationism, sustainable use.

INTRODUCTION

Beginning with the Pleistocene epoch, hunting by humans is believed to have been among the most significant factors driving the extinction of large wildlife species (Diamond 1989). To this day, widespread hunting of wildlife continues to undermine conservation efforts worldwide (Robinson and Redford 1991, Robinson and Bennett, 2000). Among all wildlife taxa, large mammals (body mass > 1 kilogram) are differentially prone to hunting by humans. Their relatively large meat-yields and commercially valuable bye-products such as hide, horn, and bone make large mammals attractive targets to human hunters.

On the other hand, biological traits of large mammals—their inherently low densities, large dietary requirements and home ranges, slow rates of growth and maturation, small litter sizes, long life-spans and generation times—also render them intrinsically vulnerable to extinctions from stochastic factors related to demography, environment, and genetics (Eisenberg 1980, 1981, Lande 1988). Thus, understanding the impacts of human hunting on large mammals is of critical importance in planning realistic strategies for their conservation.

In India too, hunting has been recognised as a major factor in historical declines of wildlife (Dunbar-Brander 1923, Gee 1964, Schaller 1967, Sankhala 1978, Rangarajan 1998). Although this awareness has prompted the enactment of a strong legislation—the Wildlife (Protection) Act, 1972—hunting is of widespread occurrence countrywide, and poses a serious threat to wildlife even today. However, in an environment where the very existence of hunting is often discounted or even denied, there have been very few attempts at assessing hunting intensities, their impact on wildlife populations, or the factors that promote and maintain hunting.

At this point, it is useful to recognise two distinct variants of hunting in India. The first, which we term *market hunting*, refers exclusively to the well-organised hunting of select species, driven by regional and global markets for their high-value bye-products such as ivory, rhino-horn, tiger-bone, bear-bile and *shahtoosh*. The second, which we term *local hunting*, is a ubiquitous, loosely organised activity, driven by local tradition, sport, or demand for bush-meat. Local hunting, arguably, is a far more pervasive threat to Indian wildlife, since it targets a wider variety of species, and is carried out by far greater numbers of people than indulge in market hunting. While there are notable attempts to comprehend market hunting (Menon *et al.* 1997, Wright and Kumar 1998), local hunting and its biological impacts remain poorly understood (see Madhusudan and Karanth, 2000).

In this paper, we use data gathered within and around two wildlife reserves in Karnataka—Kudremukha and Nagaraholé—to estimate the intensity and impact of local hunting. We also evaluate factors driving

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and maintaining local hunting in these areas. Finally, based on our data, we explore broad options available to manage local hunting in India.

STUDY SITES AND METHODS

Our surveys were conducted during 1996-97 in and around two wildlife reserves in Karnataka State: Kudremukha National Park and Nagaraholé. Kudremukha National Park spans the districts of Chikmagalur and Dakshina Kannada, and straddles the main ridge of the Western Ghat Mountains. On the western fringes of Kudremukha, where we carried out our surveys, tropical evergreen forests constitute the main vegetation type. At least 32 species of mammals (body mass ≥ 0.5 kg) occur in these forests, including the highly endangered liontailed macaque (*Macaca silenus*). Greater detail about the Park is available in Lal et al. (1994). In Kudremukha, we placed emphasis on obtaining information related to the intensity of hunting, and describing patterns of hunting vis-à-vis hunter prey-choice, hunting techniques used, and the influence of socio-cultural factors in driving the activity. To accomplish this, we chose three widely separated village enclaves bordering the forests—Kadirudyaavara, Maala, and Thingalé. The population of these villages, taken together was ca. 7000. In these villages, we held detailed interviews with 49 active and 13 retired hunters, in addition to other neutral informants.

Most data from interviews of hunters are presented in terms of percent interviewees in a certain response category; where multiple responses were permitted to a single question, the total of percentage-figures often exceed 100. We estimated intensity of hunting (incidents per month) in each of the three enclaves as the product of the monthly average of hunting expeditions carried out by each hunter in our sample, and the average number of hunters operating in a village, as estimated by our respondents individually. Subsequently, we assessed the average monthly off-take of large vertebrates as a product of the average hunting intensity and the average success rate in securing large vertebrate prey. We evaluated putative impacts of local hunting by correlating hunting pressure on a species (percent hunters hunting it) with its rarity over the last 5 years as perceived by the hunters themselves. We also estimated the relative abundance of large mammals in these sites by carrying out encounter rate surveys (total sampling effort = 212 km) in the forests where the local hunters operated.

Nagaraholé, which stretches across the districts of Kodagu and Mysore, is dominated by moist and dry deciduous forests, and supports a rich assemblage of large herbivores and their predators (Karanth and Sunquist 1992, 1995). Drawing on three decades of field experience in the area (K. M. Chinnappa, *pers. comm.*, K.U.K, *pers. obs.*), we identified two ecologically comparable moist forest patches—Nalkeri and Arkeri—each about 70 km² in area, but differing vastly with respect to incident pressures of hunting. Hunting pressure has been consistently higher in Arkeri over the last three decades owing primarily to the fact that, until 1995, it lacked a wildlife protection staff invested with the exclusive responsibility of controlling hunting. Arkeri also offered better access to—and therefore, experienced greater demand from—local meat markets, maintaining higher levels of hunting there, relative to Nalkeri. Greater detail on these aspects is available in Madhusudan and Karanth (2000) and Karanth *et al.* (1999).

Using the general methodology described in Karanth and Sunquist (1992), we carried out systematic line transect surveys (Buckland *et al.* 1993) simultaneously in Nalkeri and Arkeri (total sampling effort = 599 km) to estimate the abundance of nine species of diurnal large mammals: Indian giant squirrel (*Ratufa indica*), bonnet macaque (*Macaca radiata*), common langur (*Presbytis entellus*), barking deer (*Muntiacus muntjac*), wild pig (*Sus scrofa*), chital (*Axis axis*), sambar (*Cervus unicolor*), gaur (*Bos gaurus*), and Asian elephant (*Elephas maximus*) . We used DISTANCE software (Version 2, Laake *et al.* 1993) to obtain estimates of mean animal density and related parameters for all nine species both at Nalkeri and Arkeri. We also carried out interviews with local hunters and neutral informants (n=32), and forest department staff (n=23) to assess hunting patterns and enforcement capabilities, respectively.

RESULTS

Kudremukha

Hunting Intensity : *Our data clearly shows that hunting was widespread in the three village-enclaves we surveyed. On average, 45 hunters (38-57, 95% CI) operated in each village, an individual hunter hunting on 4.8 days (4.2-5.4, 95% CI) per month. Taken together, this yielded an estimated hunting intensity of 218 hunter-days (159-286, 95% CI) per month per enclave. Forty-three percent (38-47, 95% CI) of all attempted hunts resulted in the successful killing of at least one large vertebrate (including large birds and reptiles, besides large mammals). We were unable to estimate rates of persecution for individual species of large mammals.*

Prey Choice and Impacts : *At least 26 species of mammals were hunted in Kudremukha. On average, a hunter had hunted 18 species (16.3-18.7) species of large mammals during his lifetime. Seventy-eight percent of hunters ranked the chevrotain (Tragulus meminna) as the species that they had hunted the most, followed by the common langur (60%) and the*

Indian giant squirrel (50%). Although we were unable to obtain direct measurements of hunting impacts, we interviewed hunters to gather the impacts of hunting as they perceived it. Three-fourths of all hunters interviewed reported a general decline in the abundance of large mammals in the region. We further asked hunters to name species that had become rarer over the last decade. The rarity ranking correlated closely (Spearman's $r = 0.67$, $p < 0.05$) with the hunting pressure on the species (Figure 1). Overall encounter rates for diurnal large mammals (Table 1) was very poor at about 1.1 animals per kilometre walked (total effort = 212 kilometres), with bonnet macaques accounting for over half of all animals sighted.

Techniques in Vogue : *Hunting was common both by day (74% of hunters) and night (89%). Locally crafted, muzzle-loading guns were the most popular (94% of hunters) weapons among hunters; in addition, 45% of hunters reported using snares to hunt ungulates, mostly near crop land. Although all hunters did not own guns, 97% of them had either borrowed or lent guns.*

Socio-cultural Factors and Enforcement : *The hunters interviewed represented diverse ethnic communities. Most hunters (68%) reported that they hunted for the pot, while 48% also cited the thrill of sport as a reason for hunting. Eighty-eight percent of the hunters regarded bush-meat as a non-essential item in their diet. Nearly all of them had access to alternative sources of animal protein: 98% of hunters raised cattle for milk, while 93% raised poultry. About 80% of hunters reported crop losses from wildlife depredation. The reported annual loss incurred due to wildlife depredation averaged at Rs. 950, which, assuming a family size of five, worked out to 24% of annual per capita income. Although literacy levels in Dakshina Kannada are high, some 18% of hunters interviewed were unaware of the legal restrictions on hunting.*

Table 1. Relative abundance of diurnal large mammals in the Kudremukha area — 1997 (number of pedometer trails walked = 34; total sampling effort = 212 km).

SPECIES	MEAN ENCOUNTER RATE (*s.e.*) Individuals sighted / km
1. Bonnet Macaque	0.57 (*0.20*)
2. Giant Squirrel	0.10 (*0.03*)
3. Langur	0.15 (*0.05*)
4. Gaur	Nil (—)
5. Sambar	0.07 (*0.02*)
6. Muntjac	0.02 (*0.01*)
7. Liontailed Macaque	0.11 (*0.06*)
8. Pig	0.02 (*0.02*)
Overall	**1.04 (*0.05*)**

Enforcement efforts hitherto did not seem at all effective in controlling hunting in the region: none of the 62 hunters interviewed reported encounters with enforcement staff when on hunts, and none was ever apprehended or prosecuted. Thus, 93% of hunters regarded enforcement efforts as having been ineffective in controlling hunting. Moreover, 40% of the hunters even reported deriving assistance from enforcement staff in their activities.

Nagaraholé

Estimates by the local hunters and informants indicated that hunting in Arkeri (13.7 incidents/ month ± 2.9 s.e.) was about thrice as intense as in Nalkeri (4.3 ± 1.4 s.e.). Sixteen of the 29 large mammal species present in Nagaraholé were regularly hunted. Although shotguns were the most popular method of hunting, tribal hunters also used at least eight other traditional techniques to hunt large mammals (Table 2).

Among the nine large mammal species whose densities we estimated, six species—giant squirrel, bonnet macaque, langur, chital, wild pig and gaur—occurred at significantly lower densities in Arkeri, the heavily hunted site (see Figure 2). The abundance of muntjac and sambar did not differ between Arkeri and Nalkeri, despite the fact that they were eagerly sought out and killed by hunters. The elephant was the only species occurring at a significantly higher density in the heavily hunted site, Arkeri.

DISCUSSION

Our study presents clear evidence that local hunting is fairly widespread and intense, and has a marked influence on large mammal population densities. In this section, we discuss factors determining the intensity and patterns of local hunting, and the nature of its impact on various wildlife species. We also discuss the broader implications of our findings in managing local hunting in India.

Kudremukha : Intensity, Patterns, and Impacts of Local Hunting

Most local hunting in Kudremukha derives from a tradition-driven demand for bush-meat, and for sport. In addition, recent sociocultural changes have had a profound influence on the patterns and intensities of hunting. The availability of locally crafted guns, and the ability among local villagers to purchase them, have seen the near-total replacement of traditional hunting techniques (e.g., see Table 2, items 4 to 8) with gun hunting. Adoption of gun hunting, which is a far more efficient technique relative to traditional methods, has resulted in a wider range of species being targeted by the hunters, with greater success. While most hunting is for the pot and most bush-meat is

Table 2. Techniques used to hunt large mammals in the Nagarahole area (from Madhusudan and Karanth, *in press*).

HUNTING TECHNIQUE	PRACTITIONERS	TARGET SPECIES
1. Walk-and-seek shotgun hunting by night using spotlights	*Kodava, Vokkaliga, Moplah* (all assisted by tribal guides), and *Kuruba/Yerava* using borrowed guns	Sambar, Chital, Flying squirrel, Porcupine, Civets, Black-naped hare
2. Sit-and-wait shotgun hunting at fruiting trees /waterholes on moonlit nights	— Same as above —	Chital, Pig, Civets
3. Sit-and-wait shotgun hunting at waterholes /fruiting trees in daytime	— Same as above —	Chital, Muntjac, Langur, Bonnet macaque, Giant squirrel, Pigeons, Hornbills, Pheasants
4. Bow and clay shots by day	*Kuruba*	Primates, Giant squirrel, Flying squirrel, Monitor lizard, Birds
5. Hunting dogs + nets by day	*Kuruba*	Langur, Bonnet macaque
6. Hunting dogs + club /machete by day	*Kuruba*	Chevrotain, Black-naped hare, Langur, Mongoose
7. Physical capture from rest-sites/nests during daytime	*Kuruba*	Flying squirrel, Palm civet, Hornbills, Bird eggs/nestlings
8. Smoking/digging out burrows in daytime	*Kuruba*	Porcupine, Pangolin
9. Catapult in daytime	*Yerava*	Giant squirrel, Birds
10. Wire snare	*Kuruba, Yerava*	Chital, Pig, Black-naped hare
11. Baited explosives	*Kodava, Vokkaliga, Moplah* and others	Pig
12. Deadfall trap	*Kuruba*	Black-naped hare, Chevrotain, Pig

consumed locally, hunters are increasingly catering to fast-growing markets for bush-meat in nearby urban centres. For instance, meat from an adult wild pig sells at around Rs. 2,500 (or approximately, 50% of the average annual per capita income of the hunters) in the large towns of Dakshina Kannada. The attraction of a hefty profit definitely aggravates hunting pressures on large mammals. In addition, heavy losses suffered by villagers in crop depredation by pigs and bonnet macaques also instigate retaliatory hunting of other wildlife in the neighbouring forests. Besides the above factors that intensify hunting pressures, there has been a rampant erosion of hunting taboos that are believed to mediate hunting impacts (Gadgil and Berkes 1991). During the course of our interviews, we met hunters who hunted at all seasons, Muslims who hunted pigs, Hindus who hunted the venerated bonnet macaque even within sacred forests (*naagabana*), all of which attest to the ineffectiveness of taboos in lowering hunting intensities.

In the Kudremukha region, there is a telling absence of large mammals even where vast stretches of relatively intact habitat exists, and other anthropogenic pressures like extraction of non-timber forest produce and cattle grazing are minimal. This 'empty forest' syndrome (Redford 1992) suggests a direct persecution of large mammals through hunting. The statements of the hunters in the region also support such an inference: 75% of all hunters identified hunting as the single most important factor responsible for the depressed abundance of large mammals in this area. Further, they also demonstrated a clear awareness that the rarity of a species correlated positively with the incident hunting pressure on it (see Figure 1), indicating an appreciation of the impacts of their activity.

Thus, the high hunting intensities in Kudremukha and adjoining regions attest to a strong influence of tradition in the activity, coupled with the effective absence of deterrents against hunting. While long-term, persuasive measures such as awareness and education campaigns are essential to diminish the influence of tradition in driving local hunting, on a proximate scale, vigorous, coercive efforts focussed on wildlife protection are imperative if large mammals in the tract are to survive into the future.

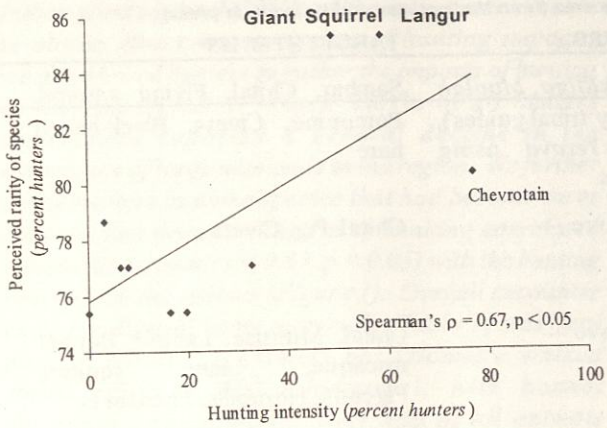

Fig. 1. Relationship between hunting intensity and the perceived rarity of a species among hunters in the evergreen forests of Dakshina Kannada (N=49).

Nagaraholé : Intensity, Patterns, and Impacts of Local Hunting

Our interviews with hunters in Arkeri and Nalkeri corroborated the differences in hunting intensities we had attributed *a priori* to the two sites. Besides poor wildlife protection efforts in the past, other factors responsible for the higher levels of hunting at Arkeri included: fewer patrolling roads and vehicles, poorer communication facilities, and an ill-equipped armoury; slack patrolling schedules, absence of permanent anti-poaching camps, and its highly-dissected boundaries, which made border patrolling in Arkeri difficult (Madhusudan and Karanth, 2000). Patterns of hunting at Nagaraholé also differed considerably from Kudremukha. Although, as in Kudremukha, most hunters catered to local bush-meat consumption, a certain segment of hunters in Arkeri operated exclusively to supply bush-meat to eateries in nearby towns, and the neighbouring Kerala State. However, unlike Kudremukha, where shotgun hunting almost completely eclipsed other techniques, Nagaraholé presented a far greater variety of traditional hunting techniques (Table 2). This, we believe, is a reflection of the fact that, even in the heavily-hunted site, Arkeri, there is some amount of vigilance and enforcement effort in place, which makes gun hunting in the area a risky proposition in general. Traditional techniques, unlike gun hunting, are inconspicuous, and therefore in common use. Still, given that traditional techniques do not allow efficient hunting of all species, hunters continue to risk the use of guns in the Nagaraholé region. The existing levels of enforcement also dissuade hunters from targeting large-bodied species, since the risk of detection associated with hunting them is higher. Although the level of protection at Arkeri was lower in comparison to Nalkeri, it appeared to have the salutary effect of deterring daytime gun hunting, and the hunting of large-bodied species to a certain extent.

Among the large mammal species surveyed, chital and wild pig were the most commonly hunted species (> 80% of hunters, n=27). Since these species do occur close to human habitation, they are commonly snared along trails. Otherwise, nighttime shotgun hunting with spotlights near water holes, fruiting trees, and cultivation (for pigs) was the main technique employed. The giant squirrel, bonnet macaque and langur—all small-bodied arboreal mammals of diurnal habits—were vulnerable to similar hunting techniques. Shotgun hunting during daytime, although most effective in targeting these species, was seen as risky by hunters, given that some daytime vigilance was present even at Arkeri.

Traditional techniques (see Table 2), which are silent, in contrast to gun hunting, take a heavy toll on these arboreal species. Gaur was another species that occurred at lower densities in Arkeri. While young gaur are sometimes accidentally caught in snares set for chital and pig, adults are too large to be snared, and are hunted with shotguns. Although, Hindu hunters rarely hunted gaur, some Christian settlers regularly hunted gaur to supply meat to the neighbouring Kerala state (this racket was uncovered in late-1997). The muntjac and sambar, although prized by hunters, are reportedly difficult to hunt. Muntjac are hard to snare using the technique of local hunters, and the only effective way of hunting the diurnal muntjac is day-time shooting under fruiting trees, a technique used infrequently because of its high detection risks. Sambar are a secretive species that keep to dense cover, visit fruiting trees infrequently, and do not bed in the open. This makes gun hunting of this species on foot difficult. Adults are normally not snared because of their large size, but young sambar are occasionally caught. Thus, the solitary habits of muntjac and sambar, their affinity for dense cover, and logistical difficulties in hunting them, ensure that hunting pressures on these species are relatively low at both sites.

A breakdown in current protection levels will almost certainly expose species such as muntjac and sambar to hunting, which has depressed the densities of other mammals so strikingly. Elephants in the Nagaraholé area are rarely hunted, although they are killed on occasion while raiding crops, and rarely, for their ivory. We believe that the density differences for elephants observed here reflect spatial variations in their abundance owing to their large-scale seasonal movements.

Overall, hunters at Arkeri target small and medium-sized prey which are easy to kill using varied hunting techniques. Our study concentrated on the diurnal complement of large mammals hunted in the region. However, we were unable to estimate densities—and hence assess impacts—of the other large mammals, which were mostly nocturnal. However, we suspect that the impact of hunting on these species—most of which are vulnerable tree-cavity and burrow dwellers—

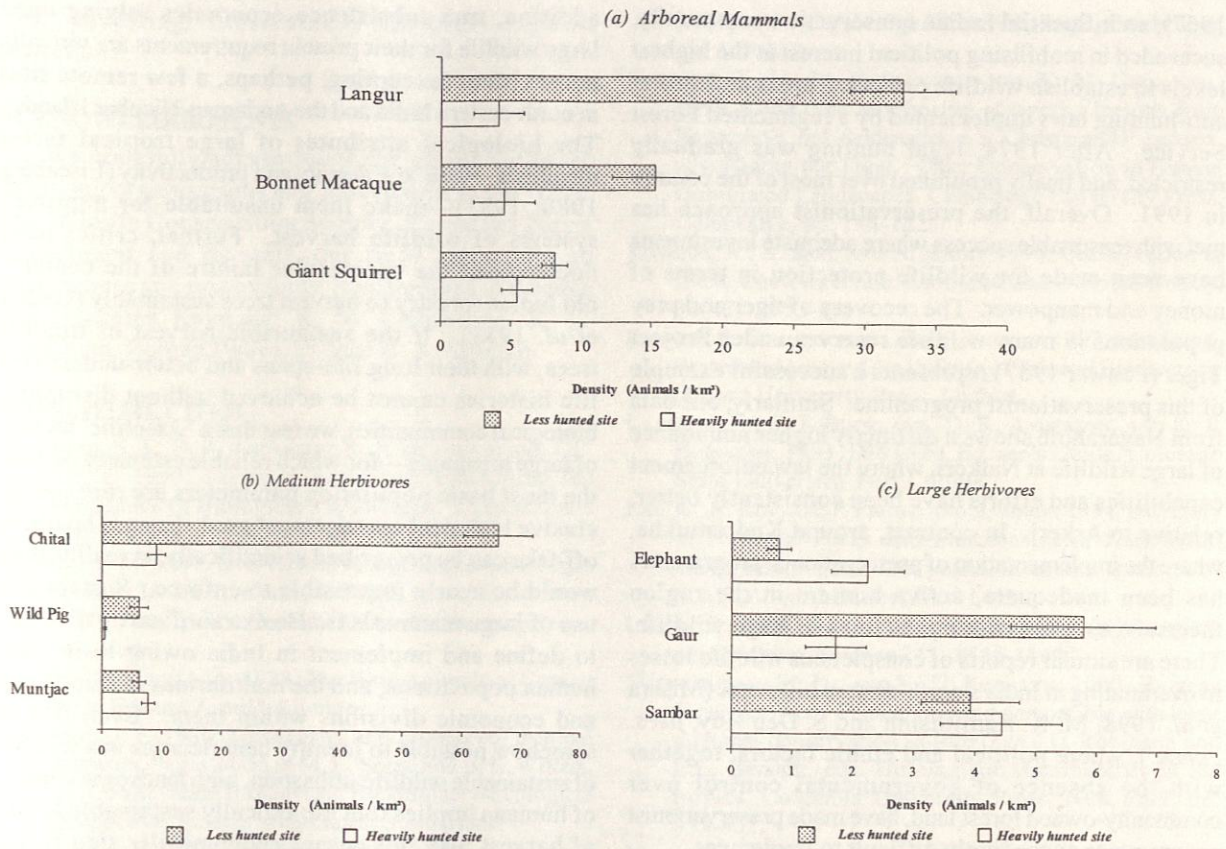

FIGURE 2. **Comparison of densities of (a) arboreal mammals, (b) medium herbivores, and (c) large herbivores in Nalkeri (less hunted site) and Arkeri (heavily hunted site). (Data from Madhusudan and Karanth, *in press*).**

may indeed be quite serious.

Experience with large mammals worldwide has shown that persistent overhunting lowers their densities, and eventually drives the local, regional and overall extinctions of species (Diamond 1989, Rabinowitz 1995). We believe that such threats are currently being acted out over most remaining wildlife habitats in the country. The ecological consequences of such action may be disastrous in the long-term. For instance, keystone frugivores and seed-dispersers are known to influence forest composition in the long-term (Gilbert 1980), while large herbivores may possibly alter habitat structure within forests. Depression in their densities could conceivably trigger changes in the habitat accompanied by a cascading effect on other species.

Similarly, lowered densities of prey species resulting from overhunting can significantly reduce the carrying capacity, recruitment, and survival of large predatory carnivores. Karanth and Stith (1999) have suggested that prey depletion is likely to be a more critical determinant of the viability of tiger populations than direct hunting on tigers themselves. We suspect that such secondary effects on large predators are already at play in Kudremukha and Arkeri due to highly depressed densities of medium-bodied prey species there.

Managing Hunting in India : Sustainable Use or Preservation?

The management of natural resources worldwide has largely been driven by two divergent and influential approaches: sustainable use (IUCN/UNEP/WWF 1991) and preservationism (Kramer *et al.* 1997). The sustainable use approach is founded on the basic premise that extraction of a resource can be so regulated that it does not compromise either the integrity of the resource, or its ability to renew itself. This approach emphasises user-restraint on resource extraction, which, it holds, may be achieved variously *via* the reinforcement of traditional conservation wisdom, or even through the deployment of contemporary western science. In contrast, the preservationist approach argues that, under prevailing contexts of rising economic aspirations of users, and spiralling demands from commercial markets for resources, restrained extraction is an unattainable practical goal. Therefore, it advocates a complete cessation on extractive use as the only practical, clear-cut, enforceable option to ensure the continued survival of a resource.

In India, since the 1970's, hunting has been managed under an essentially preservationist thrust. Following an increased appreciation of the seriousness of hunting-driven wildlife declines in the 1960's (Gee 1964, Schaller

1967), an influential Indian conservation community, succeeded in mobilising political interest at the highest levels to establish wildlife protected areas and strong anti-hunting laws implemented by a regimented Forest Service. After 1974, legal hunting was gradually restricted, and finally prohibited over most of the country in 1991. Overall, the preservationist approach has met with reasonable success where adequate investments have been made for wildlife protection in terms of money and manpower. The recovery of tiger and prey populations in many wildlife reserves under Project Tiger (Panwar 1987) represents a successful example of this preservationist programme. Similarly, our data from Nagaraholé shows a distinctly higher abundance of large wildlife at Nalkeri, where the law enforcement capabilities and efforts have been consistently better, relative to Arkeri. In contrast, around Kudremukha, where the implementation of preservationist programmes has been inadequate, active hunters in the region themselves report striking declines of large wildlife. There are similar reports of conspicuous wildlife losses to overhunting in India's north-eastern hill states (Mishra *et al.* 1998, M. K. Ranjithsinh and S. Deb Roy, *pers. comm.*), where political and ethnic factors, together with the absence of governmental control over community-owned forest land, have made preservationist programmes exceedingly difficult to implement.

The preservationist approach has come under severe criticism for its authoritarian style of functioning, and for denying local communities control over, and access to forest resources, including wildlife (Gadgil 1992, Kothari *et al.* 1995). It is also implicit in some of the criticisms that it is possible to conserve wildlife even in the presence of hunting by local communities. Largely, two mechanisms are proposed that permit such a reconciliation of local hunting with wildlife conservation: a *traditionalist* mechanism, which holds that sustainability of harvests can be ensured through local empowerment and a reinforcement of subtle folk conservation traditions (Gadgil and Malhotra 1985, Gadgil 1992); and a *technocratic* mechanism, whereby sustainability may be ensured by scientifically determining permissible levels of off-take and regulating harvest (see Pabla and Mathur, *this volume*). While we agree that the preservationist approach undoubtedly suffers from weaknesses which need to be addressed (Gadgil 1992, Kothari *et al.* 1995), for several biological, economic, and administrative reasons outlined below, we consider the sustainable use approach highly inappropriate in managing hunting of large mammals.

The sustainable use approach is based on the assumption that it is necessary to reconcile hunting with wildlife conservation. Such an assumption is highly debatable in today's Indian context, wherein viable populations of most large mammals are confined to the country's network of wildlife reserves, and in addition, true subsistence economies relying upon large wildlife for their protein requirements are virtually non-existent (excepting, perhaps, a few remote sites in north-eastern India and the Andaman-Nicobar Islands). The biological attributes of large tropical forest mammals—their low density and productivity (Eisenberg 1980, 1981)—make them unsuitable for unproven systems of wildlife harvest. Further, critics have documented the spectacular failure of the century-old Indian forestry to harvest trees sustainably (Gadgil *et al.* 1983). If the sustainable harvest of tropical trees, with their long life-spans and better-understood life histories cannot be achieved without disrupting biological communities, we fear that a 'scientific' harvest of large mammals—for which reliable estimates of even the most basic population parameters are rare—is an elusive technical management goal. Even if levels of off-take can be prescribed scientifically, in reality, they would be nearly impossible to enforce. Sustainable use of large mammals is also extraordinarily difficult to define and implement in India owing to its vast human populations, and the multifarious sociocultural and economic divisions within them. Even if it is somehow possible to identify beneficiaries in a scheme of sustainable wildlife utilisation, high landscape density of humans implies that biologically sustainable levels of harvest may not ensure economically significant returns, in turn, provoking overharvest. Overharvest in such schemes may also be triggered by close local linkages with high-value markets for wildlife bye-products. It must also be noted that, in the past (1955-74), wildlife managers in India have attempted to regulate hunting, and failed. If regulated hunting has not been achieved under authoritarian initiatives, neither are there examples of successful self-imposed, community-based regulation of large mammal harvest which demonstrate their sustainability with reliable data. In the absence of data, we believe that mere reinforcement of native 'conservation' traditions is a naïve management strategy, fraught with grave risks to large mammals. The rare Indian examples of traditional 'wildlife preservationism' (e.g., the Bishnois of Rajasthan who protect antelopes, Gadgil and Malhotra 1985), are completely overwhelmed by numerous examples of rampant native 'wildlife consumerism' (tradition-driven hunting for meat, hides, horns and other wildlife products).

In conclusion, although a variety of approaches promise the continued survival of India's large mammals, our data—stripped of their ideological content—highlight one simple, irrefutable fact: large mammals thrive under scrupulous protection, but continue to wilt under intense pressures of local hunting. Thus, while we look for socially acceptable, economically equitable, and morally agreeable ways of minimising hunting pressures on large mammals, for now, there is no escape

from investing substantially in their explicit protection.

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SOCIO-ECONOMIC AND ECOLOGICAL CONSEQUENCES OF THE BAN ON ADVENTURE TOURISM IN NANDA DEVI BIOSPHERE RESERVE, WESTERN HIMALAYA

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Abstract : Prior to 1982, the Nanda Devi area in the western Himalaya was open for mountaineers and trekkers. The adventure tourism and associated human activities were on the rise. Poaching of wild animals, felling of trees by expedition parties, collection of medicinal herbs and accumulation of garbage were identified as serious threats to the biological diversity of Nanda Devi area. To curb the increasing biotic interference, the area was declared as Nanda Devi National Park (NDNP) and adventure tourism was stopped in 1982. Further in 1988, the 2236.74km^2 area was notified as Nanda Devi Biosphere Reserve (NDBR) with an inner core zone (NDNP) surrounded by a buffer zone. Ecological studies conducted in the core zone as well as buffer zone (between 1993 and 1997) after a decade of the ban on adventure tourism, recorded improvement in the floral as well faunal composition of the area. Between 1981 and 1991, 12 km^2 and 28 km^2 of open forest (10-40% crown cover) in the core zone and buffer zone respectively, changed into closed forest (>40% crown cover), while 6.5 km^2 area in the buffer zone converted into open forest from degraded forest (<10% crown cover). Short surveys conducted in 1993 for animal species revealed that the number of sightings as well as number of individuals of Musk Deer (*Moschus chrysogaster*) and Blue Sheep (*Psuedois nayaur*) increased in the core zone compared to the studies done in 1983-84. Records of number of bird species also increased from 80 (in 1987) to 114 (in 1993). The present study, conducted between 1994 and 1997, recorded socio-economic transformation among the pre-dominate *Bhotiya* tribe of the buffer zone. Human population of the region registered 15% decrease between 1981-91 and another 13% between 1991-96. Majority of the families (>60%) of *Bhotiya* community were engaged in agriculture and activities related to the production of wool and woollen garments. The limit of biotic interference (wood cutting, fodder lopping, livestock grazing) was recorded within 2-3 km radius of village boundary. Promotion of eco-tourism in the buffer zone, employment generation schemes, setting up of interpretation centres and the need for well equipped Forest Department have been suggested as some of the measures to compensate the economic loss for the local people and to maintain the present state of biodiversity in NDBR.

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INTRODUCTION

Nanda Devi area, notified as biosphere reserve in 1988, is reputedly one of the most spectacular wilderness areas in the western Himalaya (Green, 1993). It is famous for its thick forests of blue pines, oaks and deodars, vast alpine meadows and snowy peaks. Large altitudinal variation (1800m to 7817m) with tough terrain and varied biological and cultural diversity attracted adventure tourism to the area for a long time. Prior to 1982, Nanda Devi peak (7817 m), the second highest peak in India, was most popular among mountaineers and trekkers, after Mt. Everest (Kandari, 1982). As in most of the Himalayan areas, unplanned tourism (Singh, 1989) also affected the ecology of the area. The large scale tourism in the area was responsible for deforestation (especially along the trekking routes and near the timber line *i.e.*, above 3000 m), poaching of wild animals, collection of medicinal plants, accumulation of garbage (polythene bags, toilet paper and tin containers), forest fires, soil erosion, and even cultural vandalism (Khacher, 1978; Kandari, 1982; Mehta and Kapadia, 1990). To curb human pressure, the entire area was notified as Nanda Devi National Park (NDNP), and human activities, including adventure tourism, were banned in 1982. The last adventure expedition to Nanda Devi peak took place in 1981, while in 1993 a scientific and ecological expedition was carried out by the Indian Army along with representatives from various scientific institutions to study the different ecological aspects of NDNP and surrounding areas. The ecological studies conducted during this expedition concluded that the status of forests and wildlife in the area has improved after imposing the ban (Rastogi, 1993; Sathyakumar, 1993).

But at the same time, local people residing in the buffer zone of the reserve lost their main source of income. Prior to the ban, they used to get employment as guides and porters with expedition parties for about 6 months of the year, from May to October. Besides cash income, they acquired equipment left behind by expedition parties, such as nylon ropes, high altitude clothes, boots, rucksacks, tents, utensils, and even dry rations. This paper, which is based on a study conducted in Nanda Devi Biosphere Reserve (NDBR) during 1994-1997, attempts to evaluate the impact of the ban on adventure tourism on the socio-economic and ecological aspects of the area.

STUDY AREA

Geographical description and climate : NDBR was the second biosphere reserve of the country, notified in January 1988 (Table 1). The geographical area of the reserve spreads over 2236 km^2 with two distinct zones *viz*, core zone and encircling to it is outer buffer

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zone (Figure 1). The human habitation is distributed in 19 villages of buffer zone while core zone is free from human habitation. The core zone or NDNP basically comprises of the catchment of the Rishi Ganga and eastern tributary of Dhauli Ganga river which flows into the Alaknanda river at Reni village in district Chamoli. The boundary of the core zone is formed by a series of high peaks such as Dunagiri (7066 m), Changbang (6864 m), Kalanka (6934 m), Nanda Devi East (7434 m), Trishul (7120 m) and Nanda Ghungti (6368 m) while Nanda Devi West peak (7817 m) is located within the core zone (Figure 1).

The entire area enjoys distinctive micro-climates. The approximate variation in the precipitation ranges from about 750 mm to 2000 mm, while the temperature varies between about 0°C to 35°C. The rainfall decreases from south towards north. The higher reaches of the reserve (above 4500 m), which make up about 81% of the core zone and 60% of the buffer zone, remain snow covered round the year (Sahai and Kimothi, 1996).

Biological and cultural values of the area : The area is rich in its biological wealth. A total of 793 plant species have been recorded from the entire biosphere reserve (Hajra and Balodi, 1995). Samant (1993) has recorded 620 species of plants belonging to 344 genera and 116 families. Sahai and Kimothi (1996) have reported that of the total area of the reserve, 27% (600 km2) is under forest and alpine grasslands, about 66% area remains under snow permanently, while remaining 7% area has been identified as wastelands and under human settlements. Of the total forest cover of the reserve, about 47% falls under dense forest cover (>40% crown cover), 35% under open cover (10-40% crown cover), and 17% under miscellaneous and degraded forest (<10% crown cover). Of the total forest cover of the core zone, little more than 95% falls under the dense forest cover. The tree vegetation is dominated by *Pinus wallichiana, Cedrus deodara, Quercus semecarpifolia, Abies pindrow, Taxus baccata, Symplocos cretagoides, Rhododendron arboreum* and *Betula utilis,* while the under storey has *Prinsepia utilis, Berberis aristata, Rosa macrophylla, R. webbiana* and *Rhododendron campanulatum*. Alpine meadows abound in varieties of flowering plants such as *Primula* spp, *Potentila* spp, *Anemone* spp, *Geranium* spp, *Pedicularis* spp and *Saussurea* spp. Besides these, there are varieties of medicinal plants such as *Rheum australe, Aconitum heterophyllum, Arnebia benthamii* and *Dactylorhiza hatageirea* (Hajra and Balodi, 1995).

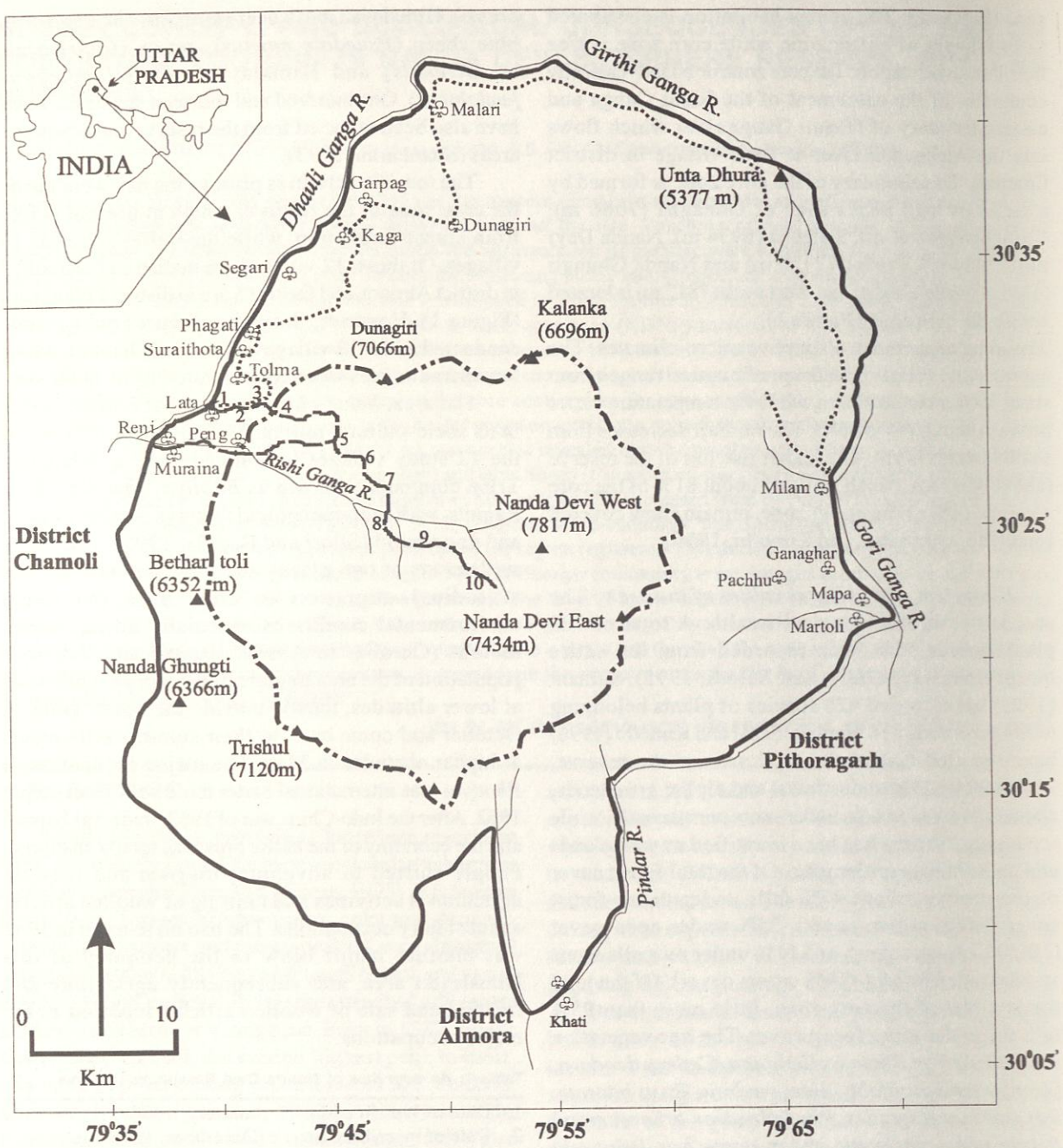
The faunal assemblage of NDBR is equally diverse. A total of 17 mammal species have been recorded from the reserve, of which 7 are listed as endangered (Lamba, 1987; Sathyakumar, 1993). The important species are snow leopard (*Uncia uncia*), Himalayan black bear (*Ursus thibetanus*), Himalayan brown bear (*Ursus arctos*), Himalayan musk deer (*Moschus chrysogaster*), blue sheep (*Psuedois nayaur*), serow (*Capricornis sumatrensis*) and Himalayan tahr (*Hemitragus jemlahicus*). One hundred and fourteen species of birds have also been reported from the reserve and adjoining areas (Shankaran, 1993).

The tourism activities prior to the ban were inside the core zone of the reserve, which at present is free from human habitation, while the buffer zone has 19 villages. Of these, 12 villages are in district Chamoli, 2 in district Almora, and the rest 5 are in district Pithoragarh (Figure 1). However, this paper focuses on the study conducted in the 12 villages of district Chamoli, where tourism activities were concentrated prior to the ban.

The area, being close to the Tibet border, is rich in its socio-cultural milieu. The human population of the 12 study villages is dominated by a Scheduled Tribe community known as *Bhotiya*, who are Hindu Rajputs, with Indo-mongoloid features, medium stature and good build (Silori and Badola, 1995). They have settlements at two places and practise seasonal and altitudinal migration to cope with the tough environmental conditions especially during winter months (October to April). Human and livestock population of the area migrate to the winter settlements at lower altitudes, mostly outside the buffer zone, in October and come back to their summer settlements at higher altitudes in May. The major occupation of *Bhotiyas* was international barter trade with Tibet before 1962. After the Indo-China war of 1962, trade was banned and the economy of the entire area was totally shattered. People shifted to adventure tourism and took up agricultural activities and knitting of woollen articles as subsidiary occupations. The ban on tourism in 1982 was another major blow to the economy of this Himalayan area, and subsequently agriculture and knitting and sale of woollen articles replaced as the major occupations.

Table-1: An overview of Nanda Devi Biosphere Reserve

1. Date of Notification	January, 1988
2. Date of inscribing on World Heritage Site	December, 1988
3. Geographical location	Western Himalayan Biogeographic Zone "2B" (Rodgers and Panwar, 1988)
4. Total area	2236.74 km²
5. Buffer Zone	1611.12 km²
6. Core Zone	625.62 km²
7. No. of Villages in Buffer Zone	19
8. No. of villages in Core Zone	Nil
9. Total plant species recorded	795 (Hajra and Balodi, 1995) 620 (Samant, 1993)
10. Total mammal species recorded	17 (Sathyakumar, 1993) 14 (Lamba, 1987)
11. Total bird species recorded	114 (Shankaran, 1993) 80 (Lamba, 1987)



LEGENDS

- Buffer Zone (1611.12km²)
- Core Zone (625.42km²)
- Trekking routes to Nanda Devi peak
- ▲ Mountain peak (height in meter)
- Village
- Proposed trekking routes for promotion of eco-tourism in buffer zone

Base camp on the way to Nanda Devi peak;
1. Lata village; 2- Belta Kharak; 3- Lata Kharak; 4- Dharansi; 5- Dibru Gheta;
6- Deodi; 7- Ramani; 8-Bhuj gara; 9- Patal Khan; 10- Sarso Patal (Nanda Devi Base camp)

Fig 1 - Nanda devi Biosphere Reserve showing trekking routes to Nanda Devi peak and proposed trekking routes for promotion of eco-tourism in the buffer zone.

