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Cover Photograph: Babul-root Boring Longicorn *Coelosterna scabrata*
By Rushikesh Chavan

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Editorial

Indian Conservation Service?

The Indian Forest Service was started by British colonists mainly to extract forest resources and export them to Britain, and to strengthen colonization in India. Conservation and sustainable use practiced by some forest communities and private forest owners at that time was of least consideration for the British. The officers were trained in forestry operations for extracting timber and other resources, and making profit. Therefore, the Service needed 'custodian' officers, some ruthless, who could use the 'native labour' for the 'operations'. Providing *shikar* to the visiting dignitaries was a welcome distraction, which many officers liked because they themselves enjoyed hunting. Whatever wildlife conservation was undertaken, was with the aim to provide 'good game' to the *Bada Sahib* and the royalty. For this job, one did not need a qualified officer with biology background, as the biology aspect in this extractive forestry was rather limited to knowing some commercial trees and 'game' animals; this could be taught easily during the 2-year training in the Forest Research Institute, Dehradun. There was no doubt that there were some fine officers in the service who based forest management on good science, but these were exceptions. Moreover, most of their research was confined to study the growth of commercial plant species, how, where and when to plant these species to maximize results, thinning or removal of unwanted trees and undergrowth, and how to protect them from frost, rain/drought or wild animals, and introduction of fast-growing exotic trees for commercial purpose. Graduation was the only basic degree one required to appear for the Forest Service examination.

Unfortunately, even after Independence in 1947, we carried on the legacy of the British. As far as forests (and forest dwellers) were concerned, only the exploiters had changed but not the exploitation of forest resources. As these resources shrunk, the number of forest officers went up, ostensibly to 'protect' the forest. As wildlife decreased due to hunting and poaching, sanctuaries were established, but they were 'managed' mostly by territorial forest officers who rarely had time to look after wildlife, as extraction of timber brought more money, accolade and promotion. Generally, individuals not wanted in forestry operations, or with no appropriate contacts to manage a lucrative forestry posting, were made wildlife warden, if that post ever existed in a forest division! After enactment of the Wildlife (Protection) Act in 1972, many more wildlife sanctuaries were declared, mainly due to the interest of Mrs. Indira Gandhi, but the working of the Forest Department did not change. Most of the new IFS officials were still from a non-biology background, and most of them with no inherent interest in forest and wildlife. From the mid 1970s, the role of Forest Department changed from exploitation to conservation. By early 1980s, there was a total ban on cutting of natural forest. The pressure on reserve forests and protected areas increased due to human population increase, the so-called 'development' projects, political exigencies and societal demands, but the attitude of the forest officers remained unchanged due to their academic background and training. Both systematic ecological knowledge and local community knowledge remained by and large not integrated in wildlife management.

India now has more than 600 sanctuaries and national parks, and some conservation and community reserves. Moreover, wildlife also lives outside the PA system in reserve forests and in larger landscape and seascape. Wildlife management concept has changed from 'no-hands' approach to active management, particularly considering the size of our PAs, including taking the landscape approach, trying out community-based methods, and so on. New conservation concepts have been developed, new methodologies are available, but wildlife officialdom remains in its fossilized shell, impervious to the changes taking place all around. Other than a handful of officials who are trained in institutions like the Wildlife Institute of India, the Forest Department remains ecologically illiterate. There are some exceptionally good forest officers in every state of India, who do their duty with dedication. The days when the fate of our wildlife is left to an uninterested middle-age wildlife guard and his equally uninterested bosses should be over. In this age of super-specialization, would one appoint a general practitioner for the job of a specialist in a medical institute? Unfortunately, only in the Indian Forest Service a non-biologist or non-ecologist is appointed to look after issues of ecology, habitat management, wildlife diseases, man-animal conflicts, conservation breeding, etc., and local community experts with their generations of experience *still* have no role in official wildlife management.

What are the fresh candidates of Forest Service taught? I quote from the Indian Forest Service (Probationers Final Examination) Regulations, 2005, gazette notification: Elementary Biology/Mathematics, Elementary Biology Practical, Overview of Forestry, Forest Statistics, Geology, Soil Science, Soil, Water and Land Management, and Computer Awareness and Applications in Forestry. This is in the Introductory Phase. In the Professional Phase I, they have the following subjects:

Forest Mensuration, Forest Biometry, Systematic Botany, Forest Ecology, Silvicultural Practices, Forest Economics, Silvicultural Systems, Forests Policy, Law and Conventions, and Biodiversity Conservation. There is another phase, which the IFS notification calls Phase II, where Forest Survey, Remote Sensing and GIS, Forest Engineering, Wildlife Management, Forest Production, Non-timber Forest Produce, and Wood Technology, Harvesting and Industries. Many of these topics are taught in 5-6 lectures!

And what are the subjects taught in these various topics? Taking only two subjects, 'Elementary Biology' and 'Wildlife Management' as an example, see what an IFS probationer is taught: Botany: Morphology – classification of plant kingdom; parts of an angiospermic plant, the seed, germination, root, stem – their functions and modification; the leaf, inflorescence, flower and fruit. Histology – the cell, the tissues, cell division, histology of stems, root and leaf. Secondary growth, Physiology – absorption, and conduction of water and mineral salts, metabolism – photosynthesis, respiration, nitrogen fixation and reproduction. Tree Genetics – genetics and its application to plant improvement, and DNA finger printing.

Zoology: Classification of animal kingdom – economic importance and distinguishing features of different classes. Theory and Practical are of 10 marks each, out of the total of 865 marks! Interestingly, 'Wildlife Management', which a manager of a PA has to look as his/her main job is of only 35 marks, and that also only theory, no practical. Practical wildlife management is taught during various field visits of other subjects or during whirlwind all-India tour of the probationers.

Just imagine, in this age when wildlife management has become a highly professional job all over the world, we still have forest officers with elementary biology background*. In the complex world of ecology, even after 30 years of research one learns everyday, but an IFS officer with non-biology background, in a 2-year training programme becomes an expert on wildlife management! For many such officers, real wildlife experts (even amongst their own colleagues) are either a nuisance or an irritant to be disdainfully tolerated.

Equally important, most forest officials are not taught to deal with the real life social and political issues that confront wildlife management both within protected areas and in the larger landscape, including relations with local communities, issues of land and resource rights, the challenges of 'development' policies, issues of poverty, and so on.

As India becomes developed, there is an urgent need to bring drastic change in the way our forest officers are selected. The first requirement is that the basic qualification for appearing in the Indian Forest Service should be biology or environmental science, or science at undergraduate level. Secondly, we should have a special Wildlife Service of wildlife professionals to look after protected areas and wildlife management. This Indian Wildlife Service should have land managers, field biologists, wildlife vets, wildlife crime detectors, and social scientists who work with local communities, as also people who come from the communities themselves. Like we have a highly trained and dedicated professional army, India needs a dedicated Indian Wildlife Service with a human face, as local communities share space with wildlife in most of our PAs; to put it another way, wildlife has to share the space in our crowded country with more than a billion people in 6 per cent of the world's land. Many countries, such as South Africa, Kenya, Tanzania, Botswana, and USA have shown that highly trained, dedicated and professional wildlife managers can restore degraded lands and depleted wildlife. We also have some very fine officers, but most of our PAs are still 'managed' by non-professionals who do not have interest to learn/use new methodologies. Thirdly, instead of Indian Forest Service, it should be called Indian Conservation Service or Indian Ecosystem Protection Service because these days most of the job of a forest officer is protection of several kinds of ecosystems, not only forests. When we have changed the term 'District Collector' to 'District Magistrate', why can't we change the term Indian Forest Service to Indian Conservation Service or something similar? During the British period, the main job of a collector was to collect revenue for the colonial power, but now it is to administer the district, with revenue generation being only a small part of the job. Similarly, the main job of an IFS officer was forestry operations – cutting timber and generating revenue. During the last 60 years as we have changed from production forestry to conservation of forest, therefore there is a need to change the title. The Government of India is planning a string of marine protected areas, some of them will be entirely underwater. Will it be appropriate for a marine protected area to be 'managed' by an officer of the Forest Service, where marine ecology is not even taught?