Background of tourism in the area : The Nanda Devi area has remained an attraction to mountaineers and nature lovers because of tough hilly terrain and mighty snow laden peaks. The first recorded attempt to enter the Nanda Devi basin was by W. W. Graham in 1883 (Green, 1993) but he was unable to proceed beyond

the gorge of the Rishi Ganga river. Subsequently, T. G. Longstaff in 1907, and Hugh Rutledge in 1926, 1927 and 1932 also met with failure. Finally in 1934, Eric Shipton and W.H. Tilman pioneered the route to Nanda Devi basin through the steep and narrow Rishi gorge. After the opening of the route, the area became famous for adventure tourism.

There are only two entry points to the route leading to the Nanda Devi peak from Chamoli district. The first one is at the point of confluence of the rivers Rishi Ganga and Dhauli Ganga, near Reni village through the Rishi Ganga gorge, while the other one originates at Lata village (Figure 1). Both these treks meet at Debru Gheta and continue as the main route till the base of Nanda Devi peak. The total distance of the track is about 52 km (Tak and Kumar, 1983), and it takes about 10 days of trekking to reach the base of Nanda Devi peak. The camping sites along the route are at: Lata village, Belta Kharak, Lata Kharak, Dharansi, Debru Gheta, Deodi, Ramani, Bhuj Gara, Patal Khan and Sarso Patal or Nanda Devi base camp (Figure 1).

METHODS

The study involved the collection of both, primary and secondary data. Based on their distance from the entry points, villages were stratified into two groups. Group I consisted of villages within 15 km radius of entry points of trekking routes. Group II villages were more than 15 km away from entry points of trekking routes. This stratification was made to distinguish the level of involvement of villagers in tourism activities, average income generation and the economic loss to them due to the tourism ban. Reni, Peng, Muraina, Lata, Tolma and Suraithota villages were classified in group I, while Phagati, Segadi, Kaga, Garpag, Dunagiri and Malari villages were classified in group II (Figure 1).

Primary data were collected through interviewing the head of each family of study villages using structured questionnaire survey method (Mukherjee, 1996). The questionnaire included both open ended and closed-ended questions on demographic characteristics of the family and questions related to the involvement of individual family in the tourism activities prior to the ban. The questions pertained to demographic characteristics included the number of family members, current occupation type, livestock holding and agriculture pattern. The questions on tourism activities included the number of family members involved in the tourism activities, the kind of involvement, whether respondent was involved as a guide, porter or owned baggage animals (goats or mules) to carry the luggage of tourists, number of days/months involved in a season and the wages earned. The average income generated through tourism and annual income from the current occupation type were also calculated based on the information provided by the individual family during questionnaire interview on the parameters mentioned above.

Human population figures for last four decades *ie.*, between 1961 and 1991, were collected from the Census Abstracts (1961, 1971, 1981 and 1991), the secondary sources, and for the study year (1996) through the questionnaire surveys mentioned above. Informal interviews with village elders were also conducted who could give detailed account of tourism activities they were involved in prior to the ban. The agencies involved in tourism activities in nearby town such as Joshimath, were also approached to gather additional information on the mode of tourism in Nanda Devi region prior to the ban. Besides these, participatory meetings at the village level were also conducted to generate information on (a) the average number of tourists (b) porters that visited the area, (c) income generated in a season per family and (d) perception of people towards the ban on tourism.

In the present study, the biotic pressure was also quantified in terms of wood-cutting, fodder lopping and livestock grazing to assess the status of the forest in the post ban scenario. Forest trails used by the villagers and their livestock were taken as transect to quantify the biotic pressure. On the transect line at every 200 m interval, two circular plots, each of 10 m radius, were laid on either side of the transect keeping a distance of 20 m in between two plots. In such a way sampling was done up to the distance of pressure free zone (where cut/lopped trees were negligible or not recorded at all). The data on following parameters were recorded to quantify the wood-cutting and fodder lopping pressure: (a) species wise number of uncut/

Table 2 : Number of families in the study villages of NDBR involved in adventure tourism prior to the ban in 1982

Villages	Total families	Number of families involved in tourism
Group – I		
Reni	50	40 (80)
Peng	25	20 (80)
Muraina	6	6 (100)
Lata	72	61 (85)
Tolma	14	5 (36)
Suraithora	3	3 (100)
		(x=80.16±SE 9.59)
Group - II		
Phagati	19	2 (11)
Segadi	14	2 (14)
Kaga	11	2 (18)
Garpag	7	2 (29)
Dunagiri	37	6 (16)
Malari	92	4 (4)
		(x=15.33±SE 3.38)

Figure in parentheses indicate percentage of total families involved in tourism

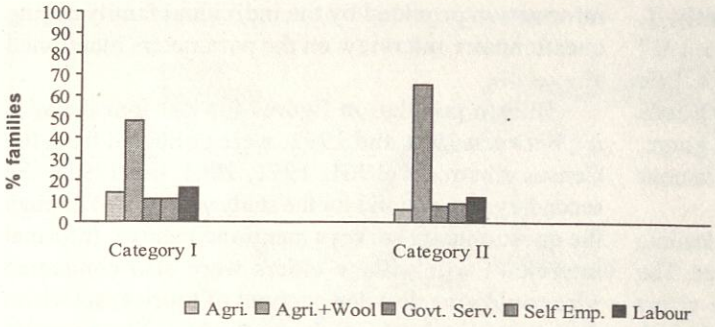


Fig 2 - Occupation pattern in the study area after the ban on adventure tourism

cut and un-lopped/lopped trees (above 20 cm GBH), (b) their GBH and (c) canopy cover. Livestock grazing pressure was recorded by laying three quadrats of 50cm*50 cm within each circular plot of 10m radius. Thus at each sampling point 6 such quadrats were sampled. Within these quadrats quantification of grazing pressure was done by recording (a) the number of livestock dung piles (b) grazing and browsing signs and (c) number of forest trails. Wood-cutting and fodder lopping pressure was also examined along the two trekking routes leading to Nanda Devi peak. The proportion of cut and lopped trees has been calculated against the total number of trees sampled for the entire study area and also for two trekking routes. To record the gradient of wood cutting and fodder lopping pressure, results of proportion of cut/uncut and lopped/ un-lopped trees have been plotted against the distance from the village boundary at every 400m for the entire study area and at every 200 m for two trekking routes.

Within the quadrats (50cm*50cm) laid for quantification of livestock grazing pressure, the evidences of presence of wild animals were also recorded in the form of indirect signs such as species wise pallet groups, footprints, hoof marks and feeding signs. The direct sightings of animals were also recorded wherever possible and number of individuals were counted. The distance to the nearest human settlement from the sampling point was also recorded to understand the impact of human disturbance on the presence of wild animals.

RESULTS

Socio-economics of adventure tourism :

The best season for adventure tourism in the Nanda Devi is between late May and early October, since the trekking routes and forest trails remain under thick snow-cover for rest of the year. Based on the interviews conducted with the village elders it was recorded that at the time of the ban, on an average about 2000 tourists used to visit the Nanda Devi region in a season for mountaineering and trekking activities, majority of which were used to be the foreigners. Each expedition party used to take about 35-40 porters and about 75-100 baggage animals from the local villages, depending upon the size of the expedition team. During the questionnaire survey and meeting with village elders, it was recorded that on an average about 1000-1200 villagers and porters from adjoining villages and towns used to get employment with expedition teams for about 6 months. Goats were mainly used as baggage animals, since they have the skill of walking comfortably on tough hilly terrain. Thus, tourism activities also provided employment to shepherds who took their sheep and goats to the alpine pastures during summer months (May to September). Most of the villagers were engaged as porter while few of them were involved as tourist guide. Women of the family had the responsibility of household activities such as cattle rearing, agriculture, knitting of woollen articles and taking care of children. The rates of one porter varied between Rs. 8 to Rs. 45 per day, depending upon the distance covered and the load carried while rates of one baggage animal were between Rs. 25 to Rs. 60 per day. However, since I could not interview any shepherd who had participated in the tourism activities prior to the ban, the income through tourism activities could not be quantified for them.

A total of 350 families were interviewed from both the groups of villages of which 170 were from group I villages while the rest were from group II villages. From group I villages, on an average 80.16% (SE?9.59) of the total families (n=170) were involved in tourism, compared to only 15.33% (SE?3.38) of the total families (n=180) from group II villages (Table 2). Statistically a significant difference was recorded between the percentage of families of two groups involved in tourism activities (t-test, $p<0.0008$). The average number of members per family involved in tourism also varied in both the groups. From group I, on an average 3 working male members (above 16 years of age) per family, were involved, while in group II, only 1 working male member from each family was involved in tourism activities. Residents of group II villages used to get employment from the tourists visiting comparatively less popular peaks such as Dunagiri, Changbang and Kalanka. Families from Reni, Lata, Muraina and Peng villages of Group I had the maximum involvement in tourism activities, averaging 86.67% (SE±6.67; n=127), because these villages were located near entry points to the trekking routes. In Group II, although Dunagiri, Kaga and Garpag villages were located in the remote valleys, but near trekking routes to Dunagiri, Kalanka and Changbang peaks, their level of involvement in tourism activities was more compared to other villages of the same group.

The average seasonal income per family varied between Rs. 14,724 and Rs. 26,244 for group I villages, while for group II villages, it ranged between Rs. 2,400

and Rs. 10,008. The average income per family per month was calculated to be Rs. 2967 (SE?Rs. 288) for group I villages while for group II it was Rs. 504 (SE?Rs. 206) (Table 3) at the time of tourism activities were on. The average seasonal income from adventure tourism from group I villages (Rs. 17,802 SE±Rs.1731) was higher than the average seasonal income per family from group II villages (Rs. 4591 SE?Rs.1234; t-test= $p<0.001$).

After imposing the ban on tourism activities, socio-economically the entire area has undergone significant transformation. In the process of compensating the economic loss due to the ban, people have concentrated more on agriculture and horticulture by growing cash crops such as Amaranth (*Amaranthus frumentaceous*), Rajma (*Phaseolus* spp), Potato (*Solanum tuberosum*) and Apple (*Pyrus malus*). Parallel to this, knitting and sale of woollen articles has also become one of the main sources of income. Both these occupations, prior to the ban, were subsidiary since villagers remained involved in the tourism activities and they had little time to get involve in such activities.

Based on present study, agriculture and knitting of woollen articles were the major occupations of more than 60% of the total families of the study area (Figure 2). Compared to the seasonal income from tourism activities, the average annual income for the entire area during the study period was recorded as Rs. 10,601(SE±Rs.1133). Of this, 23% was contributed by agriculture sector while 33% was contributed by sheep and goats in the form of wool and meat and the rest came from other occupations such as government service, labour works and other employment at local level. Thus, it can be stated that group I villages suffered more economic setback compared to the group II villages due to the ban on tourism since the seasonal income for group I villages from tourism activities was comparatively higher than the present annual income. During participatory meetings at two villages *viz*., Reni and Lata of group I, it was observed that the local people were still hopeful of reopening the tourism inside the core zone and demanded strongly for it arguing that the incidences of poaching of wild animals inside the core zone have increased due to complete absence of patrolling of wildlife guards and a free-for-all situation for poachers.

Human population trends :

The impact of the ban on tourism activities was also observed on the human population trends in the study area over the decades. It showed a steady increase from 1961 to 1981, while after 1981 a decreasing trend was recorded (Figure 3). Between 1961 and 1971, the population registered an increased of 77% and 89.5% between 1971 and 1981. However, the following decade (1981-91) registered 15% decline in the human population (Census Abstract, 1991), while another 13% decrease was recorded between 1991 and 1996 (present study). Comparatively, the human population of the villages in district Pithoragarh area of the buffer zone showed a continuous declining trend from 1961 onwards, where tourism was not a major source of income and the ban on international trade between India and Tibet came into effective in 1962. Thus, it is clear from these trends that in district Chamoli the adventure tourism remained one of the important sources of income to the local people even after the ban on international trade came into force in 1962.

However, after the ban on tourism in 1982 the human population has shown a decreasing trend. The

Table 3: Average income generation from adventure tourism in the study villages in NDBR prior to the ban in 1982

Villages	Average income (Rs.±SE per family per month)	Average income (Rs. Per family per season)
Group - I*		
Reni	2688±110.11	16,128
Peng	2454 ±73.38	14,724
Muraina	4374±163.51	26,244
Lata	2751 ±77.91	16,506
Tolma	2610±248.30	15,660
Suraithora	2925±142.33	17,550
Group - II**		
Phagati	1200±152.75	7,200
Segadi	570 ±30.00	3,420
Kaga	400 ±50.00	2,400
Garpag	438 ±12.50	2,628
Dunagiri	675 ±75.00	4,050
Malari	1668±463.81	10008

* An average of 3 members per family were involved in tourism
** An average of 1 member per family was involved in tourism

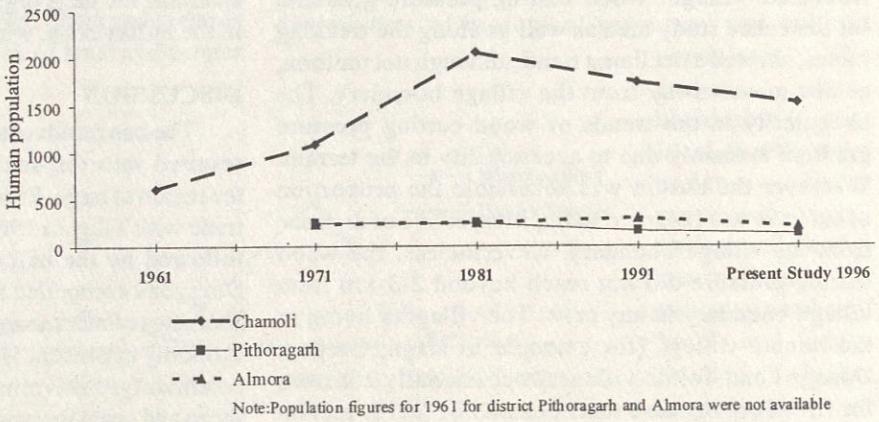


Figure 3: Human population trends in district Chamoli *(study area)* in comparison to district Pithoragrah and Almora

migration of people, especially the younger generation, to the plains has been the main cause of this phenomenon. Population from younger age groups move to the plains in search of jobs and to get higher education, facilities of which was totally lacking in the study area. It has also affected the seasonal migration between the summer and winter settlements. Every year the number of occupied houses in the summer settlements in the buffer zone keep on reducing. For example, Malari village of the study area has about 250 houses but during questionnaire survey, only 92 houses were found occupied while the rest were abandoned.

Status of wood cutting & fodder lopping pressure

The results of anthropogenic pressure have been presented in Table 4. The density of cut trees was recorded as 93.58 trees/ha as against total tree density of 242.82 tree/ha (n=121 plots) *ie.* 38.5% trees were recorded cut for firewood or to be used as timber. Regarding the fodder lopping pressure, only 12% trees (n=121 plots) were recorded as lopped. It is worth mentioning here that lopped trees were recorded mostly along the timberline away from the villages (Figure 4). The reason behind this fact was that the migratory shepherds lopped the leaves of *Betula utilis* to feed their goats on their way to and from alpine pastures during summer season. On the other hand the fodder demand of the resident livestock, particularly the young ones, which are stallfed at home, was met from the agricultural byproducts and weeds/grass collected from agriculture fields.

Wood cutting pressure gradient for the entire study area was restricted within 2-3 km radius of village boundary (Figure 4), while along both the trekking routes it was recorded up to a maximum distance of 1.4 km from the village boundary (Figure 5). The fodder-lopping pressure was not recorded along the trekking routes close to the villages while it was recorded around timber-line in Lata Khrak area in case of trekking route II originating from Lata village. Wood cutting pressure gradient, for the entire study area as well as along the trekking routes, showed a declining trend, although not uniform, as one moves away from the village boundary. The irregularity in the trends of wood cutting pressure gradient is mainly due to accessibility to the terrain. Wherever the terrain was accessible the proportion of cut trees was recorded more, irrespective of distance from the village boundary. Nevertheless, the wood cutting pressure did not reach beyond 2-3 km from village boundary in any case. The villagers living in the remote valleys (for example in Kaga, Garpag, Dunagiri and Tolma villages) occasionally cut trees for firewood, because their demand of fuel is met by dead wood logs that fall during heavy snowfall in winter season.

Status of livestock grazing pressure :

Total livestock population at the time of survey was 4817 animals (n=278 families) of which 73% were sheep and goats, 2% were ponies and the rest were cattle. The population of ponies was restricted to the villages located in remote valleys, to be used them as baggage animals during the seasonal migration. Of the total livestock population, 63% remained dependent on the biomass resources of the buffer zone for a maximum of 6 months, while the remaining population grazed throughout the year inside the buffer zone. In such a situation, the grazing pressure of sizeable livestock population shifts outside the buffer zone for six months. Besides resident population about 10,000-15,000 sheep and goats also grazed in the alpine pastures of the buffer zone and adjoining forests for 5-6 months (May till October). Livestock grazing pressure data revealed that frequency of occurrence of livestock dung piles was 18% (n=624 quadrats) while the density (no./m^{-2}) of dung piles was 9.64 m^{-2} (SE±0.65) for the entire study area. Frequency of occurrence of forest trails was 62% while frequency of grazing signs was 52% (Table 4).

Wild animal evidences :

The results of wild animal evidences have been presented in Table 5. Pika and blue sheep were seen most often. The minimum distance of sightings of wild animals from human settlements varied from half to four-and-a-half km. Himalayan musk deer was sighted near timber line (above 3000 m) around Kaga, Garpag and Dunagiri villages and Lata Kharak area above Lata village, while sightings of blue sheep were mainly recorded in alpine scrub around Dunagiri and Malari villages. The sightings of blue sheep, pika, musk deer and yellow-throated marten recorded close to the human settlements, may be an indication of lessening of human induced disturbances in the buffer zone, which probably ensured the sightings of these animals near human settlements. However, detailed studies are needed to establish the facts regarding the status of wild animals in the buffer zone, which are so far lacking in NDBR.

DISCUSSION

The ban on adventure tourism in Nanda Devi region resulted into the socio-economic transformation of the region at large. Primarily the ban on the international trade with Tibet in 1962 (Pangety 1987; Prasad, 1989) followed by the ban on tourism activities to Nanda Devi peak compelled the local people to look for other alternates of income sources. In the process the regional economy at present is more governed by the agrarian community, cultivating marginal lands and rearing of sheep and goats for wool and meat production. However, due to emigration of younger generation to the plains, the number of agriculture families is also reducing

Table 4: Status of biotic pressure in the study area.

Pressure parameters	Values
1. Tree density (tree ha^{-1})	242.82 (n=121 plots)
2. Density of cut trees (trees ha^{-1})	93.58 (n=121 plots)
3. Density of lopped trees (trees ha^{-1})	29.12 (n=121 plots)
4. Frequency of occurrence of dung piles (%)	18 (n=624quadrats)
5. Density of dung piles (no. m^{-2})	9.64±SE0.65(n=624quadrats)
6. Frequency of occurrence of grazing signs (%)	52 (n=624quadrats)
7. Frequency of occurrence of forest trails (%)	62 (n=624quadrats)

and the extent of fallow land has gone up in the study area in the recent past. Lack of employment opportunities and other basic facilities, a common phenomenon in the entire western Himalayan region, have forced the people to move to the plains, either in search of job or getting higher education (Bohra, 1996; Hoon, 1996).

Culturally, due to such practice the traditional indigenous knowledge of local people, particularly on the conservation and utilization of medicinal plants, is disappearing fast with older generation, because such knowledge is not being transferred to the younger generation due to their migration to the plains. From economic point of view, the income generated from the tourism activities prior to the ban was more or equal to the present annual income. This indicates that there has not been much improvement on the economic front, even after more than one-and-half decade of the ban on tourism activities and it has certainly hampered the regional economy. To compensate the economic loss to the local people, NDBR management authorities introduced various schemes under eco-development programme such as distribution of wool, spinning wheel for knitting of woollen articles, solar lights and pressure cookers. Nevertheless, these activities could not compensate the economic loss, which was evident during the participatory meeting with villagers where a strong negative feeling was observed towards the NDBR management. The lack of trust and proper dialogue between the villagers and management authorities for confidence building and participation of local people at various stages of programme and moreover lack of alternate employment opportunities in absence of tourism resulted into negative attitude among local people towards management of NDBR. The villagers pressed their demand of reopening of the trekking routes for tourism activities to Nanda Devi peak, which was turned down by the authorities for obvious reasons.

The unplanned tourism in and around natural resource rich areas have always contributed to the degradation of the local resources (Kenchington, 1989) and even cultural traditions. There are examples from Nepal and Indian Himalayas where due to unplanned tourism trails were eroded and littered with toilet papers, plastic bags, disturbance to wildlife, build-up of algal growth in water supplies due to improper waste disposal and hunting and plant collection (Ceballos-Lascurain 1991; Ahmed, 1993). In NDBR also, prior to the ban, indiscriminate felling of trees, collection of medicinal herbs and large scale poaching of wild animals were major ecological threats to the biodiversity. The porters used to fell the trees of Surai (*Juniper communis*), blue pine (*Pinus wallichiana*), deodar (*Cedrus deodara*) and bhoj (*Betula utilis*) for firewood (Singh, 1989). They even used to carry guns with them and blue sheep meat used to be on their menu (Khacher, 1978). Besides these, the hectic tourism activities also resulted in to accumulation of garbage on the way to Nanda Devi peak and around the base camp (Sarso Patal), which had polluted the entire area.

Members of the 1993 scientific and ecological expedition brought back over 800 kg of garbage from the core zone, most of which constituted polythene bags, tin containers and plastic bottles (S. Sathyakumar *pers. comm.*). Study conducted by Rai and Sundriyal (1997) in Sikkim Himalaya have also identified increased pressure on the natural resources due to tourism activities resulting in to additional demand for firewood for commercial purposes and fodder for pack animals, degradation of biological resources and cultural vandalism. The authors have highlighted that local forests were under heavy pressure due to fuel, timber and fodder requirements. The increased number of hotels and lodges resulted into higher consumption of firewood and according to the

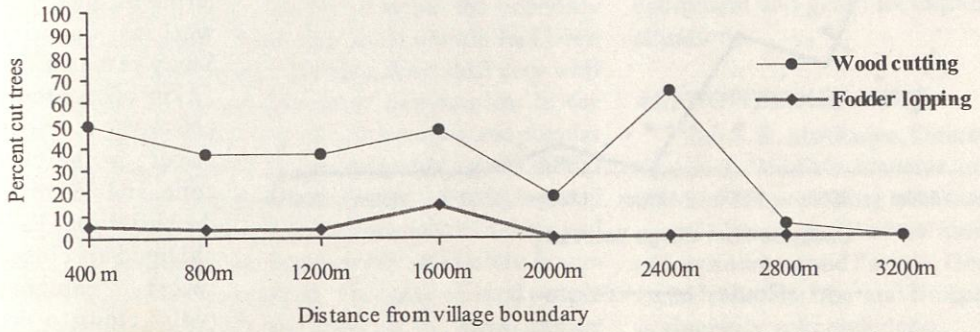


Figure 4: Wood cutting and fodder lopping pressure gradient around study villages in district Chamoli in NDBR

Table 5: Wild animal evidences in the buffer zone of NDBR recorded between 1994 and 1997

Species	No. of sightings	No. of individuals seen	No. of indirect evidences	Minimum distance from village boundary
Blue sheep (*Psuedois nayaur*)	8	110	29	1.5
Himalayan Musk deer (*Moschus chrysogaster*)	3	7	22	2.0
Barking deer (*Muntiacus muntjak*)	1	1	Nil	2.5
Himalayan black bear (*Ursus thibetanus*)	1	1	4	3.5
Himalayan weasel (*Mustela sibirica*)	2	3	Nil	4.5
Flying squirrel (*Petaurista petaurista*)	1	1	Nil	3.5
Himalayan yellow throated marten (*Martes flavigula*)	4	9	Nil	1.0
Pika (*Ochotona roylei*)	15	28	34	0.5
Monal pheasant (*Lophophorus impejanus*)	7	28	34	2

estimates about 40-50 kg of firewood was consumed per day in the hotels and lodges.

However, based on this study, the post ban scenario revealed that the state of anthropogenic pressure in NDBR at present could not be identified as the alarming one for the conservation of biodiversity of NDBR. The biotic pressure was confined around the villages and originated mainly due to the domestic needs for the subsistence of inhabitants. The commercial exploitation of natural resources was not recorded from the study area. The livestock grazing pressure was also seasonal and restricted to the certain pockets of the buffer zone unlike most of the Himalayan region where due to round the year grazing pressure the loss of biodiversity and soil erosion are common phenomenon (Babu *et al*, 1984; Reynolds and Nautiyal 1990; Sundriyal and Sharma, 1996). Rastogi (1993) conducted study in the 4 villages of buffer zone of Nanda Devi and recorded the livestock grazing signs to be the minimum and restricted to the 1-2 km of the village periphery. The fodder lopping pressure was restricted around the timber line and recorded very less compared to other protected areas such as Rajaji National Park (Johnsingh *et al.*, 1990) at the foothills of Himalayas and in the central Himalaya (Singh *et al*, 1984). Moreover, in view of present declining trends in the human population in the study area, the anthropogenic pressure should not threaten the biodiversity of the region in future as long as commercial exploitation of natural resources does not occur. The study carried out by one of the members of ecological and scientific expedition of 1993 to Nanda Devi peak also concluded that forests of the region are in fairly good condition and rate of anthropogenic pressure is much less than any other protected area of the country (Rastogi, 1993).

A study on the status of forests in NDBR through remote sensing conducted by Sahai and Kimothi, (1996) also concluded that during 1981-1991, the status of forest have shown remarkable improvement in terms of quality as well as quantity. Study revealed that 12 km^2 of open forest (10-40% crown cover) in the core zone, and 28 km^2 in the buffer zone have changed to closed forest category (>40% crown cover), while 6.5 km^2 area of

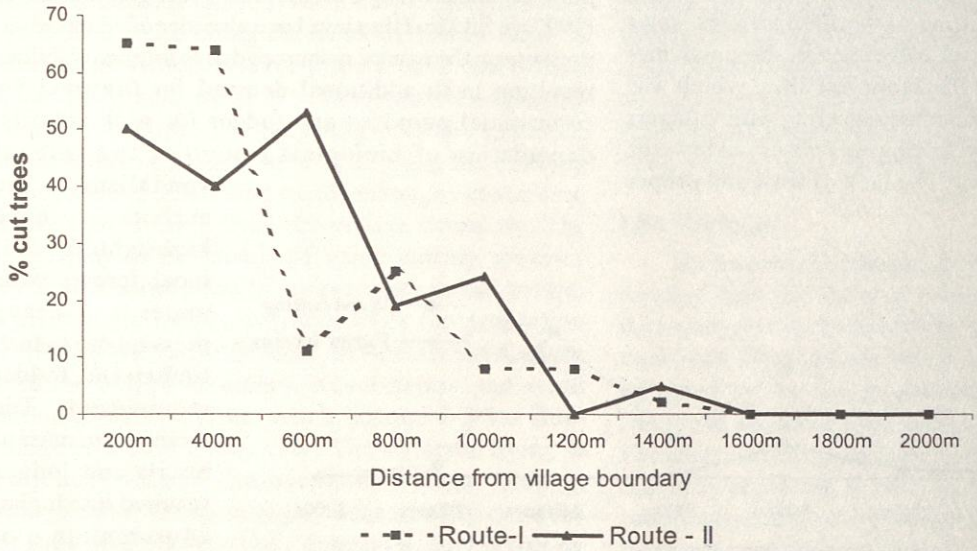


Figure 5: Wood cutting pressure along trekking routes after the ban on mountaineering activities.

degraded forest (<10% crown cover) converted into open forest. Compared to the situation prior to the ban, it can be stated that the ban on tourism activities have brought down the anthropogenic pressure on the biomass resources to the limit of designating NDBR as one of the least disturbed protected areas of the country.

The status of wild animals has also improved, both in the core zone and in the buffer zone of NDBR. The findings of the 1993 scientific and ecological expedition (Sathyakumar, 1993) when compared with the earlier studies (Tak and Kumar, 1983; Lamba, 1987 and Tak and Kumar, 1987) conducted in the core zone of NDBR, showed that the status of Himalayan musk deer and blue sheep has improved both in terms of numbers of sightings as well as total individuals. The results of the present study, particularly regarding the sightings of blue sheep also support the above fact for the buffer zone. Besides records of Sathyakumar (1993), Shankaran (1993) also recorded about 20 sightings of musk deer in the core zone of NDBR and concluded that poaching pressure appears to be minimal and occurs rarely. The status of avi-fauna of the area also improved, when compared to the earlier records. Number of bird species increased from 80 (Lamba, 1987) to 114 (Shankaran, 1993).

The direct sightings of some of the wild animals within 1.5-2 km zone of human settlements recorded through present study also supplement the fact that improved forest quality and quantity have resulted into the improved status of wild animals in the entire region. However, there is need of conducting detailed studies on the various ecological aspects of flora and fauna of NDBR to strengthen the above facts and improve the management of the biodiversity of the entire region.

CONCLUSION

Based on the present study it can be concluded that due to the ban on tourism the economy of the region has been negatively affected and needs a boost that is persuaded with the natural resource conservation of NDBR. To compensate the economic loss to the local people the eco-tourism in the buffer zone can be one of the promising venture to boost the economy of the local people. Since the local people had been involved in the tourism activities, their skill very well can be tapped for promotion of eco-tourism in the buffer zone where there are very interesting and popular trekking routes (Figure 1). The educated youths should be trained with modern techniques of trekking and mountaineering with adequate knowledge of flora and fauna of the region, so that tourists and nature lovers get return of their investment. The stake of local people should be ensured in the process by discouraging the involvement of outside tourist agencies.

In such a way the proposed plan of eco-tourism would not only ensure the people's participation, but would also help in conserving the cultural traditions of the region by involving youths and to some extent checking their migration to the plains. However, the eco-tourism should be different from adventure tourism, in the sense that it should aim at establishing linkages among tourists, local people and biodiversity conservation and also provide a symbiotic relationship between tourism and the environment in NDBR. Moreover, the concept of biosphere reserve also argues strongly in favour of the conservation of cultural values besides the conservation of natural resources (Battisse, 1985). Therefore, the preservation of cultural heritage of the region is equally important which otherwise would defeat the objectives of the area being recognised as the World Heritage Site.

Setting up of an interpretation centre at Lata village would supplement the conservation efforts of NDBR management authorities by documenting and disseminating information on the natural and cultural resource of the entire area. The proposed centre would also serve to generate awareness among local people as well as tourists, which would help in avoiding the repetition of the ugly story of tourism in the core zone prior to 1982. Moreover the rich tradition of region regarding the conservation of natural resources through "Chipko Movement" would have an additional advantage in setting up of such centre.

The knitting of woollen articles and their sale in the study area was quite un-organised. Due to this the local villagers do not get the beneficial returns of their input. Therefore to make this occupation beneficial and more popular, it need to be institutionalised. The occupation needs supported by government agencies and can be run on a co-operative basis ensuring people's participation in the occupation.

To enhance the efforts of conservation of natural resources, there is need of broadening the scientific base of such efforts through taking up long term studies on the various ecological aspects of floral and faunal components of NDBR. Additionally, the staff of Forest Department, especially the lower level staff, should be well equipped with high altitude equipment and given incentives to work in the tough situations.

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POLITICIANS, BUREAUCRATS AND CONSERVATION

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Abstract : Within discussions and writings on Indian conservation there is a continual bemoaning of the undermining of the Forest Department, with politicians permitting mining, deforestation, encroachments, etc in various areas of conservation interest. Inevitably such explanatory terms as greed, the lack of a political will, corruption and so on are provided to explain this enforced ineffectiveness of the Forest Department. In all of this there is a failure to note the historical continuity with regard to this ineffectiveness of Forest Department functioning as also the operative presence of highly rational processes that result in this undermining of the Forest Department's authority. I propose to draw on research from various parts of the country, to provide a more theoretically informed explanation of why Indian conservation is so readily undermined. I shall argue that analyses of state functioning need to disaggregate the state into its component parts - legislature and bureaucracy at one level, different departments within the bureaucracy at another, and different hierarchical levels within a single department, at a third level. Such deconstruction is necessary because differing agendas at each of these levels, critically influence the process of formulating and implementing policy. Ultimately, a large part of inefficiency in government functioning is a derivate of such agenda-based divisions within the state. An implication of my argument is that if local communities are better involved in conservation initiatives, they may be more willing to use their electoral power to ensure greater political support for conservation, generating thereby greater alignment of politician and forester interests. In turn such alignment may reduce the intra-governmental divisions that currently ensure the levels of non-performance we are familiar with.

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INTRODUCTION

We all function under a common mis-conception, which is that the knowledge we generate in scientific research feeds into the policy process, and, ultimately, into better management. When this does not happen, we bemoan the lack of political will to get things done in India. India also has among the toughest environmental legislation in the world; it also, as we well know, has a poor record of implementing this legislation. This too we blame on the lack of political will.

Surprisingly, this lack of political will is not in evidence in various other areas of Indian life - be it the explosion of nuclear bombs or Chandra Babu Naidu's computerisation of Taluk headquarters in Andhra Pradesh. Given such examples of dynamism in various social arenas in the country, we need to understand what leads to stasis or intentional governmental neglect in the area of resource conservation.

I propose to examine this issue in the context of forest conservation in India, drawing on research in various parts of the country, mine as well as of others in the social sciences, to provide a more theoretically informed explanation of why Indian conservation is so readily undermined. I'll make a simple point here, which is that when we analyse the functioning of the state or the government, we need to break it down into its different components - the bureaucracy, the legislature, different departments. Each of these can be further broken down into additional levels. Such separation is necessary because each arm within the government brings a particula r agenda to the process of policy formulation and implementation. That a politician overrides an official of the forest department is a result of the former having an agenda that differs from that of the latter. That there is considerable dynamism in Andhra Pradesh's development scene today is at least partially due to the alignment of Naidu's agendas with those of his (hand-picked?) team of bureaucrats. We need to understand such agendas, at all levels within the government, if we are to understand why things do not work as they are supposed to. Literature in the social science talks of disaggregating the state, of breaking it into its component parts (Migdal 1988). I propose to do that in the context of the state's involvement in natural resource conservation.

A Divided State

I will start by examining divisions within the forest department itself, then look at interactions between the forest department and other bureaucracies, and finally examine forest department interactions with politicians, attempting, at each stage to understand the logic or the agenda that influences the functioning of government officials at each of these levels.

As an example of the divisions within the forest department, it is unreasonable to expect that the agendas of the lowest functionaries of the state align with those of policy makers - if only because of an inability of the state to provide adequate salaries to its lowest staff. In the absence of adequate compensation, but even if compensation levels were to be raised, there is little reason to assume an alignment of forest guard and policy-maker interests regarding what needs to be conserved and the means of conserving the same. Guards hired from local villages are far more likely to have sympathies with the people among whom they have kin and other long-standing ties. As a result, guards will often allow individuals from the community

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to gain access to forest resources, simply because the person is related to the guard, or because the guard has to survive in the social context within which he is living. Guards may of course choose to prevent an individual from gaining access to a resource, but this is as likely to be an exercise of power as an attempt to conserve, say the wild flowers of the Himalaya. It is a shaky premise to effective long-term conservation. Such differences may be thought of as vertical divisions within the state.

One also comes across horizontal divisions deriving largely from conflicting mandates to different departments. The classic example of such division is linked to the fact that the forest department is an agency mandated to *conserve* resources, where as most other departments have a mandate to *use* resources. Over the past two centuries, for example, the revenue department has attempted to facilitate the spread of cultivation since its revenue base, taxation, has been directly linked to the extent of land under cultivation. In contrast the forest department has attempted to curtail both the spread of cultivation and local access to forests, owing to its mandate to manage forests either toward maximising timber harvesting or, more recently, as reservoirs of biodiversity (see Rangarajan 1996, Saberwal 1999). In the face-off that has resulted between the forest and revenue departments, the latter has often been the more powerful actor, effectively denying the forest department the authority to enforce its restrictions on local access to forests (Saberwal 1999).

Evidence of such inter-departmental resistance to conservation policies comes from a wide variety of sources. Rajan (1994) demonstrates resistance towards forest department policies throughout the British Empire, and up to the 1950s, with the issue coming up repeatedly at The British Empire Conferences as an issue that needed to be addressed by the Government. He also points out that at times of crisis, as for example during the Great Depression during the 1930s, it was the Forest Department's budget that was hardest hit.

Similarly, Guha (in preparation), Rangarajan (1996), (Saberwal 1999) and Sivaramakrishnan (1996), each in a variety of contexts - Karnataka, Madhya Pradesh, Himachal Pradesh and West Bengal – provide ample evidence to testify to the power conflicts that have taken place between the forest and revenue departments in pre-independence India, and the resultant interference in the functioning of the forest department. Although I lack data on the issue, the growing pace of economic liberalisation in the country is bound to come in conflict with conservation agendas of the forest department: I doubt that the various state departments or the environmental ministry will have the political clout to deny environmental clearance to most development projects in the coming decade - a reflection, once again, of weakness of the department relative to other agencies of the government.

The most powerful division within the state, however, is represented by differences in politician and bureaucrat agendas. In an abstract sense, bureaucrats form a part of a state machinery that is meant to form the bed-rock of Indian administration. Indeed, a key feature underpinning the Indian Administrative Service (and the same applies to other services, such as the Indian Forest Service) is the idea that an officer has security with regard to his or her position, owing to the permanence of their appointment. Theoretically then, forest officers have the freedom to act according to their perception of the optimal management of forest or other resources under their control. In the process, a forest officer is expected to be able to resist pressures from politicians, business interests, and others, with regard to granting of preferential access to the resources s/he controls. They are expected to take the long-term view of managing a resource,[1] counterbalancing thus, the necessarily short term rationale that underlies the functioning of a politician.

In contrast, a politician is an elected representative who lives from one election to the next, and when in office, is necessarily thinking towards the next election. Policy decisions are critically influenced by the electoral mileage that can be derived from them. However imperfectly Indian democracy may appear to function, politicians will eventually respond to voter demands over the lifting of restrictions on access to forest resources. It is simply a question of the issue coming to gain sufficient importance in a given constituency.

Within Himachal Pradesh, for example, the forest department has attempted to curtail Gaddi herder access to forest resources for the past century and a half. For the most part, the Gaddi have successfully circumvented or undermined many of these policies, a consequence of support from the revenue department prior to independence, and due to active intervention on part of politicians in the post-independence era. Since the 1960s, politicians from those parts of the state that have large herder populations - Kinnaur, Chamba, Kangra, and Kulu - have systematically intervened on behalf of herders to stay the imposition of restrictions, and also to open to grazing reserve forests that have been off-limits to herders for the past century (Saberwal 1999). Baviskar (1998: 76) reports similar intervention by politicians in Himachal: "Villagers think nothing of calling up their MLA who then calls up the park (Great Himalayan National Park) director to tick him off for harassing his people. Confident of

1 The same long-term thinking has probably helped generate a high degree of inertia in policy formulation. Thus, despite rapidly changing political, economic and scientific contexts, forest departments in the country have often produced an unchanging conservation rhetoric, and a policy deriving from such rhetoric, over the past century and a half (Saberwal 1999).

their rights and their political support, villagers around the park casually flout the law."

In an attempt to transform electoral politics Malayalis have been encouraged to settle in what was formerly the Tamil dominated Idukki District of the Cardamom Hills of Kerala. The incentives for such settlement have included the large scale provisioning of lands to Malayalis, inevitably hastening the transformation of forested to cultivated land (Moench 1990). A similar process of ethnic transformation has resulted in lands in Shimoga district in Karnataka being given to members of a Malayali community (Lele, pers. comm.). Thapar (1998) provides explicit details of sustained politician intervention in the functioning of the Madhya Pradesh forest department.

The links between politicians and business interests further complicate forest management by the forest department, although some undoubtedly corrupt officials of the forest department derive their share of the proceeds from the accommodation of industry. The Narayan Sarovar Sanctuary in Gujarat was recently denotified to enable a cement factory to commence mining operations within the sanctuary (Kothari et al. 1996). Similarly, a major cement factory has been in operation in the Darlaghat Sanctuary in Himachal Pradesh since 1991 (Personal observation), and mining continues within the Kudremukh National Park. There are demands for such denotification in Madhya Pradesh, in response to the recent ruling of the Supreme Court requiring all state governments to settle existing rights within protected areas, even if this means an eviction of people living within national parks. Such denotification may actually be supported by local communities, particularly where stringent regulations deny them access to forest resources, and the presence of the sanctuary prevents the arrival of industry to job-starved regions.

A final level of division within the government is represented by the centre and the state. Rangarajan (Pers. Comm) points out that the successes of the 1970s with the introduction of Project Tiger in all parts of the country, came about largely because of Mrs. Indira Gandhi's interest in conservation. She also had very firm control over a party that was in power in most states in the country. She commanded the loyalty of most chief ministers of these states, individuals who would have not wanted to cross Mrs. Gandhi, even if they disagreed with her attempts to have large areas set aside as protected areas. With the growing importance of regional centres of power in today's emerging political scenario, one is unlikely to come across the kind of unity of purpose Mrs. Gandhi was able to generate. There can be no assurance that policies originating at the centre will be supported at the level of the state.

The influence of interest groups on the formulation of conservation policy has been well documented in other parts of the world (see Cooley, 1963, West 1982, Wargo 1996). In such instances, local community leaders and politicians are determining the use of forests and grasslands and not conservation agencies of the state.[2] The effective functioning of democracy is cause for cheer; the ineffectiveness of agencies mandated to manage forest resources, is cause for grave concern.[3]

LOCAL ALIENATION

I come now to the final section of my paper, which is the link between local communities and political decision making. All of us are aware of the widespread absence of local support for conservation efforts of the Forest Department, although it will not harm to reiterate the factors that have contributed to this alienation.

As Rangarajan (1996), Gadgil and Guha (1992), and others have pointed out there is a long history of conservationist attempts to keep people out of 'protected' areas. This is true of princely India, it is true of pre-colonial India, of British India, and of Independent India. Although the extent and rationale for curtailed local access to and use of forest resources has varied enormously in each of these contexts, state attempts to retain control over forested areas has remained a constant feature of Indian conservation over the past two centuries (Kothari et al. in preparation).

As a result of such exclusionary policies, local communities have often faced reduced access to forest resources, while simultaneously noting the state's provisioning to industry of subsidised access to the same resource. Obtaining access to adequate forage for livestock, fuel for cooking, and minor forest produce for household consumption and commercial sale has become increasingly difficult for communities living in or around protected areas, resulting in tensions between local populations and forest departments in various parts of the country (Kothari et al. 1989).

In many parts of the country, resident communities also bear the costs of human and livestock losses to large carnivores. For the state of West Bengal alone, 189 human deaths were reported over the period 1979-84, with sixty three of 206 surveyed protected areas in the country reporting human injuries or deaths caused by wild animals (Kothari et al. 1989). Similarly, crop raiding by elephants, bears, wild boar, deer and other ungulates results in the routine destruction of crops

2 I will not examine the issue of whether policies introduced by the government are appropriate to managing a given resource. Rather my focus has been on the factors responsible for the ineffective functioning of the conservation agencies of the Indian state. It should be noted, however, that the often assumed responsibility of local communities with regard to accelerating a decline in forest cover, biodiversity, and other values associated with forests is under constant review.

3 In an era of economic liberalisation where provincial and federal government see growth at any cost as a prime goal, it would be short-sighted to expect an enforcement arm of the administration as a guarantor of natural resources. If anything, a transparent and accountable system of conservation has to look beyond the bureaucracy to citizens as watchdogs and as partners.

in villages close to protected areas (Sukumar 1994, Saberwal et al. 1994).

To a large extent such losses to life and property remain uncompensated by the forest department. Where compensation is available, obtaining such compensation is invariably a complicated task. Typically, in such situations, villagers have to inform a forest officer of the death of an animal or damage to crops, the latter then making an evaluation of the value of the property destroyed. Such an evaluation is necessarily influenced by the highly personal and unequal power relations that characterise those of villager and forest official. There are reports of villagers having to bribe forest officials to have a fair evaluation of compensation due, of delays in receiving compensation, of villagers not even applying for compensation owing to the problems of dealing with an exploitative bureaucracy (Saberwal et al. 1994).

For the most part, local communities have borne the costs of Indian conservation and derived very few of the benefits. Accordingly, indifference to, and in some instances high levels of animosity, characterise local attitudes toward state initiated conservation programmes. This is evident from the large number of clashes between forest officials and villagers in protected areas across the country. Forty seven of 222 surveyed protected areas attested to such clashes. (Kothari et al. 1989).

As a result of such animosity there is a general lack of local engagement in resource conservation. This absence of local involvement is likely to translate into an absence of political pressure on politicians to push for more environmentally friendly policies. In turn one can expect this absence of electoral pressure to translate into an absence of politician interest in resource conservation. Although the causal relationship has not been established within the literature, such alienation is likely to lead to enhanced local support for the denotification of protected areas to accommodate industry such as cement, if only so as to gain access to the forest themselves or in the expectation that the presence of industry will enhance employment opportunities in the region.

In contrast, there are instances of local community involvement enabling the forest department to achieve its own conservation goals.[4] In Sariska Tiger Reserve, in Rajasthan, for example, villagers have fought against mining, using the help of forest officials and the Wild Life (Protection) Act of 1972 to force the stopping of mining from the area. Inhabitants of five villages in the Alwar district of Rajasthan have declared 1200 hectares of forest as the Bhairodev Dakan `Sonchuri', promulgated their own set of rules and regulations which allow no hunting, and have protected the area against outside encroachments (Kothari et al. 1997). In Kaila Devi Sanctuary, part of the Ranthambore Tiger Reserve in Rajasthan, villagers have come together to prevent migratory pastoralists from moving through the sanctuary, owing to the fear that the annual migrations of lakhs of sheep and goats are responsible for the absence of forest regeneration (Kothari et al. 1997). In each of these instances, there is a convergence of local and state interests, with the (political) mobilisation of the villagers enabling

CONCLUSION

I will conclude by pointing out that the forest department, and conservation agencies world wide, have historically been in a weak position vis-a-vis other interests - be they of industry, of other departments, or of politicians. It is only when there has been a ground-swell of local support for conservation, as indicated by the growing political power of "green" parties such as Greenpeace in Europe and the presence of an environmental agenda to both the democratic and republican parties in the United States, that environmental agencies have been provided with real teeth to fight industry and other commercial interests. With growing liberalisation in India, there is unlikely to be a great deal of tolerance within the corridors of power for restraints on expansionary development, as advocated by the forest department. And other than the forest department, the only other advocates for conservation are a few wildlife researchers, and a small middle-class constituency who have simply not managed to shape the environmental politics of any political party in the country. That can only happen with support from local, village based communities, where political pressure is brought to bear on Members of Legislative Assemblies, and where the winning of an election is based on an MLAs performance on the environment. For the most part local involvement in conservation politics has translated into support for denotification of protected areas. Whether the forest department and others can create the space within which villagers will feel the loss of a national park or sanctuary, and will therefore vote those to power who will fight to conserve the environment is something that remains to be seen. Were this to happen, however, there may be a reduction in the nature of divisions that currently characterise the functioning of the state, and lead to the sort of non-performance all of us are familiar with.

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4 I do not wish to engage at the moment in the complexities of greater local involvement in conservation, in terms of defining what the "local" refers to or the difficulties of ensuring equitable and effective participation in management of, and sharing of potential benefits from, natural resources. These have been discussed at length by many others; my primary goal here is to highlight the necessity of providing local communities with a stake in resource conservation, for to fail in this we will necessarily be helping to generate a political backlash with negative consequences for the resource itself.

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POLICY OPTIONS FOR WILDLIFE CONSERVATION IN INDIA

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Abstract : This paper takes stock of the wildlife conservation policy options in India and suggests some new initiatives. The main instruments of wildlife conservation policies in India are the Wildlife (Protection) Act, 1972, the National Wildlife Action Plan, 1983 and the National Forest Policy, 1988. Although the Act has been amended several times to keep pace with the changing scenario it has generally been criticized as being perpetually out of tune with the ground realities. The strategy of total protection and focused attention on national parks and sanctuaries have been the two main pillars of our conservation policy so far. The principle of reducing human dependence on natural resources, and winning their trust and participation, through ecodevelopment in buffer zones of protected areas, was incorporated in the 1983 National Wildlife Action Plan and has since become the cornerstone of conservation action today. However, the cat and mouse race between conservation policies and ground realities is expectedly unending and we need to take a fresh look at our policy framework once again. Protected Areas (PAs) are invariably perceived as a problem, rather than an asset, by the neighbouring communities, as they tend to lose, inter alia, their crops, cattle and lives due to the depredations of wild animals. While the society at large enjoys the fruits of conservation, the poor rural communities bear all the costs. The paper suggests ways of dispersing these costs through a system of crop compensation, subsidies for crop protection, and ecodevelopment. The authors suggest that treating wildlife as a local resource, and its utilization, especially in the case of overabundant, crop raiding and fast breeding herbivore species, will be a more effective conservation approach as against the current policy of total protection. Another important suggestion made in the paper is that rehabilitation of villages from PAs is not all that bad and should be pursued vigorously. As it is neither desirable nor feasible to move out all the settlements out of all the PAs, the law should permit prioritization on a village to village basis, through zonation approach. Further, the cost of relocating a reasonable population outside the PAs is not so high, in the context of the overall size of India's national economy. It is just a question of having our priorities right and action correct.

WILDLIFE CONSERVATION, RESEARCH & MANAGEMENT : 84-90

INTRODUCTION

The policies of a time are both directional as well as in reaction to the prevailing realities. The current wildlife conservation policies in India are set in the realities of the seventies and were mainly framed as a reaction to the post-independence massacre of wildlife and its habitats. The main instruments of the wildlife conservation policies in India are the Wildlife (Protection) Act, 1972 and the National Wildlife Action Plan, 1983 and the National Forest Policy, 1988. Although the Act has been amended several times to keep pace with the changing realities, but it has generally been criticized as being always out of date. The policy of total protection, and focused attention on national parks and sanctuaries, created by removing human habitations, have been the two main pillars of our conservation policy so far. The principle of reducing human dependence on natural resources, and winning their trust and participation, through ecodevelopment in buffer zones of protected areas, was incorporated in the 1983 action plan and has become the cornerstone of conservation action today. However, the cat and mouse race between conservation policies and ground realities is expectedly unending and we need to take a fresh look at our policy framework once again. Some of the new realities and suggestions to deal with them are discussed in this paper.

The overall conservation programme in India, as in any other country, can be divided into three main areas viz.

(i) Creation and management of protected areas;
(ii) Protection of wildlife in managed forests; and
(iii) Control and management of wildlife trade.

While the last is just a question of effective law-enforcement, the first two involve, in addition to law-enforcement, complex socio-economic and political issues. These issues arise from the conflict between wildlife and the human communities sharing their habitats. The conflict arises from the loss of access to the resources locked up inside PAs, the damage caused by wild animals to human property, and lives, and the way these communities tend to react to these circumstances. This paper discusses this conflict and the policies aimed at its management.

THE CONFLICT

Almost invariably, the forests included in the PAs also support local lifestyles and economies, which are adversely impacted as a result of the mandatory acquisition of rights for creating a PA. The legal process of creating a PA requires the extinction of all, or most, private rights and privileges over notified lands. This, in essence, means wholesale relocation of human settlements, which fall within the bounds of such areas. This being a highly unpopular, costly, and consequently, politically inexpedient and slow process, has not yet been completed in most national parks and sanctuaries. For instance, a study by the Indian Institute of Public Administration (IIPA) reported completion of the legal

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process in only 40% of the national parks and 8% of the sanctuaries (Kothari et al., 1989). Situation is virtually the same today. Even this conclusion appears a little optimistic and was based on limited data. As a result, most of our PAs, even the well-known ones, have not yet been legally gazetted and continue to live with a doubtful legal status, although they are known as national parks and sanctuaries.

The conflict, between the government agencies and the local people, is seen almost in every forest area in the country, as a consequence of the dual control, that of the government and of the local people. However, it is generally believed to be more pronounced in and around the so-called PAs. Although the government legally owns the forests, the customary rights of the people over them and the tendency, passive or deliberate, of both sides, to strengthen their hold, results in conflict. The term 'Protected Area' itself connotes conflict between the administration and the people against whom it is sought to be protected. The law provides for resolving this conflict by settling the private rights, over the lands to be included in the PAs, before declaring the area protected. The government acquires the rights by paying compensation to the affected people in the form of land or cash, or both. But the number of people living in the proposed PAs, and consequently, the requirement for alternative land and cash, is so huge that it will take centuries to relocate all the people from all the PAs at the current rate of funding. In the IIPA study mentioned above, most national parks (56%) and sanctuaries (72%) were reported to have human settlements inside. This too appears to be an underestimate as the low database, admitted by the authors, had its own limitations. A truer picture may perhaps emerge from looking at the situation prevailing in M. P., the state with the largest area and number of PAs in the country. Almost all PAs have villages inside. There are 955 villages and 77339 families living in 45 PAs (approx. area 17000 sq. km.) of M. P., which gives an average of 21 villages and 1718 families per PA or more than 4.5 families per square km. Projecting these figures at the national level, we find that we have between 684000 (by area, total area 152000 sq. km.) and 859000 {by number (500) of PAs} families, living in our PAs, today. At the GOI's rate for resettlement expenses (Rs.1,00,000 per family) and 2.5 hectares land per family, the resettlement would require 6840 * 8590 crore rupees, in addition to agricultural land! As so much money and land for resettlement of people is not going to be available in the foreseeable future, we are likely to have to live with the current conflict for pretty long! M. P. has relocated only 34 villages till date, 27 of them in Kanha.

The conflict between wildlife and wildlife management on one side and the local people on the other, results from the way PAs are created (by extinguishing the rights of the people) and the way they have been managed so far (total protection). We do not think it is necessary here to elaborate the nature and variety of the conflict between wildlife and people, in the context of the PAs, as the subject is extensively discussed in the press, almost regularly. We would rather focus on various possible strategies to resolve and manage this strife. The reasons for PA - People are summarized in **Box 1.**

Box 1
Reasons for PA - People Conflicts

1. Threat of relocation to the people living inside the proposed PAs or the fear of an unfair deal, even if they are willing to move out; inability of the government to carry out relocations speedily; and denial of development to the villages marked for relocation;
2. Denial, to the people living in and around the PAs, of access to the resources, either used or claimed to have been traditionally used by them for sustenance;
3. Loss of crops, livestock, other property and human lives due to the depredations of the wild animals;
4. Deterioration of the condition of the forests outside PAs, due to increasing human and livestock populations, resulting in the shifting of the pressures to PAs; and
5. Instigation by petty politicians and unscrupulous NGOs for their own vested interests.

Obviously, the conflict is not only between man and wildlife. Rather, it relates more to the differences between the conflicting perspectives and interests of the local people and the government. Whereas official forest management is aimed at long-term benefits to the society, the fulfillment of the immediate needs takes precedence over every thing else, as far as people are concerned. Ideally, the restrictive management of PAs should begin only after settling the rights of the people. But if we wait for such a day, the resources, which we seek to protect, are likely to suffer irreparable damage in the meanwhile. It has, therefore, been the practice that settlement of rights, and protective management of the area, are done simultaneously, but the former has generally been accorded a lower priority. As a consequence, the resentment of the people against the regulations which tend to consolidate the official hold on the forests and cramp the peoples unrestricted lifestyles and restrict their access to critical forest products (fuel, grazing, MFPs etc.) is the basic ingredient in the widespread conflict seen these days.

MITIGATION STRATEGIES

The mitigation strategies for resolving the PA-People Conflict are discussed below :

Relocation

PAs are, no doubt, critical for ensuring the continued existence and well-being of our wildlife and biodiversity, but trying to achieve this larger objective at the cost

of only the local people, who are generally the poorest lot, is neither fair nor sustainable. It is undeniable that the people living close to the protected areas have to bear the impact of their (PAs) existence and management, but the society ought to share the cost by suitably compensating these people. Even if we are able to remove all settlements from within, the conflict with the villages situated in the neighbourhood is bound to continue unless serious efforts are made to soften the interface. The problem has snowballed into a nearly impossible one due to the devastating increase in human population and the emergence of political and other vested interests, over the last two decades. Although it is still possible to reduce human density inside 'proposed' protected areas, by generously compensating and resettling many, if not all, villages, the strategy appears to have been as good as abandoned, for want of political will and bureaucratic inaction. This is inspite of the fact that relocation continues to be the legal mandate for the administration. Inspite of the recent directives from the Supreme Court, in a public interest litigation, to show concrete results on the settlement front, not much headway has been made in view of the obvious odds.

Many NGOs, politicians and miscellaneous activists are exploiting this situation either to win new territories or to consolidate their hold on the existing ones. These groups either have a vested interest in showing the intensity of conflict higher than what it really is or tend to bark up the wrong tree. In most campaigns, the NGOs are opposing the relocation of people from proposed PAs while experts agree that at least limited movement of human population is required to create sufficiently large PAs. Not to speak of India, with extremely high population density, nowhere on earth have PAs been created without some adjustments between human habitats and wilderness. As none can honestly say that conservation of biodiversity is not important, rather than blindly opposing relocation, the activists should fight for a better deal for oustees, a timebound programme for rehabilitation and providing alternatives to the remaining populace. This might give them a much better hold on the masses and, in our opinion, a better peace with their own consciences.

This is not to say that a limited rethinking on the whole issue of relocation of habitations for conservation is not called for. So far, government agencies have been working on full relocation, however slowly and reluctantly, because the law required it. Considering the fact that relocation of all the people living in our PAs is nearly impossible, we must differentiate between areas, within PAs, where humans cannot live comfortably without seriously jeopardising the interest of wildlife and those where people can continue to live with some adjustments in their lifestyles and economic practices. After the 1991amendment to the Wildlife (Protection) Act, 1972, [sec. 24 (2) (c)], according to which the District Collector, in consultation with the Chief Wildlife Warden, can permit the continuation of any rights, even after an area has been declared a sanctuary (not national park), it is being said that even habitation can be permitted inside sanctuaries. However, looking at the thrust of the chapter in which the clause has been inserted, the intention appears to be, perhaps, to provide, to the villages located outside the boundaries of the sanctuaries, but which do not have adequate forest land outside for meeting their needs, some relief by letting them use the sanctuary forests in a limited way. This clause gives us the scope to make exceptions, in difficult situations, and cannot become the rule. Some forest departments have started using this clause as a convenient excuse against the implementation of an unpopular mandate, and instead of identifying the priority and non-priority villages for relocation, the forest departments are now taking the stand that relocation is not at all required in sanctuaries!. We think, instead of hunting for escape routes in the law, or looking dumbly at the enormity of the problem, we should seriously examine the whole issue and decide which villages to relocate and which not to, at the earliest, and have a low-key, but steady and humane, relocation programme on the agenda. As there is the danger of the prioritisation being influenced more by political than technical considerations, we need to take a fresh look at our statute and make it free from any ambiguities.

Under the current law, there is a bar on the accrual of new rights, except by succession, after an intention to make an area a national park or sanctuary is declared, and no rights can exist (in a national park) after the area is finally notified to be a PA, except those specially permitted to continue (in the case of sanctuaries only). The settlement of rights has so far been a painfully slow process and depends on the pace of the officials involved. The people, who in any case are reluctant to move, are happy with this sloth. There is no built-in motivation for the people to move out, except for those optimists who see the prospects of a more comfortable life away from the hassles of living in a controlled area. Certain countries, such as the U.S.A., have provided a built-in legal incentive to people for moving out as soon as possible, by barring the accrual of even the rights to succession after the current owners die, when a land is required for a public purpose and is so notified. These countries provide all the necessary assistance to those who want to move out but do not have to force others. Thus, people keep shifting out according to their own convenience and the population density inside the PA gradually goes down, creating a suitable environment for wildlife in due course. We, too, can examine the question of incorporation of such a provision in our wildlife (or in the Land Acquisition Act) law. If such a law is accepted, the politicians and

NGOs will be forced to fight for a faster rehabilitation of their constituents, rather than vice versa.

Whatever the law, relocation of even a small portion of the villages now situated within the PAs may appear to need huge amounts of money at first sight, but it is not so if analysed a little deeper. Using the statistics discussed in a foregoing paragraph, and making a further assumption that we cannot relocate more than a quarter of the villages in the next 10 years, the annual allocation required will be to the tune of only Rs. 150 to 200 crores, at the GOI norms for relocation expenditure, in addition to land for land compensation. One can argue that, for a poor country, this is a huge sum. But when we can afford thousands of crores of rupees in the shape of loan waivers, can give grants and loans to smaller countries, and can tolerate all kinds of sundry wastage on populist programmes (Haryana lost Rs. 600 crores annually on prohibition and Punjab loses 200 crores on power subsidy), and looking at the huge size of our economy, the amount does not look so impossible. It is a question of how much importance we give to the environment and well being of our present and future generations. Many NGOs can get us this sum if they make out a good case to foreign donors!

Buffer Zones and Ecodevelopment

At present our PAs are strictly out of bounds for human beings *(except the exercise of certain rights under section 24 (2)(c), or under section 28 for tourism and research etc., or for grazing under section 33, all of which, however, appear to be limited by section 29 of the Act, which prohibits every action that is not meant to improve wildlife management in a PA)* and strict protection is the only management prescribed by law. On the other hand, Nepal has established an additional concept of 'Conservation Area' instead of 'Protected Area', under which the unit consists of five zones, each with a different management focus ranging between strict protection and intensive use (Gurung, 1993). Conservation is being integrated with rural development, through the creation of buffer zones around PAs, all over the world, in which intensive development of natural resources, traditional land use and other economic activities are undertaken to contain the pressures outside the sacrosanct 'core'. Our own buffer zone concept has been around for as long as the Project Tiger, and was later enshrined in the National Wildlife Action Plan, 1983, too. Only the tiger reserves, which receive central assistance from the GOI under Project Tiger, have been provided with buffer zones around them. None or very few other areas have notified buffer zones. Buffer zones are meant to be actively managed, through ecodevelopment, to generate alternatives to the resources foregone by the surrounding villages due to the creation of the PA. But none of the States have taken the concept seriously and there is not a single functioning buffer zone in India. Some Tiger Reserves, like Bandipur in Karnataka, have a buffer zone inside the national park and is used to permit what law has forbidden but cannot be stopped in practice, i.e., grazing and fuel wood collection by adjoining villages. In other states, buffer zones are either under dual control of the PA management and adjoining territorial divisions (Melghat in Maharashtra), or completely with the territorial divisions, without any directions for suitable management (M.P.). Only a few years ago, the buffer zone of Kanha was ordered to be transferred to the park authorities for intensive ameliorative management. But a strong opposition to this move was launched by politicians and certain NGOs, deliberately misinterpreting the intention behind this move to the people, despite a valiant effort on the part of the park management to inform all concerned of the real intent.

Thus, there is a strong need to provide legal sanctity to the existence and management of buffer zones, in order to bring about some seriousness and direction in their management. It may be a good idea to examine the conservation area concept closely and make the core-buffer complex as one integrated legal unit. After redefining the legal boundaries of the PAs, we can also reconsider the question of relocation of villages, one at a time, with contiguity as the guiding principle, as to whether a village should remain in the bufferzone or be relocated at an alternative site, depending upon how critical its surrounding forests are for wildlife.

Fifteen years ago, when the senior author was the director of a new national park, the concern about the problems of people living inside, who were and still are, ready for relocation was relatively less. The major concerns were focused on the long-term problems of the villages outside, whose access to a part of the limited forest in their neighbourhood was to be permanently severed. It was realised that the way to control the offences committed by our neighbours was to look into the reasons for their being such incorrigible offenders rather than just to police them. We came to the conclusion that as long as the commodities they need to make a living are available only in the park, it would be impossible to stop them from stealing them. We realised that the long-term strategy to preserve the park resources would be to provide them alternatives to these products outside, through appropriate development interventions, in partnership with the other rural development agencies. Although we did not make any headway in implementing this novel idea, academics and managers elsewhere had already coined a word 'Ecodevelopment' for such development interventions by conservation agencies and a debate was going on as to how to implement such programmes. Since then, ecodevelopment has become the cornerstone of conservation, and despite

some controversy about the scope of the term, has been accepted as the only lasting conservation strategy for developing countries, where the forests are as much the sustenance for the poor people today as they could be the lifeline of future generations. Ecodevelopment recognises the traditional and bonafide dependence of the rural people on forest resources. It aims at making the relationship between the forests and user communities sustainable by either reducing their destructive overdependence on these resources, by providing alternative fuel, fodder and economic activities or by increasing the productivity of the resources, preferably both. If the former is achieved, the latter is a natural consequence. Conservation agencies all over the developing world are using this strategy in lowering the hostility between the people and park managements. Although long-term success is yet to be proved, signs are encouraging. Ecodevelopment is based on sound reasoning, there is hardly any doubt about its success, although the degree of success will largely depend on the skills and commitment of the implementing and financing agencies.

Crop Raiding

Problem ranking exercises in the vicinity of PAs have proved that crop raiding by wild herbivores is the number one problem that people face from the parks. If, somehow, either this loss could be eliminated or substantially reduced, it can go a long way in softening the interface between the people and the PAs.

However, crop raiding by herbivores may be higher around PAs, the main problem species, the elephant, the wild boar, the nilgai, monkeys and the blackbuck to some extent, are widespread outside PAs too. As man is living within the habitat of these species and has seriously degraded their habitat, certain amount of crop raiding is inevitable. Crop-raiding populations, especially those away from PAs, themselves are in serious danger of being exterminated through poaching and vindictive killing. Therefore, a solution to the problem of crop raiding must take care of the conservation of these species as well. These solutions consist of three components, namely, prevention, compensation and management of the population of invading herbivores.

Forest dwellers use traditional thorn fences and nightly vigils to prevent animal damage to their crops. These fences are hardly effective against highly agile and powerful animals. Barbed wire or chain link fences, dry rubble walls or power fences can be effective, if carefully designed, with an understanding of the species concerned. The cost would depend on the design. Out of these modern options, power fences, powered from the mains or by solar powered batteries, is the most cost-effective option. It is already becoming popular in many countries, as also in the north-east and south, for controlling elephants' depredations and can be used against other species as well. Instead of fencing individual holdings, group-holdings or the entire boundaries of villages abutting the forest can be fenced to reduce costs. Despite its relatively low cost, government will have to subsidise it substantially as the farmers living in the forested areas are generally too poor to afford such inputs. If we can afford heavy subsidies on all other agricultural inputs, which benefit the rich more than the poor, we can certainly afford this critical input as well. Moreover, it is a one-time investment, unlike most other inputs, and would help both agriculture as well as conservation of our priceless natural resources. But we hardly ever hear any body lobbying the government for subsidizing power fences and chain link fences as an agricultural input, as much as we hear influential lobbies clamouring for subsidizing chemical fertilizers, pesticides, power and canal water. All of these inputs would be futile, if the crop is at the risk of being destroyed by wild animals. In any case, tribals use little of these high-tech inputs. Agriculture in forested areas is different from the plains agriculture and needs different a kind of government support. Sadly, even the report of the working group on wildlife for the IX Plan did not recommend any scheme to subsidise wildlife-proof fences.

Although some states (West Bengal, Karnataka) have a system of compensating the farmers for this loss, it is doubtful if it is working satisfactorily anywhere, as it is difficult to differentiate between the loss due to wildlife and other factors. If the amount of compensation depends on the extent of damage, it would act as a disincentive for protection, and to let the crop be destroyed may be more beneficial than to protect it. In U.K., the amount of compensation depends upon the number of migratory ducks found feeding in a field, rather than on the damage done to the crop. In Wyoming, U.S.A., farmers, whose fields fall on the migration route of the Jackson Hole elk herd, are paid at a flat rate and people are permitted to hunt elk while on their ranches. In India, the situation is far more complex as villages honeycomb all our forests. The wildlife damage is more or less throughout the forested areas and the number of people involved is too large. Although people should be compensated irrespective of where they live, a beginning can be made with the people living close to PAs. The agricultural lands touching the boundaries of PAs can be zoned into high, medium and low damage zones depending upon their distance from the boundary of the PA, through a one-time survey. The survey can be repeated periodically. People can be paid compensation or agricultural subsidy at a flat rate, uniform within each zone. Alternatively, the government should provide subsidies on crop insurance, instead of paying compensation directly. The rate of

subsidy can be different in different zones, depending on the level of risk. The principle should work with most common animals. If such a system is found workable, people may start demanding the establishment of PAs closer home, if only to get compensation, or to be entitled to higher compensation. Wishful perhaps?

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Population Management and Utilisation

Population management of herbivorous wildlife is a part of their scientific management, otherwise the populations may explode and push themselves, and their sympatric species, into extinction, by destroying their own habitat through overgrazing (Petrides, 1975, 1983). Population management is all the more important in situations where these populations earn human hostility by damaging crops and other property, as the risk is then compounded. In India, despite the hue and cry about animal damage, the solutions being tried are only cosmetic, while all over the world, only lethal solutions, i.e. reducing the size of locally over-abundant populations, have been found effective. Although evolving an indigenous system of culling surplus animals even in some of our PAs can no longer be delayed, we can begin experimenting with non-PA situations. Let us consider a theoretical proposition. As mentioned above, the problem populations outside PAs, where they are in serious conflict with local human interests, are in serious and imminent danger of being wiped out, because they are not wanted there. Villagers either actively encourage poaching or turn a blind eye because it seems to reduce crop damage. These populations can only be saved if they either lose their nuisance value or turn into a positive resource for the people concerned. One way of doing this is to discourage poaching and officially harvest the animals, which are otherwise being killed by the poachers, and the returns are shared by the community. This can happen if we build utilasation programmes into our animal damage control programmes and turn over the revenue to the people, whose fields feed these populations. To do this, hunting licenses can be issued after deciding the sustainable bag limits and other necessary regulations and the whole operation can be managed by a cooperative consisting of affected villages, supported by the forest departments and other experts. Licenses can be auctioned annually to the travel agents, who can then turn outfitters for recreation hunting, bringing all the attendant benefits to the local people. In such a scenario, where more animals mean more returns, people will have a built-in incentive for preserving these populations, rather than exterminating them.

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Sharing PA Revenues with People

Our PAs may have a lot of national and global significance, they have no local relevance except as a source of trouble. As long as the PAs do not acquire a local acceptance and the local people do not see them as vehicles of local development and progress, it would be difficult for any villager or their representatives to speak for them. The ecodevelopment approach to PA management has the potential to make our PAs locally desirable as people can see development coming to their villages because of their vicinity to

some controversy about the scope of the term, has been accepted as the only lasting conservation strategy for developing countries, where the forests are as much the sustenance for the poor people today as they could be the lifeline of future generations. Ecodevelopment recognises the traditional and bonafide dependence of the rural people on forest resources. It aims at making the relationship between the forests and user communities sustainable by either reducing their destructive overdependence on these resources, by providing alternative fuel, fodder and economic activities or by increasing the productivity of the resources, preferably both. If the former is achieved, the latter is a natural consequence. Conservation agencies all over the developing world are using this strategy in lowering the hostility between the people and park managements. Although long-term success is yet to be proved, signs are encouraging. Ecodevelopment is based on sound reasoning, there is hardly any doubt about its success, although the degree of success will largely depend on the skills and commitment of the implementing and financing agencies.

Crop Raiding

Problem ranking exercises in the vicinity of PAs have proved that crop raiding by wild herbivores is the number one problem that people face from the parks. If, somehow, either this loss could be eliminated or substantially reduced, it can go a long way in softening the interface between the people and the PAs.

However, crop raiding by herbivores may be higher around PAs, the main problem species, the elephant, the wild boar, the nilgai, monkeys and the blackbuck to some extent, are widespread outside PAs too. As man is living within the habitat of these species and has seriously degraded their habitat, certain amount of crop raiding is inevitable. Crop-raiding populations, especially those away from PAs, themselves are in serious danger of being exterminated through poaching and vindictive killing. Therefore, a solution to the problem of crop raiding must take care of the conservation of these species as well. These solutions consist of three components, namely, prevention, compensation and management of the population of invading herbivores.

Forest dwellers use traditional thorn fences and nightly vigils to prevent animal damage to their crops. These fences are hardly effective against highly agile and powerful animals. Barbed wire or chain link fences, dry rubble walls or power fences can be effective, if carefully designed, with an understanding of the species concerned. The cost would depend on the design. Out of these modern options, power fences, powered from the mains or by solar powered batteries, is the most cost-effective option. It is already becoming popular in many countries, as also in the north-east and south, for controlling elephants' depredations and can be used against other species as well. Instead of fencing individual holdings, group-holdings or the entire boundaries of villages abutting the forest can be fenced to reduce costs. Despite its relatively low cost, government will have to subsidise it substantially as the farmers living in the forested areas are generally too poor to afford such inputs. If we can afford heavy subsidies on all other agricultural inputs, which benefit the rich more than the poor, we can certainly afford this critical input as well. Moreover, it is a one-time investment, unlike most other inputs, and would help both agriculture as well as conservation of our priceless natural resources. But we hardly ever hear any body lobbying the government for subsidizing power fences and chain link fences as an agricultural input, as much as we hear influential lobbies clamouring for subsidizing chemical fertilizers, pesticides, power and canal water. All of these inputs would be futile, if the crop is at the risk of being destroyed by wild animals. In any case, tribals use little of these high-tech inputs. Agriculture in forested areas is different from the plains agriculture and needs different a kind of government support. Sadly, even the report of the working group on wildlife for the IX Plan did not recommend any scheme to subsidise wildlife-proof fences.

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the PA. The plethora of internationally aided projects are providing significant amounts of money in the hands of PA managers and the impact of this strategy is likely to be visible in the next 4 or 5 years. Another factor, mentioned earlier, relevant in this context is that the PAs are a drag on the economy and will remain underfunded as long as they themselves do not generate resources for their upkeep. As, according to the prevailing financial system, all revenues earned by government agencies, go to the treasury, instead of being available for local management, their is little incentive for park managers to make efforts to increase the revenues. However, a path-breaking decision was taken by the Government of M. P. some time ago to allow all the tiger reserves of the state to accumulate their income from tourism etc. in a local fund and use it for park management and ecodevelopment under the guidance of a committee. Although the revenues so far have been insignificant, the park entry fees and other related rates have been hiked from ridiculously low levels (e.g. entry fee Re.1 per head) to reasonable levels (entry fee Rs. 15 per person). The park managers now have the incentives to make extra efforts, such as the sale of souvenirs, catering, donations etc. to generate more funds. As a result, the size of this local fund is likely to become more and more significant with time. These resources can now be shared with the neighbouring communities, directly or indirectly, to win their support and loyalty for the PA. Another novel effort at fund-raising for conservation in M.P. is the recent formation of a government trust, called the Madhya Pradesh Tiger Foundation, to raise and channelise private funds for conservation. If this trust is successful at raising significant amounts, it will go a long way to win the support of the local people, as well as that of the government, for PAs and might prompt other states to promote similar ventures.

CONCLUSION

To conclude, we can say that the strife between the PAs and the local people is a reality and is a major bottleneck in conservation. Although some problems will always remain, most can be solved or at least significantly mitigated if the nation shows some commitment to conservation, more so to the people living in the wilderness. The most important fact is that, although we need to reduce human density in and around PAs, it is possible for man and wildlife to co-exist in other areas, with some compromises. This can be possible if wildlife is managed as a local resource rather than making it a liability for the poor people, and if the nation as a whole, rather than only the local people, bear the real cost of conservation. Any delay in winning the popular support for conservation will bring the doom of many known, and many more unknown, forms of life that much closer.

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THE DISTRIBUTION OF ARBOREAL REPTILES IN THE RAINFOREST OF KALAKAD-MUNDANTHURAI TIGER RESERVE, SOUTHERN WESTERN GHATS

N.M. ISHWAR[1], AJITH KUMAR[2] and RAVI CHELLAM[1]

Abstract : We studied the abundance and species richness of arboreal reptiles in relation to several habitat parameters in the rainforest in Kalakad-Mundanthurai Tiger Reserve. The reptiles were sampled along 18 transects, each 250 m long, within an altitudinal range of 700-1350 m. Each transect was surveyed nine times and reptiles sighted above the forest floor up to a height of about 8 m were recorded. Several habitat variables were recorded from 3 m x 3 m plots at 25 m intervals along each transect. A total of 311 reptiles (9 species each of agamids and snakes, and 3 of geckos) were sighted. Nearly 85% of the variance in total reptile abundance was accounted for by its linearly declining relationship with altitude. The relationships with most other habitat variables were weaker. The abundance of geckos and snakes had a peak in mid-altitudes. Species richness showed a unimodal relationship with altitude, accounting for 48% of the variance. This study shows that the reptile community has a strong altitudinal gradient, with species poor agamids dominating the lower altitudes and the more speciose geckos and snakes dominating the mid-altitudes. Hence the conservation of mid-altitude rainforest becomes important.

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Key words : Abundance, Altitude, Kalakad-Mundanthurai Tiger Reserve, Reptiles, Species richness, Transect, Western Ghats.

The wet evergreen or rainforests of southern Western Ghats supports a very rich and varied fauna and flora, a large number of them being endemic (Mani 1974; Inger and Dutta 1986; Nair and Daniel 1986). Of nearly 200 species of reptiles reported from the Western Ghats, 50% are endemic to this region. The rainforests of Western Ghats have approximately 130 species of reptiles, with a majority being endemic to these rainforests. Many of these diverse and endemic reptiles are known from single locality records and habitat fragmentation may have already caused the extinction of some of them. It has been documented that loss of habitat, habitat fragmentation and human interference are the major threats to the reptilian fauna in the country (Kumar et al. 1998). In spite of this high degree of endemism, the distribution and ecology of this rich reptile fauna have received very little research attention. Inger et al. (1987) carried out an intensive, but short-term, survey of in western Ashambu Hills to examine microhabitat features that governed the distribution of herpetofauna. Bhupathy and Kannan (1997) conducted a survey of agamid lizards in Tamil Nadu part of the Western Ghats, and found considerable variation among hill ranges, habitat types, and altitude levels in the species richness and diversity.

In this paper we examine the distribution and abundance of arboreal reptiles in an undisturbed tropical rainforest, especially in relation to altitude which is a major determinant of reptile distribution elsewhere (Scott 1976; Fauth et al. 1989). The arboreal reptile community in the rainforest consists of several snakes (Familes Colubridae, Elapidae and Viperidae), agamids (Agamidae) and geckos (Gekkonidae). The distribution and abundance of forest floor reptiles are discussed elsewhere (Ishwar et al. 2000).

STUDY AREA

Data were collected between June 1997 and May 1998, from the rainforest in Kalakad-Mundanthurai Tiger Reserve (8°25'– 8°53' N, 77°10' -77°35' E). We selected this Reserve since it and adjoining protected areas have nearly 400 sq.km. of relatively undisturbed rainforest. It is also at the southern most part of the Western Ghats where species richness and endemism are particularly high (Ramesh et al. 1996). The altitude of the Reserve ranges from 100 m to 1880 m (Agasthyamalai peak), giving rise to a range of vegetation types from dry scrub to tropical rainforest. The rainforest in the Reserve is restricted to an altitudinal range of 650 m to 1600 m. The vegetation is of the *Cullenia-Mesua-Palaquium* series (Pascal 1988). The annual rainfall varies from 750 mm in the rain shadow areas in the east to >3000 mm in the west. The rainforest occurs primarily in the high rainfall areas. Three distinct seasons can be recognised based on the rainfall and temperature regime : Wet season I or southwest monsoon (June to September), Wet season II or northeast monsoon (October to January) and Dry season (February to May). Sampling was centred on three sites; Sengaltheri (980 m) in the southeast, Kakachi (1200 m) in the centre, and Kannikatti (760 m) in the northwest of the Reserve (Figure 1). Sampling of arboreal reptiles was restricted to an elevational range of 700 m to 1350 m.

METHODS

Six transects, each 250 m long and on a random compass bearing, were permanently marked around each of the three sites, by lightly clearing the undergrowth. The average time taken to walk these transects was

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about 90 minutes. Each transect was surveyed thrice in each of the three seasons, between June 1997 and May 1998. Thus each of the 18 transects was surveyed nine times. During the survey, two observers walked slowly along the transect scanning either side of the transect above the forest floor. All reptiles sighted were recorded, with details of the microhabitats and activity. This was a non-destructive search (*i.e.* it did not involve active turning over of litter, rocks/stones or the pulling apart of fallen logs as done in the quadrat search). Many of the reptiles were captured for positive identification and morphological measurements after which they were released at the site of capture. Reptiles seen on the forest floor were not recorded. Sightings of reptiles were generally restricted to 3 m on either side of the transect and up to a height of about 8 m. Surveys were carried out between 0800 hrs and 1300 hrs, when the atmospheric temperature varied from 19°C to 25°C.

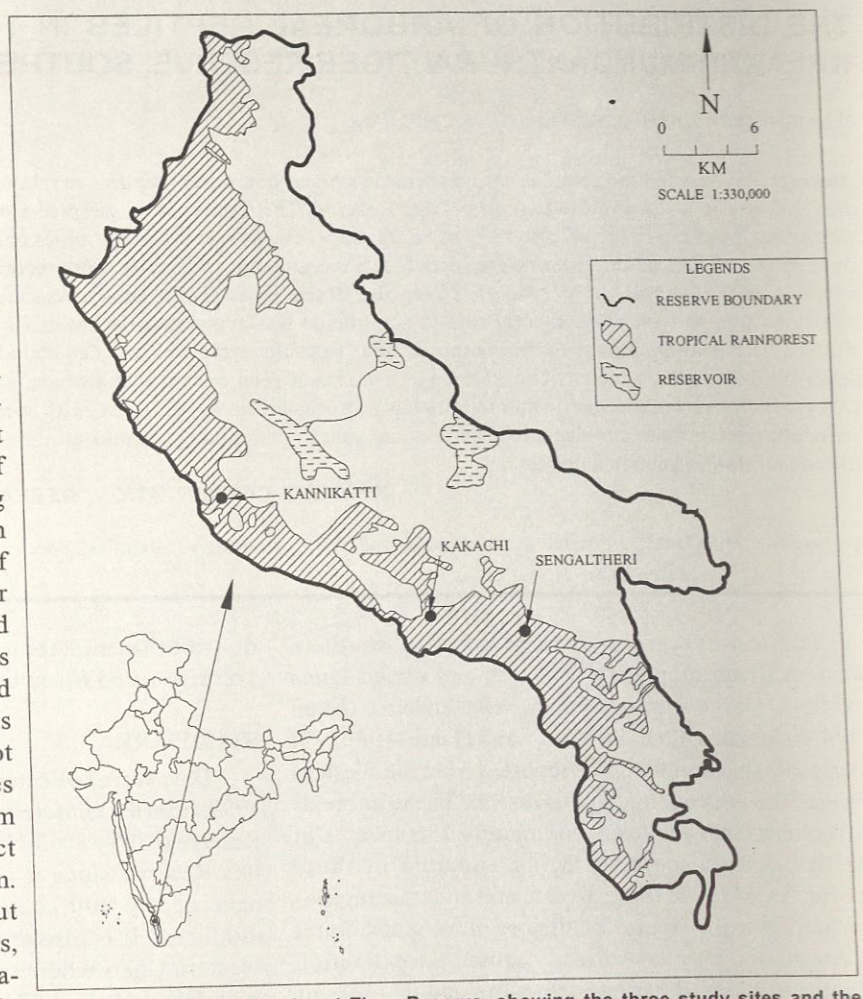

Figure 1. Kalakad-Mundanthurai Tiger Reserve, showing the three study sites and the extent of tropical forest.

Since reptile sightings were few and sampling effort was the same for all seasons, we pooled data across the seasons in order to estimate the following parameters from the above data :

a. ***Reptile abundance in a transect*** : mean number of arboreal reptiles sighted in a transect during 9 replicates;

b. ***Species richness in a transect*** : number of arboreal species recorded in a transect for all 9 replicates together;

c. ***Species overlap*** : Sorensen's index of overlap between all pairs of transects (Index = $(2C/A+B)$ x100, where C = number of species common to two transects, A and B are number of species in transect A and B, respectively).

Several habitat variables reflecting the topography, vegetation, and climate were measured from 3 m x 3 m plots laid at 25 m intervals along each transect. Apart from this, similar 3 m x 3 m plots were laid at every point a reptile was sighted with the location of the animal as the centre, and similar habitat variables were recorded. Only the climatic variables were repeatedly measured, as the others were not expected to vary between seasons.

We used linear and quadratic models to examine the relationship among habitat and reptile community variables. The latter was selected as the best fit model only when an increase in R^2 was accompanied by a decrease in P value; otherwise, linear models were selected as the best fit. The turnover of species across an altitdudinal gradient was depicted using the Sorensen's index of species overlap on a scatter plot. This was also tested for statistical significance using Mantel's test. For this test the Sorensen's index of species overlap between pairs of transect was one matrix while the difference in altitude between transects was the second matrix. As these two matrices are independent, Mantel test Z statistic was used (1000 iterations) using the program MATSQUAR (Hemelrijk 1990).

RESULTS

Abundance

A total of 311 arboreal reptiles belonging to 21 species were recorded from all transects together.

Table 1. R^2 values in the relationship of total arboreal reptile abundance and species richness on transects with habitat variables in the rainforest of Kalakad-Mundanthurai Tiger Reserve. (L=linear model; Q=Quadratic Model).

Habitat variables	Abundance	Species richness
Altitude (m)	0.848 (L)***	0.487 (Q)**
Buttress trees (N)	0.107	0.359 (L)**
Canopy height (m)	0.321 (Q)*	0.362 (Q)*
Canopy cover (%)	0.159	0.339 (Q)*
Herbs (#/plot)	0.310 (Q)*	0.333 (Q)*
Shrubs (#/plot)	0.352 (Q)*	0.141
Litter depth (cm)	0.380 (Q)*	0.248
Rock cover (%)	0.118	0.157
Root cover (%)	0.440 (Q)*	0.132

***$P<0.001$, **$P<0.01$, *$P<0.05$

Agamids (Family:Agamidae) were the most abundant with 261 individuals of 9 species. Snakes (Families: Colubridae, Elapidae, Viperidae) were represented by 38 individuals of 9 species, while geckos (Family : Gekkonidae) were the least common, with 12 individuals of 3 species. The flying lizard, *Draco dussumieri*, was the most common species, accounting for nearly 50% of all the individuals.

The number of arboreal reptiles recorded in a transect (pooled across nine replicates) varied from 1 to 45. Among the habitat variables, altitude of the transect accounted for the highest amount of variance in the mean number of reptiles sighted in a transect, which declined linearly as altitude increased (Figure 2). Several other habitat variables showed a quadratic or unimodal relation with total abundance of arboreal reptiles (Table 1). However, the amount of variance accounted for by these relationships were considerably lower than that accounted for by altitude.