Asad R. Rahmani

**Recently Indira Gandhi National Forest Academy, Dehradun has prepared a draft of the syllabus on Wildlife Management to be taught to IFS probationers in about 200 lectures by experts and experienced forest officers. This is a very good step in the right direction.*

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PREY SELECTION BY TIGERS (*PANTHERA TIGRIS TIGRIS*) IN SARISKA TIGER RESERVE, RAJASTHAN, INDIA

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Prey selection by tigers (*Panthera tigris tigris*) was studied in Sariska Tiger Reserve, Rajasthan, India, from November 2002 to April 2003. The line transect method was used for estimating prey availability and prey selection was determined from scats. Sariska was observed to have a high wild ungulate density of 42.8 animals/sq. km, Chital (*Axis axis*) was the most common ungulate species (27.6/sq. km) followed by Sambar (*Cervus unicolor*) (8.4/sq. km) and Nilgai (*Boselaphus tragocamelus*) (5.2/sq. km). Seventy-seven tiger scats were collected and analyzed for prey remains. Scat analysis revealed that Sambar constituted the major prey species in terms of number and biomass. It was the principal and preferred prey ($P<0.05$) of tigers. Other medium to large sized prey species, including domestic livestock, contributed significantly to the tiger diet. The order of selection on the basis of prey occurrence in scats was sambar>chital>nilgai>cattle-buffalo>common langur>wild pig. It was evident that tigers were heavily dependent on sambar in greater proportion to their availability. This study provides food habits of now extinct tiger population. Two tigresses and a tiger were recently reintroduced from Ranthambhore to revive the population.

Key words: Food habits, prey selection, tiger, *Panthera tigris*, line transect, scat analysis, ungulate density

INTRODUCTION

The Tiger (*Panthera tigris* Linnaeus) occurs in a large variety of habitats showing remarkable tolerance to variation in altitude, temperature and rainfall regimes (Sunquist *et al.* 1999). There has been a drastic reduction in the distribution of the tiger in the last 100 years resulting in the extinction of three subspecies (Caspian, Javan and Bali) and massive reduction in numbers of the rest (Seidensticker 1986, 1987, 1997; Sunquist *et al.* 1999; Qureshi *et al.* 2006; Jhala *et al.* 2008). The depletion of prey populations, habitat fragmentation, disturbance and poaching are the major factors responsible for the decline of tigers in the wild (Karanth 1991; Chapron *et al.* 2008).

The tiger is the largest obligate terrestrial carnivore in any of the mammalian assemblages in which it occurs and preys on the larger ungulates living in those assemblages (Seidensticker 1997). Despite their potential to hunt a wide variety of prey animals, ranging from small mammals to large bovids, the mean weight of species hunted is around 60 kg (Biswas and Sankar 2002). This is obtained predominantly from cervids, which constitute up to 75% of the prey biomass requirement in most parts of the range (Sunquist *et al.* 1999; Biswas and Sankar 2002; Bagchi *et al.* 2003). Food habits comprise one of the major determinants of various life history patterns including spacing pattern, movement, habitat selection, social structure, success of reproduction and geographical distribution (Krebs 1978; Beckoff *et al.* 1984; Sunquist and Sunquist 1989). The factors affecting prey choice are a result of a complex interplay of various ecological parameters, which vary at the extremes of distribution of the same species (Sunquist and Sunquist 1989). Carbone and Gittleman (2002) estimated 10,000 kg/100 sq. km would support 0.33 tigers/100 sq. km. The effective size of the territory is a function of density and biomass of larger prey species in its habitat (Sunquist 1981; Karanth 1991). This makes the species vulnerable to changes in the habitat and prey abundance (Karanth 1991).

STUDY AREA

The study was conducted in Sariska Tiger Reserve (Sariska TR) (25° 5'-27° 33' N; 74° 17'-76° 34' E), Rajasthan. The total area of the Tiger Reserve is 800 sq. km, of which 302.2 sq. km is a buffer zone and 497.8 sq. km is the core zone. Sariska National Park of 273.8 sq. km was notified in 1982. The intensive study area was 45 sq. km situated in core zone I. The terrain is undulating to hilly in nature and has numerous narrow valleys and two large plateaux, Kiraska (592 m above mean sea level) and Kankwari (524 m above mean sea level).

The climate of this tract is subtropical, characterised by a distinct summer, monsoon, post monsoon and winter. Summer commences from mid-March and continues till the end of June (max temperature recorded was 44 °C in March (Sankar 1994)). The monsoon extends from June to September with the annual average rainfall ranging from 60 to 70 cm. In winter the temperature has been observed to drop to 3 °C

(Sankar 1994). The vegetation of the region falls under Northern Tropical Dry Deciduous Forest (subgroups 5 B: 5/E1 and 5/E2) and Northern Tropical Thorn Forest (sub group 6 B) (Champion and Seth 1968).

Prey species of tigers in the area include Chital (*Axis axis* Erxleben), Sambar (*Cervus unicolor* Kerr), Nilgai (*Boselaphus tragocamelus* Pallas), Common Langur (*Presbytis entellus* Dufresne), Indian Wild Boar (*Sus scrofa* Linnaeus), Four-horned Antelope or Chowsingha (*Tetracerus quadricornis* Blainville), Chinkara (*Gazella bennettii* Sykes), Rhesus Macaque (*Macaca mulatta* Zimmermann), Indian Porcupine (*Hystrix indica* Kerr), Rufous-tailed Hare (*Lepus nigricollis ruficaudatus* Geoffrey), and Indian Peafowl (*Pavo cristatus* Linnaeus). The predominant domestic livestock found inside the reserve are buffaloes (*Bubalis bubalis* Linnaeus), Brahminy cattle (*Bos indicus* Linnaeus) and goats (*Capra hircus* Linnaeus).

METHODS

Estimation of prey availability

The variable distance line transect method was used to estimate prey density in the study area (Burnham *et al.* 1980; Buckland *et al.* 1993). This method has been extensively used to determine animal densities in similar habitats (Sunquist 1981; Karanth and Sunquist 1995; Varman and Sukumar 1995; Chundawat *et al.* 1999; Biswas and Sankar 2002; Sankar and Johnsingh 2002; Bagchi *et al.* 2003; Karanth *et al.* 2004). Twelve transects were laid in the study area in a random manner. The lengths of each transect varying from 2 km to 2.4 km. All transects (24.8 km) were walked seven times during the course of the study period totalling to 173.6 km. Transects were walked early in the morning in the first three hours after sunrise when the animals are said to be most active (Schaller 1967). For each cluster of prey animals encountered on transects, the following variables were noted: (1) time (2) species (3) cluster size (4) radial distance (Using *Yardage Pro 400* Rangefinder) (5) sex and age (6) sighting angle.

The density of all prey species was calculated using the program Distance (Thomas *et al.* 2005). The analysis involved fitting of different detection functions to the observed data for estimation of densities. The best model was selected on the basis of the lowest Akaike Information Criteria (AIC) values (Burnham *et al.* 1980; Buckland *et al.* 1993).

Reconstruction of tiger diet

Hairs from the scats were observed for prey identification, because they pass undigested through the gut and can be used for species identification (Sunquist 1981; Mukherjee *et al.* 1994a,b; Karanth and Sunquist 1995). Scat analysis was used to estimate the proportion of different prey species consumed by tiger, since it is non-invasive, cost and time effective (Schaller 1967; Sunquist 1981; Johnsingh 1983; Johnsingh *et al.* 1993; Karanth and Sunquist 1995). Tiger scats were collected wherever encountered in the intensive study area. They were distinguished from leopard scats by the size of the scat and associated pugmarks as described by Sunquist (1981), Karanth and Sunquist (1995), and Biswas and Sankar (2002). Scats were washed in water, and held over a sieve. The washed hairs were sun dried and kept in zip lock bags for further analysis.

Prey species in the scats were identified based on the variables described by Mukherjee *et al.* (1994b). Sample slides were compared with reference slides available in the laboratory of the Wildlife Institute of India, Dehradun.