To examine the variation in the abundance of agamids, geckos and snakes, transects were grouped into four altitude classes, as the number of sightings of arboreal reptiles was low (Figure 3). The abundance of agamids declined with altitude and that of geckos also followed a similar pattern. Snakes increased in abundance with altitude, becoming greater in abundance than geckos and agamids at sites >1100 m in elevation.

Species richness and overlap

The number of species in a transect, for all nine replicates together, varied from 1 to 8. This showed significant correlation with some of the habitat variables (Table 1). Species richness in transects showed an initial increase with altitude before declining at higher altitudes (Figure 4). This quadratic relationship accounted for the highest amount of variance in species richness, which however, was considerably lower than in the case of total abundance. The number of species sighted was too low to clearly examine the effect of habitat variables on species richness among agamids, geckos, and snakes separately.

In order to examine the relationship between species overlap (estimated by Sorensen's index) and altitude, a scatter plot was used (Figure 5). The highest overlap was among transects which were at a similar altitude, while transects separated by more than 500 m in altitude showed very little overlap in species composition. Species overlap and altitudinal similarity showed a negative correlation (Mantel test $Z=1739750$, $P_l=0.001$, N=18).

DISCUSSION

The influence of altitude on reptile abundance and species richness has been reported by many authors (*e.g.* Porter 1972; Scott 1976; Fauth et al. 1989). This relationship is often unimodal, with a greater abundance and species richness in the mid-altitude. In the present study, total abundance declined linearly with altitude, while species richness showed a unimodal distribution. The former relationship was primarily due to the linear decline with altitude in the abundance of agamids, especially *Draco dussumieri*, which formed >50% of the sightings. When agamids, geckos, and snakes were examined separately, it was seen that the latter two groups in fact reached higher abundance in mid elevation. These three taxa have been reported to respond differently to altitude elsewhere also (Fauth et al. 1989; Woinarski and Gambold 1992). Although the unimodal relationship between species richness and altitude was weaker than the relationship between abundance and altitude, it is similar to the relationship from several studies elsewhere (Brown 1964; Scott 1976; Heatwole 1982; Fauth et al. 1989). Due to the low number of

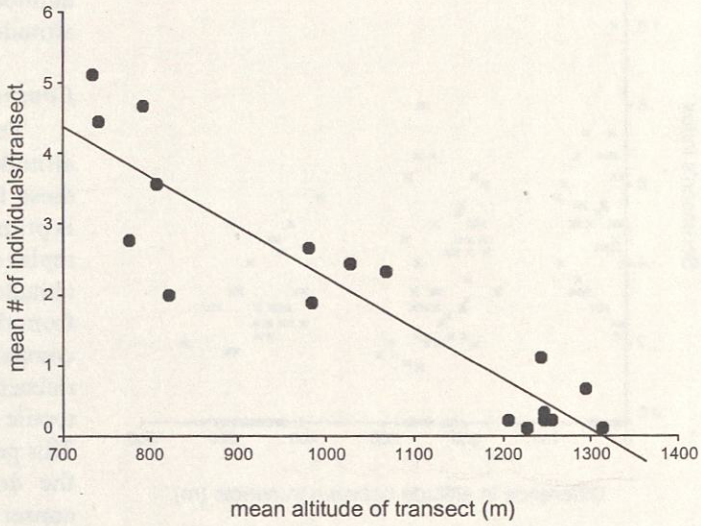

Figure 2. The relationship between mean reptile abundance per transect (animals/250 m) and altitude, in Kalakad-Mundanthurai Tiger Reserve 1997-98.

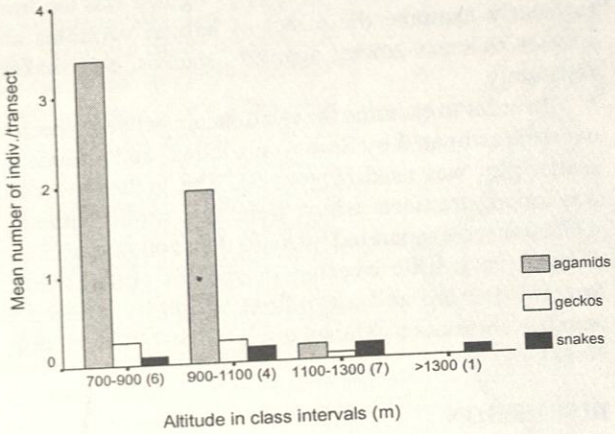

Figure 3. The abundance of agamids, geckos and snakes in transects (animals/250 m) in four altitude classes, in Kalakad-Mundanthurai Tiger Reserve 1997-98. Figures in parenthesis gives the number of transects sampled in each of the altitudinal classes.

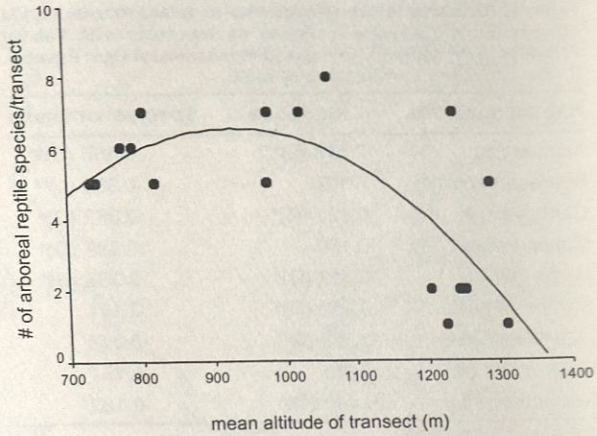

Figure 4. The relationship between species richness per transect (animals/250 m) and altitude, in Kalakad-Mundanthurai Tiger Reserve 1997-98.

species, we could not examine differences among the three taxonomic groups in the their relationship with altitude. However, the strong negative relationship of species overlap between transects and difference in altitude indicates a turnover of species with altitude. It is likely that at higher altitude reptile species that are more tolerant to cold temperatures replace other species and many of these are rare and little studied.

Several hypotheses, often not mutually exclusive, have been put forth to explain the relationship between altitude and species richness in many taxonomic groups. Especially important for reptiles is the altitudinal gradient in temperature to which reptiles are sensitive (Porter 1972). Several habitat features such as canopy height, leaf litter fall, and tree densities vary along an altitudinal gradient (*e.g.* Patterson et al. 1990). This variation might in fact reflect overall productivity of the habitat, which has been reported to reach a peak at mid-elevation. The unimodal distribution of reptiles along the altitudinal gradient might reflect this (Scott 1976). In this study, however, the correlation of reptile abundance and richness with macrohabitat variables was considerably lower than that with altitude.

This study was restricted both in altitudinal range (700 m to 1350 m) and vegetation type (tropical rainforest). The restriction in altitudinal range, especially the lack of samples at < 700 m, might be a reason for the linear relationship between abundance and altitude, rather than a unimodal relationship reported by many other studies. This together with the restriction of sampling to rainforest might be the reason for a relatively weak unimodal relationship between species richness and altitude.

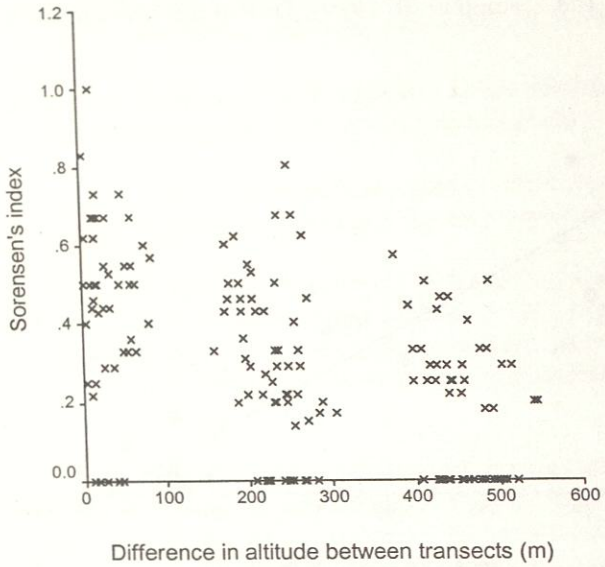

Figure 5. The relationship between species overlap (Sorensen's index) and difference in altitude between transects in Kalakad-Mundanthurai Tiger Reserve 1997-98.

Conservation Implications

This study has highlighted the importance of mid-altitude forests in the conservation of reptiles, since these forests harbour highest species richness. This is primarily because at mid-elevation the agamids are replaced by the more speciose geckos and at higher altitudes by even more speciose snakes. This is obvious from the number of individuals caught in these taxa compared to the number of species. Although species richness decline rapidly at >1200 m, this impoverished reptile community has a higher proportion of endemics. This pattern of distribution has major implications for the design of protected area networks for the conservation of these taxa. It would be necessary to ensure an altitudinal coverage in the protected area network if the plans to protect and conserve the rich

and varied reptilian diversity in our forests have to succeed.

ACKNOWLEDGMENTS

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TIME BUDGET AND FEEDING ECOLOGY OF NILGIRI LANGUR IN RAIN FOREST FRAGMENTS IN THE ANAMALAI HILLS, SOUTH INDIA

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Abstract: Habitat fragmentation is likely to cause major changes in the time budget and feeding ecology of animals due to substantial changes in the distribution and abundance of food resources. We studied the time budget and feeding ecology of the Nilgiri langur (*Trachypithecus johnii*), an arboreal folivore, in four rain forest fragments in the Indira Gandhi Wildlife Sanctuary in the Anamalai Hills, southern Western Ghats. Two fragments were relatively large (>185 ha) and undisturbed while two were small (<35 ha) and moderately degraded due to human activities. We estimated time budget, time spent feeding on different plant parts and number of plant species eaten, from group scan in each of the three seasons during January and December 1995. There was considerable difference among the large and small fragments in tree density and species richness. However, there were no consistent differences among the large and small fragments in the time spent on feeding, resting, and ranging by the langurs. However, the number of plant species eaten was significantly lower in the small fragments. The lack of major differences was due to the colonisation of disturbed forest by some plant species, which were major food sources for the langurs. Some species planted as shade trees in coffee estates adjoining forest fragments were also of high food value to the langurs. Dietary diversity is of critical importance to many mammals that are adapted to arboreal folivory in tropical rain forests. The reduction in plant species richness in the diet might therefore affect the dietary quality in the Nilgiri langur in small and disturbed fragments.

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Key words : Anamalai Hills, feeding ecology, fragmentation, group scan, Nilgiri langur, rain forest, time budget, *Trachypithecus johnii*, Western Ghats.

Habitat fragmentation causes substantial changes in the abundance and distribution of resources available to the isolated populations of animals. Some of the changes immediately follow fragmentation (*e.g.* those resulting from reduction in habitat area) while others occur in the long term (*e.g.* absence of regeneration, windfalls and human disturbance). The first response of animals to fragmentation of their habitat and associated disturbances are changes in their time budget and feeding. Only a few studies have examined this aspect, even though there have been several studies on the factors governing the occurrence and abundance of animals in habitat fragments in the last two decades. Many species face a reduction in food abundance and show increased ranging and foraging activities, *e.g.* the lion-tailed macaque *Macaca silenus* (Menon and Poirier 1996) and chipmunks *Tamias striatus* (Yahner and Mahan 1997). Some species are, however, able to exploit the vegetation around the fragments, and might even show an increase in abundance. For example, forest humming birds that exploit food resource in the vegetation around the fragments survive better than insectivorous birds that are unable to do so (Bierregaard et al. 1992). Thus, the response of animals to fragmentation is related to the nature of changes that occur in and around the fragments as well as to the ecology of the species, especially its diet.

In this paper, we examine differences in the time budget and feeding ecology of the Nilgiri langur (*Trachypithecus johnii*), an arboreal folivorous primate, among four rain forest fragments that vary in area and disturbance levels. Time budget is examined with reference to the percentage of daytime spent on major activities, and feeding ecology with reference to the relative time spent on various plant parts and the number of food species used.

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Nilgiri langur

The Nilgiri langur is endemic to the Western Ghats, where it occurs primarily in the rain forests south of Kodagu District in Koranumudi langur lives in groups of 3 to 25 animals with an average of 10-12 animals. Most groups consist of one adult male, 4 to 5 adult females, and the rest are infants and juveniles.

STUDY AREA

The study was conducted in four rain forest fragments within and adjoining the Indira Gandhi Wildlife Sanctuary (10°12' -10°54' N and 76°44' - 77°48' E) in the Anamalai Hills. Almost in the centre of the Sanctuary are nearly 180 sq. km of tea and coffee estates which were created between 1860-1930 after extensive clear-felling of rain forest. Several forest fragments varying from <10 ha to >2000 ha were formed during this period, surrounded by tea and coffee estates (Figure 1). These fragments harbour remnants of the original populations of arboreal mammals such as the Nilgiri langur, lion-

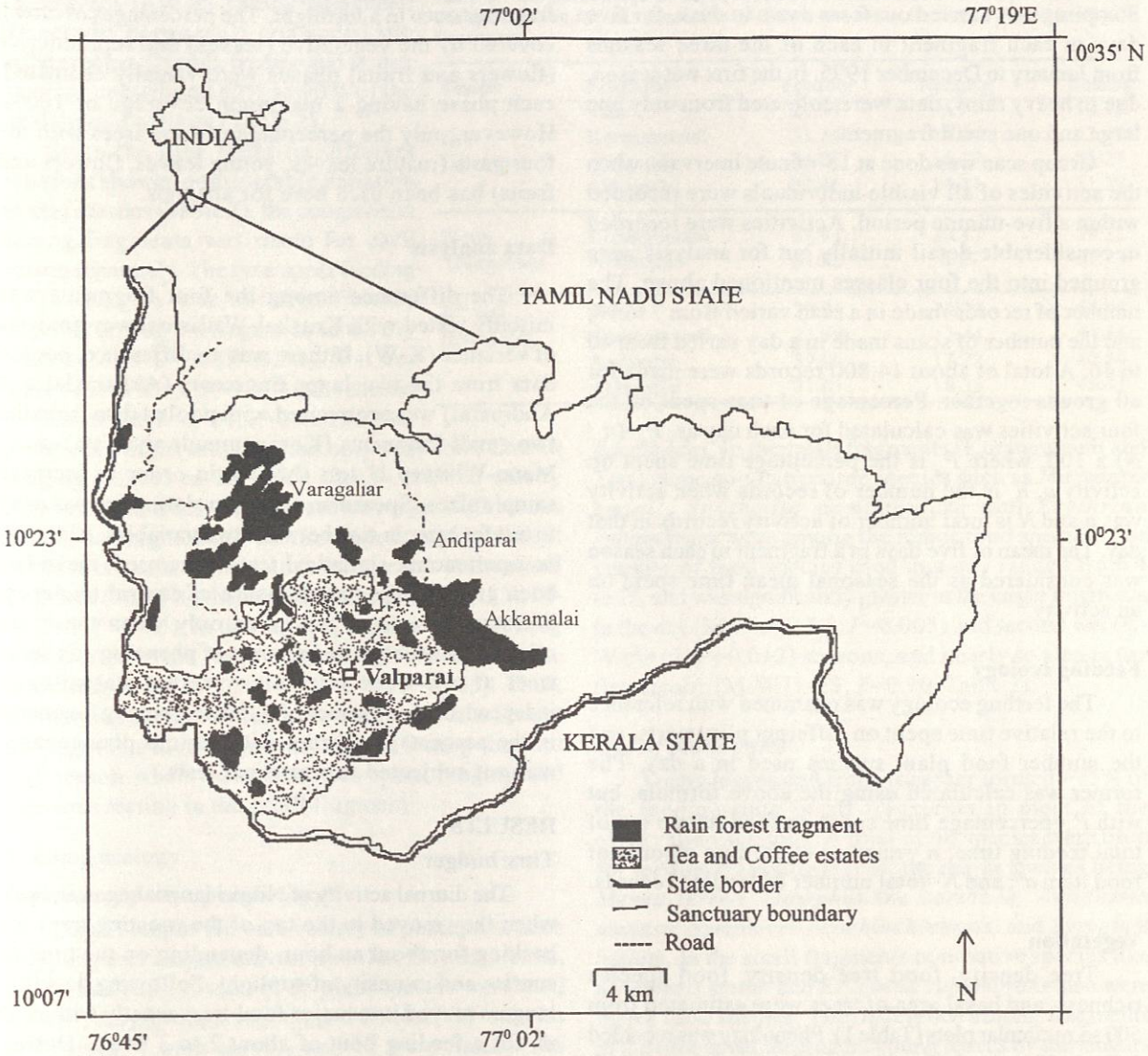

Figure 1. The rain forest fragments in the Indira Gandhi Wildlife Sanctuary, and tea and coffee estates in the Anamalai Hills.

tailed macaque (*Macaca silenus*), Malabar giant squirrel (*Ratufa indica*), and two species of flying squirrels. A description of rain forest fragments in the area and the occurrence of arboreal mammals in them is given elsewhere (Umapathy and Kumar 2000).

The altitude of the Sanctuary ranges from 220 m to 2,513 m, but the general altitude of the study area was about 1100 m. Annual rainfall was about 400 cm, 80% of it during the south-west monsoon (May-August) and most of the remaining during the north-east monsoon (October-November). The daytime temperature in the study area varied from 28°C in April-May to 17°C in December-January. Based on rainfall and mean temperature, we identified three seasons; 1) *Dry*: low rainfall (January to April); 2) *First wet* (south-west monsoon): moderate temperature and high rainfall (May to August); and 3) *Second wet:* moderate temperature and moderate rainfall (September to December).

For this study, we selected four rain forest fragments that were representative of nearly 30 fragments in the area. The status of vegetation varied considerably among them, the low tree density and canopy cover of the small fragments indicating the greater levels of human disturbance (Table 1). Akkamalai and Andiparai represented large and relatively undisturbed fragments, and Korangumudi and Tata represented small and disturbed fragments.

METHODS

Time budget

One group of Nilgiri langur was selected in each of the four fragments and habituated to the observers for two to three months, prior to data collection. Time budget was defined as the percentage of daytime spent on feeding, ranging, resting, and other activities, and estimated using group scan sampling (Altmann 1974).

Sampling was carried out from dawn to dusk, for five days in each fragment in each of the three seasons from January to December 1995. In the first wet season, due to heavy rains, data were collected from only one large and one small fragment.

Group scan was done at 15-minute intervals, when the activities of all visible individuals were recorded within a five-minute period. Activities were recorded in considerable detail initially but for analysis were grouped into the four classes mentioned above. The number of records made in a scan varied from 7 to 14, and the number of scans made in a day varied from 40 to 46. A total of about 14,800 records were made for all groups together. Percentage of time spent on the four activities was calculated for each day as, $P_a=(n_a/N) \times 100$, where P_a is the percentage time spent on activity a, n_a is the number of records when activity was a and N is total number of activity records in that day. The mean of five days in a fragment in each season was considered as the seasonal mean time spent on an activity.

Feeding ecology

The feeding ecology was examined with reference to the relative time spent on different plant parts, and the number food plant species used in a day. The former was calculated using the above formula, but with P_a=percentage time spent on food item a out of total feeding time; n_a=number of feeding records of food item a'; and N=total number of feeding records.

Vegetation

Tree density, food tree density, food species richness, and basal area of trees were estimated from 500 sq.m circular plots (Table 1). Phenology was recorded for 5 to 10 trees for each major food species in each fragment once in a fortnight. The percentages of crown covered by the vegetative (leaves) and reproductive (flowers and fruits) phases were visually estimated, each phase having a maximum coverage of 100%. However, only the percentage of food trees with the four parts (mature leaves, young leaves, flowers and fruits) has been used here for analysis.

Data analysis

The difference among the four fragments was initially tested with Kruskal-Wallis oneway analysis of variance (K-W). If there was no difference, pooled data from the two large fragments (Akkamalai and Andiparai) were compared with pooled data from the two small fragments (Korangumudi and Tata) using Mann-Whitney U test (M-W), in order to increase sample sizes. Spearman rank correlation (r_s) was used to test for associa-tion between two variables. Although non-parametric statistical tests were used, mean has been given as the best measure of central tendency, but standard errors are given only when these are relevant. Since repeated records of phenology on same trees at two-week intervals were not statisti-cally independent, significance of difference among fragments in the percentage of trees with various phenophases was not subjected to statistical tests.

RESULTS

Time budget

The diurnal activity of Nilgiri langur began at dawn when they moved to the top of the roosting trees for basking for about an hour, depending on the time of sunrise and intensity of sunlight. Following basking, langurs moved into major food trees mostly within 50 m, for a feeding bout of about 2 to 3 hours. During this time they fed on one or several plant species in the same area. This was often followed by a long resting period of three to four hours. Most of the social interactions such as grooming and play took place during this period. After resting, once again the groups moved into other food trees for another feeding bout. This feeding bout ended with resting in the evening between

Table 1. Some habitat parameters of four rain forest fragments in the Indira Gandhi Wildlife Sanctuary in which Nilgiri langur was studied. The number of 500 sq.m plots from which the vegetation parameters were estimated is also given. Standard error is given in paranthesis. (Source: Umapathy and Kumar 2000).

Name of fragment	Area (ha)	Owner	Tree Density (/ha)	Basal area (sq.m/ha)	Canopy height (m)	Canopy Cover (%)	No. of plots
Tata	24	Private	93.3 (28.78)	11.01 (10.82)	19.62 (5.40)	56 (5.49)	8
Korangumudi	35	Private	161.4 (14.3)	37.82 (9.25)	24.69 (3.93)	23 (0.99)	14
Andiparai	185	Forest Dept.	357.1 (46.81)	29.41 (16.97)	17.80 (4.91)	77 (7.51)	8
Akkamalai	2500	Forest Dept.	492.4 (40.01)	97.54 (9.13)	22.64 (4.22)	67 (4.21)	9

1800 hrs and 1830 hrs. During the summer the activity began early and ended late in the evening. Overall, feeding and resting together constituted 80% to 90% of the total diurnal activity (Table 2).

Since the time spent on different activities showed considerable variation among seasons (Table 2), the comparison among fragments was made for each season separately. The time spent feeding by the langurs was not significantly different among the fragments in the dry season (M-W U=33, P=0.32), first wet season (M-W U=2, P=0.27) or the second wet season (M-W U=31, P=0.42). All four groups of Nilgiri langur spent only very little time in ranging (6.27% to 20.15%) which occurred mostly between food trees. There were no major differences among the fragments in the time spent ranging, except in the first wet season when it was greater in the small fragment (20.17%) than the large fragment (6.27%, M-W U=1, P=0.05). In this season, the time spent resting was greater in the large fragment (57.78%) than the small fragment (39.32%, M-W U=1, P=0.05). Thus, there were no major differences among the time budget of langurs in four fragments, except during the first wet season when more time was spent ranging and less time resting in the small fragment.

Table 2. The percentage of daytime spent on various activities by Nilgiri langur groups in four forest fragments in three seasons, in Indira Gandhi Wildlife Sanctuary

Season	Fragment	Feeding	Ranging	Resting
Dry (Jan-Apr)	Tata	29.44	9.97	56.12
	Korangumudi	31.34	14.04	53.07
	Andiparai	34.06*	11.17	53.27
	Akkamalai	32.46	14.31	51.39
I[st] wet (May-Aug)	Korangumudi	37.91	20.17	39.32
	Akkamalai	31.92	6.27	57.78
IInd wet (Sep-Dec)	Tata	28.94	14.22	53.44
	Korangumudi	33.98	17.44	44.54
	Andiparai	39.06	17.22	40.84
	Akkamalai	31.61	18.33	48.41

Feeding ecology

Number of plant species used

Nilgiri langur fed on a variety of plant parts such as young and mature leaves, petioles, flowers, fruits, seeds, and bark. A total of 55 plant species were used by all study groups together. Of these, 39 species were trees, 4 were shrubs, and 12 were lianas. The major food trees were *Mesua ferrea*, *Antidesma menasu*, *Gomphandra coriacea*, *Syzygium* spp, and *Myristica dactyloides*. In the small fragments (Korangumudi and Tata) some non-native tree species such as *Maesopsis eminii*, *Spathodia campanulata* and *Erythrina subumbrans* were among the major food species. The number of food species used in a day ranged from 4 to 16, and was significantly greater in the larger fragments in the dry (K-W c^2=13.2, P=0.005) and second wet (K-W c^2=11, P=0.012) seasons, and nearly so also in the first season (M-W U=25, P=0.10, Table 3).

Use of plant parts

Young leaves and fruits together formed >75% of the feeding time in all fragments in most of the observation sessions. A total of 40 species were used for feeding on young leaves, the major species being *Mesua ferrea, Gomphandra coriacea, Antidesma menasu, Symploccos cochinchinensis,* and *Syzygium laetum*. In the small fragments non-native species like *Maesopsis eminii* and *Erythrina subumbrans* also were major food species. The difference among fragments in the time spent feeding on young leaves by the langurs was significantly different only in the second wet season and was greater in the larger fragments (60.63%) than in the smaller fragments (34.51%, M-W U=3, P=0.04, Table 3).

Table 3. Percentage of time spent of different plant parts out of total feeding time, and the mean number of plant food species used in a day by the Nilgiri langur groups in four forest fragments in three seasons.

Season	Fragment	% young leaves	% mature leaves	% flowers	% fruits	Plant spp used/day
Dry (Jan-Apr)	Tata	58.16	1.00	5.92	34.90	6.00
	Korangumudi	73.54	0.40	13.13	12.91	8.80
	Andiparai	54.42	0.52	8.38	36.68	12.00
	Akkamalai	41.69	1.37	7.26	49.80	12.00
I[st] wet (May-Aug)	Korangumudi	27.92	22.98	0.96	48.13	6.30
	Akkamalai	36.29	15.73	5.74	42.23	7.00
IInd wet (Sep-Dec)	Tata	27.30	17.89	22.40	29.44	5.00
	Korangumudi	41.71	11.80	9.20	39.89	6.00
	Andiparai	47.56	7.73	7.11	37.61	14.00
	Akkamalai	73.69	12.92	9.67	3.72	13.20

Mature leaves of 11 species were eaten, the major ones being *Gomphandra coriacea*, *Macaranga peltata*, *Syzygium laetum* and *Erythrina subumbrans*. Feeding on mature leaves was generally low, especially in the dry season. Even though it was greater in the first wet season, there was no difference among the fragments in this season (M-W U=3, P=0.51) and in the

Table 4. Percentage of trees with young and mature leaves, flowers and fruits out of monitored food trees of Nilgiri langur in four rain forest fragments in Indira Gandhi Wildlife Sanctuary.

Season	Fragment	% with young leaves	% with mature leaves	% with flowers	% with fruits/seeds
Dry (Jan-Apr)	Tata	35.50	64.50	17.78	20.00
	Korangumudi	43.60	56.40	11.60	39.10
	Andiparai	23.12	76.91	10.00	38.89
	Akkamalai	35.83	64.20	12.20	46.34
Ist wet (May-Aug)	Korangumudi	11.70	88.30	19.10	32.70
	Akkamalai	10.40	89.60	15.38	50.00
IInd wet (Sep-Dec)	Tata	17.50	82.51	22.22	32.35
	Korangumudi	19.20	80.80	32.25	49.54
	Andiparai	26.21	73.82	12.50	28.12
	Akkamalai	13.00	87.00	15.15	27.27

second wet season (M-W U=23, P=0.56).

Flowers of 19 species were eaten, *Mesua ferrea, Symplocos cochinchinensis, Cullinea exarillata, Erythrina subumbrans* and *Spathodia campanulata* being the major ones. Feeding time on flowers was <10% in eight of the ten observation sessions. It was greater in the large fragment (5.74%) than in the small (0.96%, M-W U=1, P=0.04) in the first wet season. There were no differences in the dry (M-W U=26, P=0.12) and second wet (M-W U=15, P=0.13) seasons.

Ten species were used for feeding on fruits and seeds, which formed more than 30% of the diet in eight observation sessions. Most of the fruits were eaten when unripe (*e.g. Macaranga peltata, Canarium strictum, Artocarpus heterophyllus* and *Myristica dactyloides*) and a few when ripe (*e.g. Symplocos cochinchin-ensis* and *Glochidion bourdillonii*). Considerably greater time was spent on feeding on fruits in the larger fragments (40.29%) than in the small fragments (23.9%), the difference being nearly significant in the dry season (M-W U=24, P=0.086). In the first wet season fruits were a major food item in both the large and small fragments. In the second wet season, it was very low in Akkamalai (3.72%), but >30% in the other fragments. There was, however, no significant difference between large and small fragments (M-W U=15, P=0.13).

Abundance of food plants

The number of total and food tree species, and basal area of food species in 500 sq.m. plots were all greater in the larger fragments (Figure 2). Total tree density was also greater in the larger fragments (Table 1). A total of 500 trees of 20 species were monitored for changes in the abundance of the young leaves, mature leaves, flowers and fruits. The abundance is expressed as percentages of trees with young leaves, mature leaves, flowers, and fruits. As expected the percentage of trees with mature leaves did not vary much among the fragments in any season. The abundance of trees with young leaves was highest during the late dry season (after the pre-monsoon showers), and lowest during the first wet season. The abundance of trees with flowers was highest during the second wet season. Trees with fruits were more abundant during the late summer and the first wet season. It should however be noted that this variation in the abundance of trees with different phenological stages is only with reference to food plants of the Nilgiri langur. The time spent (the seasonal mean) on young leaves was not correlated with the abundance of young leaves (r_s=0.45, n=10, P>0.05) and fruits (r_s=-0.37, n=10, P>0.05). However, feeding on mature leaves was negatively correlated with the abundance of young leaves (r_s=-0.85, n=10, P<0.05).

DISCUSSION

In spite of considerable differences among the large and small fragments in the abundance of food trees, there was no major difference in the time budget as well as time spent on different plant parts. The only difference was in the number of species eaten in a day, which was greater in the larger fragments. The major reason for the lack of difference was the occurrence of several colonisers (such as *Macaranga peltata* and *Lantana spp.),* and shade trees planted in the coffee estates in the forest edges (such as *Erythrina subumbrans* and *Maesopsis eminii*), which were of high food value to the langurs in the small fragments. In the same area, the lion-tailed macaque (*Macaca silenus*), and Malabar Giant squirrel (*Ratufa indica*) also show a similar pattern, with a reduction in dietary diversity in small fragments but with no major changes in the time budget (Menon and Poirier 1996; Umapathy and Kumar 2000). Even though arboreal folivores were

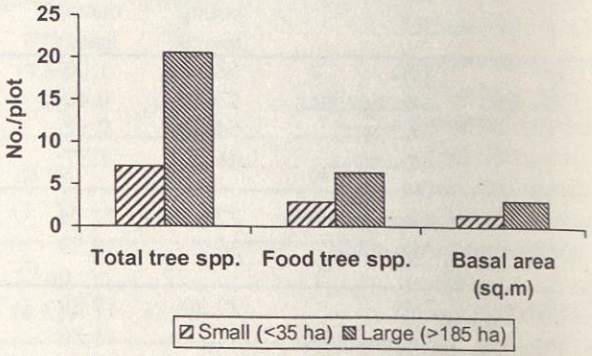

Figure 2. Mean tree species richness, food tree species richness, and tree basal area in 500 sq.m circular plots in the large (>185 ha) and small (<35 ha) fragments. See also Table 1.

thought to have been more adversely affected than long-ranging omnivorous primates (such as cercopithecines) in a logged forests (*e.g.* Southwick and Cadigan 1972;), the importance of colonising species to folivorous primates in disturbed forest is now better appreciated (Goodall 1977; Oates 1977; John and Skorupa 1987; Johns 1988; Gupta and Kumar 1994). Such colonising species might be particularly important in forest fragments in enhancing the persistence of many animal species. Another factor is the nature of vegetation that surrounds the forest fragments. In many parts of parts of Western Ghats, rain forest fragments are surrounded by either tea or coffee estates. The former has no food value to most animals while the shade trees planted in coffee estates are of considerable food value to many arboreal animals. Animals which are able to use such vegetation around the fragments especially for feeding are better able to survive (Laurance 1991; Bierregaard et al. 1992).

Despite the absence of major differences in time budget, especially time spent feeding, it is very likely that the dietary quality might have been adversely affected in the small fragments. The fruits and seeds eaten by frugivores do not vary much in their composition, mostly containing simple carbohydrates, lipids and very little protein (Milton 1981). In contrast, leaves of different species and phenological stages in tropical rain forest vary considerably in their fibre content, and the occurrence and abundance of several secondary compounds (Waterman 1984). Arboreal folivores vary in their tolerance to different secondary compounds. One of their strategies is to avoid the consumption of any secondary compound beyond its tolerance level, by feeding on a wide variety of plant species (Hladik 1978; Waterman 1984). The number of plant species in the diet or dietary diversity is thus more important to arboreal folivores, than to frugivores. Secondary compounds are known to be important in diet selection in the Nilgiri langur (Oates et al. 1980). Thus, the drastic reduction in number of plant species fed on by the Nilgiri langur in the smaller and more degraded forests can be expected to lead to a reduction in diet quality due to various reasons. These could include greater energy expenditure in detoxification of secondary compounds consumed in excess of tolerance levels, toxicity, and the unavailability of particular amino acids.

Conservation implications

Rain forest fragments often harbour significant components of the regional biota. Recent studies have shown that area is only one of the many factors that influence the persistence of species in forest fragments. The nature of vegetation within and around the fragment *vis-a-vis* the ecology of the species is equally important. A thorough understanding of these factors is, therefore, important if we are to retain native fauna in forest fragments. Particularly important for many arboreal mammals in the Western Ghats, such as the Nilgiri langur, is the retention of friendly vegetation around the fragment. Coffee estates, for example, retain some natural vegetation and also contain trees planted for shade which are of considerable food value to arboreal mammals. Measures to retain this vegetation are therefore for necessary. In contrast, tea estates contain nothing of food value to arboreal mammals. For the Nilgiri langur, it is also necessary to enhance the species diversity of plants in forest fragments.

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TRENDS IN DIVERSITY AND FLORISTICS OF FOREST VEGETATION IN NILGIRI BIOSPHERE RESERVE : A COMPARISON WITH OTHER TROPICAL FORESTS

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Abstract : Diversity of different forest types was estimated by randomly laying 0.1 ha belt transects in various forest patches, located in different geographical regions and in various altitudinal gradients. Standard vegetational parameters of diversity like Shanon-Weiner index, Simpson's index and Fisher's alpha were calculated. It was found that tropical evergreen forest was the most diverse forest patch with mean Shanon-Weiner diversity index of 3.10 +_0.4. An attempt was also made to look at correlation with environmental factors, which influence the diversity across the gradient. It was found that rainfall had a significant effect on the number of species along the gradient. Altitude had a positive relation with diversity and canopy cover also had a positive relation with rainfall. Results are discussed in comparison with other studies conducted elsewhere in the tropics and attempt is made to draw similarities between the forest patches in the tropics. Floristic composition of individual sample unit and as a community was looked into by calculating Family Index Value (FIV) which is a sum of relative density, relative abundance and relative frequency. The family Fabaceae dominated the floristics of dry vegetation types. This family had a FIV value of 90.97 (16 sp., 100 individuals) in the thorn scrub forest community and 48.07 (4 sp., 83 individuals) in the riverine forest patch. The family Combretaceae dominated the floristics of dry (5sp., 259 individuals and FIV=74.72) and moist (4 sp., 150 individuals and FIV=55.19) deciduous vegetation types. Fabaceae is in the second position in both these forest types. The wetter forest communities like tropical evergreen forest and tropical montane forest (shola) was dominated by Clusiaceae (8 sp., 117 individuals and FIV=37.49) and Lauraceae (23 sp., 545 individuals and FIV=78.16) respectively. Families like Euphorbiaceae, Lauraceae and Moraceae dominated the floristics of evergreen forest while families like Rubiaceae, Myrtaceae dominated the floristics of tropical montane forest community.

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INTRODUCTION

Characterization of tropical vegetation is an important task. However characterization of tropical forests is difficult for one. There is a great range of species composition and their abundance. UNESCO under Man & Biosphere program proposed to establish Biosphere reserves all over the globe for conserving biological diversity. Nilgiri Biosphere Reserve (NBR) was one such reserve in India. NBR was the first biosphere reserve to be officially declared in 1986 at a conference in Octacamund. NBR establishes its credibility as a biological reserve by its strategical location in Western Ghats (one of the hot spots of biodiversity), so that if provides a corridor between Eastern and Western ghats for dispersal and migration of species. It is also a confluence of two distinct biogeographic zones (the Deccan and Western Ghats) of India. Tropical forests are comparatively well studied ecosystems of the world for species richness, dynamics etc. Comparing tropical forests is a difficult task because of dissimilarity in the available data with respect to scale of sampling. There are hardly any studies on the comparable scale except Gentry (1988) and subsequent publications.

Generalisation and understanding of the species composition of tropical forest and their affinities with other forest patches elsewhere in the tropics is essential when various afforestation programs are undertaken by various governments as a measure to mitigate the effect of emission of greenhouse gases. This paper attempts to compare and contrast the forests of Nilgiri Biosphere Reserve with other parts of the tropical world.

STUDY AREA

This study was conducted in NBR spanning an area of approximately 5520 sq.km. located between 10°50' and 12°16'N latitudes and 76°0' and 77°15'E longitude. NBR encompasses three states of peninsular India, namely Karnataka, Kerala and Tamil Nadu. Nilgiri district in Tamilnadu forms the center of the reserve, which is a high raised mountain with a average elevation of 1800 meters MSL. The highest peak "Doddabetta" reaching 2640 meters forms highest point on the plateau and second highest point in the peninsula. This central mass of mountains has to its north Mysore plateau that is a part of Deccan plateau, to the south and east it has Coimbatore plains and to its west is the Malabar plains. Geologically it is made up of arechen gnesis and schists. Soils are mainly red and red loamy. Alluvial soils are found in the richly drained Malabar plains. Climate is tropical in nature except at higher altitudes where it becomes temperate to sub-tropical and shows pronounced diurnal fluctuations. Meher-Homji (1986) and Von Lengerke (1977) give a detailed climatic profile of the Nilgiri plateau. The Southwest monsoon brings most of the rainfall on the Western face of the reserve. As the monsoon moves inwards it gets weakened creating a rainfall gradient. Retreating monsoon is also active and brings rainfall to the eastern side. Sometimes there are cyclonic showers. Two major rivers Moyar

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and Bhavani drain the reserve with many small perennial and seasonal streams.

VEGETATION

The rainfall gradient across the biosphere reserve has resulted in array of vegetation types ranging from lush tropical rain forests to dry thorn scrub. Due to the orographic effect the rain bearing clouds pour heavily on the western face of the biosphere resulting in lush tropical rain forest and as the monsoon progress inwards it gets weakened hence the vegetation changes to thorn scrub through deciduous type. Brief description of vegetation is given below. For a detail description refer Puri et.al. (1983) Champion and Seth (1933) and Gadgil and Meher-Homji (1986).

The association of "Mesua-Palaquium-Cullenia" characterizes tropical wet evergreen forest. This forest type in the altitude range of 600-1800 meters MSL. This forest type is found in western parts of the biosphere comprising of Silent valley, Gudalur slopes and New Amarambalam reserve forest which receives rainfall over 3000 mm per annum. As the intensity of rainfall decreases towards eastern side moist and dry deciduous forests replace the wet forests. The association of *"Lagerstroemia-Tectona-Terminalia-Dalbergia"* characterizes tropical moist deciduous forest of the NBR. Other important species in the canopy include *Anogeissus latifolia, Grewia tillifolia, Stereospermum personatum* etc. The understorey is dominated by species like *Phyllanthus emblica, Cassia fistula* and *Kydia calycina*. Associations of *"Anogeissus-Tectona"* and *"Anogeissus-Tectona-Terminalia"* dominate the dry deciduous forest. Large chunk of the forested land is under deciduous forest. This belt supports high concentration of mega herbivores like elephant *(Elephaus maximus)*, gaur *(Bos gaurus)*, sambar *(Cervus unicolor)* and chital *(Axis axis)*. large cats like tiger *(Panthera tigris)* and panther *(Panthera pardus)* inhabit this forested tract.

Commercially exploitable timber like teak, nandi, matthi and axel-wood are extracted from this forest tract. On the eastern fringes of the biosphere reserve where annual precipitation is less than 700 mm the forest formation changes to tropical thorn scrub, which is dominated by *"Acacia-Ziziphus"* association. The trees in this forest are adapted for xeric conditions by developing thorns, spines and leaf modifications, which prevent excess transpiration of water. Important tree species in this forest formation are several *Acacia sp., Albizia chinensis, Givotia rotteleriformis, Naringi crenulata, Moring concanensis* etc. *Gyrocarpus americanus,* which is an important facies of the thorn scrub, is also seen in some parts. There are dense bushes amidst the trees, belonging to rubiaceous species, *Maytenus emariginata* and *Erythroxylon monogynum.* Many annual creeping grasses dominate the ground flora. This forest zone has tremendous biotic pressure like grazing the and fuel wood collection. Along the river courses there is formation of gallery or riverine forest which is dominated by species like *Mangifera indica, Pongamia pinnata, Terminalia arjuna, Salix tetrandra.* The higher altitudes have tropical stunted montane evergreen forest patches surrounded by grasslands. Tropical montane stunted evergreen forest (shola) is dominated by species belonging to Lauraceae, like *Litsea sp., Cinnamomum sp., Phoebe sp.,* and *Actinodaphne bourdillonni.* Other species in the canopy include *Syzygium sp., Symplocos sp., Daphnipyllum neilgherrensis* and *Ilex sp.* The nature and stability of the two ecosystems are of academic interest. For detailed review refer Sukumar et.al. (1995), Vasanthy, G. (1988).

METHODS

Belt transects were employed to enumerate vegetation. A 0.1 ha (250m x 4m) in strips of five 50m x 4m were laid randomly at various places in NBR and an effort was also made to cover entire spectrum of vegetation types. Along the transect all woody individuals above 10 cm GBH (Girth at breast height) were enumerated for their girth and species identity. Height (nearest to 0.5m) and height at first branch was also recorded. At every 10-meter interval canopy coverage was estimated qualitatively. A voucher specimen was collected for documentation and deposited at the Center for Ecological Sciences herbarium.

Floristic structure of each forest community was looked into by calculating FIV (Family Importance Value) as sum of relative dominance, relative frequency and relative density (Keel et.al. 1993). Data were pooled from all the samples representing each vegetation type and their FIV values were calculated. In this article we are going to present a comparative account of floristic similarities and dissimilarities with rest of the species.

RESULTS & DISCUSSION

Tropical wet evergreen forest patches were the most diverse (H^1=3.12 +-0.88, N=8) followed by tropical montane forest. The results are tabulated in the Table-1. We would at this stage like to deal more about the general trends in the diversity with respect to two important environmental factors namely rainfall and elevation. We at first instance tried looking at the relationship between rainfall and elevation. These two factors had a positive trend but nevertheless the relationship is not significant (r=0.10, N=60), (Fig.1). This gave us the freedom of looking at the trends of diversity with respect to elevation and rainfall independently.

Diversity VS Precipitation : Simplest parameter of diversity i.e. species richness had a significantly positive correlation with annual rainfall (r=0.623, N=60, p<0.001)

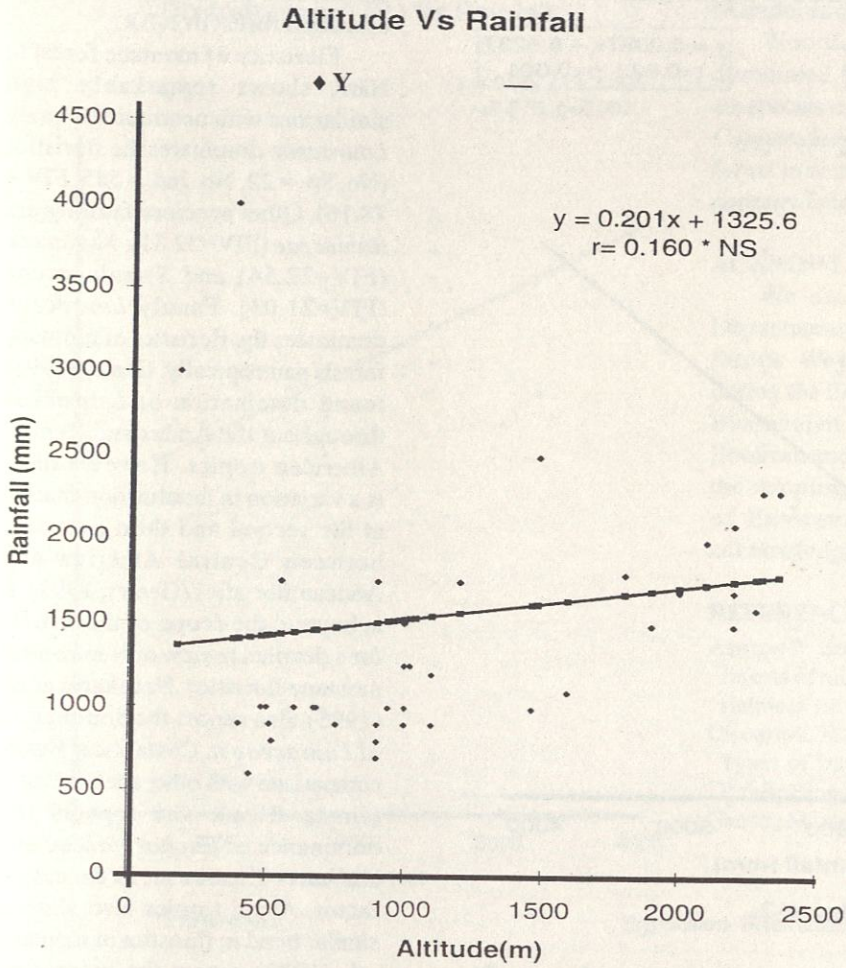

Figure -1.

(Fig.2). Shanon-Weiner's species diversity index and absolute number of species were also significantly correlated (r=0.85, N=60, p<0.001), hence the diversity index (H^1) had a significant positive correlation with precipitation (r=0.576, N=60, p<0.001) (Fig.3). The Simpson's index of diversity also showed a significant trend with rainfall (r=0.405, N=60, p<0.01).

Diversity Vs Altitude : There was a significant positive relation with number of species and altitude (r=0.481, N=60, p<0.001) (Fig.4). The Shanon-Weiner's index of diversity also showed significantly positive with altitude (r=0.369, N=60, p<0.02).

Global trends : In neotropics the species richness is strongly correlated with absolute annual rainfall (Gentry, 1988). Gentry (1988) opine that the relationship may not exist at all in Asian tropics. In fact Ashton, P. (in press) reports that high rainfall area in Asia like Chirapunji (Assam, India) have fewer species. This corresponds with the trend in African tropics as two high rainfall sites (>5000 mm per annum) have marginally higher species than the site with <2000 mm rainfall per annum (Gentry, 1988). Gentry (1988) also caution that the relation is curvilinear as rainfall crosses 4000 mm. We do not have such data set to draw inferences about the relationship.

There is a declining trend of diversity with the increase in altitude in neotropics (Gentry, 1988). There

Table 1. Vegetation parameters of different forest types in Nilgiris. Mean±SD (range)

Sl. No.	Forest type	Number of species (range)	Number of Indv. (range)	Shanon-Weiner Diversity (range)	Simpson's index of diversity (range)	Fisher's alpha (range)	N
1.	Evergreen forest	38.6±7.9 (26-53)	183.5±58.8 (121-284)	3.09±0.35 (3.57-2.51)	0.92±0.04 (0.96-0.84)	15.73±4.60 (23.63-9.20)	8
2.	Shola forest	31.75±7.92 (23-53)	156.83±53.43 (93-263)	2.87±0.23 (2.52-3.29)	0.91±0.03 (0.80-0.95)	12.49±3.55 (7.57-20.17)	12
3.	Moist Deciduous forest	21.0±8.12 (10-39)	85.16±57.03 (30-277)	2.43±0.29 (2.09-3.13)	0.84±0.06 (0.72-0.93)	10.51±5.04 (3.64-23.96)	12
4.	Dry Deciduous forest	15.30±5.28 (9-28)	67.92±26.86 (38-122)	2.11±0.43 (1.15-2.77)	0.80±0.11 (0.46-0.91)	6.77±3.01 (2.62-12.91)	13
5.	Thorn scrub forest	14.36±3.31 (11-21)	37.90±11.61 (16-59)	2.28±0.28 (1.79-2.75)	0.85±0.04 (0.46-0.91)	9.58±3.39 (2.62-12.91)	11
6.	Riverine forest	16±4.52 (11-21)	66.25±38.73 (26-130)	2.24±0.38 (1.39-2.69)	0.83±0.08 (0.69-0.91)	8.67±3.88 (3.22-13.62	4

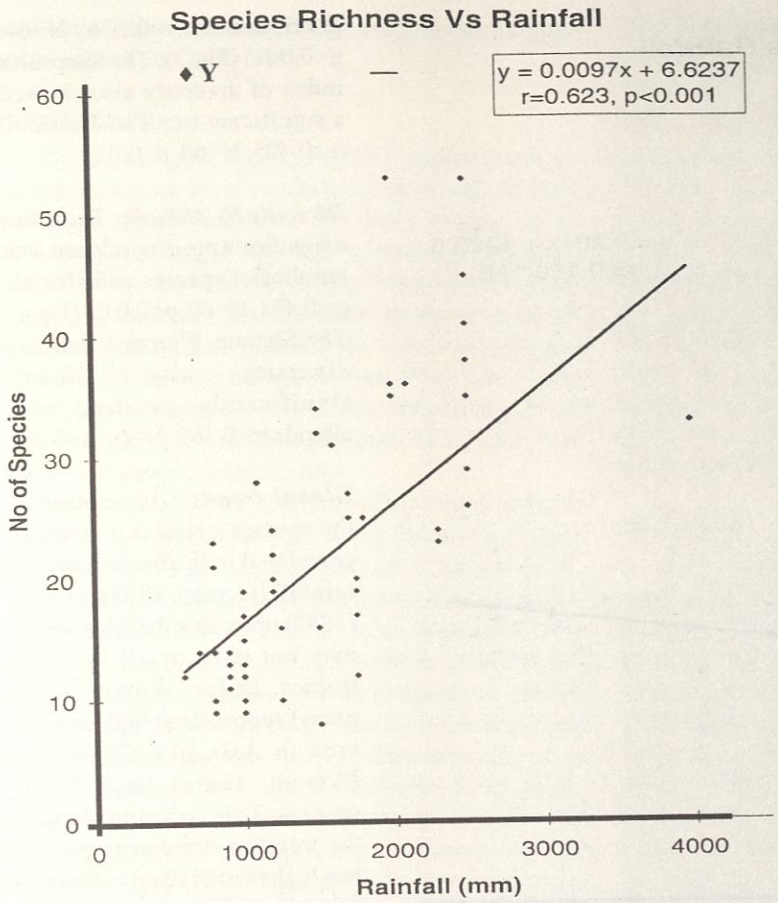

Figure -2.

is a similar trend in Himalayan forest samples (Singh, et.al. 1994). But in NBR the diversity and species richness shows a significantly positive trend. Although there is a concentration of points at the mid elevation, we cannot conclude the evidence for "mid elevation bulge" in the diversity that is being talked about in the literature (Janzen, 1973).

FLORISTICS

Wet evergreen forest in NBR is dominated by the family *Clusiaceae* (No. Sp. = 8, No. Ind. = 117, FIV = 37.49). The dominance of the family *Clusiaceae* is seen also in Malaysian forest plots (Manokaran and Kochummen, 1990). Other speciose families of NBR are *Euphorbiaceae* (FIV=35.09), *Lauraceae* (FIV=32.86) and *Moraceae* (FIV=17.38). The forests of NBR differ from other Asian tropics by the absence of *Dipterocarpaceae* among top ten families. This may be attributed to the fact that *Dipterocarpaceae* is principally a low land forest family and forest plots in NBR are at medium elevation. This family also lacks profuse speciation in a genera e.g. genus *Shorea* alone has 73 species in Malayan island (Whitmore, 1995). Genera like *Hopea,* and *Vateria* represent *Dipterocarpaceae* in the medium level elevation forest of NBR.

Floristics of montane forest in NBR shows remarkably high similarities with neotropics. Family *Lauraceae* dominates the floristics (No. Sp. = 22, No. Ind. = 545, FIV = 78.16). Other speciose families are *Rubiaceae* (FIV=32.81), *Myrtaceae* (FIV=22.54) and *Symplocaceae* (FIV=21.03). Family *Lauraceae* dominates the floristics of montane forests pantropically. Gentry (1993) found domination of *Lauraceae* throughout the Andes and Central American tropics. However there is a variation in familial domination at the second and third positions between Central America and Andean floristics (Gentry, 1993). it is beyond the scope of this article for a detailed review of Neotropical montane floristics. Nadakarni *et.al.* (1995) also report the domination of *Lauraceae* in Costa Rica. But in comparison with other site i.e. Barva (Costa Rica), she reports the dominance of *Euphorbiaceae* and attributes disturbance as the casual factor. Asian tropics also show a similar trend in floristics of montane forests. Proctor et.al. (1988) report the increasing domination of Lauraceae along altitudinal gradient in Malayan montane forests. Kitayama (1995) also concludes in his floristics analysis of Mt. Kinabalu that "The canopy of montane forests of Kinabalu has a high floristic affinity at genus or family level with cloud forests of continental tropical montane systems elsewhere". The montane forests of NBR have large commonalities with Srilankan montane forests, which are geographically closer to Indian peninsula. Lauraceae, Myrtaceae and Symplocaceae dominate the floristics but the difference is the predominance of genus Calophyllum in Srilankan montane forests. Other contrasting feature is the presence of Stemnoporus, a Dipterocarp in the Srilankan montane forest. This is the only dipterocarp genus to be recorded at higher altitudes.

Dry forests types (dry and moist deciduous) of NBR has *Combretaceae* (FIV=74.72, Dry deciduous; FIV=55.19, Moist deciduous) as most dominant family, *Fabaceae* (FIV=22.35, Dry deciduous; FIV=39.64, Moist deciduous). Other speciose families in the dry deciduous forest are *Verbenaceae* (FIV=20.17), *Euphorbiaceae* (FIV=1982) and in moist deciduous forest are *Sterculiaceae* (FIV=28.32), *Verbenaceae* (20.69). The

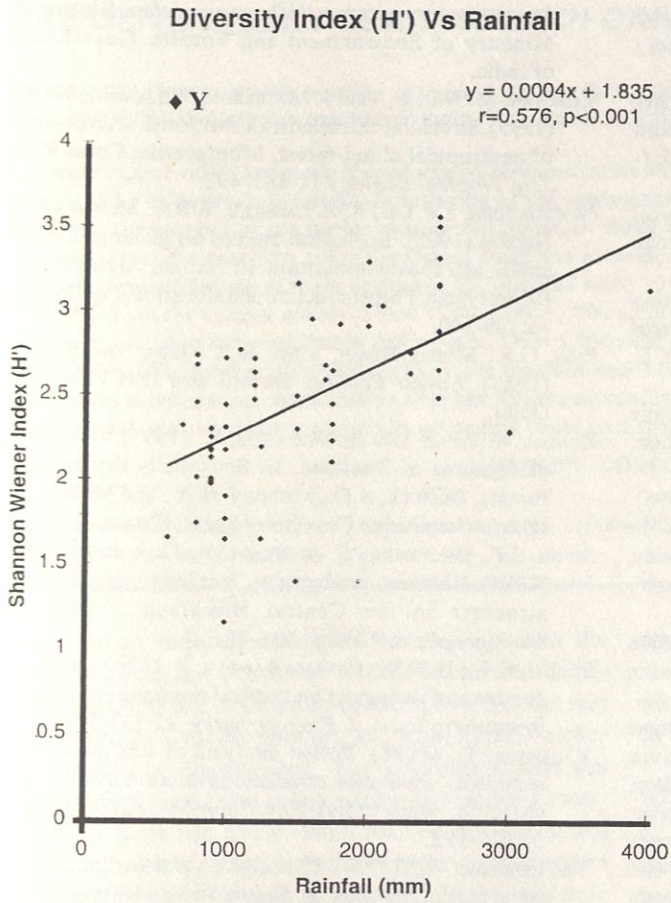

Figure -3.

driest vegetation Thorn scrub has *Fabaceae* as the dominant family (FIV=90.97, No. Sp. = 16, No. Ind. = 117). Floristically dry forests of NBR are *Combretaceae* dominated with *Anogeissus* and *Terminalia* as main association genera. *Leguminosae* is the most dominant family in the dry forests of neotropics (Gentry, 1995). *Bignoaceae* is second, with large representation in liana species (listed in moist deciduous forest floristics as tenth dominant in NBR). Other families of special interest in neotropics would be *Rubiaceae, Sapindaceae, Europhorbiaceae, Flacourtiaceae* and *Capparidaceae.* Of these families listed, NBR samples have Rubiaceae and Euphorbiaceae in the abundant family category. Other families do have representation in the floristics but not among the top ten families. Dry forests in Southeast Asian region (Extending from India to Vietnam through Myanmar, Thailand Laos and Cambodia) have similar species composition, ecology and structure with NBR forest samples (Rundel and Boonpragob, 1995).

Woodlands of Africa have *Fabaceae* dominated floristics, whereas the dry forests are species rich (Jean-claude Menaut, et.al. 1995). *Capparidaceae* dominates the floristics of driest forest in neotropics (Gentry, 1995) but in NBR *capparidaceae* is not of the abundant families.

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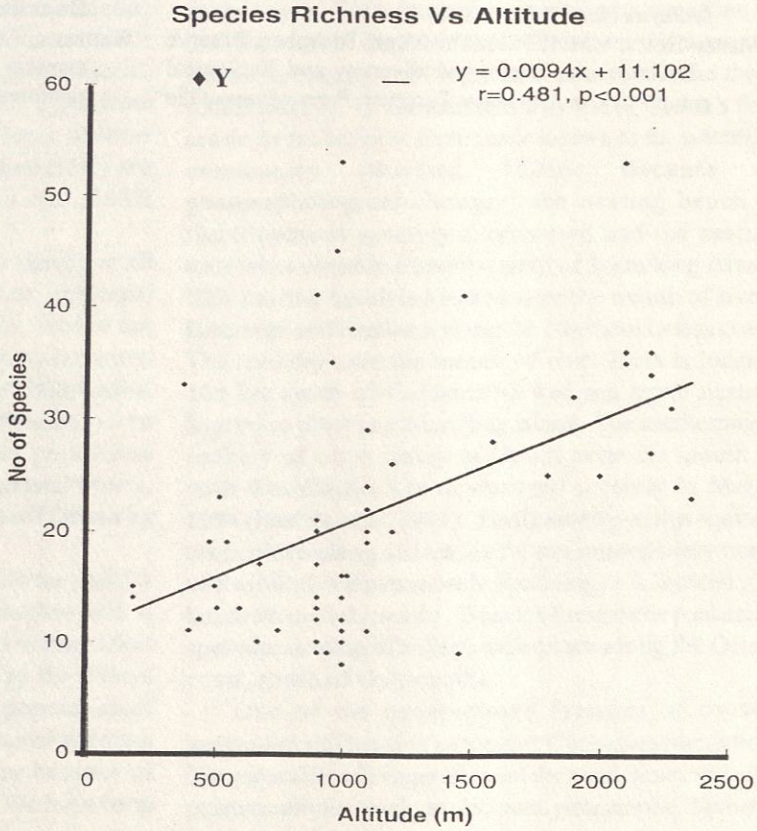

Figure -4.

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ECOLOGICAL STATUS AND IMPACT OF ANTHROPOGENIC ACTIVITIES ON THE OLIVE RIDLEY SEA TURTLE IN ORISSA

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Abstract : Olive ridley sea turtle (*Lepidochelys olivacea*) nests en-masse at three major rookeries (Gahirmatha, Devi River mouth and Rushikulya), in Orissa. Monitoring of the nesting sea turtle population at these three rookeries was initiated in 1995. The number of sea turtles nesting during an *arribada* was estimated using the fixed strip nesting turtle count method. Over the past four years the Orissa coast has witnessed a drastic decline in the number of nesting sea turtles. The consecutive failure of mass nesting at Gahirmatha since 1997 is attributed to the loss of nesting habitat and heavy disturbance in the coastal waters. Since 1994, over 33,000 adult olive ridleys have been washed ashore the Orissa coast after being incidentally captured in fishing nets. Over 5,000 ridleys have been double tagged at five tagging sites in Orissa since 1997. The fact that olive ridleys use more than one beach for nesting in a single season has been established by tag recoveries at these three mass nesting beaches. Elimination of human related disturbance factor is extremely crucial for the survival of olive ridleys, especially since this could be a single population that is nesting in Orissa.

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Key words : arribada, Gahirmatha, incidental capture, *Lepidochelys olivacea*, mass nesting, mortality, olive ridley, Orissa, Rushikulya, sea turtle, tagging.

Human induced activities have resulted in the worldwide decline of most species of sea turtles. Today their numbers are drastically reduced to the point that all seven sea turtle species are considered either threatened or endangered. The challenges that sea turtles now face from human activities impact every stage of their life cycle, from loss of nesting beach and foraging habitats to mortalities in the coastal waters through intense fishing activities. Anthropogenic activities have been a major reason behind the decline in the number of one of the most gregarious sea turtle species – the olive ridley turtle (*Lepidochelys olivacea*). Direct harvest of adult turtles and their eggs from nesting beaches have resulted in the collapse of some of the major nesting congregations of olive ridley sea turtles in Mexico in recent times (Cliffton *et al.*, 1982; Green and Oritz-Crespo, 1982).

Olive ridley sea turtle nests in low densities all along the East Coast of India. However, the most important nesting beaches lie in Orissa, where the mass nesting or *arribada* (Spanish for arrival) occurs. The three sea turtle rookeries in Orissa at Gahirmatha, Devi River mouth and Rushikulya together support a significant portion of India's olive ridley population that migrates every winter to the Indian coastal waters. Olive ridleys arrive in the coastal waters off Orissa by late October.

After their arrival, mating takes place in the shallow coastal waters off the mass nesting beaches and is followed by sporadic and mass nesting. Hatching takes place during March and April and by May the ridleys migrate back from Orissa. This nesting population of ridleys in Orissa has recently been the focus of attention of national and international community because of the large-scale mortality of adult turtles. We have been monitoring the olive ridley nesting beaches in Orissa since 1995. In this paper we describe the status of olive ridley turtles and the factors affecting their survival in Orissa.

STUDY AREA

The 480 km long coastline of Orissa stretches from the Udaypur village bordering West Bengal in the North to the marshes of Ichhapuram bordering Andhra Pradesh in the south. We constantly monitored a coastline of 360 km south of the Brahmani – Baitarani River mouth. Intensive beach patrolling was carried out at the three rookeries (Fig. 1). Gahirmatha was one of Orissa's first sea turtle rookeries to have made known to the scientific community (Bustard 1976). Because of geomorphological changes, the nesting beach at Gahirmatha is severely fragmented and the nesting now takes place in a narrow strip of 3-km long island. This nesting beach is located near the mouth of rivers Brahmani and Baitarani along the Northern Orissa coast. The rookery near the mouth of river Devi is located 100 km south of Gahirmatha and sea turtle nesting here takes place in a 2-km long island. The southernmost rookery of olive ridley in Orissa near the mouth of river Rushikulya was discovered recently in March 1994 (Pandav *et al.* 1994). Turtle nesting at this rookery takes place along a stretch of 4 km immediately north of Rushikulya River mouth. Rushikulya is located 320 km south of Gahirmatha. Besides these three rookeries, sporadic nesting of ridleys take place along the Orissa coast, south of Gahirmatha.

One of the conspicuous features of coastal vegetation of Orissa is extensive Casuarina plantation. The natural beach vegetation on the sand dunes includes psammophytes such as *Ipomea pescaprae*, *Spinifex*

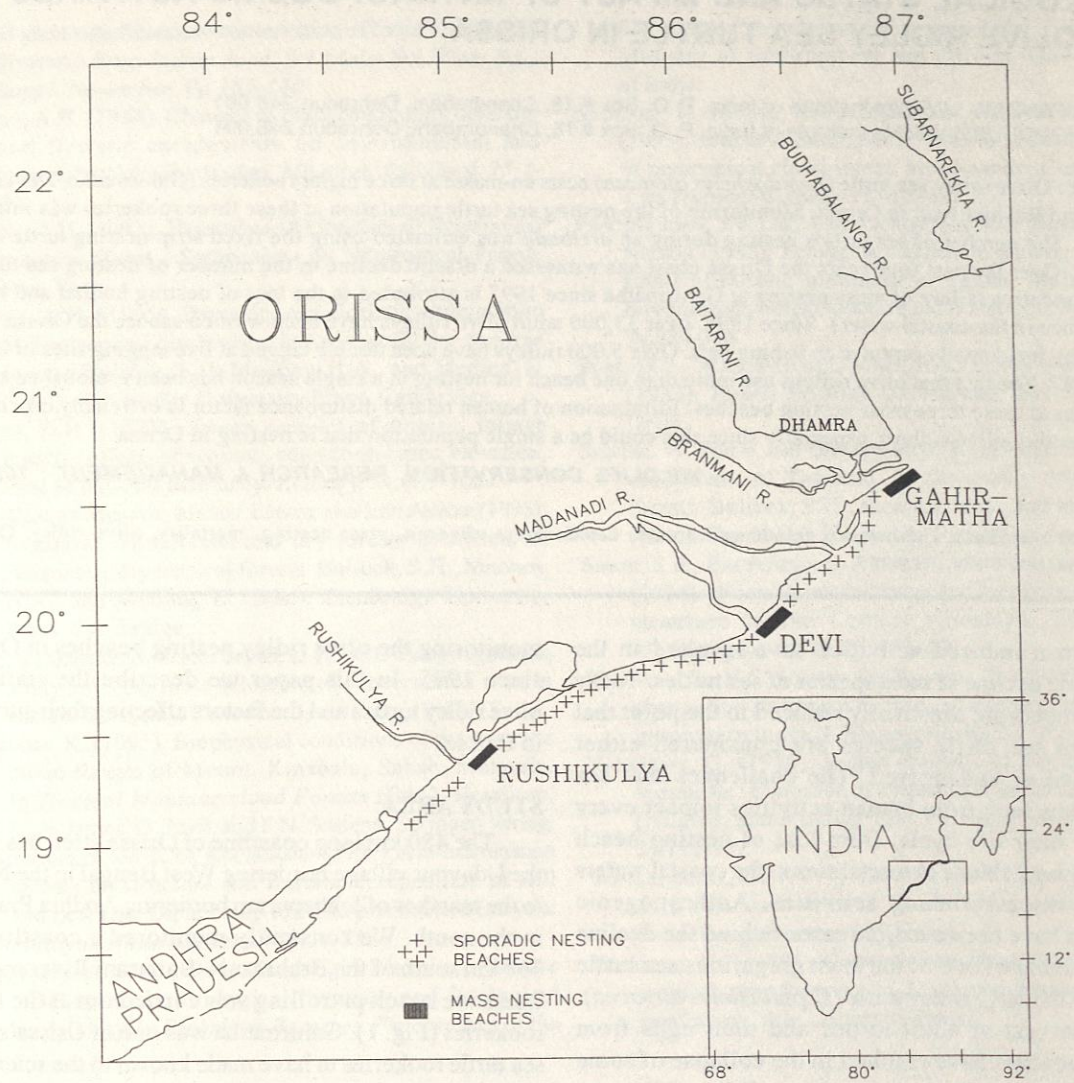

Fig. 1. Olive Ridley nesting beaches in Orissa

littoreus, *Gisekia phranacoides* and *Hydrophylax maritima*. Besides this, mangrove formations occur near Gahirmatha and Devi rookeries.

METHODS

Nesting beach monitoring – For systematic coverage the nesting beaches at the three rookeries were divided into 100-m segments. The segments were marked with either wooden poles or with cemented pillars. Patrolling by foot was carried out every night during the nesting season (January to April) at the rookeries to monitor turtle activities. Turtle crawls on the beach were classified into nesting and non-nesting types. A nesting crawl was characterized by the presence of a nest pit. In contrast, the non-nesting crawls lacked a nest pit and the turtle had gone back to sea without nesting. The number of turtles nesting during an *arribada* was estimated using a fixed strip nesting turtle count method. A 20 m strip transect was laid at every 100 m segment of the nesting beach. Transects were set up above the high tide mark. Three sticks were established along the longitudinal limits of the transects, one set per side, every 10-15 m between sticks depending on the extent of available nesting area. A thread was tied on the sticks waist high so as to join the three sticks along one side of the transect to clearly define the sampling area. Each of these transects were walked once in an hour. Only egg laying females (turtles in oviposition) within the strip were counted during the transect surveys. Sampling in the transects at hourly interval started with the initiation of arribada and were carried out till the completion of *arribada*. Available nesting area on the beach was calculated by measuring the length of individual transects and then multiplying their average value by the length of the stretch of beach used by gravid females. The average number of turtles nesting in the transect area was then extrapolated to the total available nesting area in the

beach to estimate the size of *arribada*.

At Gahirmatha beach width was recorded at fortnightly interval at every 100-m segment. A fiberglass tape was used to measure the beach width. Beach width here refers to the extent of beach available between the high tide line of the sea and the high tide line of the estuary.

Tagging – We started tagging the ridleys in Orissa from November 1996. Our tagging program comprised of two phases: offshore tagging of ridley mating pairs during November and December and on the beach tagging of nesting females during January and April. Offshore tagging was carried out in the coastal waters off Gahirmatha, an area of roughly around 25 sq. km. We used a mechanized boat and an indigenously developed triangular trap to capture the ridley mating pairs. Once a mating pair was sighted, the boat was brought near to it and the triangular trap in the boat was lowered down. The turtles after getting entangled in the trap were scooped out of water. After finishing tagging and taking body measurements the turtles were released back to sea. This entire operation took 5-7 minutes.

On the beach tagging was carried out at five sites (the three rookeries and two sporadic nesting sites) during the nesting season. Precautions were taken not to disturb the emerging turtles and the nesting turtles were tagged only after they completed the process of egg laying. We used monel metal tags (size 1005, style 49) manufactured by National Band and Tag Company, Newport, USA to mark the ridleys. All tags were applied as self-piercing and self-locking by means of the specific tag applicator supplied by the manufacturer. The tags were applied on the front flippers of the turtles and were located besides the large scale on the proximal rear edge of the flipper immediately adjacent to the axilla. This tagging position has been recommended by Schulz (1975), Balazs (1983) and Limpus (1992). All the turtles were double tagged.

Quantification of anthropogenic activities - Offshore fishing activities has been identified as a major reason behind the large-scale mortality of sea turtles in Orissa. We monitored a stretch of 360-km coastline, south of the Gahrimatha rookery till the mouth of Bahuda River along Southern Orissa coast and documented the sea turtle mortality in this stretch. To enable systematic coverage, the coastline was divided into eight survey sectors based on major geographical features, such as estuaries, sand spits, bays and other coastal landmarks. Three teams consisting of nine members covered these eight survey sectors by foot once in a fortnight throughout the breeding season (November till April). A total count of the dead turtles washed up in each sector was carried out during the fortnightly surveys. Dead turtles were marked on their carapaces with white paint to avoid repeat counting during subsequent surveys. The turtles were sexed, using external characters. Males were characterised by the presence of a long tail, which extends much beyond the posterior end of the carapace, and the strongly curved claw on the fore flipper. Females had shorter tails extending little beyond the post central, with a small and straight claw on their fore flipper. In case of decomposed turtles, the claw character of the fore flipper was used to determine the sex. Highly decomposed specimens with no visible external characters were classified as turtles of unknown sex. Curved carapace length (CCL) was measured from the nuchal notch to the posterior marginal tip. Curved carapace width (CCW) was measured at the widest part of the shell. All the measurements were taken in centimetre. Whenever possible, cause of death was determined based on external injuries on head and carapace.

RESULTS

Nesting beach monitoring - Ridleys in Orissa showed a distinct temporal pattern of nesting with most of the nesting activity taking place during neap tidal nights. We also recorded a great variation in the number of turtles nesting at these rookeries during the study duration (Table 1).

Table 1. Number of nesting olive ridleys estimated at the three rookeries in Orissa during 1996-98.

Rookery/Year	1996	1997	1998
Gahirmatha *arribada*	<2,000	<500	----
Devi River mouth	------	15,000	<200
Rushikulya	60,000	45,000	8,000

Whereas the average beach width ± St. dev. was 140.56 ± 32.92 m. in 1996 it got reduced to 82.44 ± 54.13 m. in 1998, (Fig.2). With the reduction in beach width from 1996 to 1998, a change in proportion of nesting emergences to that of non-nesting emergences of ridleys was observed at Nasi rookery. Whereas 84.3% of the total emergences resulted in nesting in 1996, it got reduced to only 15.4% in 1998 (Fig. 3).

Tagging - In total we spent 129 hours in the sea over a period of 51 days and captured 818 ridley mating

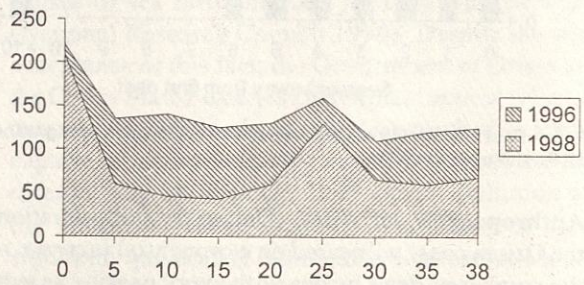

Fig. 2. Change in beach width recorded at Gahirmatha during 1996 abd 1998.

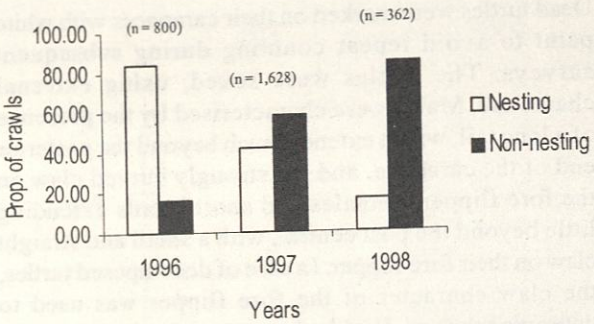

Fig. 3. Nesting vs. non nesting crawls encountered at Gahirmatha rookery during the study.

pairs of which 780 males and 743 females were tagged. Males tagged were smaller in size and were lighter when compared to that of the females. Mean CCL ± St. dev. of males and females tagged were 69.9 ± 2.9 (range = 51.0 to 79.0 cm, n = 740) and 71.2 ± 2.5 (range = 61.2 to 82.0 cm, n = 723) respectively. Mean weight ± St. dev. of males and females were 39.7 ± 4 kg (range = 25-56 kg, n = 702) and 47.08 ± 3.9 kg (range = 32-62 kg, n = 670) respectively. Some males have been recorded in courtship activity in more than one breeding season and all such recaptures were made at the same area where the male had been originally captured while courting in a previous year. For these males recorded mating in more than one year, mean (± St. dev.) remigration interval was 0.99 ± 0.06 years (range = 0.86 to 1.14 years, n = 28). Nearly 4,000 nesting females were tagged at five sites in Orissa. Monitoring at the nesting beaches revealed beach exchange by olive ridleys nesting in Orissa. The range of inter-rookery movement obtained during the present study ranged from 35 to 220 km (n = 6). Upon remigration, tagged females at Rushikulya rookery showed a high degree of nesting site fixity. Ridleys generally placed their nests within 100-300 m of their previous nest with a range of 0 to 1,000 m (Fig. 4).

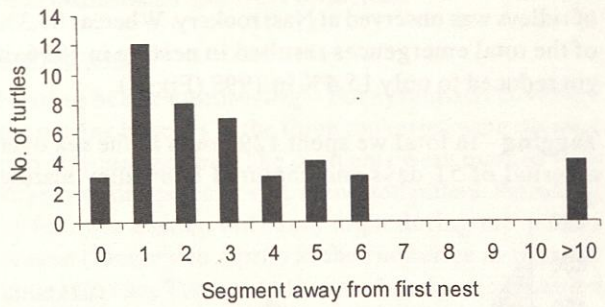

Fig. 4. Nest site fidelity of Olive ridley sea turtle upon remigration at Rushikulya rookery.

Anthropogenic activities – During the study duration, the Orissa coast witnessed an exponential increase in the number of dead turtles with every passing season and reached an all time high in 1997-98 when 13,575

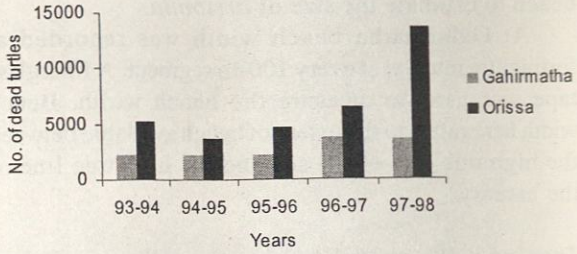

Fig. 5. Dead olive ridleys washed ashore the Orissa coast druing 1993 and 1998 (n = 33,617).

dead olive ridleys were washed ashore. In total we counted 33,617 dead olive ridley during our periodic surveys over five breeding seasons in Orissa (Fig. 5).

Mortality due to such illegal trawling has been increasing each year and reached a record high of 13,575 ridleys in 1997/98 season. The majority (89.6%) of the recorded stranding occurred on the coast near Gahirmatha, Paradeep, Kujang and Devi (Sector I to IV, Fig. 6).

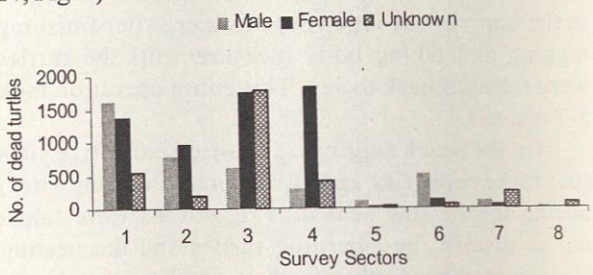

Fig. 6. Dead olive ridleys counted in the eight survey sectors during 1997-98 nesting season in Orissa (n = 13,575).

Mean CCL ± St. dev. for the dead females and males counted were 67.9 ± 2.8 cm (range = 54.5 - 78.4 cm, n = 1066) and 67.2 ± 2.6 cm (range = 52.5 - 76.4, n = 1025) respectively (Figure 7). Mean CCW ± St. dev. of dead females and males were 66.9 ± 2.6 cm (range = 54.4 - 77.8, n = 1055) and 66.2 ± 2.5 (range = 56.3 - 75.3, n = 989) respectively.

DISCUSSION

Olive ridleys have been reported to exhibit distinct temporal pattern of nesting. Marquez *et al.* (1976) correlated Mexican arribadas with the phases of the moon; emergences usually take place during the waning quarter when tidal amplitude is low. Dash and Kar (1990) have also recorded nesting of ridleys during neap tidal nights. Spring tidal days are marked by high variation in tide. Tidal variation during neap tidal days is minimal and sea remains relatively calm, thus providing an easy access to the nesting beach. This could have been the possible reason behind the distinct temporal patterns of nesting exhibited by ridleys in Orissa.

During normal nesting season when beach formation is proper, Gahirmatha witnesses a high proportion of nesting emergences. During peak nesting years in 1982

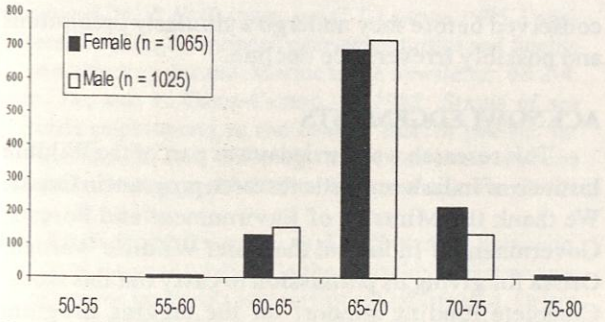

Fig. 7. Size distribution of the dead olive ridleys washed ashore the Orissa coast during the study period.

and 1983, Dash and Kar (1990) recorded low percentage of non-nesting emergences (9.4 to 13.1 %). During the present study when beach formation was proper in 1996, only 15.7% of crawls resulted in non-nesting emergences. However, with the reduction in beach width during 1997 and 1998, most part of Gahirmatha rookery was subjected to frequent tidal inundation. The beach remained wet and was not suitable for the turtles to nest. The high proportion of non-nesting emergences (86.4%) reflected this in 1998, indicating the unsuitability of beach condition for turtle nesting.

Most of the mating pairs sighted during our offshore tagging operation were concentrated in the coastal waters of roughly around 25-sq. km. immediately south of the Gahirmatha rookery. Multiple capture of the same male at the same courtship site in different seasons has also been reported for green sea turtles *Chelonia mydas* (Balazs 1980, Limpus 1993, Fitzsimmons *et al.* 1995). However, the remigration interval of olive ridley males obtained in this study is much shorter compared to that of green turtles (2.08 ± 1.14 years, Limpus 1993). This nearly annual remigration interval of male olive ridleys also shows a strong fidelity to the coastal waters off Gahirmatha. Nest site fidelity by female ridleys at Rushikulya was high. Results of our tagging study on the nesting site fixity confirms to that of Dash and Kar (1990) on olive ridleys at Gahirmatha, Bosc and LeGall (1986) on green turtles and Chaves et al. (1996) on leatherbacks at Playa Langosta, Costa Rica. Like the olive ridleys in Orissa, green and leatherback mentioned in these above studies were found to have re-laid their nests usually less than 300 m and often within 100 m of the previous nests with a range of about 600 m to 1,100 m. However, six of the nesting females in the present study were found nesting in more than one beach during same nesting season. The range of this inter-rookery movement recorded during the present study appears to be the longest for olive ridleys compared to that of previous instances (Table 2). Two of the turtles tagged during 1997 arribada at Rushikulya rookery were found nesting after 45 days in another arribada at Devi River mouth. One of the turtles tagged during 1997 arribada at Devi river mouth was recorded nesting at Gahirmatha in a small arribada comprising of 300 nesting females after 33 days. Similar observations on beach exchange by olive ridleys have also been recorded in the Costa Rican mass nesting beaches (Nancite and Ostional). Valverde et al. (1998) cites the movement of 29 Ostional ridleys at Nancite and 35 Nancite turtles at Ostional between 1980 and 1984. Olive ridleys are known to interchange freely between the Nancite and Naranjo nesting beaches in Costa Rica (Pritchard and Trebbau 1984). Schulz (1971) reported that three of 690 olive ridleys moved some 85 km from Bigisanti (Surinam) to Galibi (Surinam) during the 1970 breeding season. This dynamic movement between beaches is remarkable and may represent an exception to the natal homing hypothesis as applied to green turtles (Bowen et al., 1992). It is possible that beach exchange is part of a complex mechanism that olive ridleys use to colonise or even move to another beach all together.

Table 2. Long distance inter-rookery movement by gravid olive ridley sea turtles. n = the number of turtles recorded while exchanging the nesting ground in one season and km = estimated minimum oceanic distance between two nesting grounds.

Range –35 to 220 km.	n = 6 (this study)
Range – 160 km.	n = 1 in Surinam (Meylan 1982)
Range – 85 km.	n = 3 in Costa Rica (Schultz 1971)

All the dead turtles counted during the study were adults. Uncontrolled mechanised fishing in areas of high sea turtle concentration has resulted in large-scale mortality of adult sea turtles during the last two decades in Orissa (James *et al.*, 1989; Dash and Kar, 1990; Pandav *et al.*, 1994, Pandav *et al.* 1997). Dash and kar (1990) reported the stranding of 4,682 adult olive ridley turtles at Gahirmatha between 1978 and 1985. James *et al.* (1989) documented the stranding of more than 8,000 ridleys between 1983 and 1987. In the 1993/94 season, 5,282 dead olive ridley turtles were recorded in Orissa (Pandav *et al.*, 1997). Near shore mechanised fishing, specifically shrimp trawling, is thought to be the major cause of this high mortality. Gahirmatha and its adjoining areas (Sector I to IV) are subjected to the highest levels of shrimp trawling in Orissa. The intensity of trawling in reflected by the presence of highest no. of dead turtles in these sectors. Shrimp trawling has been identified as one of the greatest causes of sea turtle mortality throughout the world (National Research Council 1990). Despite the wide acceptance of this fact, the Government of Orissa and the Orissa State Fisheries Department appear reluctant to accept this large scale mortality as a result of incidental capture of turtles in fishing nets. They speculate that disease, migration fatigue and marine pollution are the causes of these deaths. To counteract these arguments quantitative information on observed capture of sea turtles and their rate of mortality during offshore fishing operations is absolutely essential. In the interim,

strict enforcement of Orissa Marine Fishing Regulation Act 1982 and Rules 1983, which prohibit any kind of mechanised fishing within five km of the shore along Orissa coast, is needed. A blanket ban on near shore mechanised fishing should significantly reduce the turtle mortality. A second step towards minimising this mortality would be the mandatory use of Turtle Excluder Devices (TED) in trawl nets. Currently, none of the trawlers operating off the Orissa coast use TEDs in their nets.

However, the use of TEDs alone will not eliminate turtle mortality resulting from fisheries. Additional factors must be considered are that in areas of high fishing intensity, turtles that are captured and released several times may die and turtles are also caught and drowned in gill nets. Therefore strict enforcement of the existing law, prohibiting near shore mechanised fishing seems to be the best short-term solution to reduce turtle mortality.

MANAGEMENT IMPLICATIONS

The number of nesting females at Gahirmatha has declined in recent years. Although intense offshore fishing activities may have played a role, it is also possible that this may be due in part to unsuitable beach conditions. A third possibility is that artificial illumination created by construction work at the Outer Wheeler Island, has caused disturbance.

Notwithstanding, the high levels of marine turtle mortality in the area are a matter of utmost concern and urgently need to be addressed. A result of our tagging study have revealed the movement of sea turtles between the rookeries and has proved the fact that turtles use more than one beach for nesting during the same breeding season. Thus protection of the three rookeries is extremely crucial for the survival of sea turtles in Orissa, which could be a single population. Therefore a major step towards saving this population would be giving protected area status to the nesting beaches as well as the coastal waters having high sea turtle concentration. Of the three mass nesting beaches in Orissa, only the Gahirmatha rookery and its coastal water comes under protected area (PA) network. Nesting beaches near Devi River mouth and Rushikulya lack any kind of PA status and hence there is an urgent need to bring these areas under PA network, thus making them less vulnerable to anthropogenic disturbances.

L. olivacea remains the most numerous sea turtle species in the world, mainly on the strength of the massive colonies in India, Costa Rica and Mexico. It is possible that its number exceed those of all other species of sea turtles combined. Nevertheless, the rapid and virtually complete disappearance of its congener *L. kempii* during the last two decades suggest that populations of olive ridley should be carefully conserved before they undergo a similarly precipitous and possibly irreversible decline.

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TOWARDS PARTICIPATORY CONSERVATION IN INDIA : NATIONAL SCENARIO AND LESSONS FROM THE FIELD

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PART- 1 : THE NATIONAL SCENARIO

1.1 Introduction

For the last few decades, legal and administrative protection to ecosystems and species has been the main strategy for wildlife conservation in India. The declaration of national parks, sanctuaries, and other categories of protected areas (P As) under the Wild Life (Protection) Act, 1972, has resulted in protecting a large number of areas from certain destruction by commercial, industrial, or biotic forces. Legal protection against hunting and capture, given under the same Act to listed species, has also helped to safeguard threatened and rare species. Related legislation like the Forest (Conservation) Act has also helped to curb diversion of natural habitats for non-conservation purposes.