Estimation of biomass and number of prey

The biomass and number of individuals of the prey consumed by tiger was estimated using Ackerman's equation (Ackerman *et al.* 1984; Karanth and Sunquist 1995; Biswas and Sankar 2002; Sankar and Johnsingh 2002; Bagchi *et al.* 2003).

$Y = 1.980+0.035X$, where X = average weight of a particular prey type and Y = kg of prey consumed per field collectible scat (Ackerman *et al.* 1984).

The assumption for extrapolation of the above equation is that the tigers and cougars (*Felis concolor concolor* Linnaeus) have similar utilization and digestibility (Karanth and Sunquist 1995). We also presume that the scats containing various prey items have similar decay rate and their detection is equally probable.

Estimation of prey selectivity

Prey selectivity by tigers was estimated for each species by comparing the proportion of prey species recovered from scats with the expected number of scats in the environment for each of the prey species consumed. Frequencies of the identifiable prey remains in the scat do not tell us about the actual proportion of prey type eaten. This is more so when the prey types vary in size to a considerable degree. Smaller prey species have more undigested material (i.e., hair) due to higher body surface to mass ratio. Hence, intake of smaller body sized prey induces relatively more amount of scat production per unit mass of prey consumed leading to an over estimation of smaller prey species in the diet studies of carnivores (Floyd *et al.* 1978; Ackerman *et al.* 1984). The average weight of prey species of the tiger required for biomass estimation was taken from Karanth and Sunquist

Table 1: Individual and group densities of major Tiger prey species estimated using line transect method in Sariska Tiger Reserve, Rajasthan, November 2002 to April 2003

Species	Model	No. of Groups	Density	SE	Group Density	SE	ESW	SE	Encounter rate/km	SE
Chital	Uniform Cosine	99	27.62	7.63	5.62	0.52	51.46	4.61	0.57	0.11
Livestock	Half Normal Cosine	45	6.47	3.35	1.40	0.78	93.52	8.77	0.26	0.19
Langur	Uniform Cosine	40	14.13	4.86	6.63	1.18	54.91	2.81	0.23	0.06
Nilgai	Uniform Cosine	63	5.19	1.26	1.88	0.24	66.64	3.72	0.36	0.07
Peafowl	Half-Normal Cosine	181	20.81	6.46	1.90	0.09	47.93	3.54	1.04	0.31
Wild Pig	Half Normal Cosine	14	1.64	0.60	0.60	0.19	67.74	0.51	0.87	0.02
Sambar	Half Normal Cosine	57	8.44	2.53	2.28	0.26	40.01	5.08	0.33	0.08

Density : Individual density
SE : Standard Error
Group Density : Mean group density of each species encountered during the transect walks
ESW : Effective Strip Width
Encounter rate : Number of animals encountered per kilometer of transect walk. Total transect length walked 173.6 km.

(1995), Khan *et al.* 1996, Sankar and Johnsingh (2002).

Prey selectivity by tigers was estimated for each prey species by comparing their availability and utilization data. The expected proportion of scats in the environment (i.e., availability) was calculated using the following equation (Karanth and Sunquist 1995):

$$fi = [(di /dt) * \lambda i]/ \Sigma [(di/dt) * \lambda i],$$

where fi= expected scat proportion in the environment, di= density of i th species, dt = sum of density of all species, $\lambda i = X/Y$ the average number of collectible scats produced by tiger from an individual of i th prey species, X = average body weight of the species and $Y = 1.980 + 0.035X$.

Multinomial likelihood ratio test was used to evaluate prey selection of tigers in the study area (Manly *et al.* 1972; Chesson 1978; Reynolds and Aebischer 1991; Link and Karanth 1994; Karanth and Sunquist 1995). The exact variability of prey items in scats is not known and in order to account for it sensitivity analysis was done by changing coefficient of variance from 10 to 40% (Link and Karanth 1994). Program Scatman (Hines 1999) was used to do multinomial test and sensitivity analysis by bootstrapping data 5,000 times. Sample size needed to construct tiger diet was estimated by bootstrapping prey presence data in scats using program Simstat© 2.0 (Provalis Research). The variance in data significantly reduced after 60 scats suggesting that the sample size collected was adequate to reconstruct tiger diet.

RESULTS

Availability of prey species

The uniform key model fitted for density estimation of chital, common langur and nilgai. Half normal cosine was the best-fitted model for sambar, wild pig, cattle, buffalo, and peafowl (Table 1). All density estimates were done after 1% truncation of the farthest sighting data from the line transect. The highest density was of chital 27.62, followed by peafowl 20.81, common langur 14.13, sambar 8.44, livestock 6.47, nilgai 5.19 and wild pig 1.64 (Table 1). Amongst wild prey cervids contribute maximum biomass of which chital contribute maximum (1,243 kg/sq. km) followed by sambar (Table 2).

Composition of tiger diet

Altogether 87 prey items were found in 77 tiger scats collected from the study area (Table 3). The analysis of 77 tiger scats revealed the presence of seven prey species with a high preponderance of medium to large sized ungulates in the tiger's diet (Table 3). Eighty-seven per cent of tiger scat contained single prey species and 13% contained two prey species. The wild prey species in tiger scats constituted 83.9% and remaining 16.1% by domestic livestock (cattle and buffalo). Of the wild prey species sambar constituted 48.2% followed by chital (18.1%), nilgai (14.5%), common langur (4.8%) and wild pig (1.2%). Cattle and buffalo constituted 11.5% and 5.7% of the remains encountered in the tiger scats.

The wild prey base in total contributed 74.5% in terms of relative biomass of prey consumed by tiger (Table 3), of which cervids contributed 73.9% of the total biomass, and livestock (buffalo and cattle) contributed 25.5% (Table 2). Sambar contributed 254.2 kg biomass to the diet of tiger followed by nilgai (99.36 kg), cattle (82.8 kg), buffalo (57.67 kg), chital (53.32 kg), common langur (9.04 kg) and wild pig (3.31 kg) (Table 3).

Estimation of prey selectivity

Sambar was consumed by tiger more than expected on basis of the availability of individuals and groups (Tables 4a,b and 5). Chital utilization was proportionally less than available group and individual density. Common Langur

Table 2: Frequency of occurrence of food items in 77 Tiger scats and contribution of different prey species in terms of biomass to the Tiger diet in Sariska Tiger Reserve (November 2002 to April 2003)

Prey species	Average Body weight (X)	Prey species remains (F=87)	Percent occurrence of prey species (n = 77)	Relative occurrence (R) in %	Number of collectible scats produced per kill (Y)	Prey biomass consumed B = F*Y	Percentage relative biomass of prey contribution (P = F*R in %)
Chital	45	15	19.48	17.24	3.55	53.32	9.52
Sambar	125	40	51.95	45.97	6.35	254.2	45.41
Nilgai	180	12	15.58	13.79	8.28	99.36	17.75
Wild Pig	38	1	1.3	1.14	3.31	3.31	1.59
Domestic Buffalo	273	5	6.49	5.74	11.53	57.67	10.03
Domestic Cattle	180	10	12.99	11.49	8.28	82.8	14.79
Common Langur	8	4	5.19	4.59	2.26	9.04	1.61
						559.71	

X = Average body weight of an individual prey type in kg
Y (kg of prey consumed per field collectible scat) = 1.980+0.035 X (Ackerman *et al.* 1984)

and Wild Pig were used in proportion to their available individual density and in less proportion to their group density (Tables 4a,b and 5). Nilgai was utilized in proportion to their available individual and group density (Tables 4a,b and 5). Based on the index of selection at individual level the prey species used by tiger were ranked as sambar > nilgai > wild pig > cattle and buffalo > common langur > chital. Ranking on the basis of group density was in the following order: sambar > cattle and buffalo > nilgai > chital > wild pig > common langur. The order of selection on the basis of prey occurrence in scats was sambar > chital > nilgai > cattle-buffalo > common langur > wild pig.

DISCUSSION

Availability of prey species

Chital were the most abundant wild ungulate species in Sariska study area. However, the crude density estimates for Chital in Sariska were less than other protected areas in India; Pench (Biswas and Sankar 2002), Kanha, Nagarhole (Karanth and Nichols 1998), Gir (Khan *et al.* 1996) and Bandipur (Johnsingh 1983). Chital was also the least widespread of the three large wild ungulates found in the study area. Chital had a clumped distribution pattern, largely encountered in the valleys interspersed between the hills and in areas in the plains, which had a tall vegetation cover with least disturbance.

Sambar density in the study area (8.44 animals/sq. km) was higher than the density figures obtained for Kanha, Nagarhole (Karanth and Nichols 1998), Mudumalai (Varman and Sukumar 1995), Chitwan (Seidensticker 1976). Sambar densities in Sariska can be compared with protected areas like Pench (Biswas and Sankar 2002) and Bandipur (Johnsingh 1983). Sambar is predominantly a browser and has evolved in forest environment (Eisenberg and Lockhart 1972). Its abundance in any particular area probably is limited by the dispersion of browse species in the forest, the phenophase of browse species and water availability (Sankar

Table 3: The estimated biomass of prey species in Sariska Tiger Reserve (November 2002 to April 2003)

Species	Density/sq. km	Confidence Interval		Avg. Body weight (kg)	Mean Biomass sq. km (kg)	Confidence Interval	
		Lower	Upper			Lower	Upper
Chital	27.62	19.98	35.25	45	1,242.9	899.23	1,586.56
Livestock	06.47	03.11	09.82	217	1,403.99	675.73	2,132.24
Common Langur	14.13	09.26	18.99	8	113.04	74.09	151.98
Nilgai	05.19	03.92	06.45	180	934.2	706.68	1,161.72
Peafowl	20.81	14.34	27.27	4.2	87.40	60.26	114.53
Wild Pig	17.52	16.91	18.12	38	665.76	642.69	688.82
Sambar	08.44	05.90	10.97	125	1,055	738.62	1,371.37
Total (kg)					5,503.37	3,797.33	7,207.25

Table 4a: Preference of prey species by tiger in Sariska Tiger Reserve based on availability of individuals and utilization based on scat data (November 2002 to April 2003)

Species	Chi-square value	Un-adjusted P-value	Adjusted P-value 10% CV	Adjusted P-value 20% CV	Adjusted P-value 30% CV	Adjusted P-value 40% CV	Ivlev's index
Chital	11.18	0.001	0.00	0.00	0.00	0.03	-0.34
Sambar	54.82	0	0	0	0	0	0.48
Cattle & Buffalo	05.75	0.01	0.03	0.03	0.03	0.04	-0.27
Common Langur	01.00	0.31	0.32	0.32	0.32	0.33	-0.32
Nilgai	00.32	0.56	0.57	0.57	0.58	0.58	0.08
Wild Pig	00.16	0.68	0.68	0.68	0.68	0.68	-0.19

1994; Biswas 1999). Of the two cervids, sambar was the most widely distributed in the study area. This may be attributed to the fact that a large portion of the terrain is hilly in the study area that was relatively undisturbed.

Nilgai density in the study area was observed to be 5.2 animals/sq. km, which is comparable to the Royal Bardia National Park (RBNP) (Dinerstein 1980). It is higher than the nilgai densities recorded in Pench (Biswas and Sankar 2002) and Gir (Khan *et al.* 1996). Nilgai was observed to be widely distributed across the entire study area. However, their occurrence was recorded more in the plains than in the hills. This could be attributed to their higher tolerance of anthropogenic pressure than the cervids. The nilgai's wide dispersal in Sariska TR was attributed to its tolerance of disturbance (Sankar and Johnsingh 2002).

The observed density for wild pigs (1.64 animals/ sq. km) was lower than recorded densities in other studies – Pench: 2.6 animals/sq. km (Biswas and Sankar 2002), Nagarhole: 3.3 animals/sq. km (Karanth and Sunquist 1995), Bandipur: 2.5 animals/sq. km (Johnsingh 1983), Royal Bardia National Park: 4.2 animals/sq. km (Dinerstein 1980) and Chitwan: 5.8 animals/sq. km (Seidensticker 1976) (Table 5). Though Chowsingha was not encountered during transect walks, their pellet groups were recorded along transects. This showed the presence of chowsingha in the study area. Sankar (1994) reported low occurrence of chowsingha in Sariska. Common Langur density in the study area was observed to be 14.1 animals/sq. km. It was observed to be very low compared to the density recorded in Pench, which was 77.2 -animals/sq. km (Biswas and Sankar 2002).

Domestic cattle and buffalo were distributed largely in the plains, their combined density was 6.47 individuals/ sq. km. Buffaloes and goats were accompanied by villagers in the forest, whereas the cattle were left unattended.

Prey Selection by tigers

Sambar were observed to be the principal prey species for tigers as inferred from the percentage occurrence of prey remains in scats (Table 3). Sambar also contributed to the highest biomass of prey consumed by the tiger. Sambar was selected in greater proportion than its available group and individual densities.

Of the prey remains encountered in scats, sambar constituted the maximum amounting to 46% of the total. This is high compared to the frequency observed in Pench – 13.8%, (Biswas and Sankar 2002), Kanha – 10.4% (Schaller 1967) and Nagarhole – 34.9% (Karanth and Sunquist 1995) (Table 6). Sambar ranked first in terms of frequency of occurrence in scats, which is not observed in all previous studies (Table 6). Chital constituted 17.2% of the total prey

Table 4b: Preference of prey species by tiger in Sariska Tiger Reserve based on availability of groups and utilization based on scat data (November 2002 to April 2003)

Species	Chi-square value	Un-adjusted P-value	Adjusted P-value 10% CV	Adjusted P-value 20% CV	Adjusted P-value 30% CV	Adjusted P-value 40% CV	Ivlev's index
Chital	05.31	0.02	0.03	0.03	0.03	0.03	-0.25
Sambar	34.17	0.001	0.001	0.001	0.001	0.001	0.38
Cattle & Buffalo	00.06	0.79	0.82	0.82	0.82	0.82	0.03
Common Langur	05.68	0.01	0.01	0.02	0.02	0.02	-0.62
Nilgai	01.68	0.19	0.21	0.22	0.23	0.25	-0.17
Wild Pig	00.96	0.03	0.33	0.33	0.33	0.33	-0.43

Table 5: Densities of ungulate species from different areas in south Asia

Species	PNP	RAN	KNH	NGH	BDP	MML	RBNP	CTW	STR
Chital	80.75	31.05	49.7	38.1	43	25.03	29.7	17.3	27.62
Sambar	6.09	17.15	1.5	4.2	8-9	6.61		2.9	8.44
Wild Pig	2.59	9.77	2.5	3.3	2.5		4.2	5.8	17.52
Gaur	0.34			4.5	0.5	14.38			
Nilgai	0.43	11.36					5.0		5.19
Chowsingha	0.29								
Muntjac			0.6	6.0	1		1.7	6.7	
Chinkara		5.2							
Barasingha			3.0						

PNP (Pench National Park) - Biswas & Sankar (2002); RAN (Ranthambhore) - Bagchi *et al.* (2003); KNH (Kanha) & NGH (Nagarhole) - Karanth & Nichols (1998); BDP (Bandipur) - Johnsingh (1983); MML (Mudumalai) - Varman & Sukumar (1995); RBNP (Bardia) - Dinerstein (1980); CTW (Chitwan) - Seidensticker (1976), STR (Sariska) Present study 2002

remains in tiger scat in Sariska, which is less than that was observed in other studies – Pench 53%, (Biswas and Sankar 2002), Kanha 52.2% (Schaller 1967), Nagarhole 31.2% (Karanth and Sunquist 1995) and Bandipur 39% (Johnsingh 1983) (Table 6).

Nilgai remains were observed in 13.7% of the scats. This is higher than the percentage observed for all other areas mentioned above. Sankar and Johnsingh (2002) reported the occurrence of remains of rodents, insectivore, chowsingha, peafowl (*Pavo cristatus*) and Grey Francolin (*Francolinus pondicerianus*) in tiger scats in Sariska. However, during the present study the remains of these species were not observed. Remains of domestic cattle was recorded in the present study, but not reported earlier (Sankar and Johnsingh 2002).