But increasingly, chinks in the armour of this strategy are being exposed. Public and political support for conservation is falling everywhere, state governments are trigger-happy about sacrificing notified areas for so-called developmental activities, illegal hunting and tree-felling has been hard to curb in many areas, and conflicts between wildlife officials and local people living in and around P As are getting more common. Several species whose existence had been relatively well-secured over the last 2-3 decades, are once again facing the threat of extinction. It is clear that unless there are significant attempts to respond to such issues, including changes in the policy and legal direction of conservation, wildlife will remain in deep trouble.

A centralised, bureaucracy-dominated approach to conservation is doomed to failure in the new circumstances that India finds itself in. Firstly, new macro-economic policies, responding to the globalisation process that is sweeping the world, are essentially in contradiction to conservation and sustainable use of natural resources. The same government which declares a P A is now willing to sacrifice it at the altar of 'development' and 'economic growth'. Second, a new political dynamic has empowered state parties and governments much more than before, and the central government is unable to wield its environmental clout as before. Third, government controls are generally loosening under the impact of the private corporate sector, both domestic and foreign, which has far more clout to influence policies now than just a few years ago. Fourth, local communities everywhere are no longer willing to take things lying down; they want, and rightly so, a voice in making the decisions that affect their lives. This relates as much to top-down development processes as to conservation measures taken by governments. Privatisation and decentralisation are powerful forces, and they militate against the form of centralised control that conservation and natural resource management has enjoyed over the last century or so.

The conservation movement has yet to organise itself to respond to these new challenges. In a sense, this failure has a lot to do with history: in the past, urban conservationists found favour with a tiny section of the political elite which was sympathetic to wildlife conservation, and able to wield power with state governments. However, little attempt was made to broad-base the movement, so that when the political support at the top ended, conservationists were suddenly left out in the cold. All the conservationists at the Wildlife Institute of India and the Bombay Natural History Society and the Salim Ali Centre for Ornithology and World Wide Fund for Nature and Sanctuary Magazine and Ranthambhor Foundation and Wildlife First and Kalpavriksh and myriad other organisations, brilliant and dedicated as they are, now find themselves helpless against the forces mentioned above. Urban-based conservation helped India's wildlife to buy time; that time is now running out, and a new orientation is needed if the gains made in the last few decades are to be sustained.

The only thing that can save the conservation movement is to move away from its elitist base to a much broader base oflocal community members, academics, NGOs, and sensitive government officers. Together, these constituents can defeat the destructive forces engulfing natural habitats,. divided, they will be powerless against these forces.

Is this possible? To answer this, I will briefly go into the history and contours of the current situation, below[2].

1.2 Ignoring People's Needs, Rights, And Knowledge

Conventional conservation policies and programmes in India have been characterised by an amazing ignorance or deliberate neglect of the integral

[1] Thanks are due to Neema Pathak, Sunita Rao, Bansuri Taneja, and Simronjit Singh, for useful inputs to this paper.

relationship between rural communities and natural habitats. The majority of the country's population still depends directly on natural resources for some or other crucial element of their survival. This is even more true of P As than elsewhere, for the simple reason that they are predominantly inhabited by highly ecosystem-dependent people. A study by the Indian Institute of Public Administration in the mid and late 1980s revealed that 69% of surveyed P As had human population living inside, and 64% had rights, leases, or concessions to extract fuel and fodder, to graze, or to carry out other activities (Kothari et.al. 1989). The situation has not substantially changed, since in the last decade or so not so many people have been moved out of P As, nor have so many adjacent communities been provided alternatives. A rough extrapolation of the same data suggests that *there are at least three million people living inside PAs, and several million more using them .from adjacent settlements.* Official policy never came to grips with this reality, with the result that legal and administrative structures of restriction and denial of access to resources were imposed on every area which become a P A. While actual displacement of communities has fortunately not been very prevalent, curtailment of rights to resources has been commonplace. Simultaneously, restrictions on hunting (perhaps usually justified from the conservation point of view) have denied communities a means of self-defense against wild animals which attack livestock or humans and damage crops.

As short-sighted was the neglect of the enormous knowledge of ecosystems and wildlife that India's local communities had, and in many cases still have. This knowledge and the associated practices of prudent resource use and conservation, have been documented by several people (Gadgil, Berkes and Folke 1993, Sen 1992, Deeney and Fernandes 1992, Gokhale 1997, Ramakrishnan 1984) and I will not recount them here. One senior wildlife official recently told me that ins ~h knowledge is neglected, for officials often rely on local people to tell them about plants and animals and ecological factors. However, community knowledge is not merely bits of information which are used when convenient and djscarded when not, and which are in any case rarely acknowledged when used (as for instance is happening in the ecodevelopment process in Great Himalayan National Park, see Baviskar 1998). The relevance of traditional knowledge of biological resources needs to be understood in the context of the social and cultural milieu of the community as a whole, and within the context of its relations with its surrounding habitats. Official policy has not given this entire context the respect it deserves; rather, the knowledge and its milieu were considered essentially antithetical to the conservation objective, and therefore even where pieces of traditional knowledge were used in conservation programmes, the community as a whole continued to be alienated from its natural context. Almost never were community members (even the much-celebrated Bishnois, or the lrulas, or other communities which official wildlife pamphlets pay lip-service to) asked to be in any decision-making or planning capacity. As we will see below, this attitude continues to characterise even more progressive official policies of recent times, such as ecodevelopment.

The result of the above aspects of conservation strategy has been the following :

1. Communities, even those which continued to practice sustainable or conservationist resource use, were increasingly alienated from natural habitats, resulting in a break-down of traditional practices, erosion of knowledge, and loss of the desire to protect resources from degradation (the "sarkari tiger" syndrome).
2. Hostility towards official conservation efforts and officials, manifested in a range of responses including: non-cooperation (e.g. during fire incidence or illegal timber cutting incidents); outright violence against officials (e.g. against the former director of the Ranthambhor Tiger Reserve Shri Fateh Singh Rathore); deliberate destruction (including poaching and setting fire to forests); undermining of regulations by obtaining political and other patronage (Saberwal1998); and demands for denotification of p As.

What is particularly tragic is that many instances of curbing human uses, and the general prescription to eliminate all human uses (except, for some strange reason, for tourism) from national parks, is based on the mistaken assumption that all such uses are detrimental to biodiversity conservation, Evidence from various parts of the world suggest that limited human use may not only be possible to absorb within ecosystems, but that in many cases it may enhance local biodiversity levels; and indeed that many of the so-called 'pristine' wildlife habitats that we want to preserve in their 'virgin' character (the Amazonian forests, the American prairies, the African savannah, freshwater wetlands in India) actually owe their current levels of diversity partly to a long history of human use (Gomez-Pompa and Kaus 1992, Bush and Colinvaux 1994, Adams and McShane 1992, Arhem 1985, Saberwal1998); and further, that stoppage of human activities (including grazing and fire) from such ecosystems could actually reduce biodiversity levels; and even make the habitat worse for the species sought to be conserved (Ali and Vijayan 1986, Vijayan 1990; Naithani et,al, 1992, Pandey and Singh 1992, all citing cases from India), It would of course be dangerous and foolish to extrapolate from these examples and suggest that all human use is compatible with biodiversity

2 These aspects are explored in more detail in Kothari, Singh, and Suri 1995; Kothari 1996; Rangarajan 1996; and Tucker 1991.

conservation, but surely they do indicate that a blanket policy either way is unscientific and potentially detrimental to conservation objectives.

1.3 Conflicts and Cooperation

The current conservation scenario is confusing in its complexity, making any generalisations hazardous. Look at the following examples :

- In some areas, local villagers/communities are totally rejecting the official concept of P As and consequently are even willing to sacrifice the forests and wildlife for immediate gains. In Narayan Sarovar Sanctuary of Gujarat (western India), many villagers have welcomed the recent denotification of the sanctuary to make way for a cement factory. Such local communities have invariably realised no benefits from the establishment of the P As around them. If anything it has only meant livelihood insecurity and lost opportunities because of lack of commercial development. This phenomenon has received a major boost due to the recent haphazard and insensitive processes of settlement of rights that have been launched in all states, as a result of a Supreme Court order in a case that WWF-India is fighting. In Udaipur district, a *sarpanch* has filed a case asking for the denotification of the Phulwari ki Naal Sanctuary, arguing that the settlement process is violative of his rights.
- Commercial forces are invariably very strong and often influence-industrial states to reverse their own conservation measures. In 1991, the government of the Himalayan state of Himachal Pradesh denotified the Darlaghat Sanctuary to make way for a cement factory; the same purpose drove Gujarat to denotify the Narayan Sarovar Sanctuary in coastal Kutch. In 1994, Kamataka gave fresh mineral prospecting leases inside the evergreen forest habitat of the Kudremukh National Park. News came in July 1998, that permission had been granted to the Atomic Minerals Division to prospect for uranium inside the Nagarjunasagar-Srisailam Tiger Reserve.
- In many areas, having realised the critical importance of these resources for their livelihood, and dissatisfied with the Forest Department managing it, the local people on their own or sometimes with the help of sympathetic forest officers or NGOs are struggling to conserve these areas. For instance, in Sariska Tiger Reserve in Rajasthan, villagers have fought against mining, using the help of forest officials and the Wild Life (Protection) Act and going all the way to the Supreme Court to seek redressal. Inhabitants of two villages in the Alwar district of Rajasthan have declared 1200 hectares of forest as the Bhairodev Dakan 'Sonchuri', promulgated their own set of rules and regulations which allow no hunting, and are zealously protecting the area against any outside encroachments. In Jardhar village of Tehri Garhwal, as in many other settlements of the Western Himalayas, forests and high- altitude pastures have obtained strict protection from the communities associated with the Chipko Movement.
- At several places, bold forest officers and NGOs are also standing in the way of destructive commercial interests. F or example, at Radhanagari Sanctuary , part of the evergreen forests of Maharashtra, local forest officers dug up the road leading to a proposed mining site, local NGOs campaigned to get the mining lease cancelled, and a Bombay-based NGO obtained a stay order on further mining. NGOs and politicians have successfully stalled attempts to use the Bhitarkanika Sanctuary in Orissa (home to the world's largest nesting sites of the threatened Olive ridley sea turtle) for trawling jetties.
- Many governments, or individual officers, are realising that either the survival needs of communities must be allowed to be met from PAs, or acceptable alternatives must be provided in place. In Uttar Pradesh, a government order has made it possible for villagers around Rajaji National Park to once again legitimately collect bhabbar grass for rope-making (though the Park management has not been so forthcoming in implementing this); in many states, ecodevelopment activities have offered livelihood opportunities to villagers. In Tamil Nadu, the Kalakad-Mundantharai Tiger Reserve is experimenting with innovative ways of reaching financial and developmental benefits to villagers in the adjacent areas.

While some of these examples show continuation of serious conflicts, others show the existence of significant opportunities for more effective conservation in the future. There are many instances of conflicts being resolved, dialogues opening up new partnerships, communities protecting habitats on their own steam or with support from officials, forest officers entering into informal arrangements with communities for conservation and access to livelihood resources, and so on.

1.4 Why A Change?

At this stage, let us review the major reasons why Indian conservation strategies must change to being far more participatory than they are at present :

I. Substantial dependence for survival and livelihood resources continues in a majority of natural habitats, including most PAs; it is impossible, even if the government had the good intentions, to resettle or provide non-ecosystem based alternatives to the several million people with such dependence;

2. People have a right to the resources on which they have traditionally depended, especially when their access to such resources pre-dates official conservation efforts;
3. The wildlife wing or department continues to be given step-motherly treatment by governments, with serious shortages of funds, human power, equipment, and training;
4. Public and political support for conservation has declined considerably, and politicians are unlikely to see the need for change unless a substantial part of their electorate were to demand it;
5. Considerable knowledge and experience about natural habitats and wildlife exists, even now, with traditional communities; this is fast eroding, and needs to be protected, respected, and built on for conservation programmes;
6. Serious new challenges have come from the commercial-industrial world, especially in the 'liberalised', 'globalised' context, and it is only committed partnerships between local people and outside conservationists/officials which is going to be able to face these challenges.

1.5 Ecodevelopment: Is it an Adequate Response?

Wildlife and forest officials have not been blind to the above situation. In the last few years, realisation of the impossibility of saving wildlife in the midst of hostile and hungry humans has grown considerably. Perhaps the single most ambitious official response has been *ecodevelopment*. Advocated as a strategy even as far back as the National Wildlife Action Plan (1983), ecodevelopment aims at providing alternative livelihood options to villagers, thereby weaning them away from dependence on natural ecosystems. Typical ecodevelopment inputs include employment opportunities like dairying, horticulture, handicrafts, etc., energy saving devices such as more efficient stoves, and market linkages such as roads and transportation. A Central Government scheme has disbursed funds for ecodevelopment to various states since 1990; in addition, the World Bank in association with other groups has funded ecodevelopment in several reserves (notably Great Himalayan National Park and Kalakad-Mundantharai Tiger Reserve over the last four years), and recently approved a Global Environment Facility (GEF) loan to implement ecodevelopment in another 7 PAs.

There is, unfortunately, no systematic account available of the earlier attempts at ecodevelopment. Last year when asked at a Planning Commission committee meeting for any monitoring that had been done of these efforts, only vague answers (such as the number of smokeless chullahs distributed) were forthcoming. Some accounts are available of the work in Great Himalayan Park and Kalakad-Mundantharai. NGO accounts in the former suggest that ecodevelopment inputs (pressure cookers, roads, etc) do not match the requirements of the poorer sections of the villages, and that there is little evidence of the work having benefited the Park (Baviskar 1998). On the other hand, official and donor accounts in the latter suggest that people's livelihood status in many villages has improved, pressure on the P A has come down, and financial management by village committees has been successful (World Bank n.d.; Melkan-n"998). The GEF funded project is still too new to judge; officials and some NGOs who worked on it clai~that it was built up in a far more consultative manner than previous conservation programmes, while some other NGOs and communities claim that essentially it was still planned in a top-down manner. The truth is probably somewhere in the middle.

But while it is undoubtedly a serious effort at tackling the conservation-people conflict, and certainly more people-oriented than conventional conservation programmes, ecodevelopment has a great distance to go if it is to become a truly participatory form of conservation. In particular, it will have to confront the following major weaknesses :

1. Since the major objective remains that of reducing people's 'pressure' on natural habitats (with the mistaken assumption that all human activities in the area are necessarily negative), the dominant model is still one of 'separation' or 'exclusion' rather than 'integration' or 'inclusion', In other words, ecodevelopment advocates would still much rather alienate local communities from the natural habitats which are sought to be officially protected (giving rise to the risk that their stakes in its conservation may actually go down), rather than find ways of integrating their livelihood needs and their traditional practices into the conservation of the area. This could be a short-lived, unsustainable form of gaining people's participation.
2. Ecodevelopment largely restricts itself to peripheries of P As, or to the immediate surrounds of their settlements within P As. Though it is sometimes claimed to be a means of involving people in P A management, ecodevelopment is not a model of participatory planning and management of the P A as a whole. Even the new ecodevelopment project, funded by the GEF, separates the "Improved PA management" component (exclusively carried out by existing bureaucracies) from the "Village ecodevelopment" component (which involves villagers in planning and implementation) (World Bank 1996).

3. Ecodevelopment largely limits itself to working within the existing framework of law, essentially the Wild Life Act and related legislation (though some of its proponents, e.g. Kishore Rao of the Ministry of Environment and Forests, do advocate some changes in this framework). Thus even where it talks of only allowing "voluntary displacement" (as directed by the World Bank, which, after its Narmada and other fiascos, is now mortally scared of the charge of forcibly evicting people from their lands), it does not attempt to create the legal and administrative conditions within which people would be able to stay on if they so wished, and be given the powers and responsibilities for effective conservation and sustainable use.

4. There is very little attempt to build on available local community institutions, knowledge, and practices, even though some conceptual documents related to ecodevelopment suggest this as a part of the strategy. Typically (though not always), official agencies have come in asking villagers to create institutional structures in formats pre-determined by the government, and the use of traditional knowledge has been restricted to PRA mapping exercises and building up ethnobiological checklists (see, for instance in the case of Great Himalayan National Park, Baviskar 1998).

5. Though the GEF project talks about 'leveraging' the inputs (including finances) of other government agencies working in and around the identified P As, available accounts suggest that this has rarely happened. State governments have not bought into the idea, and have therefore made little attempt to reorganise their plans and allocations in such a way that all official agencies would cooperate with wildlife officials in providing conservation-oriented developmental inputs. Indeed, it can be argued that if this was seriously done, it would eliminate the need for World Bank or any other foreign funding, since the amount of money available in various government welfare and developmental schemes is far more than is given by foreign aid agencies.

6. It is not yet clear whether the strategy of diverting people's pressure by providing alternatives does actually help wildlife conservation. Some conservationists have argued that rapid development of the peripheries of P As could attract many more people from further away to come in, thereby increasing pressure. Even if this does not happen, there is the issue of introducing lifestyle changes which make villagers more like the resource-guzzling consumers that we in our cities have become. Like us, their immediate impact on the nearby ecosystems may decrease, but their indirect impact on ecosystems locally or elsewhere will only increase to unsustainable levels. There is also the danger of making people even more dependent on government or NGO doles rather than encouraging them to become self-reliant. It is not clear whether the ecodevelopment thinking and implementation is seizing on the opportunity of showing the world an alternative development path based on sustainable, self-reliant rural lifestyles.

7. Finally, and perhaps most important, ecodevelopment does not attempt to reverse the historical process of state take-over of community lands, and the common (though not universal) denial of rights and tenurial security over resources for local people. It has taken the important step of involving people in planning the development inputs they want, but these inputs are still predominantly handouts from government, and there is a continued denial of the revival of people's resource rights within and around p As. Evidence the world over suggests that handouts are not an adequate stake for communities, and that one of the most effective long-term stakes is tenurial security over livelihood resources, with appropriate responsibilities built in.

To be truly participatory , and therefore more sustainable, ecodevelopment needs to build in these elements:

1. A model of conservation which admits (while not taking for granted) the possibility of integrating human uses within conservation values, and evolves alternatives only where this is not possible;

2. The full participation of local communities in the planning and management of the entire conservation area (except remote areas with no human populations or influence, or areas with new populations who are disinterested in conservation);

3. Readiness to question and continuously evolve legal and policy measures to respond to conservatioll8Dd livelihood requirements;

4. Building on available local knowledge and institutions, supplementing it with formal knowledge and institutional Structures from outside where necessary;

5. Re-organisation of local, state, and national planning to coordinate the activities; humanpower, and funds of various government agencies, towards conservation and sustainable resource use;

6. Devising ways to utilise or evolve sustainable livelihoods which can be based largely on local resoources (related to Point I above);

7. Providing long-term stake in the conservation and sustainable use of habitats and wildlife by reviving resource rights and tenurial systems, with appropriate

powers and responsibilities, and suitable checks and balances to avert misuse.

In theory, ecodevelopment could build these elements into its future planning. Indeed, World Bank officials or Indian consultants who have been questioned about their support to ecodevelopment have said that the GEF project has built-in processes of self-correction. However, given that many of the above issues require, far more planning, organisation, and re-orientation amongst all stakeholders, it is doubtful that they can be built into a process that is already going ahead full-steam, and where the reigns are still held by the government.

Perhaps it would be possible for these aspects to be built in for future ecodevelopment projects, such as the new one which the Government of India is considering for submission to the GEF (for 40 more PAs). However, if indeed such changes were made, the result would be a very different creature; it would be some form of joint or participatory management of natural habitats and species. That, perhaps, is what many NGOs and community groups are asking for, and what we shall explore in more detail in Section 2 below.

1.6 Towards a New Paradigm

Non-official responses to the crisis facing India's wildlife and the conflicts mentioned above have ranged from an advocacy of more stringent, military-like protection of habitats and species (the 'animal rights' lobbyists), to strident voices arguing that people's rights should prevail over wildlife interests (the 'human rights' lobbyists). Somewhere in between these two extremes has been a group of people who argue that both wildlife and human rights are critical, and that given appropriate changes in attitude and policies, this can well be achieved.

A series of dialogues and other events over the 1990s have helped considerably to build bridges between hitherto warring factions, and this has been further aided by the perception of a common enemy, the rampant 'development' process which bulldozes both natural habitats and local communities. In two successive consultations between wildlife conservationists and social activists (1997 and 1998, at Bhikampura, district Alwar, Rajasthan), a common declaration was adopted, asserting the need to protect both wildlife and human rights, to oppose forcible displacement in the name of conservation, to protect threatened species even against use in traditional practices, and to use other means to both conserve wildlife and ensure sustainable livelihood rights. The plea for joint or participatory management of PAs was strongly made at these and other meetings, as was the appeal to jointly monitor and check poaching, timber smuggling, encroachment, etc.

PART 2 : LESSONS FROM THE FIELD : TOWARDS PARTICIPATORY CONSERVATION

It is one thing to realise and advocate the need for people's involvement, and quite another to actually make it happen. What are the circumstances, the ground and policy conditions, under which it would work? Is it relevant everywhere, for all habitats and species? What precisely is meant by participatory/joint management, and what processes are needed to achieve it? What are the major hurdles and opportunities in its path?

As group of people affiliated to the Indian Institute of Public Administration and Kalpavriksh, we have carried out a series of case studies, and been involved in work on the ground, relating to people's participation in conservation. While the case studies have been conducted in India, lessons have also been learnt from other countries of South Asia, and currently we are helping to coordinate field studies in Pakistan, Nepal, Sri Lanka, and Bangladesh. In addition, we have been involved in the series of consultations and workshops mentioned above, and in responding to the periodic crises that natural habitats (including P As) and resident communities face in various parts of India.

This involvement over the last few years, in addition to the experience of a number of other groups and individuals, has provided a number of critical lessons which need to be heeded in our quest for participatory conservation methods. These lessons are described below.

2.1 Research/Information/Monitoring

Despite decades of existence, India's protected area network and other natural habitats remain considerably understudied. Information on several individual areas (including PAs) and many species, is thus severely lacking, and it is no wonder that management is more often than not piecemeal and haphazardly planned. There are several specific aspects to this:

i. A historical understanding of the area or species to be conserved is needed. This would include assessment of the changes in ecological conditions, land and water use, political and economic relations, legal status, and other parameters, over at least a brief historical period. Given that these factors have given rise to the current situation of conflicts and opportunities in and around each of the areas, such an understanding is clearly of paramount' importance.

More focus on historical research, including the oral history of local community members, is needed. Often information or knowledge of this does exist, but needs to gathered together and analysed adequately.

ii. An ecological understanding of the area, especially the impacts of various human activities on elements of local biodiversity and on the ecosystem as a whole, is also weak in most areas, especially amongst the managers of p As. Indeed, on enquiry we have found that the vast majority of management decisions, including those to curb human use, have been done on the basis of assumptions and generalisations, not solid research or evidence from site-specific circumstances. That is perhaps why, research (especially long-term) has often shown these decisions to be mistakes, and to have caused unintended negative consequences. The ban on grazing in some reserves (e.g. Keoladeo National Park and Valley of Flowers National Park; see Ali and Vijayan 1986; Vijayan 1990; Naithani et.al. 1992), the deliberate setting of fire in some circumstances or its complete stoppage in others, are examples of this. One does not thereby deny the role of decision-making on the basis of quick indicators or even intuition, but then conservationists (including wildlife officials) must be willing to constantly put these decisions to test, and agreeable to changing their prescriptions if found to be wrong.

Much greater emphasis on ecological assessments, involving both local people and outside scientists, is needed. Simple and short-term indicators and methods which can be used should be popularised, to supplement long-term and in-depth studies.

iii. The indigenous/local community knowledge base, where relevant, needs to be built upon in the management of these areas and species, including in the research mentioned above. Understanding of such knowledge (in its full context, as explained in Section 1.2 above) is often very low amongst the officials managing PAs and other areas (with exceptions such as at Melghat Tiger Reserve where Korku tribal knowledge has been studied by forest staft). Even though local communities are rapidly losing their traditions, we have found considerable evidence of the continuation of their knowledge base, especially amongst the elderly members (e.g. in Kailadevi Sanctuary of Rajasthan, Dalma Sanctuary of Bihar, Melghat Tiger Reserve of Maharashtra, tribal and non-tribal communities in many Reserve and Protected Forests of the country, fishing communities in Andaman and Nicobar Islands, Lakshadweep, and others). Given that we have in our studies only scratched the surface (anthropologists admit that even after years of study, they often do not fully understand the knowledge/ practices of a community in its full context), what is potentially available amongst the villagers is probably quite substantial. This knowledge could be critical in better managing the area, especially if more participatory processes have to be built up, though it is not contended by us that this knowledge alone would be adequate for the purpose. But in order for it to be of use, it must first be better understood by the formal sector, respected for its own worth, and protected against misuse (see also below, on benefit-sharing relating to indigenous knowledge). It will require a major educational effort to instil officials of the Forest Department an attitude of learning from local people.

Mutual learning exercises between forest staff local villagers, and NGOs are urgently needed, especially to understand local and other forms of knowledge in their own contexts, and to use these in synergistic ways.

iv. Access to available information must be enhanced to all stakeholders. At Kailadevi Sanctuary (Rajasthan), for instance, we found that even the front (ground) staff of the Forest Department was ignorant about the nature of the massive ecodevelopment plan that had been launched for the p A; and the villagers had simply not heard of it. And it is not only governmental information which is thus not accessible; in the case of Dalma Sanctuary (Bihar), we found that a detailed study on the elephant conducted in the Sanctuary by the Bombay Natural History Society, was not available with the officials in charge of the area. We finally obtained a copy and sent it to them! Moreover, what little information exist for most such areas, is often in English or the state language, and therefore often inaccessible to the local villagers.

A system of sharing all information, especially amongst the various stakeholders, is urgently needed," there is no justification for any governmental or NGO document being withheld from the public"

There needs also to be greater networking and sharing of information amongst personnel managing protected and other areas, especially those who could learn from each other's experiences. Exchange visits of personnel and community members would be one effective medium of such sharing. Relevant management plans, research reports, and other documents from one conservation area should also be more easily available to another area than is currently the case.

v. Universal acceptance of available information has to be attempted. This is currently absent. For instance, Gujjars and NGOs working in Rajaji refuse to accept the official figure of the number of sedentary and migratory Gujjars in the area, while officials scorn NGO figures. Very often, even formal ecological research by independent people has not been accepted by wildlife managers, resulting in valuable data being left unused. The process of negotiation

between stakeholders in Rajaji, currently underway, includes some such research (Rathore 1997), and will hopefully yield data which are more universally acceptable.

There is a need for a participatory method of conducting research and investigation,' which would yield information which is acceptable to all.

vi. Monitoring of ecological and social parameters in and around conservation areas and relating to protected species needs to be instituted as a systematic management activity .It is very weakly developed in India's protected areas (not to speak of other areas of conservation significance), with the exception of the periodic census of some animal species in PAs, some biodiversity monitoring (such as in a few PAs in Maharashtra), and some ecological monitoring in ecosystems outside PAs (e.g. some JFM areas). What this means is also that we have only rough indicators of whether or not conservation programmes are being successful; we know that tiger and elephant populations have gone up (or at least had till this decade), but we do not know if in the process some other lesser known species may have declined or increased in the same habitat. In Dalma, Kailadevi, Rajaji, and many other PAs, some mega-species are annually counted, but there is virtually no other monitoring. Even many externally aided ecodevelopment programmes have this weakness; some attempts are being made to plug it in the new GEF-funded project, but it is too early to tell their effectivity. With an inadequate database, it will in any case be difficult to judge the impact of management and ecodevelopment plans. Such monitoring should assess the impacts of human activities and management strategies on the ecological status of the P A and surrounds, and on the social and economic conditions of the local communities. Advocates of community participation in conservation also, of course, need to build in such monitoring, to ensure that the switch to community controls does not endanger the ecological status of the area.

Long-term monitoring and evaluation programmes need to be instituted in conservation areas. However, since such comprehensive monitoring may be unrealistic in many immediate situations, there is an urgent need for some good qualitative and quantitative indicators (including some that may emerge from local knowledge) to be used, and for simple monitoring procedures with local community involvement to be put into place.

2.2 Stakeholder Dialogue

A basic problem plaguing India's conservation programmes seems to be the absence of any form of dialogue among the various stakeholders, and in particular between wildlife authorities and local communities. What little interaction that exists, is strongly one-sided, with the Forest Department being dominant; or else it is confrontationist. The result is that each group is rather misinformed about the others' positions and justifications and circumstances. For instance, many officials are sharply critical of traditional resource uses of villagers, and do not understand the cultural significance of the event; on the other hand, villagers universally label the Forest Department as corrupt and inefficient, and are not fully conversant of the pressures under which Department staff has to work.

Regular and open dialogue, with neither side assuming the position of supremacy, could considerably ease tensions between wildlife officials and local communities. This has become clear from the experiments at achieving a more participatory process going on in various places, whether initiated by officials, NGOs, or community members: Rajaji National Park (Rathore 1997), Kalakad-Mundanthurai Tiger Reserve (Melkani and Venkatesh 1998), Kailadevi Sanctuary (Das 1997), Dalma Sanctuary (Christopher 1997), dozens of JFM areas (Poffenberger and McGean 1996). By no means, however, is this process a panacea, since there are also deep differences in attitudes and motivations which cannot be resolved only through talking...but at least talking and listening is the first step towards such resolution.

Clearly, forums for such dialogue, both informal and formal, are amongst the earliest steps that need to be taken in each of India's protected areas where conflicts are taking place. It must also be stressed that the dialogue should be consciously open to all stakeholders (with an appropriately special focus on resource users and conservers, especially local communities), and should not be a mere formality that government agencies go through because a donor requires it.

2.3 Institutional Structures

Current centralised, top-heavy institutional structures for conservation of natural habitats and species, are clearly unable to fulfil their responsibility for reasons mentioned in Section 1 above. Serious changes in this system have already been made with reference to forest lands under JFM (Poffenberger and McGean 1996), or village lands in the case of some ecodevelopment projects (e.g. Kalakad-Mundantharai Tiger Reserve, see World Bank n.d.). However, there is still considerable resistance to such changes in the case of standing forests (especially Reserve Forests), PAs, and protected wetlands or marine areas. Some changes are beginning even here; e.g. the Forest Department has recognised Van Suraksha Samitis in Kailadevi Sanctuary .Several different aspects of the

present conservation effort are striking :

i. Far more openness is needed in the official system to recognise existing institutions amongst local communities, and strengthen them towards meeting the needs of conservation and livelihood security .In the case of Dalma and Kailadevi Sanctuaries, for instance, there are extremely innovative structures established by the villagers in the form of Forest Protection Committees, which are obvious candidates for devolving management functions such as patrolling, fire prevention and control, and catching or reporting offenders. To some extent, the Forest Department appears to recognise this, but it also lacks the flexibility to allow for local variations in the structure and functioning of these bodies. So in Kailadevi, it has started its own Van Suraksha Samitis, which (with a single exception) appear to work less effectively than the villager-initiated Forest Protection Committees (Das 1997). In Dalma, as in many other areas under ecodevelopment or other schemes, the Forest Department has started or proposes to start Ecodevelopment Committees, since it feels that this is the only structure permitted under current government programmes and laws. Unfortunately, such government-initiated institutions have to confirm to uniform guidelines and format (e.g. having a forest officer as a major functionary), which mayor may not suit the local conditions.

A potentially powerful opportunity for utilising local institutions for conservation and resource management, is the 73rd Constitutional Amendment related to panchayati raj bodies. In particular, the extension of this amendment to Scheduled (tribal) Areas through a specific enactment in 1996, has opened up the possibility of devolving more resource controls to communities while ensuring conservation responsibility and accountability. It is not yet clear how the provisions of these enactments relate to PAs or other government lands such as Reserve Forests, but certainly they can be used to promote community-based conservation. By the same token, they can also be used by vested interests to subvert conservation programmes, so it would be well worth the while of conservationists to study and utilise its potential before the enemies of wildlife do so.

There is a need to understand existing community structures much better, and to build on their diversity and strengths as far as possible rather than displacing them with new, uniformly structured institutions. The recent constitutional and legal changes decentralising decision-making functions to village-level bodies can be creatively used, though they also have the potential of creating great damage if misused.

ii. To involve people at more than their village scale, there is a need for institutional structures covering the entire conservation area or substantial parts of it. At the moment, even where village-level committees have been set up under JFM or ecodevelopment schemes, the overall management of the conservation unit or protected area remains exclusively in the hands of a government agency, with no formal involvement of the local communities. While an immediate change in such a process may not be feasible, as a first step, advisory bodies comprising various stakeholders should be established for each of these P As. This proposal has already found partial acceptance in the draft new Wild Life (Protection) Act which is currently under consideration by the Central Government; it provides for advisory bodies in the case of sanctuaries.

Eventually, however, there needs to be a gradual shift towards joint or participatory management institutions, which involve the Forest Department and local communities as equal partners in decision-making and implementation. These would, of course, only be relevant where local communities have a substantial stake in the conservation and/or sustainable use of the area or species in question. We have even suggested such a joint structure for the ongoing procedure of settling people's rights, which is being urgently and rather haphazardly being carried out by state governments (primarily district collectors) under direction .from the Supreme Court. It is only through such a participatory process that a fair and sustainable settlement will be worked out.

iii. Most tricky but absolutely crucial, is the need for institutional structures which could ensure regular coordination within and amongst the various governmental departments which have a bearing on the habitats or species sought to be conserved. In all the p As and other areas studied so far, we found a severe lack of interaction and joint planning between the Forest Department on the one hand, and other government agencies on the other hand. The serious shortage of water inside the Kailadevi Sanctuary (a severely drought-prone area) must have been common knowledge with the forest staff, yet the district administration appeared unaware of the situation in several villages when we were conducting research in 1997. In Dalma, the Bihar Irrigation Department appeared to have taken decisions (e.g. the alignment of the Subarnarekha canal) without consulting the sanctuary authorities; the classic case of mining in the Sariska Tiger Reserve is of course well known. In the case of many areas, e.g. at Kailadevi, there are also significant complaints of a lack of coordination within the Forest Department itself, between the wildlife wing and the territorial wing.

As mentioned above (Section 1) in the case of ecodevelopment, it is our contention that if all government agencies working in an area were to coordinate their activities according to a regional land/water use plan, within which were nestled areas earmarked for conservation, there would be little need for foreign funding. And if this is not done, conservation will in any case be difficult, as development plans will keep pulling in directions away from those set by the wildlife agencies. Such coordination was for a few years achieved by an enterprising district officer in the case of Melghat Tiger Reserve (Pardeshi 1996), and in the case of the forests in Harda district by an equally enterprising forest officer (Rathore 1996), so there appears little reason why it cannot be done elsewhere.

An interesting example from the forests of central India illustrates that, here too, people's empowerment and participation may be one potential key to achieving inter-governmental coordination. In the village of Mendha-Lekha, Gadchiroli district, villagers are so well-organised and self-empowered that they can call all government departments to the village and organise a joint meeting to pool their funds together (Pathak, pers. comm., 1998).

There is a need for a clear state governmental order, issued to all its agencies working in and around PAs, that they must coordinate their work in the larger interest of conservation and meeting people's livelihood requirements. Appropriate empowerment of people's institutions, and the use of NGOs and other agencies as watchdogs, can also help to achieve this.

2.4 Benefit-sharing Mechanisms and Rights

The realisation that in the absence of tangible benefits emanating from the protected area, local communities are not likely to become a strong support base for the area, has resulted in the search for innovative mechanisms of generating and sharing the benefits. Perhaps the most powerful stake, is the continued and guaranteed access to survival resources, including biomass, as a matter of traditional right and not merely concession by the state. Linked to this is secure tenure over land and other resources; not, however, to unsustainably sell off to the highest bidder, but to assume the responsibility for conservation and sustainable use.

Conservationists have conventionally believed that p As cannot yield substantial benefits for local people, hence they are unlikely to have the incentive to participate in conservation (e.g. Singh 1996). This view is based on the assumption that (a) biomass resources are the primary benefits that local people require and this is not possible to give since (b) human activities would inevitably degrade ecosystems. Therefore, the conclusion is, protected areas must generally be off-limits to human use. Neither of these assumptions is necessarily valid. As stressed above in Section 1.2, some forms and levels of human use do not cause irreversible damage to biodiversity, and indeed may even locally enhance it, though it would be dangerous and invalid to extrapolate this to all activities and all ecosystems. Moreover, substantial benefits may accrue from non-biomass based use of the p As, even though biomass resources will remain a major component.

A rough list of possible benefits that a PA can yield is:

Subsistence

fuel
fodder
non-timber forest produce timber
fish/other aquatic produce

Economic/livelihood

forest/aquatic/grassland produce
value enhancement of traditional products
employment
returns from commercial use of local knowledge/ resources tourism revenue
compensation for wildlife damage/opportunities lost development inputs

Social/cultural/political

protection of cultural values
social recognition
empowerment/control

It stands to reason that if these are possible within a p A, they are certainly also possible in the case of wildlife habitats outside the p A system. Indeed, many JFM and wetland areas provide adequate proof that a range of biodiversity can coexist with sustained generation of benefits for local populations.

In our work in the field, some striking features have emerged in relation to benefits:

i. Access to regenerating and protected biomass resources is seen by local people as being critical. In Kailadevi and Dalma, villagers stress this as a traditional benefit; in Rajaji, they are more vocal in arguing that such access should be considered a customary and legally defensible right. The provision of bhabbar grass to villagers around Rajaji, by order of the Chief Wildlife Warden of Uttar Pradesh on May 8, 1995 (Vania 1997), though not amounting to such a right, is nevertheless a welcome step in that it recognises the need to share the resources of the P A as benefits to local communities. So is the order of June 26, 1996, of the West Bengal government, under which Ecodevelopment Committees are to be set up for P As, and resources within the PAs can

be shared with villagers in return for conservation functions (Government of West Bengal 1996).

In many areas, conservation actually increases the biological resources (fish, fodder, medicinal plants, etc) which local communities can harvest, yet sometimes they are not quite aware of this. In Sunderbans Tiger Reserve, for instance, fish stock in surrounding areas has reportedly increased due to protection of breeding grounds inside the Reserve. Lack of awareness of such benefits could be simply because they do not have actual access to these regenerating or multiplying resources; or it could be because, though access is available, the connections with the conservation programmes are not evident. This happens, for instance, with the increase in water availability as hydrological cycles improve with conservation of forests. In such situations conservation authorities and NGOs could playa significant role in highlighting the connections, thus also building a stake amongst local communities.

The sticky issue that remains is one of whether the access so granted should be a legal right. or merely a concession offered by the government. As in Rajaji, communities everywhere are saying that they do not want to be at the mercy of a fickle government, which one day will allow access and the next day ban it (e.g. what happened with grazing in Keoladeo National Park, Rajasthan). They would much rather take on conservation responsibilities if they are guaranteed some security of access, in other words tenurial rights. Perhaps unknowingly, they are reflecting a lesson that has been learnt the world over (and, for that matter, in JFM in India), viz. that resource rights are a much surer stake in conservation and sustainable use than uncertain access dependent on the whims of more powerful authorities.

Whatever the kind of benefits that accrue to local communities, it seems imperative that these be considered not as acts of charity by the government, but as a matter of rights for people who have otherwise 'sacrificed' for the PA. Resolving issues of resource tenure and rights is critical if a long-term stake in conservation is to be created amongst local communities. Undoubtedly also, conservation responsibilities must go tandem with these rights, a point that many local communities themselves will stress. Awareness about the connections between conservation and benefits is critical for all stakeholders.

ii. Though in relation to countries like Kenya, India's returns from wildlife tourism are miniscule, nevertheless they are substantial in some PAs and non-PA areas (e.g. mountains). Without at this stage judging the ecological or social advisability of these levels of tourism, it is a shame that the revenue being earned from it does not go back to the P As or the local communities. Reportedly this is now being considered in the case of Keoladeo National Park, Rajasthan (where detailed studies have shown the potential of benefiting the local villagers from this source of income; see, for instance, Murty 1996). India would do well to learn from experiments such as the Annapuma Conservation Area Project in Nepal, where local communities and NGOs are completely managing the enormous trekking tourist flow, and generating very substantial returns from it.

It is high time that the country made the financial and administrative changes that are needed to r~turn wildlife tourism benefits to local communities and wildlife authorities for use in conservation and livelihood generation activities. Appropriate checb may be needed to ensure that this does not become an encouragement to increase tourism beyond the ecological and cultural limits of the area.

iii. Villagers themselves often have very innovative ideas for benefit-sharing. One, mooted by villagers of Kailadevi as part of a resolution adapted at an IIPA - sponsored workshop, was that the penalties imposed by the Forest Department on offenders whom the Village Forest Protection Committees (FPC) help to catch, should be returned to the village. In addition, the issue of compensation for damage by wild animals to crops, livestock, and humans needs to be urgently addressed, both to improve the rates of payment and the efficiency with which it is paid. This is a universal demand from affected communities all over India. A suggestion made by the Kailadevi villagers in this regard is to accept the recommendations of the FPC with regard to individual compensation claims, rather than insisting that a doctor or official certifies the damage, a process which not only consumes time but also often forces villagers to bribe officials to obtain a favourable report. Another innovative attempt is by some NGOs (such as Corbett Foundation and the WWF through its Tiger Conservation Programme), which quickly detect cases of livestock kills and pay compensation equivalent to the difference between the market rate and what the government provides, or have given vehicles to the Forest Department to quickly reach villages reporting such cases (see Tigerlink Vol. 4 No.2, September 1998).

Benefit-sharing (or cost-sharing) plans should be rooted in local ideas and technologies where available, enhancing these or introducing external ideas and technologies if necessary, as supplementary to what is locally available.

iv. Benefits linked to natural resource related knowledge and innovations that local people have, are a part

of the global debate on biodiversity. The protection of indigenous knowledge through appropriate community and individual intellectual property rights, and the generation of benefits from the use of these knowledge, are now being considered all over the world, especially in the wake of the Convention on Biological Diversity. The Convention mandates countries to protect such knowledge, seek permission from its holders before using it, and equitably sharing any benefits that come out of such use. India too is considering National and State-level Biodiversity Funds, which could be used to give incentives to communities and individuals who promote conservation and sustainable use. There are several possible methods of doing this (Nijar 1995; Shiva 1997; Gupta 1997; Pathak and Kothari in press), which should be considered for use in conservation programmes.

Researchers in the formal sector should be particularly aware of such issues. Academics get extremely upset if someone takes their information or ideas without due acknowledgment; indeed, the person can even be sued for plagiarism. It is strange then that the same yardsticks are not applied by most of us when using local people as guides, informants, etc.; how many PhD dissertations, research reports, forest working plans, PA management plans, and other such documents actually name each of the local villagers who has provided information that has gone into these documents?

Benefits and incentives linked to the knowledge and innovations of local communities, as relevant for conservation, should be seen by conservationists as a potentially powerful tool to employ. To do this, however, they will need to support far greater respect for this knowledge, and legal means of protecting it from misuse and expropriation by outsiders. Researchers must evolve some code of conduct for use of such knowledge, ensure that it is properly acknowledged, and return some degree of benefits arising from its use to the original holder.

v. Even those basic survival and developmental needs of communities which are seemingly unconnected to wildlife conservation requirements, are equally vital to address. Indeed, it may well happen that some rural areas which were earlier neglected by government, receive some attention because of the establishment of a PA or conservation scheme in their region. In Kailadevi, the serious deficiencies in water which are faced by villagers, may get alleviated if current trends are an indication: both NGOs and government agencies (including the district administration and the Forest Department) are investing time and money into water harvesting structures, and communities are re-organising themselves to participate in this. The institutional capacities and partnerships which are thus built up may help ultimately in conservation too. To some extent, ecodevelopment also aims to do this.