The preference for sambar could be attributed to the larger body weight and wide distribution of sambar across the study area thereby the higher frequency of encounter. The tiger distribution range also coincided with the good sambar habitat in the reserve. Nilgai were selected in proportion to their available individual density and were second in terms of biomass contribution to the tiger diet. Chital were selected in less proportion to their available individual and group density, and were fifth in terms of biomass

Table 6: Frequency of occurrence of major prey species in Tiger (*Panthera tigris tigris*) scats from different areas of the Indian subcontinent

Species	Sariska	Kanha	Bandipur	Nagarhole	Chitwan-1	Chitwan-2	Bardia	Pench	Sariska-1	Ranthambhore
Chital	17.24	52.2	39	31.2	33.3	61.8[a]	77.7	53.01	33.19	45.67
Sambar	45.97	10.4	30.5	34.9	29.3	20		13.78	31.51	36.86
Muntjac				6.1	4.1			5.34		
Barasingha		8.6					1.4			
Hog Deer					15.4		7.7			
Wild Pig	1.1	0.8[b]	5.5	9.4	10.6	3.6	8.8	8.88		2.89
Gaur		8.3	5.5	17.4						
Nilgai	13.79						1.9		1.26	3.27
Chowsingha								2.67	2.1	
Chinkara										0.58
Common Langur	4.59	6.2		3.9	5.7	3.6	2.3	3.65	10.08	4.86
Cow	11.49	5.9	5.5[c]			1.8[c]		4.34		2.89
Buffalo	5.7	1.7						2	1.26	2.6
Others	0	6.1	14	7.1	1.6	9	5.2	6.33	20.58	

a: Includes percent occurrence of Chital, Hog Deer and Muntjac

b: Both domestic and Wild Pigs

c: Domestic livestock as a whole

Kanha - Schaller (1967); Bandipur - Johnsingh (1983); Nagarhole - Karanth & Sunquist (1995); Chitwan-1 - McDougal (1977); Chitwan-2 - Sunquist (1981); Bardia - Stoen & Wegge (1996); Pench - Biswas & Sankar (2002); Sariska-1- Sankar & Johnsingh (2002); Ranthambhore - Bagchi *et al.* (2003)

contribution to the tiger diet. Chital were the least widespread of the three ungulates and their distribution was clumped thereby reducing the frequency of encounter.

Different factors like abundance of the prey species, temporal and spatial distribution, size, defences, and anti-predator tactics determine the predator choice (Sunquist and Sunquist 1989). For tigers in the Indian subcontinent, sambar and chital constituted the main prey base wherever they occur in considerable numbers (Schaller 1967; Tamang 1979; Sunquist 1981; Johnsingh 1983; Johnsingh *et al.* 1993; Stoen 1994; Karanth and Sunquist 1995). Other common prey species of tiger are wild pig, gaur and nilgai (Biswas and Sankar 2002; Sankar and Johnsingh 2002).

Mammalian carnivores are characterized by classic relationship with their prey. It seems that carnivores are closely tied not only to prey size, but also to prey biomass (Karanth and Nichols 1998; Carbone and Gittleman 2002; Karanth *et al.* 2004). Carbone and Gittleman (2002) suggested that 10,000 kg of prey support about 90 kg of a given species of carnivore irrespective of body mass and that the ratio of carnivore number to prey productivity scales to carnivore mass near -0.75, and that the scaling rule can predict population density across more than three order of the magnitude. Prey density is critical to maintenance of a large carnivore population. Habitat loss, poaching and prey loss are most critical factors determining tiger population (Cardillo *et al.* 2004; Chapron *et al.* 2008). Looking at the current socio-political scenario it is important to maintain core-breeding areas for tigers at landscape level. In any given Protected Area it is important to maintain mini-cores as a source area for tiger and its prey. In Sariska Tiger Reserve, the Sariska-Kalighati – Pandupole valley (*c.* 80 sq. km) is the only area that can be considered as mini-core. As the rest of the Park area is disturbed due to the anthropogenic pressure, having very low wild ungulate density, and hence it can support only a few tigers (Johnsingh *et al.* 1997).

Wikramanayake *et al.* (1999) classified the Sariska Tiger Reserve as Tiger Conservation Unit 3 (TCU 3) among the dry deciduous habitat types. The long-term survival of tigers in such units is threatened due to various anthropogenic factors. These areas require active interference to prevent the extinction of tigers. In the study area, evidences of tiger (tracks, signs, scats) were recorded only from the hilly tracks, which is relatively undisturbed. This forms a very small area (*c.* 80 sq. km) of the Core Zone I and corresponds to the area where there is a high wild cervid density (Sankar 1994; Sankar and Johnsingh 2002). The reported total tiger population in the entire Tiger Reserve was 26 (Anon. 2002), a gross over estimate. The maximum of 15 tigers would have been supported by prey density, based on the equation of Karanth *et al.* (2004). Tiger population got extinct in 2004 due to poaching, but proximate causes were isolation, habitat degradation and loss of prey from a large area.

Denial of poaching, long history of passive management, inaction, carnivore-people conflict, lack of interest and organized poaching were the reasons of extinction of tiger. If we forget these and fail to respond in appropriate time, there might be many more extinctions. It is now extremely important to relocate villages with appropriate package to make available the meaningful area to sustain demographically viable tiger population. There are 12 villages located in the proposed national park of the tiger reserve and are due for relocation (Sankar 1994; Johnsingh *et al.* 1997). In 2006-07, Bhagani village was relocated; rest are in process of relocation. This will make available 120 sq. km of intact forest (Sankar 1994; Johnsingh *et al.* 1997). Two tigresses and a tiger were reintroduced in 2007-2008 from Ranthambhore.

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PREY SELECTION BY TIGERS *PANTHERA TIGRIS* (LINNAEUS 1758) IN THE SUNDARBANS EAST WILDLIFE SANCTUARY OF BANGLADESH

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This study was conducted to determine prey selection by Tigers *Panthera tigris* in the Sundarbans East Wildlife Sanctuary of Bangladesh. A total of 145 scats were analysed and 78 kills were studied. The frequency of occurrence of different prey species in scats and kills was significantly different. On an average, the Spotted Deer *Axis axis* was the most frequent prey in scats and kills (78%). Most Spotted Deer kills were adult animals and were in good condition before they were killed. The frequency of occurrence in scats was converted to the relative number of kills, which showed that the Spotted Deer was still the most frequent prey (29.9%). Other than the Spotted Deer, tigers also preyed on Wild Boar *Sus scrofa*, Rhesus Macaque *Macaca mulatta*, and Lesser Adjutant *Leptoptilos javanicus*. Soil and sungrass blades were found in scats as non-food items. Scats with soil were more available in winter than in summer. In general, the trend of prey selection appeared to follow prey size and abundance, but Wild Boar and Lesser Adjutant were two most high-ranking prey species, because their selectivity was higher in comparison to their abundance.

Key words: mangroves, tiger food habit, tiger kills, tiger scats, spotted deer

INTRODUCTION

The acquisition of food is a fundamental component of every predator's daily existence. Hence, knowledge of food selection is critical to understanding life history strategies and developing sound conservation recommendations (Miquelle *et al.* 1996). Predatory strategies are shaped and refined by natural selection to maximise nutrient intake within the bounds of a wide range of biologically relevant ecological constraints (Clutton-Brock and Harvey 1983; Sunquist and Sunquist 1989). Carnivores often regulate or limit the numbers of their prey, thereby altering the structure and function of entire ecosystems (Schaller 1972; Smuts 1978; Berger *et al.* 2001; Terborgh *et al.* 2002). The role Tigers *Panthera tigris* play as top predators is vital to regulating and perpetuating ecological processes and systems (Sunquist *et al.* 1999; Terborgh 1999). The analysis of food habits provides practical and immediately useful information for the management of a particular species, and occasionally aids law enforcement and management needs (Korschgen 1971).

The general objective in this research is to identify whether Tigers in the Sundarbans have any preference for prey in terms of species, availability, age and health. The specific questions are: 1) What are the proportions of different prey species in Tiger scats and kills? 2) Do Tigers sometimes ingest non-food items? 3) Does prey abundance have any effect on prey selection? 4) What are the proportions of kills in different age and health classes? 5) Does the abundance of the Spotted Deer *Axis axis* in different age classes have any effect on its selection?

MATERIAL AND METHODS

Study area

The study was conducted in a part of the Sundarbans. The entire Sundarbans is an area of about 10,000 sq. km in the Ganges-Brahmaputra delta of Bangladesh and India, but roughly 60% of this forest lies in the south-west of Bangladesh and the rest 40% is in the south-east of the Indian state of West Bengal. The monthly mean temperature and relative humidity normally varies from 23 °C (during December-January) to 35 °C (during May-June) and from 70% to 80%, respectively. There are three wildlife sanctuaries in the Bangladesh Sundarbans that together form a UNESCO World Heritage Site. The Sundarbans East Wildlife Sanctuary (WS) (312 sq. km) is one of these three sanctuaries where this research was concentrated (Fig. 1). Geographically the area is located between 21° 47'-22° 03' N and 89° 44'-89° 56' E.

Scat analysis

The scat samples were collected from the field, on a monthly basis, for 18 months (September 2001 to February 2003). Since the Tiger is the only large carnivore in the Sundarbans, Tiger scats could be identified without any confusion. The samples were sun-dried whenever necessary, preserved in a tagged polythene bag, and brought to the laboratory for analysis. At first, each of the dried scats was classified according to the relative volume, weighed using the Lark JPT-2 (range: 0.1-200 gm) beam balance (big scats were weighed in sections), and were classified according to their weight. Then each scat was broken and carefully soaked in water to separate prey remains, such as hair, bones, hooves, teeth,

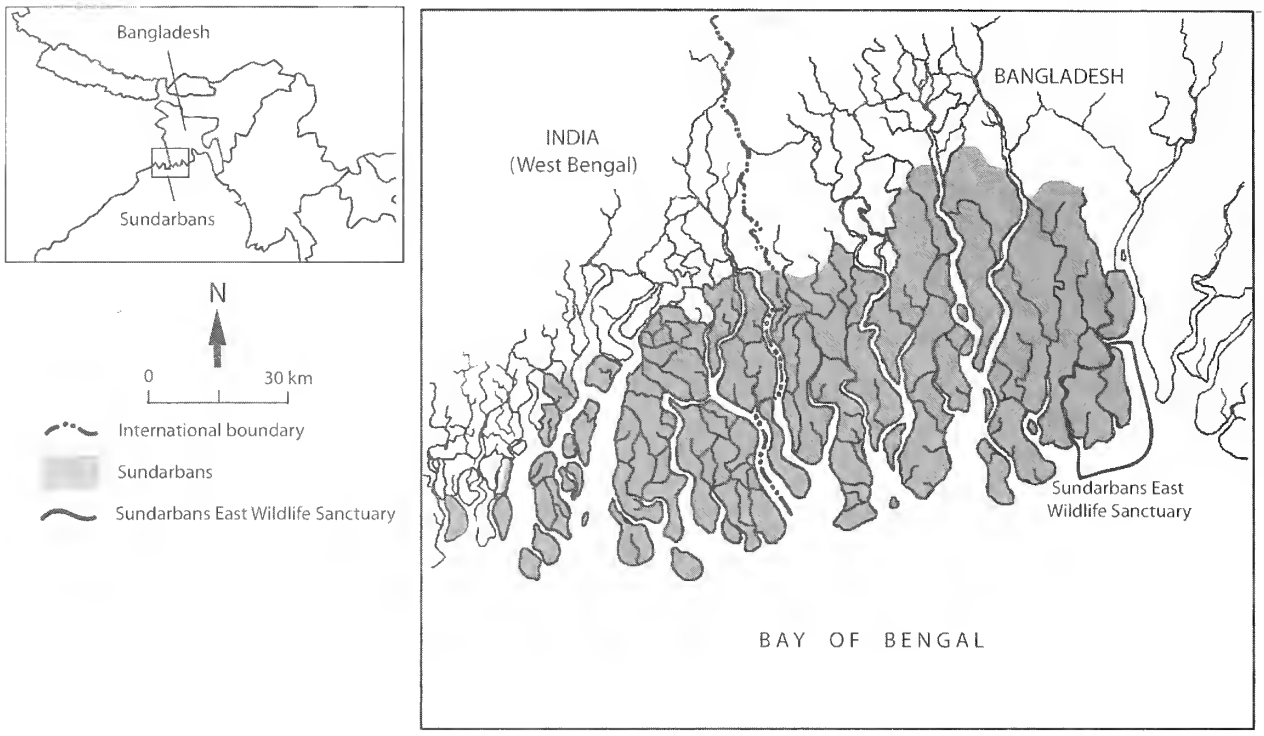

Fig. 1: The Sundarbans of Bangladesh and India showing the Sundarbans East Wildlife Sanctuary

feathers. The separated items were studied with the unaided eye and with a magnifying glass, as well as under a light microscope, if necessary, and were identified by comparing with a reference collection (from different species of kills and from captive animals) using features such as structure, colour, and medullary configuration to identify prey species (Koppikar and Sabnis 1976; Amerasinghe 1983; Kitsos *et al.* 1995; Ramakrishnan *et al.* 1999). The remains of one prey species in one scat were considered as frequency one. If there were remains of two prey species in a scat (which was a rare case; found only in a few scats), the frequency was divided into 0.5 for each prey species. The non-food items were recorded when the item formed more than 50% of the scat volume (Schaller 1967; Johnsingh 1983), but these were excluded while estimating diet composition and the biomass of food consumed (Reynolds and Aebischer 1991). Reynolds and Aebischer (1991) defined non-food items in the scats as remains of ingesta that have little or no nutritive benefit (i.e., soil and sungrass in this study).

To determine whether the scat sample size is sufficient, the method was followed from Mukherjee *et al.* (1994), who studied the effect of scat sample size on frequency of occurrence in scats of a given prey species and identified the minimum reliable sample size (MRSS) as that which does not cause any further change in a prey with increase in sample size.

Although the frequency of occurrence of prey species in carnivore scats is a commonly-used parameter in the study of carnivore food habits, if prey size is highly variable (as in this study), the frequency of occurrence can considerably distort the relative numbers of different prey species in the diet (Panwar 1990; Karanth and Sunquist 1995). However, the frequency of occurrence of different prey species in the scats of Tigers can be converted to relative numbers and biomass of different prey taken, which represents the actual selectivity pattern (Floyd *et al.* 1978; Ackerman *et al.* 1984; Karanth and Sunquist 1995). In the light of the previous approaches (Schaller 1967; Johnsingh 1983; Putman 1984; Emmons 1987; Karanth and Sunquist 1995), the method developed by Ackerman *et al.* (1984) for Puma *Puma concolor*, to convert the frequencies of occurrence into relative numbers and biomass of individuals killed, was used. Assuming that the digestive system and the degree of carcass use of the Tiger is comparable to that of the Puma, the following regression was used to relate live weight of prey killed (X) to the weight of that prey represented in one field-collectable Tiger scat (Y) –

$$Y = 1.980 + 0.035\ X$$

The average number of collectable scats produced by a Tiger from an individual animal of each prey species ($\lambda_i = X/Y$), and the relative numbers of each prey killed were computed from the above equations (Ackerman *et al.* 1984). The relative numbers were then converted to relative biomass by multiplying with the minimum adult weight.

Prey selectivity index

The selectivity index (S) (Sourd 1983; Julliot 1996), used to compare the abundance of each edible prey species in the habitat and its proportion in the Tiger diet, was calculated by using the equation mentioned below –

$$S = (PC_{sp} - PA_{sp})/(PC_{sp} + PA_{sp})$$

Here PC_{sp} = proportion of one particular prey species in the Tiger diet as a percentage of the relative number of that prey species in the Tiger diet (Spotted Deer *Axis axis* = 43.4, Wild Boar *Sus scrofa* = 8.5, Rhesus Macaque *Macaca mulatta* = 22.2, Lesser Adjutant *Leptoptilos javanicus* = 8.5, Red Junglefowl *Gallus gallus* = 17.4, Water Monitor *Varanus salvator* = 0; Table 3), and

PA_{sp} = proportion of the same prey species available in the habitat as a percentage of the individual density of that prey species in total prey population (Spotted Deer = 48.2, Wild Boar = 1.1, Rhesus Macaque = 15.0, Lesser Adjutant = 1.4, Red Junglefowl = 16.1, Water Monitor = 18.2; Khan 2004).