Conservation agencies and advocates must therefore go beyond their narrow confines and look into broader issues of livelihood and development, if they are to earn the support of local communities. The sort of inter- governmental and inter-sectoral coordination mentioned in Section 2.3 above would also help considerably in this.

vi. Finally, and this is a point that social activists are often loath to admit, many benefits being derived by communities from p As may already be causing irreversible damage to ecosystems or species. Others that are being demanded may do the same. There is therefore a critical need for assessment of all such unsustainable activities, and the search for on-site or other alternatives (ranging from modifications in these activities, to completely unrelated alternatives) where they cannot possibly be in harmony with the conservation objectives of the area. Ecodevelopment activities are essentially aiming at this. Both the assessment and the search for alternatives, however, are likely to be much more effective if conducted in a participatory manner; otherwise, they run the risk of either being biased or inaccurate, or being rejected by the affected communities. In several successful community-based conservation efforts, activities have been curtailed when villagers have been convinced that they are destructive.

Human activities relating to benefit-generation must be assessed for sustainability (whether they are not causing irreversible damage to the area or species sought to be conserved), and alternative benefits devised where they are not sustainable. These assessments and development of alternatives should be done in a participatory manner with the affected communities.

2.5 Intra- and Inter-community Dynamics

Both social activists and conservationists often assume the local community to be a homogenous entity .In India, it is far from that, especially in non-tribal areas. Official programmes of involving people in forest regeneration (JFM) and PA conservation (ecodevelopment), as also many NGO projects, have generally failed to disaggregate the community by class, caste, and gender. Even when they are aware of it, these agencies have been reluctant to address the rather thorny issues of inequities and power play within and between communities, hoping that general prescriptions for community participation will sort these problems out on their own. But this does not happen.

In particular, the way in which inequities in social status, political power, economic standing, and other attributes influence conservation, does not appear to have been well-studied. Exceptions include Sarin (1996) and Baviskar (1995). We have been especially mindful of this factor while studying the potential for people's participation in protected areas. Some important results which have emerged are :

i. Women continue to be disprivileged in conservation programmes, both in those initiated by communities themselves as also in officially-sponsored ones. For instance, women are generally unrepresented in the Forest Protection Committees of Kailadevi, though in Dalma they are at times represented, which may be a reflection of the generally more equal status of women in tribal societies. In Kailadevi, women complained that the forest protection work of the FPCs (which were male-dominated) caused greater hardships for them, at least in so far as fuelwood collection had become harder (though they also admitted that fodder shortage had eased as a result of the forest protection). Most villagers, including men, agreed that there was a need for greater women's participation in decision-making, but they also strongly felt that this could not be achieved merely through formal reservation of seats in the local institutions (as has already happened with village panchayats in many parts of India). There was a need to build the capacity amongst women to be able to confidently speak and make their opinions matter, which, given the centuries of male domination in the area, would not be an overnight development. This is of course also true of the Forest Department and other line agencies of the government; Sarin (1996) reveals that out of 2576 Indian Forest Service officials in the country in 1995, only 72 (i.e. 3%) were women. The ratio is probably even worse in the case of the wildlife wing, since it is not considered 'safe' for women to take the kind of field-based jobs that are required.

   There is clearly a need for more women's involvement in decision-making in the local and wider level institutions, both governmental and non-governmental.

ii. Landless people, lower castes, minority communities, and other disprivileged sections within a community are often left out of the decision-making process. However, in some other cases, there have been conscious attempts on part of the village community to have representation of all these sections in the decision-making body. Villagers themselves increasingly realise the need to resolve the inequities in representation at decision-making bodies, and also admit that government or NGO intervention may at times be necessary to make this happen. In the tribal villages of Dalma, the problem appeared less acute, possibly because of the inherantly more equitable and homogeneous societies they are characterised by.

   Indifference towards this issue could doom the conservation effort in the long run, for people left out of the process are likely to consciously or accidentally undermine it. In the Great Himalayan National Park, Baviskar (1998) reports that the ecodevelopment process does not really reach benefits to the poorest sections of the villages, those who in fact are most dependent on the Park's resources. Such people will continue to "steal" into the Park for survival and livelihood, and chances are they would abandon whatever sustainable use practices they may have earlier employed in the quest to "cut and run" as fast as possible.

   Such issues can of course also be misused by politicians and others for populist purposes, and it often becomes very tricky to determine whether majority or minority views should prevail. Sustained dialogue, coupled with Conservation and development efforts need to be specially mindful of the needs of the disprivileged sections, taking care both to involve them as central partners and to ensure that their just share of benefits accrue to them.

iii. Inter-community inequities could also strongly influence the success or failure of people's participation in conservation attempts. Both in Kailadevi and Dalma, the forest protection efforts of some villages were often thwarted because adjacent villages did not undertake the same responsibility , and allowed their forest patches to be degraded/cut down, with detrimental effects on the protected patches. This brings into focus the need for larger level coordination bodies which can mediate between different villages, between villages and the protected area authorities, and among other stakeholders. The Baragoan ki Panchayat (council of 12 villages) in Kailadevi, created to bring together people of 12 villages who have a common interest in forest protection, is one such example.

   In all conservation areas where people's participation is being sought or is desirable, larger-scale forums or bodies which can link up various communities and institutions need to be established.

2.6 Intra- and Inter-departmental Dynamics

It is interesting that while the inequities and differences within and between local communities are increasingly being focused on by researchers, the internal dynamics of the government is not yet well-studied, much less seriously tackled. While we too have not examined this in detail, even casual observations

are adequate to indicate that the problems are severe:

i. There is little vertical interaction among the various levels of the p A authorities; the experience of the ground situation being gained by the frontline staff (forest guards, foresters, daily wagers) has no systematic way of getting to the 'higher' officials, and there is little reverse flow of the policy/ programmatic priorities being fixed by the latter. In Kailadevi, the Project team found that very little was known amongst the frontline staff about the ecodevelopment scheme. Scattered and individual efforts to redress this situation (e.g a meeting on ecodevelopment between senior and frontline staff, and some villagers, held on 26-30th November, 1996) are exemplary in all these areas, but they do not add up to any systemic response. Recent management planning exercises in Dalma and ecodevelopment planning exercises in Kailadevi, and the stakeholder meetings being organised in Rajaji, are giving an opportunity to partially increase vertical interaction; but it is too early yet to tell if they will result in a systemic change.

   Forest and wildlife authorities will have to devise ways of increasing the flow of information and ideas amongst the different rungs of the agencies, and throw out the stiflingly heirarchical atmosphere that the British colonial rulers taught their Indian counterparts.

ii. At the same time, horizontal coordination among the various wings/divisions of the Forest Department is also seriously deficient. There were, for instance, complaints by the wildlife staff in Kailadevi about the programmes of the territorial staff around the sanctuary , which, they claimed, had an adverse impact on the habitat. The wildlife officials also appeared to feel less powerful compared to their counterparts in the other wings of the Department. In many states, even p As have not been fully handed over by the territorial wing of the Department to its wildlife wing, sometimes because it is felt that the latter does not have the resources to manage them, but more often because the former simply does not want to relinquish control.

   The Forest Department needs to take a hard look at its own internal coordination amongst various wings/ divisions, and devise innovative ways to build more synergy towards the goal of conservation.

iii. Finally, coordination between the Forest Department and other departments/agencies of the government is far from satisfactory , as noted 'above. In the case of Dalma, forest officials complained of the lack of support from the police in tackling offenders, e.g. illicit liquor brewers. Lack of coordination between the Forest Department and the civil administration on the provision of water sources to villages inside Kailadevi, and on the problem created by the migratory graziers, was also prominent.

There is therefore a need for serious introspection by the Forest Department on their internal problems, and by the state governments on the need for inter-departmental coordination, followed by appropriate restructuring to improve coordination and motivation. This could include, for instance, interaction workshops between the senior and frontline staff of the wildlife wing, held in a neutral surrounding where participants could be more open and frank; and similar workshops and joint practical exercises among the various wings of the Forest Department and among the various government departments active in the area.

Other needs are well-known, though not yet fully addressed: training of conservation staff in wildlife/ habitat management, better facilities for the ground staff and for their families, and others.

2.7 Role of Outsiders

Apart from the local communities, the conservation authorities and some other government agencies, a critical role is being played by other organisations and individuals, including NGOs, In many of the areas we have been involved with, local or national NGOs have been instrumental in mediating between villagers and wildlife officials, gathering data, helping local communities to organise for their rights, and keeping a watchdog eye on local activities. Independent experts have also helped to make scientific assessments, though, as mentioned above, the research done till now is far from adequate.

Given the important role played by such 'outside' parties so far, one question naturally arises: in any process of participatory or joint management, what should the role of these parties be? Should it be in a controlling and decision-making capacity, equivalent to that of the government and the local communities, or should be more advisory? While certain flexibility may be required in deciding on a case by case basis, it is our opinion that the role of such parties should be mainly advisory and mediatory. This is because NGOs (as distinct from community-based organisations like the FPCs) have no direct stake in the resources, nor any formal responsibility, nor any formal accountability to anyone. They cannot claim to represent the communities (though they can, and do, act as central supporters), as this would only perpetuate a system in which villagers themselves continue to be sidelined. However, groups or individuals who are very active/ knowledgable may be co-opted onto the overall multi-stakeholder management body (as advocated in Section 2.3 above).

Wildlife authorities need to be far more open than is currently often the case, to external intervention and mediation, where this is constructive. However, caution is also needed against agencies and individuals who have vested interests in continuing conflicts or using local people as covers for exploitative activities, as for the instance the fish mafia appear to have done in the case of Pench National Park, Madhya Pradesh.

2.8 Legal Measures

Many of the steps described above are possible within India's current policy and legal framework governing conservation. For instance, the Ut tar Pradesh order concerning grass harvesting from within P As (including within national parks which are supposed to be devoid of human presence), was passed using the Wild Life Act's provisions concerning management activities which are beneficial to wildlife: it was argued that grass harvesting would help in fire prevention.

However, these spaces within current legislation only go a certain distance. There is inadequate legal mandate, and indeed a barrier, where it comes to steps such as setting up joint management committees for P As and other areas, or providing tenurial rights (or custodianship) to people in national parks even if conservation would be better served by this. Settlement procedures for rights remain vague, and large loopholes exist with regard to the entry of large development and commercial projects into conservation areas. Perhaps most important, the laws the sort of flexibility which would allow their constructive and creative use for a variety of ecological and social situations.

Both the Wild Life (Protection) Act and the Forest Act are currently (late 1998) under review, and citizens have strongly urged the government to make the changes necessary to facilitate participatory conservation. This has also been argued in the context of the proposed Biodiversity Act (being promulgated as a follow-up to India's ratification of the Convention on Biological Diversity), and the panchayati raj legislation. Mainly, three kinds of thrusts are required in the new legislation (Kothari 1997):

- Strong provisions against the use of conservation areas and threatened species for industrial or large-scale commercial purposes;
- Provisions empowering local communities to participate in management of such areas; and
- Provisions enabling resource-dependent communities to receive, as rights, appropriate benefits from such areas, in a way that is not detrimental to their conservation values.

Also suggested is a larger system of PA categories (renamed 'conservation areas' since they are not strictly protectionist), which would allow the flexibility of accommodating different kinds of ecological and social situations without compromising conservation values or livelihood rights. Bhatt and Kothari (1996) have suggested four additional categories to the two existing ones of national parks and sanctuaries: Strict Nature Reserve, Resource Reserve, Biosphere Reserve, and Community Reserve. A summary table of these is appended here.

Of these, the categories of Biosphere Reserves (as described in Chapter 4, this concept, which has the potential of harmonising conservation and human livelihood objectives over large land/waterscapes, has not really been applied in its full meaning in India), and of Community Reserves (which would provide a legal backing to communities who are trying to protect their sacred groves, catchment forests, village tanks, etc., but would retain control in their hands), are particularly important.

We would argue that with such an expanded set of categories, and using a much more inclusive range of conservation areas (see below), India's PA network could increase to well over 10% of its landmass (over double the present). This could in fact also include over 1% of its landmass under totally inviolate areas, jointly decided by government agencies and local communities, and including uninhabited islands, forests with no human use, sacred landscapes, etc.

2.9 The Larger Context of Land/Water Use

Most habitats of wildlife significance in India are not only themselves inhabited by humans, but also surrounded by human settlements, private lands, and developmental infrastructure. What happens in these adjoining areas has significant bearing on the ecological status of the wildlife habitat; e.g. the enormous fuelwood demand from Jamshedpur (Bihar) appears to be putting an unsustainable pressure on Dalma Sanctuary's forests (Christopher 1997).

In addition, economic and social policies and programmes at the state, national, and international level, can also have strong impacts on the P A. The decision to make a major dam at Tehri town, in the Garhwal Himalaya of Uttar Pradesh, has had a detrimental impact on far-away Rajaji National Park, as people to be displaced by the project have been resettled in the middle of the elephant corridor adjacent to the Park. In India as a whole, the ongoing phase of' liberalisation', has led to demands to denotify or alter the boundaries of several PAs, to enable commercial-industrial activities in these areas (Kothari et.al. 1995). The entire coastline and marine areas of India are threatened by plans to increase the export of fishery products (entailing the spread of polluting aquaculture and destructive trawlers), and to locate tourism and shipping facilities and industries.

While national and international forces cannot be tackled at the level of each conservation area, there is an urgent necessity, and possibility, of carrying out integrated land use plans for the whole region within which a critical wildlife habitat is embedded. One view is to declare the conservation area and its surrounding region as a special management unit, and set up an institutional structure to build up a detailed land/water use plan and manage this whole area. This is somewhat akin to the Special Area Development Authorities set up in many parts of India, but with an orientation towards conservation in this case. Examples of participatory management from across the world, reveal that such an approach is increasingly being taken by many countries (Suri 1997).

In the Indian situation, this option may still be tried only several years from now, for major structural changes in the way the government functions will have to be made. A few test cases, however, can be taken up almost immediately, provided the state/central governments are ready to back the experiment to the full. To a cetain extent, Tiger Reserves are attempting this, by handing over a substantial buffer area around the designated national park or sanctuary to the wildlife authorities; however, coordination amongst government agencies active within this area has not yet been very heartening, and community involvement remains very weak. This reveals that what is also needed is a close re-examination of the impacts of several state/national policies and programmes, on the ecological health of wildlife habitats in India.

In addition, it is vital to get away from the almost exclusive protected area focus of conservationists. True, representative and rich biodiversity sites need special attention, but this is not an excuse to neglect the need for conservation in non-P A sites. As is well-known, considerable wildlife (including many of the 'flagship' species of Indian conservation, the so-called charismatic mega-fauna) is found outside PAs, including in human-dominated ecosystems, and its only protection is what the Wild Life Act provides rather ineffectually, or what local people themselves are providing. A range of incentives to local communities where these species exist, or encouragement of beliefs and practices which allow them to thrive, would perhaps be the most effective way of protecting such wildlife.

In sum, closer examination of the various external factors influencing wildlife habitats and species, and steps to tackle these factors, are urgently needed. This includes, as mentioned above, strengthening the Wild Lite (Protection) Act against destructive industrial-urban influences and projects.

Eventually, it would be critical to ensure some level of conservation across the entire range of human land/water uses, rather than focus exclusively on a small percentage of biodiversity-rich areas.

3.CONCLUSION : HURDLES AND OPPORTUNITIES

India's conservation policy and programmes are moving increasingly towards more participatory processes. Rather than resist such a move, we (as conservationists) must see this as an opportunity to do what we have not been able to do for decades: make the conservation movement truly broad-based and grassroots rather than restricted to a small and increasingly ineffective elite. Indeed, it is only if we see village communities as conservationist in their own right, albeit with often different motives, and only if we see the legitimacy of their rights to survival and livelihood resources, will we be able to make conservation a sustainable effort. Some compromises may appear necessary (by both urban conservationists and local communities) to make these new alignments and strategies possible: some wildlife habitats may be lost, some communities may have to give up cherished traditions (such as mass hunts in areas with considerably depleted wildlife). But in the long run, a range of options in which co-management and community-based conservation figure prominently, offers a much surer vision of conservation than we have built over the last few decades.

The basic assertions made above can be summarised as follows :

I. The conventional method of protecting wildlife, especially the creation of p As, has undoubtedly saved many habitats and species from destruction, but also caused severe hardships for local communities dependent on these habitats and species.

2. The alienation of these communities from their resource base, which has been the result of exclusionary conservation policies and strategies, is both unjust and shortsighted, for wildlife cannot survive in the midst of dispossessed and hostile populations. A strategy of exclusion is in any case unviable, given the extent of dependence of several million people on wildlife habitats and the impossibility of finding alternative lands and resources for all of them.

3. People, especially those who have traditionally subsisted on local resources, have a continuing right to these resources, except where they are causing irreversible ecological damage, in which case viable alternatives have to be provided.

4. Official and non-governmental conservation agencies are becoming increasingly ineffective, in the face of declining political support and mounting 'developmental' pressures. Such agencies have inherent limitations of human, financial, and technical resources.

5. Both wildlife and local communities are threatened by a third party: the urban-industrial sector which

is bent on gobbling up natural resources as raw material and rural dwellers as cheap labour. Only a partnership between conservationists and communities/social activists, and the empowerment of ecosystem-dependent communities, can withstand this destruction, as can be seen at dozens of sites across India.

6. Changes are therefore needed in conservation policy, law, and administration, to allow for a much more participatory system, one which is respectful of both the needs of wildlife and the rights of humans. Such changes will have to bring in several factors previously ignored or only weakly integrated: relevant community knowledge and practices, customary laws and local institutional structures, vertical and horizontal integration within government agencies, land/water use planning in a regional context within which special areas for wildlife protection are supplemented by incentives for conservation across the spectrum of human resource uses, mutual learning sessions amongst various stakeholders, open access to information, and so on.

7. Decisions regarding conservation should be based much more on ecological, historical, and socio-economic research than is currently the case, research that is participatory and integrates the informal paradigms of local communities with the formal approaches of ecologists and wildlife scientists.

There are, undoubtedly, several hurdles to cross in achieving such a redirection of conservation strategy. These include :

- the rapid erosion of community knowledge and practices;
- loss of sustainability due to increases in human and livestock population and changes in lifestyle;
- social inequities at various levels;
- continued resistance from those who have power to share it with those who don't;
- severe distrust between government officials and local people;
- inappropriate development paths and national laws/ policies;
- political interference; corruption; and
- lack of capacity amongst all stakeholders.

But for each of these hurdles, there are also examples of people having overcome them and creating opportunities:

- revival of community-level knowledge, practices, and institutional structures relevant to conservation (such that, according to one recent estimate, upwards of 2.5 million hectares of forests are being protected by communities in India today);
- voluntary reduction of livestock numbers and/or regulations on free grazing by many communities;
- willingness to accept family planning if adequate incentives are available and where women are empowered;
- decentralisation opportunities created by recent constitutional amendments;
- informal and formal arrangements between communities and government agencies/officers for conservation and sustainable livelihood options;
- challenges to destructive development processes (the coastal ecosystems would be far more degraded were it not for the widespread agitation by traditional fisher folk against the introduction of trawlers and aquaculture);
- politicians taking up cudgels on behalf of conservation (e.g. to save Bhitarkanika and Balukhand Sanctuaries in Orissa from 'development' projects);
- reduction in the incidence of corruption where people's organisations have empowered themselves; and
- increasing awareness and capacity amongst different stakeholders to handle the complex job of managing natural resources.

The opportunities are there, and I believe that if the urban conservation community can respond adequately, and in time, to seize these opportunities, it will help to forge a new path of conservation. If it does not, it risks becoming increasingly redundant as larger forces take over.

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EXPANDED SYSTEM OF CONSERVATION AREA CATEGORIES FOR INDIA

(For explanatory notes, see Bhatt and Kothari, 1977)

Protected area category	IUCN category	Objectives	Features	Management structure	Stake of local community	Management activities	Examples
I. Strict Nature Reserve	I	Absolute protection to species or habitats	Totally or almost totally natural; no human habitation in or adjacent, and no human use; small size	Central or state agency, with advisory committees of independent experts	Not relevant	Only protection; no human intervention, including tourism; restricted research and monitoring	Most A&N sanctuaries "Silent Valley" core areas of several current parks
II National Park	II	Conservation of species or habitats with minimal or very low intensity human activity	Largely natural; small (a few families) or no human habitation inside, some use by transient humans; small to medium size, except where large uninhabited area is available	Conservation Area Management Committees, of government officials, independent expert, and local community representatives	Employment in Park activities; bona fide survival rights of resident populations; tourism revenue	Minimal management, mostly protection; research and monitoring of activities, including of bona fide resource uses; very restricted tourism; awareness programmes	Nanda Devi, etc. (about 50% of current national parks)
III. Sanctuary	IV	Conservation of species or habitats by manipulative management	Largely natural habitat; moderate to no human settlements (few dozen families each, largely traditional), moderate to no use by outside humans; medium to large size	Conservation Area Management Committees, of government officials, local community representatives, and independent experts	Bona fide and essential livelihood rights within area's conservation objectives; employment; tourism revenue, etc.	Intervention for protection and regeneration, and reversal of negative influences; research and monitoring, of resource uses, etc., awareness programmes.	Over 50% of current protected areas, including national parks (excluding most A&N ones)
IV. Resource Reserve	VI	Sustainable resource use with conservation of identified habitat elements and species	Human-influenced or regenerated areas, with substantial human settlement; medium to large size	Largely local community body, with involvement of and assistance from government agencies	Bona fid and livelihood (including economic) needs; employment; tourism revenue, etc.	Sustainable resource extraction; research and monitoring on impacts of resource use; checks on commercial exploitation; awareness programmes	Many Reserve Forests and Joint Forest Management areas, CRZ 1 (and 2?) areas, river catchments
V. Biosphere Reserve	V?	Conservation of mosaic of complementary land/water uses, natural and human ecosystems; encouragement of traditional land-use systems, including agriculture	Mix of natural and human-influenced ecosystems; substantial human settlement (rural); very large size	Regional management boards, with all relevant government agencies, local community bodies, and NGO/expert representatives	Sustained livelihood and cultural security; support to traditional activities; ecologically sensitive livelihood options as alternative to large-scale commercial ones	Interventions to protect and regenerate ecosystems and species, safeguard corridors; encouragement to traditional resource uses; ban on large-scale developmental/ Commercial activities	Most existing Biosphere Reserves
VI. Community Reserve	None	Protection of landscapes, ecosystems, and species as practiced by local communities	Largely natural, minimal or low intensity human intervention; mostly small, some large size	Local community body	Protection of cultural /religious values and ecosystem functions	Mostly protection; controls on limited resource use, with safeguards against outside commercial forces	Sacred groves; Tanks like Kokrebellur; Chipko-protected areas

FOOD FOR THOUGHT: BEHAVIOURAL STRATEGIES ADOPTED BY WILD BONNET MACAQUES TO REDUCE SOCIAL TENSION DURING PROVISIONING

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Running head : Provisioning in wild bonnet macaques

Abstract : Artificial provisioning of free-living primate groups usually leads to a significant increase in competition for these newly available resources. Are individuals, however, capable of adopting suitable behavioural strategies to alleviate such tension? We studied the changing patterns of social interactions between adult females of a wild group of bonnet macaques (*Macaca radiata radiata*) in the Mudumalai Wildlife Sanctuary, Tamil Nadu, under two conditions of foraging. The group spent approximately 66% of the observation time foraging on their natural diet; during the remaining period they gathered provisioned food from tourists visiting the sanctuary. Behavioural observations primarily consisted of about 139 hours of focal animal sampling on the 9 adult females in the group. Statistical analyses employed non-parametric tests including Kendall's rank correlation, Mann-Whitney *U*-test and Wilcoxon's signed-ranks test. Provisioning was marked by a sharp 2-fold increase in Aggression, particularly Non-contact Aggression, and in Feeding-supplants (2.5-fold) directed down the dominance hierarchy. Dominant females directed Contact Aggression specifically towards higher-ranked subordinates. Subordinate females too increased Non-contact Aggression towards dominant individuals but Retreated more from them than they did under conditions of natural foraging. Frequency of Allogrooming and other affiliative behaviour, in contrast, decreased significantly by 50 - 65 % during provisioning when most of the time was spent in active feeding or scavenging. Subordinate females, nevertheless, initiated relatively more Allogrooming towards dominant individuals during this period; grooming was much more reciprocal under conditions of natural foraging. Finally, dominant females showed less Aggressive Approaches towards those females who had groomed them more during these provisioning episodes. Social tensions thus increase significantly among bonnet macaques when they interact with tourists; such stress, however, appears to be reduced, though only partially, through social strategies adopted by individuals under these conditions. These findings may have implications for the management of endangered primates in our country.

Key words : bonnet macaque, foraging, *Macaca radiata radiata*, Mudumalai Wildlife Sanctuary, provisioning, Social behaviour.

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INTRODUCTION

Primate societies are generally structured organisations with fairly clear social rules that determine patterns of interactions between different classes of individuals comprising these societies. Kinship and dominance rank, for example, are important factors regulating within-group cooperation and competition among individuals in typical cercopithecine societies including that of macaques (Smuts *et al.* 1986). Individual primates, however, also have fairly sophisticated social cognitive abilities that allow them to occasionally alter their usual patterns of interactions especially when the social or ecological environment makes such behavioural flexibility advantageous (de Waal 1989a, Cheney and Seyfarth 1990, Sinha 1998a).

Short-term behavioural changes in response to changing conditions of food availability and distribution have been investigated in only a few species of primates (in captivity: Erwin *et al.* 1976, de Waal 1984, Belzung and Anderson 1986, Boccia *et al.* 1988, Gore 1993; in the wild: Post 1978, Whitten 1983, Barton and Whiten 1993). Although most of these studies have documented the nature of feeding competition and aggression that develops within groups faced with either low availability or clumped distribution of food, they have not typically focussed on the mechanisms by which social tensions are subsequently reduced.

A notable exception to this is the early experimental study by de Waal (1984) on behavioural interactions in small captive isosexual groups of rhesus macaques provided with different amounts of food. He observed that individuals were willing to exhibit a particular adaptive behavioural response, such as aggression, if the situation so demanded, but only if the negative consequences of such behaviour were reparable. Allogrooming turned out to be a successful social mechanism by which individuals were able to restore peace amongst themselves. Reconciliation through such affiliative interactions is now known to be the most effective way individual primates re-establish the harmony of social relationships temporarily disrupted by uncharacteristic aggression (reviewed in de Waal 1989a).

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Very little is known about the nature of such behavioural interactions in free-ranging primates faced with variability in food distribution and abundance. A particularly interesting situation is that of a number of Asian and African cercopithecine groups that are occasionally provisioned or have adapted to scavenging from neighbouring human habitations. Altmann and Muruthi (1989), in one such study, compared feeding patterns and energy intake of naturally foraging and scavenging troops of savanna baboons in Amboseli, Kenya, but their behavioural analyses were restricted to only that of individual activity patterns and foraging choices.

Free-ranging groups of bonnet macaques (*Macaca radiata*) are typically provisioned by tourists visiting a number of wildlife sanctuaries in southern India (Sinha, unpublished observations). Since the food obtained during such interactions is not only nutritionally rich but also clumped in distribution, provisioning is usually marked by a significant increase in feeding competition among individual troop members. The amount of such food available is, however, unpredictable and directly proportional to the tourist inflow into the area. These macaque groups, therefore, regularly forage on their natural food sources, and only resort to provisioned food during particular seasons and during certain times of the day when tourist traffic peaks within the sanctuary.

This study investigates the changing patterns of social interactions among adult female bonnet macaques in one such group that alternates between bouts of natural foraging and feeding on provisioned foods, often during the course of the same day. It documents the dramatic increase in feeding competition during provisioning, and examines the behavioural flexibility of individuals in adopting strategies to reduce social tension within the group. Finally, implications of these findings for the management of wild primate populations in sanctuaries and other protected areas are discussed.

METHODS

Study Species

The bonnet macaque (*Macaca radiata radiata*, Geoffroy), an endemic cercopithecine primate occurring ubiquitously in peninsular India, commonly lives in multi-male, bisexual troops of about 15 to 60 individuals (Prater 1971). Females of this species, like those of many other cercopithecines, remain in their natal group throughout their lives, and during adulthood, form strong, linear dominance hierarchies with daughters occupying dominance ranks just below those of their mothers. Juvenile and adult males usually emigrate from their natal troops, another typical cercopithecine feature, but bonnet macaque males appear to be unique in being rather unpredictable in this regard, some individuals even staying back to become the most dominant males in their respective natal troops (Sinha, unpublished). Adult males form unstable dominance hierarchies through direct aggression and coalitions, with individuals in most coalitions demonstrating extensive affiliative interactions with each other (Silk 1994, Sinha 1998b).

Study Group

The study was conducted in the Mudumalai Wildlife Sanctuary, Tamil Nadu, southern India on a free-ranging partially provisioned group of bonnet macaques that ranged along the Moyar river near the Theppakadu Forest Office of the sanctuary (*c.* 11°30'N, 76°33'E). Although a range of vegetation types, from moist deciduous forest through semi-evergreen forest to dry evergreen forest, can be seen within the sanctuary, the study troop inhabited an area with predominantly dry mixed deciduous vegetation.

During the observation period, the troop consisted of 34 individuals with 9 adult females, 6 adult males, and 3 subadults and 10 juveniles of both sexes. Six infants were born in the group during the course of the study.

The natural diet of the study troop consisted predominantly of fruits, flowers, and leaves of *Tamarindus indicus*, *Azadirachta indica*, *Ficus bengalensis*, *F. retusa*, *Alphonsea sclerocarpa*, *Zizyphus oenoplia*, *Memecylon edule*, *Randia malabarica*, assorted herbs and several grasses. Insects also formed an important part of their diet; these included crickets, grasshoppers, and caterpillars. In addition, the group occasionally fed and scavenged on high-calorie human food handed out or left behind by tourists visiting the sanctuary. The amount of such food accessible to the troop was, however, seasonal, unpredictable and directly proportional to the tourist inflow into the sanctuary.

Observed Behaviours

The behaviours that have been considered in the present analysis include Foraging, Provisioning, Allogrooming, Affiliation, Aggression (including Contact Aggression and Non-contact Aggression), Aggressive Approaches, Retreats and Feeding-supplants (Sinha, unpublished ethogram).

Foraging has been defined as the feeding by the study individuals on any component of their natural diet; this includes leaves, flowers, and fruits of different food plants and insects.

Provisioning, in contrast, refers to their feeding on human foods offered by tourists during direct interactions and their scavenging on the remains left behind by these visitors.

Allogrooming (here used interchangeably with grooming) refers to the manipulation of the fur and

skin of an individual by another with the fingers, mouth, or teeth in order to remove bits of dirt, dead skin, ectoparasites, or dried blood from wounds.

Affiliation is a composite behaviour of 20 affiliative behaviours including Bite Gently, Cheek-touch, Follow, Friendly Approach, Grapple, Grunt, Hold, Huddle, Hug with Lip-smacking, Hug without Lip-smacking, Nibble, Nuzzle, Pat, Pull Close, Raise Eyebrows, Seek Grooming, Seek Support, Sit in Contact, Sleep Together, and Touch.

Aggression is also a composite behaviour, constituted by agonistic interactions of two kinds. **Contact Aggression**, involving actual physical contact between the adversaries, includes the more severe acts of Bite Hard, Chase, Hold Down, Pinch, Pull Roughly, Push, and Slap. **Non-contact Aggression**, in contrast, consists of agonistic interactions at a distance that do not involve any physical contact; these include the relatively milder acts of Aggressive Scream, Bared-teeth Display, Eye-flash, Ground-slap, Head-jerk, Lunge, Open-mouth Threat, Stare and Warning Growl.

Aggressive Approach refers to an approach made by an individual towards another that is followed by the former displaying any of the acts of Contact and Non-contact Aggression listed above. **Retreat**, on the other hand, consists of the moving away or fleeing of an individual from another in response to an act of Contact and Non-contact Aggression shown by the latter.

Feeding-supplants consists of the replacement of a feeding individual by another at a feeding site, which may or may not be accompanied by a snatching of the food by the supplanting individual.

The 9 adult females in the study group formed a linear dominance hierarchy that could be unambiguously assigned on the basis of the direction and frequency of Contact and Non-contact Aggression between each pair of females.

Data Collection

Data were collected from the study troop during a continuous period of four months – from December 1996 to March 1997. Initial qualitative observations *ad libitum* for two months (May - June 1996) allowed the observers and the troop to habituate to each other and led to the identification and naming of all the adult individuals in the troop on the bases of their physiognomy as well as other facial and body marks. The study troop was found to be active approximately between 0700 h in the morning and 1800 h in the evening. Observations were, therefore, conducted during three sessions – Morning (0800-1100 h), Midday (1100-1400 h) and Afternoon (1400-1700 h) – with data being collected only during any two sessions on each day in order to avoid observer fatigue.

The study troop, being accustomed to the presence of humans, allowed detailed observations at close range, although binoculars were used whenever the individuals were in areas that were physically unapproachable. No attempt was made to feed or interfere otherwise with the study animals during the study.

Behavioural data, used for this analysis, are based on approximately 139.2 h of focal animal sampling (Altmann 1974) on the 9 adult females in the group with a mean (± SD) of 15.5 (± 1.4) h of sampling per female. Each focal sample of an individual, chosen randomly without replacement, had a duration of 10 min. Observations were primarily directed towards every occurrence of Foraging and Provisioning for the focal individual, and all inter-individual interactions for each female-female dyad that necessarily involved the focal individual. Such effectively focal dyad sampling was distributed according to the time spent by these females in periods of foraging (on their natural diet) and on being provisioned (when they fed or scavenged on human foods), and totaled a mean (± SD) of 20.4 (± 1.4) h per dyad during foraging and a mean of 10.6 (± 1.2) h per dyad during provisioning.

Data Analyses

Foraging by focal individuals and their Provisioning have been measured in terms of the frequency of their feeding on the respective food sources during the observation period. The initiation of an Allogrooming event by an individual has been considered as basic data for the analysis of grooming relationships in this study. Accordingly, Allogrooming frequency has been expressed as the number of grooming events initiated by an individual towards another per hour. The display of Affiliation, Contact and Non-contact Aggression, Aggressive Approach, Retreat and Feeding-supplants have similarly been measured in terms of their demonstrated frequency per unit time. For all these behaviours that occasionally involved more than two individuals, only dyadic interactions between pairs of females have been considered in the final analysis.

The statistical analyses of the data employed primarily non-parametric tests including the Mann-Whitney *U*-test, Wilcoxon's signed-ranks test, and Kendall's rank correlation, whenever appropriate. These were performed as described by Sokal and Rohlf (1995). All tests, unless otherwise specified, were two-tailed.

RESULTS

Foraging and Provisioning

The study group regularly moved between two kinds of habitats, roughly comparable in area, within their home-range. One was a relatively more forested area where they foraged on their natural diet of leaves,

flowers, fruits, and insects. The other was a more open area in the vicinity of the Forest Office where they either interacted with tourists and directly obtained human food from them, or where they scavenged on remains left behind by the visitors. All social interactions in the former area have been considered to be associated with natural foraging, and those in the latter area with the artificial provisioning of the study individuals.

The adult females in the study group spent a significantly greater length of time in the foraging area during the observation period (91.5 h) than in the area where they were provisioned (47.7 h) than would be expected by chance alone (chi-square test, $X2 = 13.78$, $df = 1$, $p < 0.001$). Inspite of the less time spent in the provisioning area, however, the females exhibited a much higher frequency of Provisioning (mean ± SD of 13.23 ± 2.70 acts/h) than they did of Foraging (3.73 ± 1.53 acts/h; Wilcoxon's signed-ranks test, $T = 4$, $n = 9$ individuals, $p < 0.03$).

Feeding competition during provisioning

There was a marked increase in social tension in the study group during periods of provisioning; this was usually manifested as enhanced aggression among members of the troop. The overall rates of Aggression, Non-contact Aggression and Feeding-supplants between the adult females, for example, increased significantly during this period from that exhibited during foraging (Figure 1; Wilcoxon's signed-ranks test, $n = 72$ dyads; Aggression: $T = 204.5$, $p < 0.01$; Non-contact Aggression: $T = 171.5$, $p < 0.02$; Feeding-supplants: $T = 103$, $p < 0.003$). Interestingly, however, there was no marked change in the levels of Contact Aggression under the two conditions (Figure 1; $T = 84$, $p > 0.1$).

A closer examination of the patterns of Contact Aggression, nevertheless, revealed that dominant females exhibited increasing rates of Contact Aggression towards subordinates of increasing rank only during

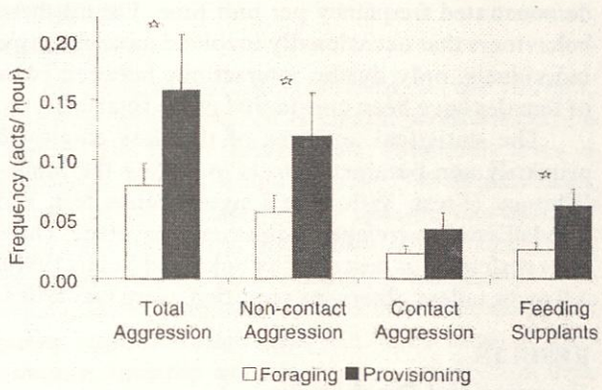

FIGURE 1 : Aggression and Feeding-supplants among adult females during foraging and provisioning. Error bars represent standard deviation. The asterisk denotes a statistically significant difference between the displayed frequencies of that particular behaviour across the two conditions (Wilcoxon's signed ranks test, n = 72 dyads, p < 0.05)

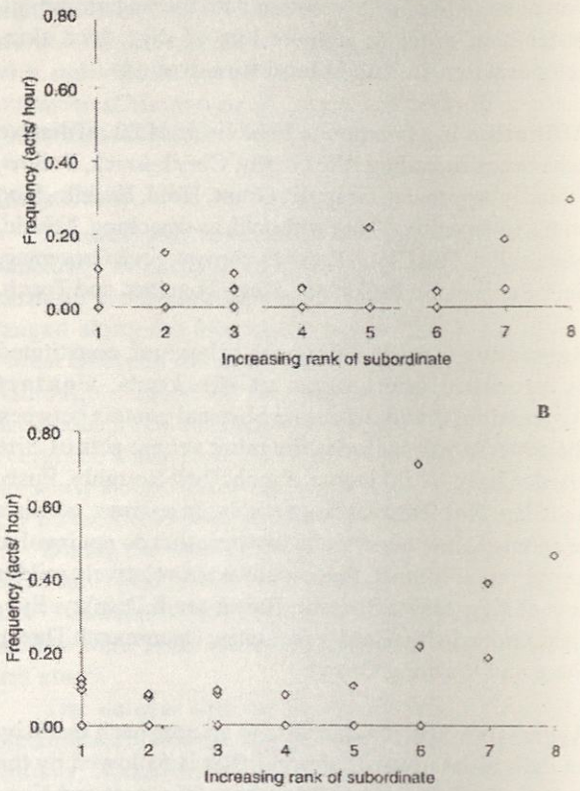

FIGURE 2 : Contact Aggression directed by dominant females towards subordinate individuals of increasing dominance rank. Panel A: during foraging (Kendall's rank correlation, t = 0.2811, n = 36 dyads, p < 0.02). Panel B: during provisioning (t = 0.1822, p > 0.10)

foraging (Figure 2, panel A; $t = 0.2811$, $n = 36$ dyads, $p < 0.02$). During provisioning, such aggression was almost exclusively displayed by the highest-ranked females in the group and preferentially only towards subordinates closest to them in the dominance hierarchy (Figure 2, panel B; $t = 0.1822$, $p > 0.10$). In fact, Contact Aggression was significantly more often directed towards subordinate females in the upper half of the rank hierarchy (mean ± SD of 0.21 ± 0.24 acts/h, $n = 10$ dyads) than those in the lower half (0.04 ± 0.05 acts/h, $n = 26$ dyads) during provisioning (Mann-Whitney *U*-test, $U = 186$, $p < 0.05$); no such discrimination was evident during foraging (towards subordinates in the upper half of the hierarchy: 0.08 ± 0.11 acts/h; towards those in the lower half: 0.02 ± 0.04 acts/h; $U = 164$, $p > 0.10$).

Agonistic attacks in the form of Contact Aggression, although not very frequent, was also increasingly directed by dominant individuals towards those subordinate females who exhibited more Aggression during provisioning (Kendall's rank correlation, $t = 0.2570$, $n = 36$ dyads, $p < 0.05$). In contrast, foraging dominant females preferentially directed milder forms of agonism, such as Non-contact Aggression, towards subordinates who showed relatively less Aggression ($t = -0.2591$, $p < 0.05$).

Adult bonnet macaque females typically do not exhibit aggression towards those higher than them in the dominance hierarchy (Sinha, unpublished observations). During provisioning, however, when there is an evident rise in overall aggression within the troop, do subordinate individuals now direct aggression towards their dominant adversaries? Indeed, subordinate females did display significantly enhanced Non-contact Aggression towards dominant individuals during provisioning (Figure 3; Wilcoxon's signed-ranks test, one-tailed, T = 3, n = 36 dyads, p = 0.05). Subordinate females also Retreated at higher rates from dominant individuals than they did during natural foraging (Figure 3; T = 196, p < 0.05). Finally, dominant females successfully (Feeding-)supplanted subordinate individuals much more during provisioning (mean ± SD of 0.12 ± 0.14 acts/h) than during foraging (0.05 ± 0.05 acts/h; T = 122.5, p < 0.01). As expected, no such difference in the supplanting of dominant individuals by subordinates were observed under the two conditions (provisioning: 0.005 ± 0.022 acts/h, foraging: 0.001 ± 0.009 acts/h; T = 1, p > 0.10).

Affiliative interactions during provisioning

There was a significant decrease in the frequency of Allogrooming and Affiliation as the females moved to the provisioning site from areas of natural foraging (Figure 4; Wilcoxon's signed-ranks test, n = 72 dyads; Allogrooming: T = 190, p < 0.0005; Affiliation: T = 303, p < 0.0005). An examination of individual patterns of these affiliative behaviours, however, revealed that while subordinate females decreased the display of both Allogrooming and Affiliation towards dominant individuals (Allogrooming: foraging – mean ± SD of 0.48 ± 0.45 acts/h, provisioning – 0.17 ± 0.23 acts/h,

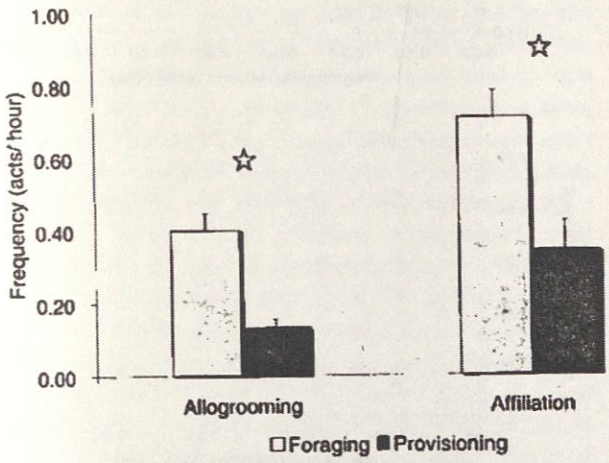

FIGURE 4 : Allogrooming and Affiliation among adult females during foraging and provisioning. Error bars represent standard deviation. The asterisk denotes a statistically significant difference between the displayed frequencies of that particular behaviour across the two conditions (Wilcoxon's signed ranks test, n = 72 dyads, p < 0.0005)

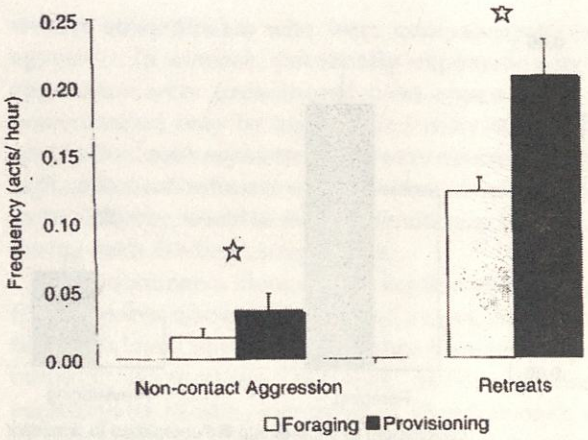

FIGURE 3 : Non-contact Aggression towards and Retreats from dominant individuals displayed by subordinate females during foraging and provisioning. Error bars represent standard deviation. The asterisk denotes a statistically significant difference between the displayed frequencies of that particular behaviour across the two conditions (Wilcoxon's signed ranks test, one-tailed, n = 36 dyads, p £ 0.05)

Wilcoxon's signed-ranks test, n = 36 dyads, T = 71, p < 0.0005; Affiliation: foraging – 0.67 ± 0.52 acts/h, provisioning – 0.26 ± 0.38 acts/h, T = 94, p < 0.0005), the latter only reduced Allogrooming of their subordinate partners (foraging: 0.32 ± 0.30 acts/h, provisioning: 0.09 ± 0.17 acts/h, T = 115, p < 0.0005).