The species was then considered as: a) a high-ranking species, when S > 0.3 (PC_{sp} at least double than PA_{sp}); b) a middle-ranking species, when S lies between -0.3 and 0.3 (PC_{sp} similar to PA_{sp}); c) a low-ranking species, when S < -0.3 (PC_{sp} at least half than PA_{sp}); and d) an uneaten species, when S = -1 (PC_{sp} = 0, non-used edible species).

Kill study

Crows and vultures are good advertisers of Tiger kills in most of the Tiger ranges of the Indian subcontinent (Schaller 1972; Johnsingh 1983; Karanth and Sunquist 1995), but the dense vegetation, and the rarity of crows and vultures in the Sundarbans, forced me to depend mainly on odour and dragging signs. In addition to the species of prey killed, if the kill was relatively intact, the age class and health of the killed individual was recorded on the basis of the size, colour and overall condition of the animal. Whenever possible, the colour and texture of femur marrow fat were examined in order to record the health condition of the kill more accurately (Schaller 1967; Sinclair and Duncan 1972; Riney 1982). The lower jaws were collected whenever available, and taken to the laboratory where the total length and diastema length were measured, and used to classify the kills into age categories as adult, yearling/juvenile and fawn/young on the basis of eruption and wear of premolar and molar teeth (Schaller 1967; Riney 1982; van Lavieren 1983). I also tried to determine the age of kills by counting tooth cement rings (Ashby and Santiapillai 1986; Ballard *et al.* 1995; Landon *et al.* 1998), but no distinct annuli were found.

Selectivity of the Tiger predation for age classes of the Spotted Deer was assessed by Ivlev's selectivity index (D) (Okarma *et al.* 1997; Khorozyan and Malkhasyan 2002) –

$$D = (fE - fL)/(fE + fL - 2fEfL)$$

Here fE = fraction of a given age class among Spotted Deer eaten by Tigers (adult = 0.765, yearling = 0.176 and fawn = 0.059; ages identified on the basis of the eruption of the teeth (Table 5), and fL is the fraction of a given age class in the habitat (adult = 0.722, yearling = 0.205 and fawn = 0.073; Khan 2004). The positive or negative value of D for a certain age class means that the individuals of that age class were positively or negatively selected.

RESULTS

Scat volume and weight, and minimum sample size

In terms of relative volume, there were no significant difference in the frequencies of small, medium and large scats (χ^2 = 0.68, df = 2, p = 0.713), but medium-sized scats were the commonest (36.6%). On the other hand, classes based on dry weight show that there were significant differences in the frequencies of scats in three different weight classes (χ^2 = 25.00, df = 2, $p < 0.001$), but relatively light weight (<100 gm) scats were the commonest (51.0%) (Table 1). The mean weight of dried scats was 124.9 gm (n = 145, range = 10.6-406.6 gm, sd = 94.8).

The results of the test for minimum sample size of the scats, required for actual presentation of the proportion of a prey species in the scats is illustrated in Fig. 2. It is evident that even 34 samples are sufficient to represent adequately the occurrence of the Spotted Deer in the Tiger diet, which stays virtually steady-state regardless of the larger sample size.

Prey selection

The frequency of occurrence of different prey species in scats and kills (Table 2) shows that excluding zero values, the frequencies of different prey species were significantly different (in scats: χ^2 = 545.71, df = 7, $p < 0.001$; in kills: χ^2 = 316.15, df = 6, $p < 0.001$). On an average, Spotted Deer

Table 1: Scat size of the Tiger on the basis of volume and weight

Relative volume			Weight (gm)		
Class	No.	%	Class	No.	%
Small	46	31.7	<100	74	51.0
Medium	53	36.6	100+ to 200	46	31.7
Large	46	31.7	200+	25	17.3

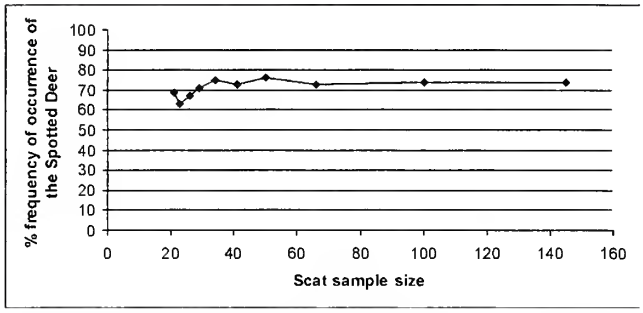

Fig. 2: Relationship between the sample size of Tiger scats and percentage of the frequency of occurrence of the Spotted Deer in scats in the Sundarbans East Wildlife Sanctuary

was the most frequent (78%), but Tigers also consumed Wild Boar, Rhesus Macaque, Porcupine (Indian Crested *Hystrix indica* or Brush-tailed *Atherurus macrourus*), Leopard Cat *Prionailurus bengalensis*, Irrawaddy Dolphin *Orcaella brevirostris* (died in the fishing net, which was thrown away and floated to the bank, and finally eaten by the tiger), Lesser Adjutant, Red Junglefowl, Mud Crab *Scylla serrata* and Water Monitor *Varanus salvator*, which together form the rest of the frequency percentage (Table 2). Since the prey sizes varied considerably, the frequency of occurrence was converted to the relative numbers of prey animals killed, and it was found that Spotted Deer was still the most frequently consumed (29.9%) (Table 3). When relative numbers of different prey animals consumed by Tigers were converted to the relative biomass, it shows that the Spotted Deer forms the bulk of the diet (80%) and Wild Boar is the second-most consumed (11%) (Fig. 3). These are the two species on which Tigers in the Sundarbans are thriving.

Non-food items in scats

Other than the prey animal remains, 74 (51%) scat samples had large quantities of soil (more than 50% of the volume). Sungrass (*Imperata* sp.) blades, and rarely leaves,

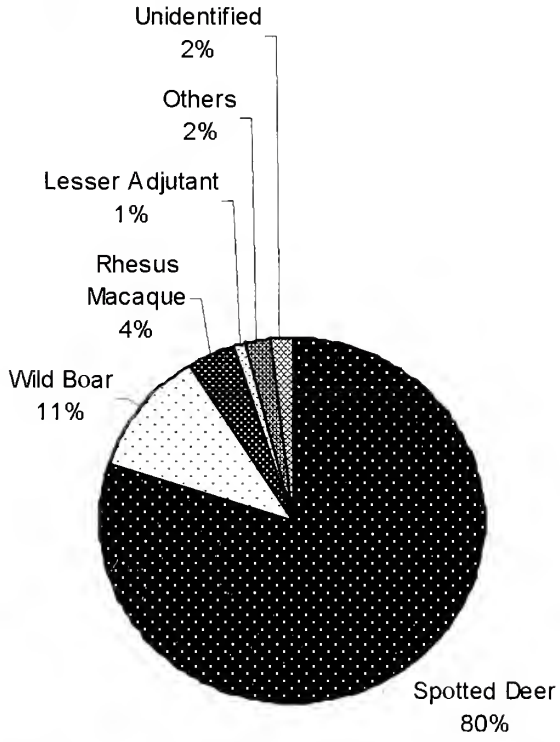

Fig. 3: Proportions of the relative biomass of different prey species consumed by Tigers in the Sundarbans East Wildlife Sanctuary

were also found in a number of scats, but only one scat (collected in January 2002) had sungrass more than 50% of the volume. In almost all cases the soil was very hard in the scat, probably due to contraction in the intestine. The occurrence of scat samples with more than 50% soil in different periods of the months was significantly different ($\chi^2 = 27.19$, df = 8, $p = 0.001$). More than 80% of the scats with soil were found in winter/dry season (October-March), with the peak in November-December (*c.* 15%), which indicates a strong seasonality in soil ingestion by Tigers (Fig. 4). Notably, the monthly total collection of scats was almost equally proportional in different seasons. The presence