Was reciprocation of affiliative behaviours, a typical feature of social relationships among female bonnet macaques, affected by provisioning? It is interesting that only Affiliation, and not Allogrooming, was reciprocally exchanged between the adult females of the study troop, and only during periods of foraging (Kendall's rank correlation, t = 0.2452, n = 36 dyads, p < 0.05). No such reciprocation was observed for this behaviour during provisioning (t = 0.0143, p > 0.90).

Behavioural strategies to reduce social tension

Higher-ranked individuals were observed to Retreat more from their dominant adversaries during provisioning than did females of relatively low rank (Kendall's rank correlation, t = 0.3005, n = 36 dyads, p < 0.01) – a pattern not evident during foraging (t = -0.0362, p > 0.70). Surprisingly, with the rise of aggression during provisioning, dominant females Retreated from subordinate individuals as well; the frequency of Retreat increasing significantly with increasing dominance rank of the subordinate (provisioning: t = 0.2412, p < 0.05; foraging: t = 0.1837, p > 0.10).

Patterns of affiliative interactions changed dramatically as the study troop alternated between periods of foraging and provisioning. For example, there was a prominent decrease in Allogrooming displayed by dominant individuals towards their subordinates during provisioning (discussed above). What is remarkable, however, is that levels of Affiliation did not change significantly, frequencies of this

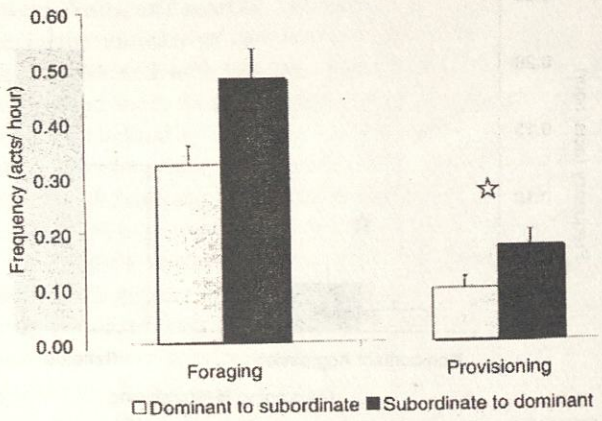

FIGURE 5 : Allogrooming between dominant and subordinate members of adult female dyads during foraging and provisioning. Error bars represent standard deviation. The asterisk denotes a statistically significant difference between grooming frequencies in the two directions (Mann-Whitney *U*-test, n = 36 dyads, p < 0.05)

behaviour remaining comparable across the two situations (foraging: mean ± SD of 0.75 ± 0.67 acts/h, provisioning: 0.42 ± 0.87 acts/h, Wilcoxon's signed-ranks test, n = 36 dyads, T = 327, p > 0.80).

Affiliative behaviours, which are of a reciprocal nature, can also be analysed at the level of dyadic interactions. Such an examination revealed that subordinate individuals exhibited relatively more Allogrooming towards their dominant partners, than did the latter, during provisioning (Figure 5; Mann-Whitney *U*-test; n = 36 dyads; U = 823; p < 0.05). Grooming was much more reciprocal during natural foraging (U = 760, p > 0.20). No such change in dyadic patterns was, however, evident for Affiliation under the two conditions (data given above; foraging: U = 664.5, p > 0.80; provisioning: U = 748.5, p > 0.20).

Finally, during provisioning, dominant females displayed significantly less Aggressive Approaches towards those subordinate individuals who had Allogroomed them more under these conditions (Figure 6, panel A; Kendall's rank correlation, t = -0.3152, n = 36, p < 0.01). This particular behavioural interchange was, however, absent during periods of foraging (Figure 6, panel B; t = -0.0140, p > 0.90).

DISCUSSION

Changes in social structure in response to ecological parameters have often been observed in different animal societies (reviewed in Lott 1984). Although most of these species usually have an evolutionarily selected (and genetically determined) basic pattern of social organisation, limited intraspecific variations do arise in response to fluctuations in the local environment. One form of such variation consists of short-term behavioural changes that may allow individuals to overcome rigid constraints imposed by the prevailing social structure, and thus, effectively compete with each other under changing conditions of resource availability.

Classical studies in primates investigating short-term variation in behaviour have typically focussed on the effects of crowding and high population densities on social structure (reviewed in de Waal 1989b). Only a few studies have considered changing patterns of behavioural interactions under different conditions of food availability and distribution. Again, most of these studies have examined the influence of food competition on social behaviour in only captive groups of different species (Erwin *et al.* 1976, de Waal 1984, Belzung and Anderson 1986, Boccia *et al.* 1988, Gore 1993). In contrast, investigations into the social dynamics of free-ranging groups faced with ecological variation in food distribution and abundance are few (Post 1978, Whitten 1983, Barton and Whiten 1993).

Foraging and Provisioning

Artificial provisioning of wild primate groups usually lead to changes in behavioural strategies, both at the level of individual activity and that of social interactions. Although individual behavioural patterns and food choices in such naturally foraging and provisioned groups have been investigated (Altmann and Muruthi 1988), observations on the nature of changing social relationships within these groups have remained

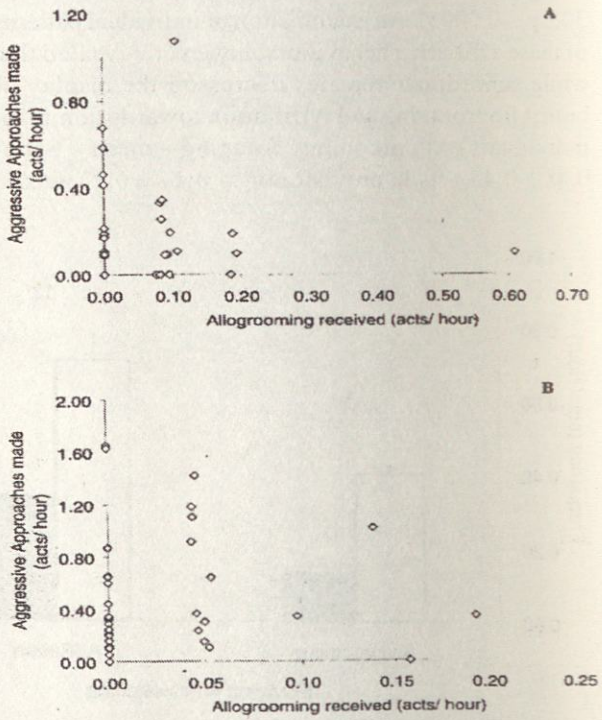

FIGURE 6 : Aggressive Approaches displayed by dominant females towards subordinate individuals as a function of Allogrooming received. Panel A: during provisioning (Kendall's rank correlation, t = -0.3152, n = 36 dyads, p < 0.01). Panel B: during foraging (t = -0.0140, p > 0.90). Note that the scaling of the ordinates in the two figures are different.

surprisingly neglected. Such studies are, however, essential for a basic understanding of the behavioural strategies that individuals adopt when faced with rapidly changing food regimes and the mechanisms that facilitate the promotion of social harmony in the midst of rising intra-group competition for food.

This study examines the changing nature of social relationships among the adult females of a free-ranging group of bonnet macaques that regularly alternated between bouts of natural foraging and visits to a site where they were provisioned with human food. Although these females spent a significantly smaller period of time feeding or scavenging on provisioned food, this was more a reflection of the short periods of the day (usually in the evenings alone) when food was provided by tourists visiting the sanctuary. That this food was nevertheless greatly attractive to the monkeys is borne out by the much higher rates of feeding or scavenging (Provisioning) exhibited at this site relative to that during bouts of foraging on their natural food during the greater part of the day (Foraging). It would be worthwhile to compare the nutritional values of these two kinds of food in order to investigate the possibility that the provisioned diet was so much more attractive also because it was relatively richer in its energy content (see Altmann and Muruthi 1989).

Feeding competition during provisioning

The clumped distribution of the provisioned food around their human sources was likely to be directly responsible for the observed significant increase in intra-group feeding competition that accompanied provisioning over that during natural foraging. It is also possible that the nutritional quality of the human food (if indeed higher than that of the natural diet) could have contributed to such elevated levels of aggression and feeding supplants exhibited by the females. It is noteworthy, however, that it was Non-contact Aggression that greatly contributed to this overall rise in total aggression. Contact Aggression, which imposes higher energetic demands and obviously carries much greater potential costs for the adversaries, did not increase significantly during provisioning.

The patterns of Contact Aggression that characterised provisioning, nevertheless, were different from that during foraging and revealed some interesting features. While foraging dominant females directed physical aggression increasingly towards subordinates of progressively higher rank, such aggression was preferentially directed only towards the highest-ranked subordinates during provisioning. Contact Aggression was also exhibited significantly more towards those subordinates who had, in turn, shown more aggression during the stressful periods of provisioning. In contrast, under the relatively more peaceful conditions of foraging, aggression was selectively directed towards weaker subordinates who were comparatively less agonistic. In essence, potentially expensive acts of aggression over provisioned food appeared to be demonstrated only by high ranked individuals, who could afford such encounters, and were directed towards high ranked subordinates who, by virtue of their position in the hierarchy, would be the most threatening adversaries during such feeding competition.

The dominance hierarchy among free-ranging adult female bonnet macaques is extremely rigid; subordinate females almost never exhibit either Contact or Non-contact Aggression towards their dominant counterparts (Sinha, unpublished observations). As overall agonism rose during provisioning, however, subordinate females in this particular troop began to display significantly elevated levels of Non-contact Aggression towards dominant individuals. Yet another manifestation of such heightened social tension within the group was the remarkably high frequency with which subordinates Retreated from their dominant counterparts during competition over provisioned food. This, in turn, contributed to the ability of high ranked females to (Feeding-)supplant lower ranked individuals much more during such encounters. As expected, there was no difference in the supplanting of the former by the latter under the two conditions.

It has been suggested that stable linear hierarchies in female primates are a result of conflict competition for food (Janson 1985, van Noordwijk and van Schaik 1987, Janson and van Schaik 1988, Mitchell *et al.* 1991, Gore 1993). The intensity of competition over provisioned food was manifest not only in the sharp rise of intra-group aggression during this period but also in the appearance of agonistic acts directed by subordinate females towards their dominant counterparts only during provisioning. A strong competitive advantage due to positions of high rank in the dominance hierarchy, nevertheless, did reveal itself as greater success enjoyed by dominant females during Feeding supplants. In addition, there could be other behavioural measures reflecting the advantage of being a high ranked female that have not been considered in this study. These could include, amongst others, differences in feeding rates, total feeding time, daily food intake, dietary diversity, or even dietary composition (Post *et al.* 1980, Barton and Whiten 1993).

Affiliative interactions during provisioning

The troop's movement from a regime of natural foraging to that of provisioning was accompanied by a significant decrease in the frequency of both Allogrooming and other affiliative behaviours. The group was able to opportunistically spend only short periods of time at the provisioning site and even this was marked by high rates of feeding and scavenging, as well as intense conflict over food. It is thus possible

that there was very little time that individuals could devote to such energy- and time-intensive interactions as Allogrooming during these periods. Support for this comes from the observation that dominant individuals who reduced their frequency of grooming of subordinate females during provisioning did not similarly lower the display of other affiliative behaviours (Affiliation); these consist of simple behavioural actions that are not time-consuming.

An alternative hypothesis for the observed patterns of affiliative interactions could be that the dramatic increase of feeding competition and intra-group social tension brought about by provisioning may have led individuals to avoid each other and thus decrease their rates of affiliative interactions. This would most likely be the situation for the low ranked females in the group who invariably face the brunt of the increasing aggression over food. In addition, if this hypothesis also applies to the dominant individuals, it is perhaps significant that they reduced only the display of Allogrooming, but not Affiliation, towards their subordinate counterparts. Interestingly enough, Affiliation alone was reciprocated symmetrically between each pair of adult females during the more peaceful periods of natural foraging. Allogrooming was also exchanged between these pairs of individuals; it was, however, not symmetrical in distribution.

Behavioural strategies to reduce social tension

The adult females in the study group appeared to adopt two distinctive kinds of behavioural strategies to reduce tension brought about by feeding competition within the group. First, individuals of high rank actively avoided interacting with more dominant females, Retreating from them at much higher rates than they did under less stressful conditions of natural foraging. What was even more remarkable is that dominant individuals too Retreated from their high-ranked subordinates during provisioning – a feature almost never encountered in free-ranging bonnet macaque societies (Sinha, unpublished observations; Rauf Ali, personal communication). Mutual avoidance of this kind may be the only strategy that can be utilised by individuals of high dominance rank to alleviate intra-group aggression. Given the tension that individuals seem to be under during provisioning, attempts to bring about peace through more active affiliative interactions could carry the threat of potentially high costs of physical conflict, a cost that would be maximum for individuals of high dominance rank.

The second kind of behavioural strategies consists of active affiliative interactions directed towards those individuals from whom the threat of aggression is the most, or towards those who are victims of conflict competition. This was originally suggested by de Waal (1989b) who emphasised that primates, being highly adaptable, would, when confronted with a stressful situation, modify their behaviour to reduce the risk of aggression. Thus, in the Mudumalai troop, subordinate females displayed relatively more initiated Allogrooming towards dominant individuals than they received from them under conditions of provisioning. In contrast, exchange of grooming was much more reciprocal during episodes of natural foraging. Dominant individuals, in turn, did not effectively reduce the frequency of Affiliation directed towards their subordinates as the troop began episodes of provisioning. Levels of Allogrooming, however, did come down significantly. It is perhaps noteworthy that subordinate individuals had to take recourse to the more energetically demanding activity of grooming, while dominant females could afford simpler, shorter, behavioural interactions in order to reduce intra-group social tension.

How successful were these behavioural strategies in actually reducing social tension? The fact that there continued to be high levels of intra-group aggression during provisioning suggested that these strategies may not have had enough power to completely reduce the effects of feeding competition on the nature of social interactions under such stressful conditions. Nevertheless, it is also true that, during provisioning, dominant individuals were less aggressive, as manifest in the reduced display of Aggressive Approaches, towards those subordinate females who had Allogroomed them more during these periods. Thus, although such interactions may appear to be only partially successful in reducing aggression when overall competition within the troop is considered, individuals may be adept at reducing the risk they themselves face from certain more powerful adversaries through the adoption of flexible social strategies.

A final point concerns the relationship between intra-group conflict competition and reproductive success in wild primates. Although much literature exists on rank-related differences in foraging success as related to differences in reproductive status (reviewed in Harcourt 1987), not much is known about the direct influence of social status and aggressive behaviour on reproductive fitness. High levels of aggression have earlier been shown to decrease reproductive success in free-ranging savanna baboons in at least two African national parks (Gombe, Tanzania: Packer *et al.* 1995; Mikumi, Tanzania: Wasser 1995; but see Altmann *et al.* 1995 for a dissenting view on the baboons in Amboseli, Kenya). These studies clearly indicate that stress brought about by the pressures of maintaining high dominance status through aggression can lead to increased rates of conception failure and abortion in adult female baboons.

Active interactions of wild primates with human beings, particularly tourists, are unavoidable in most

sanctuaries and other protected areas in India. Such interactions would obviously lead to provisioning of these otherwise free-ranging groups. It is imperative that the long-term impacts of increased feeding competition and social tension, brought about by provisioning and scavenging, on the life history parameters of primates be explored urgently. The management implications of such findings for the conservation of the endangered or threatened primate populations of our country can hardly be overstated.

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THE DISTRIBUTION OF STREAM AMPHIBIANS IN THE RAINFOREST OF TWO HILL RANGES IN THE SOUTHERN WESTERN GHATS

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Abstract: This paper examines the factors that influence the geographical distribution of hill stream amphibians in the rainforests of Ashambu and Anamalai hill ranges. The study was conducted in Kalakkad-Mundanthurai Tiger Reserve between June 1996 and August 1997 and in Indira Gandhi Wildlife Sanctuary between November 1997 and May 1998. Twelve sites sampled in two hill ranges were located in six drainages, three in each hill range. The sites were sampled using nocturnal time constrained searches along streams. Thirty-five such surveys during summer were used for analysis. Twenty species were encountered during the searches. Species overlap (Sorensen's index) and community composition (Morisita's index) differed between sites in a hierarchical manner. Sites within a drainage had the greatest species overlap, sites between drainages had lesser overlap, and sites in different hill ranges had the least species overlap. Species similarity decreased with increasing distance and difference in altitude between the sites sampled. We propose that drainages influence amphibian species composition and cause turnover of species within a hill range and between hill ranges. This finding has implications for designating a protected area network for the conservation of rare and endemic amphibian fauna of the Western Ghats.

Key words : Amphibian assemblages, Geographic distribution, , rainforest, Western Ghats.

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INTRODUCTION

The Western Ghats in southern India is rich in biological diversity and the amphibian taxa are no exception to it. The Western Ghats has about 120 species of amphibians (Daniels, 1992), of which about 86% of the species in this region are endemic and show different distribution patterns (Daniels, 1992). Patterns in species richness in the Western Ghats and factors which govern their distribution have been explored using plants (Nair and Daniel, 1986; Pascal, 1988), amphibians (Jayaram, 1974; Inger and Dutta, 1986), reptiles (Jayaram, 1974) and birds (Ali and Ripley, 1983; Daniels *et al,* 1992). This amphibian has received considerable attention from biologists. However, only two studies (Daniels 1992; Inger *et al*, 1987) have attempted to identify the factors that govern their distribution. An understanding of the factors that control the diversity of various taxa in the region forms the basis for formulation of conservation programs (Gadgil, 1996). Over the years, the choice and design of protected areas in the country have been ad hoc without identifying critical habitats for protection or management (Ramesh *et al.* 1997). In this paper we have identified factors that influence the diversity of amphibians and discuss its implications at a landscape level in the Western Ghats.

This study was carried out in the wet evergreen forests of two protected areas, Kalakkad-Mundanthurai tiger reserve (KMTR) in the Ashambu hills (8° 25'- 8° 35' N and 77° 25'- 77° 35' E) and Indira Gandhi Wildlife Sanctuary (IGWLS) in the Anamalais (10° 13'- 10° 33'N and 76° 49'- 77° 21' E). The wet evergreen forests in these mountain ranges are well known for their diverse fauna and flora. The annual rainfall here is about 700 mm in the eastern slopes to 3000 mm in the western slopes. The temperature ranges between 4° C to 32° C during the year. The sampling sites were located in an altitudinal gradient from 740 m to 1400 m msl. The stream sites were intact and experienced little or no disturbance by humans. The study was conducted in KMTR between June 1996 and August 1997 and between November 1997 and May 1998 in IGWLS.

METHODS

Stream amphibians were sampled using Visual encounter surveys. These are time-constrained searches in which the encounter of amphibians within a given time is recorded. The streams that were sampled had widths varying between 8 m to 12 m. All searches took place between 1730 hr to 2300 hr, by two persons walking abreast using a flashlight. The search involved no disturbance, each encounter of an amphibian was recorded with the time of sighting and its microhabitat description. During the study period 85 surveys were conducted. In KMTR and IGWLS we sampled three drainages, each of which had two sites marked (table 1). Comparisons were between twelve sites that were sampled. One sampling year had three seasons and the surveys were replicated for seasons. Data from 32 surveys in KMTR during summer 1997 and from IGWLS during summer 1998 were used for analysis. Summer or dry season lasted from February to May and received little (< 100 mm) rainfall. We observed seasonal changes in abundance and species richness in the streams in

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KMTR, hence avoided comparisons pooled across seasons.

Sorensen's index of overlap for species occurrence (Wolda, 1981), and Morisita's index of overlap for species abundance (Horn, 1966) were computed for 66 possible combinations of sites. Overlap estimates were arrayed in a two-way matrix (appendix 1). In this matrix there are six combinations, which represent overlap within drainage, 24 combinations represent overlap between drainages, and 36 combinations represent overlap between hill ranges. Similar matrices were developed for difference in altitude and distance between sites (appendix 2). We tested our data against the null hypothesis of no difference in overlap within drainage, between drainages, between hill ranges.

Table 1. Sampling sites for stream amphibians in different drainages and hill ranges.

Sampling sites	Altitude in m	Drainage	Hill range
Kannikatti 1 (KN1)	780	Tamarabarani	Ashambu
Kannikatti 2 (KN2)	740		
Sengaltheri 1 (S1)	990	Manimuthar	
Sengaltheri 2 (S2)	1010		
Kakkachi 1 (KA1)	1200	Pambar	
Kakkachi 2 (KA2)	1180		
Andiparai 1 (AD1)	1240	Kadamparai	Anamalai
Andiparai 2 (AD2)	1290		
Akkamalai 1 (AK1)	1360	Nadumalai	
Akkamalai 2 (AK2)	1370		
Manamboli 1 (M1)	880	Parambikulam	
Manamboli 2 (M2)	870		

RESULTS

A total of 1453 amphibians were sighted and the mean encounter rate was 6.3 amphibians per survey, SD± 3.06. During this study twenty species were recorded using this method. Sites within a drainage, between drainage and between hill range had different species occurrence overlap and species composition overlap values (one way ANOVA, F = 85.6 & 46.08, df2, P<0.001). Sites within a drainage had maximum overlap, sites between drainages lesser overlap and sites between two hill ranges had the least overlap (table 2).

Distance and difference in altitude between sites influence species occurrence and composition overlap weakly and negatively. An increase in distance between sites and an increasing difference in altitude between sites caused decrease in the overlap values (table 3).

DISCUSSION

Drainage is one of the macrohabitat parameter that influences amphibian species distribution in the rainforests of the southern Western Ghats. During our intensive study in the area we used quadrat search as a method to quantify amphibian diversity and the microhabitat preference of various species. Distance from water (stream) was the major factor that influenced amphibian occurrences in the quadrates. Similar patterns have been observed with amphibians in the rainforest streams of Sarawak (Inger 1969). However, this study contradicts patterns seen in stream amphibian communities in Bornean forests by Inger and Voris (1993). In Bornean streams, amphibian species composition tend to show greater overlap in streams that were further away and the width of the stream influenced species composition (Inger and Voris, 1993). This may be because of the availability of new microhabitats or the lack of it with changing width of streams. The streams sampled during our study were in the middle elevation wet evergreen forest and they did not vary much in their characteristics.

The Western Ghats is a linear habitat along the West Coast of peninsular India, and has slopes on the eastern aspect and western aspect. Mountains bind the river valleys in the Ghats, which could be responsible for the restricting the dispersal of the amphibians across drainages. The patterns we observed across hill ranges conform to the 'hill range effect', which contributes to turn over of species over each hill range along the Western Ghats (Inger *et al.* 1987). The other possible explanations for the patterns in

Table 2: Mean and variance of species occurrence and abundance overlap values in different categories for stream amphibians.

Categories	Species occurrence overlap		Species abundance overlap	
	Mean	SEM	Mean	SEM
Within drainage	0.814	0.024	0.752	0.105
Between drainage	0.621	0.027	0.415	0.049
Between hill range	0.3	0.018	0.082	0.021

Table 3. Pearson's correlation matrix of distance and difference in altitude with overlap values (N = 66).

	Log distance (m).	Difference in altitude (m).
Sorensen's index	-0.535 P<0.005	-0.32 P<0.01
Morisita's index	-0.322 P<0.01	-0.236 P<0.1

amphibian species diversity observed in this study could be effects due to latitudinal difference between Ashambu and Anamalais or difference in altitude between sites. Evidence from angiosperm diversity (Nair and Daniel 1986; Pascal 1988) and bird diversity (Ali and Ripley 1983) suggests a decline in diversity above 13°N along the Western Ghats. Our study sites were located well below the zone of such influence on the amphibian communities. Further amphibian richness was documented to be highest in 13°N latitude (Daniels, 1992). This area also has high elevation wet evergreen forests (>1400 m) which harbours most of the endemic species (Daniels, 1992). Our study sites were restricted between 740 and 1290 m and we demonstrated that the influence of altitude on species composition was weak. Hence, the effect of altitude in influencing species richness in different hill streams was limited and could not have given rise to such a distinct pattern.

During this study we recorded nearly 40 species in the Anamalais, whereas Ashambu had 32 species. It is interesting to note that long term studies in different hill ranges have all reported 30-40 species in a hill range *e.g.* Nilgiri hills (Esa, 1998), Brahmagiri hills (Krishnamoorthy *pers.com.*). When the latitudinal zonation of amphibian species richness (data from Daniels, 1992) was revisited, four latitudinal zones between 8°N and 12°N had mean species richness of 36.5, and the values range from 22 to 51. The observed variation in species richness between the two hill ranges fall within the range of species richness values already documented. This reinforces the fact that latitude has no influence on diversity of this taxa south of 13°N and it possibly cannot account for the hierarchical increase in species overlap with increasing proximity of the sampled streams in these two hill ranges. However, along the entire length of the Western Ghats latitude might influence diversity of amphibians (Daniels, 1992), based of the increase in number of dry months above 13°N (see Pascal 1988).

The above theories fail to explain the observed pattern in species distribution in six different hill streams. In our study drainage emerges as an important factor controlling diversity of stream amphibians in the southern Western Ghats. There is also evidence to suggest that there is turnover of species across drainages. If this hypothesis on the geographical distribution of amphibians were to be generalized for the entire Western Ghats, it would mandate networking of protected area in order conserve the rare and endemic amphibian fauna of this region.

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Appendix I

Matrix of species overlap values. The values in bold are Sorensen's index and those below it are Morisita's overlap index.

Sampling sites

	KN1	KN2	S1	S2	KA1	KA2	AD1	AD2	AK1	AK2	M1	M2
KN1												
KN2	**0.9**											
	0.984											
S1	0.778	0.625										
	0.529	0.477										
S2	0.8	0.667	0.875									
	0.28	0.206	0.769									
KA1	0.588	0.533	0.769	0.8								
	0.15	0.094	0.111	0.431								
KA2	0.4	0.308	0.545	0.615	0.8							
	0.1	0.067	0.064	0.131	0.874							
AD1	0.333	0.375	0.429	0.375	0.462	0.364						
	0.502	0.457	0.278	0.32	0.157	0.052						
AD2	0.421	0.471	0.4	0.471	0.429	0.167	0.8					
	0.052	0.03	0.037	0.087	0.173	0.005	0.55					
AK1	0.118	0.133	0.154	0.133	0.167	0.2	0.615	0.571				
	0.01	0.001	0.012	0.139	0.068	0.016	0.65	0.519				
AK2	0.211	0.353	0.4	0.353	0.429	0.167	0.8	0.75	0.714			
	0.032	0.025	0.017	0.058	0.054	0.007	0.573	0.573	0.972			
M1	0.316	0.353	0.267	0.353	0.286	0.167	0.667	0.75	0.571	0.625		
	0.036	0.03	0.019	0.059	0.017	0.005	0.695	0.762	0.561	0.463		
M2	0.25	0.286	0.167	0.286	0.364	0.222	0.5	0.615	0.545	0.462	0.769	
	0.006	0	0.005	0.079	0.102	0.007	0.723	0.598	0.651	0.544	0.795	

Appendix II

Matrix of distance between sites (in bold) in meters and difference in altitude between sites in meters above sea level. Distance between sites in different hill ranges is not included.

Sampling sites	KN1	KN2	S1	S2	KA1	KA2	AD1	AD2	AK1	AK2	M1	M2
KN1												
KN2	250 20											
S1	22500 220	22500 250										
S2	22500 240	22500 270	200 20									
KA1	14375 460	14375 430	8125 210	8125 190								
KA2	14375 450	14375 420	8125 190	8125 170	20 20							
AD1	480	500	250	270	40	60						
AD2	530	550	300	320	90	110	500 50					
AK1	600	620	370	390	160	180	3400 120	3600 70				
AK2	610	630	380	360	170	190	3750 130	3950 80	300 10			
M1	120	140	110	130	320	300	11300 320	11250 370	11500 480	11600 490		
M2	100	120	130	150	340	320	11900 340	11750 390	12050 500	12100 150	1500 20	

PEOPLE PARTICIPATORY APPROACH FOR CONSERVATION OF ELEPHANT CORRIDOR - A CASE STUDY IN THE NILGIRI BIOSPHERE RESERVE

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Abstract: Application of about 150 elephants use the narrow corridor connecting Moyar Valley and Thakamalai Plateau. This corridor (0.5-3 km width and 7km long) was under severe pressure due to anthropogenic use, primarily commercial fuel wood collection. A take holder analysis coupled with logistic and financial support from Governmental, NGO and local administration promoted diary and weaving as viable attractives for livelihood. Though in its initial phase and not fully self dependent, the project has been successful in weaving off 80% of fuel wood collectors to other livelihood options. The major problems and potential implementations in other areas are discussed.

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INTRODUCTION

The Salim Ali Centre for Ornithology and Natural History (SACON) and Sathyamangalam Forest Division has launched a pilot project on People Participatory Approach for the Conservation of elephant corridors in Moyar Valley of teh Nilgiri Biosphere Reserve (NBR), Southern India. This project was funded by the Global Environmental Facility (GEF) of teh United Nation Development Programme (UNDP) thorugh the Development Alternatives, New Delhi for a period of two years from February 1996 to February 1998. The project goal is expected to set in motion a process leading to deflection of wood collectors into conservationists for preserving elephant corridor through people's paticipatory approach. The excercise took only the fuel wood harvesters as a major stakeholder of the corridor.

STUDY SITE

A narrow elephant corridor is located between the foot hill forests of the Nilgiri Eastern Slope near Sujalkuttai settlements and Bannari RF (Fig. 1). The corridor has connectivity with the Nilgiri plateau of the biosphere reserve and it is about seven km in length with width varying from 0.5 to 3 km between in Sathyamangalam Forest Division. Although this corridor habitat is small in soze, it is heavily used by the elephants for their seasonal movement between Sathyamangalam and Mettupalayam forests. The concentration of elephant number reaches its peak between January and May. As many as 120-150 individuals use this corridor during this period. Twenty nine herds of elephants comprising of 136 individuals used this corridor to reach Thalamalai plateau and Moyar Valley and vice versa from January to April 1997. Thus, the corridor act as a "genetic pathway" for animal to move from one area to another. Demographic studies showed that the ratio of male and female was 1:8. The proportion of juveniles was 20% in the population indicating a healthy reproductive performances. Currently the corridor is under various anthropogenic pressures such as collection of fuel wood and non-timber forest produces (NTFP) grazing and vehicular movement for sand collection.

Impact of fuel wood collectors

Fuel wood collection affects the integrity of the corridor. The predominant elephant food plants collected by villagers for commercial exploitation are : *Albizia amara, Acacia spp., Cordia spp., Dichrostachys cineria,* and *Grewia spp*. Our studies revealed that browse in the form of bark, leafy branches and fruits constituted 70% of the diet of elephants in this region. Sale of fire wood has been an important source of income, especially for woman in this region. The corridor is used by 122 villagers belonging to mostly non tribals from Sujalkuttai, Karachikorai, Pungar, Peerkadavu, Doddampalayam and Rajan Nagar use the corridor for collection of fuel wood for their daily livelihood. Seventy fuel wood collectors traditionally use the corridor for wood collection. This stakeholder of the corridor is mostly represented by woman. Wood cutters venture into the elephant infested jungle on foot more than 10 km for collection of both dry and wet wood as part of their income generation activity. The risk involved in their activity is enormous due to the un-friendly pachyderm. So far, four woman from these cillages trampled by elephants during wood gathering.

The fuel wood collectors carries 25 to 40 kg of wood a head load and travel more than 10 km to sell it in the market for an average rate of Rs. 35-40 per headload. This is their daily income per family per day. It was found that 13 food species of elephants were selectively lopped by vilalgers from teh corridor. We examined 112 headloads of fuel wood collected by the villagers from the corridor and found that 80% of them belonging to food plants elephnats. The pole size regenerating saplings were selectively removed by the woman communities while large trees are preferred by the men folk. The removal of such pole sized saplings has

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prevented forest regeneration and also deplete elephant food resources. The other group of stakeholder using the corridor is NTFP collectors. The common NTFP produces collected by them are leaves of *Albizia amara*, fruits of *Solanum* spp, *Terminalia chebula* (gull nut), *Tamarindus indica* (Tamrind), *Sapindus emerginatus* (soap nut), *Phyllanthus embilca* (Nelli) and to some-extent parts of various medicinal plants.

PROJECT STRATEGY

Currently forest managers attempt to focus more on the ways by which local communities could be involved in biodiversity conservation in India. This is referred to "Community or People Participatory Programme".

To protect this corridor from these multi-dimensional biotic threats, a realistic conservation approach is needed with community participatory programme. A strategy was developed with an inter-sectoral assiatance from various agro-forestry institutions to protect the corridor. Various agencies such as District Rural Development Agency (DRDA) of Erode District, State Bank of Inida (Bhavanisagar), Indian Overseas Bank (Rajan Nagar and Doddampalayam), Rural Extension Training Centre (RETC) and Panchyat unions of Sathyamangalam and Bhavanisagar were contributed their support at various levels while implementing the participatory project.

We have collected data on a) documentation of resource users in the corridor and their social status; b) identified various government agencies such as District Rural Development Agencies Panchayat Union of Bhavanisagar and Sathyamangalam, Rural Extension Training Centre (RETC), Public Works Department (PWD), Agricultural Research Station (ARS) and Banks (State bank of India and Indian Overseas Bank) which would provide institutional support and techical expertise for this programme; c) identified funding agencies for alternate livelihood scheme for the forest dependent people during the initial phase of the project and d) monitoring the participatory programme to assess its impact on corridor.

A multi-sectoral committee consisting of various stakeholder, village presidents, field personnel from panchayat union and institutions was formed to develop an outline scheme for launching the alternate income generating activity for the fuel wood collectors. The various activities of the project were informed to teh local legislative members and village presidents to gain their support for executing for innovative schemes.

Workshop and livelihood activities

Livelihood schemes namely sericulture, apiculture, duckey, piggery, poultry, mushroom cultivation, handicraft, sewing and gem cutting and their merits and demerits were discussed in the workshops. Individual stakeholder expressed their views while choosing activities. Activities that would increase degradation of forests were explained in detail. For instance, loan assistance for the purchase of goat, sheep and stone quarry were discouraged. At the end, stakeholder selected community dairy scheme and weaving units as their livelihood activities to wean away from the corridor.

The workshops discussed issues such as a) ways and means of financing activities related to alternate livelihood from the project on a demonstration scale; b) mechanism for effective implementation of such activities and c) mechanism for effective monitoring of project activities including impacts and feed back mechanism. Discussions with each village member was organized in order to win their confidence for achieving the project goals and also to involve them on the corridor management activities. Workshops for policy makers at all levels such as panchayat and legislative members to highlight the conservation of the elephant corridors is in the pipeline. Such activities would help project findings to implement in a practicable way.

Training on alternate livelihood activities were organized for the stakeholder at in various local institutions. Beneficiaries were assessed individually for their interest in the training programmes. The workshops and training livelihood programme conducted for the villagers made them to interact closely with the project team and took the schemes in a promising fashion.

Establishing alternate livelihood

Various government institutions rendered their support for establishing the dairy scheme for the wood harvesters apart from the incentive funds of this project. Ten acers of dry land was made available to the villagers of Sujalkuttai and Pungar by the Public Works Department on a yearly lease to raise green fodder and cattle sheds. Similarly, five acres of land was given by the Peerkadavu Panchayat Union. The lease amount was paid from the incentive funds of the project. The Sathyamangalam Forest Division hsa supplied infrastructure materials such as bamboo poles and stone pillars for establishing cattle sheds. The project incentive funds were used for supply odf dry fodder (paddy straw and dry maize) for the cattle and the materials were distributed for all the members as an incentive to start off the project.

The Collectors Discrenatory Quota (CDQ) was sanctioned for the wood collectors after a great deal of attempts focusing the plight of the elephant habitats in this region. Each beneficiary received Rs. 12,500/- as loan including subsidies which is rated according to their social status. Alternate livelihood for fifty nine villagers was established using subsidized loan provided by the District Rural Development Agency. A total of Rs. 7,37,500/- was granted under the centrally

sponsored IRDP scheme and the money was spent creating alternate activities for the wood collectors through the panchayat unions. The assistance rendered by resourceful Shri Kumar Jayanth, Additional Collector and S. Natarajan, Additional Project Officer, for interlinking the Integrated Rural Development Programme (IRDP) scheme for the participatory micro planning for conservation of elephants and their habitats is a best initiative by the Tamil Nadu State Government as part of poverty alleviation programme.

The village panchayat presidents have ignored their political colours and unilaterally supported the project for the upliftment of the wood collectors. This is a surprising scenario in the present political environment. The panchayat union and bankers have assisted the villagers for the purchase of improved breeds of cows (sindi-cross breed) in the presence of the project team as well as panchayat presidents. This breed thrive well in the local conditions. The norms of NABARD was followed while purchasing the animals. As part of the Ist intalment loan a total of 59 milch animals were purchased and dispersed to 59 stakeholder using the IRDP-CDQ funds. These animals were kept under stall feeding in their respective houses. Seven members have purchased weaving units for their livelihood in Doddampalayam village where the major occupation is weaving.

Motivation was developed for the villagers to enroll themselves as members with the local co-operative milk producers societies at Bhavanisagar and Rajan nagar to get several benefits. The prompt payment of loan and proper maintenance of the assets by the villagers are well appreciated by the bankers and District authorities.

A revolving fund of Rs. 1000/- was contributed for each village using the incentive funds. The fund is being operated by a joint account (Principal Investigator and Group leader) from local banks. The strategy is to make the alternate livelihood programme more viable and self supportive so that the elephant corridor will be protected on a long run without any assistance from outside agencies. Each villager contribute a nominal amount every week to the fund in order to increase the fund for purposes related to the management of alternate llivelihood activities after the ongoing project.

Wood collectors & Corridor protection

The dedicated intiatives for getting loans, initial fodder supply, training on alternate livelihood activities, periodical interaction with the villagers and free supply of materials for erecting sheds for housing the animals have attaracted the villagers to start off the scheme with less effort. This developed a mutual reciprocal agreement between the fuel wood collectors, the forest authorities and teh project team for protecting the corridor. It is interesting to note that the fuel wood harvesters once known as "forest destroyers" are now turned to be "forest protectors" and also developed their own subsistence livelihood using the incentive schemes. The disturbance caused to the elephant corridor by removing wood by the villagers was relieved significantly. Now only for domestic purpose these wood collectors gather weed plants from outside the reserve forests where weeds such as *Prosobis julifflora* is abundantly available.

Each target member ha given the oath of declaration for not visiting the elephant corridor any more for wood collection. The target member were permitted to collect dry wood for their own consumption once a week on a prior approval from the concerned forest beat staff. There were incidence of target villagers paying fine Rs. 750/- to the forest department for violating their oath of declaration. The Ist instalment IRDP assistance does not provide much economic benefit to the members. The fuel wood collectors have expressed their willingness to involve in the forestry works. The photographs of the stakeholders and their addresses were submitted to the Range Forest Officer toprovide them temporary jobs in the wildlife management works. These members have given priority on various departmental works.

Temporary seasonal jobs for the family members of the fuel wood collectors are also being explored. Various departments such as Fisheries, Public Works Department, Agriculture Research Station and Rural Extension Training Centre at Bhavanisagar are potential institutions to offer such jobs. This would reduce dependency of the forests by the members of the fuel wood collectors. The combination of IRDP loan facilities and temporary job avenue for their families would relieve the pressure on the elephant corridors so that the corridor would restore on its own.

ELEPHANT CORRIDOR PROTECTION COMMITTEE

Currently the forest department has deployed the fuel wood collectors as anti-poaching watchers and for planting, check dam construction and soil conservation works. These activities also slowly weaving their regular wood collection business. The project started recruiting dedicated villagers in teh "Corridor Protection Committee" (CPC). The members were recruited from the families of the wood collectors. The CPC members discourage other stakeholder of the forests who exploit the resources of the corridor. This scheme is being tested for its practicability. Recently the CPC members have reported two female elephant carcasses (natural death) to the department.

The CPC members need to be deployed by the forest department on a trial basis as a field level strategy for protecting the corridor. In Philippines and Bolivia through the participatory approach special programmes the forest dependent communities are involved in the

wildlife management, forestry conservation and protected areas regimes.

FEEDBACK MECHANISM

Workshops for the field staff (ranger officers, foresters, guard, watchers) on people participatory programme revealed that viable alternate schemes for the traditional forest dependent people is needed to minimize the pressure on elephant corridor. The forest staff claim that now the stakeholder of the elephant corridor have a better mutual reciprocal agreement with them on various conservation issues. This initiave would help the managers to preserve the corridor in the long run, if it is implemented in a corridor where the biotic pressure is manageable.

CONSTRAINTS

The major problems witnessed by the project team while implementing the goals were a) expectation of more subsidized loans from government by the stakeholder; b) lack of exposure for any enterprenuers; c) poor initiatives by the villagers and d) impoverished condition.

Till date, the major complaints on the alternate income generation activities by the target wood collectors are; increased workload for collecting green fodder from crop fields, lack of money for the supply of concentrated feeds for better and involvement of a dedicated family member for proper maintenance of cows. Now a days the benefits from the dairy income for the wood cutters is just marginal (Rs. 1000/- per month) or little more (Rs. 1200/- per month) considering the expenditures incurred in the management of improved breed.

MONITORING

The villagers heavily depended on the project staff for every aspect of the programme. ALthough we have trained them in every activity and allowed them to work at their own pace, the outcome was not significant. Therefore, monitoring is crucial to make the villagers to live with the local environment by proper utilization of the participatory programme.

Therefore, it is proposed to monitor the project with special emphasis on a) economic benefits to the fuel wood harvesters from the alternate source; b) response to this project from other stakeholder; c) extent of changes in the use pattern by elephants in the corridor and d) extent of biotic pressure relieved from the corridor. After the establishment of livelihood scheme, 80% of the wood collectors have abandoned their activities in the corridor. However, it is too early to conclude precisely the success rate of this project. However, this approach is certainly an avenue for the forest managers to apply it on a trial basis after collecting adequate groud data on social status of the people and forest resources.

CONCLUSION

The attaraction of loan facilities to selected stakeholder of the corridor, so far did not create any negative impact on the corridor management from stakeholder. The replicability of this kind of project elsewhere depends on factors such as social, economic and ethnic acceptibility. The sustainability of the project, may in fact depend as much upon the nature of the relationship which evolve among, forest authorities, local communities and other government agencies. On the whole, the various activities of the project have tuned conservation importance among various stakeholder for preserving the elephant corridor on a regional scale.