Table 2: Occurrence of different prey species in scats and kills of Tigers

Prey species	Frequency in scats	% frequency in scats	Frequency in kills	% frequency in kills	% total frequency in scats and kills
Spotted Deer	108	74.5	66	84.6	78.0
Wild Boar	16	11.0	2	2.6	8.1
Rhesus Macaque	8	5.5	1	1.3	4.0
Porcupine	2	1.4	0	0.0	0.9
Leopard Cat	1	0.7	0	0.0	0.5
Irrawaddy Dolphin (stranded carcase)	0	0.0	1	1.3	0.5
Lesser Adjutant	3	2.1	5	6.4	3.6
Red Junglefowl	1	0.7	1	1.3	0.9
Mud Crab	1	0.7	0	0.0	0.4
Water Monitor	0	0.0	2	2.5	0.9
Unidentified	5	3.4	0	0.0	2.2

Table 3: Estimated average number of collectable scats produced from individual prey animals and relative numbers of different prey species killed by Tigers in the Sundarbans East Wildlife Sanctuary

Prey species	Weight (kg)	Frequency of occurrence in scats	No. of collectable scats produced/ kill	Total no. of animals eaten to provide collected-scats	Relative no. of prey animals killed (%)
Spotted Deer	47.0[1]	108	13.1	8.2	29.9
Wild Boar	32.0[1]	16	10.3	1.6	5.8
Rhesus Macaque	4.0[1]	8	1.9	4.2	15.3
Porcupine	8.0[2]	2	3.5	0.6	2.2
Leopard Cat	3.0[3]	1	1.4	0.7	2.6
Lesser Adjutant	4.0[4]	3	1.9	1.6	5.8
Red Junglefowl	0.6[5]	1	0.3	3.3	12.1
Mud Crab	0.3[6]	1	0.2	5.0	18.3
Unidentified	5.0[7]	5	2.3	2.2	8.0

N.B. Mainly the minimum adult weights of the prey species were considered.
[1]Source: Karanth & Sunquist (1992); [2]Source: Karanth & Sunquist (1995); [3]Source: Prater (1971); [4]Source: www.ndngrd.com; [5]Source: www.international.tamu.edu; [6]Source: local crab collectors; [7]Source: arbitrarily assumed, as in Karanth & Sunquist (1995)

of a large amount of soil proves that these were not accidentally ingested.

Prey abundance versus prey selection

The selectivity index (S) for six potential prey species shows that Wild Boar and Lesser Adjutant were high ranked; Spotted Deer, Rhesus Macaque and Red Junglefowl were middle ranked; and Water Monitor was a non-used species (Table 4). It is notable that the two least-available prey species were highest in the ranking, i.e., rates of their selectivity by Tigers were highest in comparison to their abundance.

Age and health of kills

The mean lengths of lower jaw bone and diastema of the Spotted Deer were 18.7 cm (n = 34, range = 12.0-21.7 cm, sd = 2.1) and 5.0 cm (n = 34, range = 3.2-6.3 cm, sd = 0.8), respectively. Other than the Spotted Deer, only two intact lower jaws of Wild Boar were found. The lower jaw lengths of these two specimens were 20.5 and 21.7 cm, and the diastema length in both cases was 0.5 cm. Most of the kills were adult animals (based on fresh kills – 56.5%, based on eruption of teeth – 76.5%) (Table 5), and were in good condition before they were killed (78.8%) (Table 6).

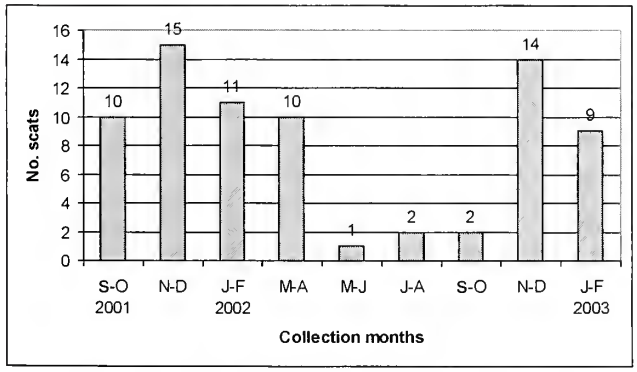

Fig. 4: Bi-monthly occurrence of Tiger scats with soil consisting of more than 50% of the volume in the Sundarbans East Wildlife Sanctuary

Abundance and selection of Spotted Deer in different age classes

Based on Ivlev's selectivity index, the values of D for adult, yearling and fawn age classes of the Spotted Deer were calculated at 0.112, -0.094 and -0.113, respectively. Since the value is positive only for adult age class and negative for yearling and fawn classes, it can be concluded that the adult Spotted Deer were positively selected, whereas the yearling and fawn Spotted Deer were negatively selected. In other words, the predation was higher than the abundance of adults, but lower than the abundance of yearling and fawn.

DISCUSSION

Prey selection

The preference for large prey species (Spotted Deer), as found in this study, supports the hypotheses related to foraging theory (Stephens and Krebs 1987), which suggest

Table 4: Prey species ranking based on selectivity index

Prey species	Selectivity index (S)	Rank of the prey species
Spotted Deer	-0.05	Middle
Wild Boar	0.77	High
Rhesus Macaque	0.19	Middle
Lesser Adjutant	0.72	High
Red Junglefowl	0.04	Middle
Water Monitor	-1.00	Non-used

that predators may select species containing the most 'profitable' prey, as measured by the ratio of energy gain to handling time (MacArthur and Pianka 1966; Schoener 1971; Charnov 1976; Scheel 1993; Karanth and Sunquist 1995). For large felids the most profitable prey type would seem to be the largest available prey that could be safely killed, but the importance of search time, encounter rates, and the energetic costs of capture for various prey types also need to be considered (Sunquist and Sunquist 1989). Tiger and Leopard *Panthera pardus* usually catch the kill when it is large enough to afford more than one meal (Johnsingh 1983).

It has been reported that Tigers prefer to hunt larger prey species (>176 kg), especially when there are other carnivores like Leopards and Asiatic Wild Dogs *Cuon alpinus* in the same habitat (Schaller 1972; Karanth and Sunquist 1995, 2000; Bagchi *et al.* 2003). In the Sundarbans, Tigers mainly hunt the largest available prey species, i.e., the Spotted Deer, despite the fact that there is no Leopard over there.

Reza *et al.* (2001) reported that in the Sundarbans East WS the average percentage by weight of Spotted Deer, Wild Boar and Rhesus Macaque hair, and unidentified animal parts and soluble material were 69, 15, 5, 4 and 6, respectively. Their methods were questionable, because the weight, size and density of hairs of these three species were not uniform. Hence, the relative weights of hair samples in scats do not accurately represent either relative biomass or relative numbers of different prey species consumed. They have found the mean weight of scat as 122 gm and the Spotted Deer as the principal prey, which was generally the same as in this study.

According to Tamang (1993), the principal prey of the Tiger in the Sundarbans are Spotted Deer and Wild Boar, but Tigers are opportunist feeders and there are records of predation of Rhesus Macaque, Barking Deer *Muntiacus muntjak*, otters, small carnivores, birds (mainly Red Junglefowl), lizards (*Varanus* spp.), other reptiles, frogs, fish, crabs, and occasionally humans. My findings generally agree with this.

In India, the Spotted Deer is the main prey of the tiger in Kanha, Bandipur and Nagarhole (Schaller 1967; Johnsingh 1983; Karanth and Sunquist 1995), but it is the second or third main prey in Ranthambhore, Panna and Melghat (Koppikar and Sabnis 1979; Gogate and Chundawat 1997; Bagchi *et al.* 2003). In Huai Kha Kheng, Thailand, the Barking Deer is the main prey species (Rabinowitz 1989). In the Russian Far East, Elk *Cervus elaphus* and Wild Boar were consistently the two key components of the Tiger diet (Abramov 1962; Miquelle *et al.* 1996). Karanth and Sunquist (1995) reported that in Nagarhole, India, the biomass of the Spotted Deer, Sambar, Gaur *Bos frontalis*, Wild Boar, Barking Deer and Common Langur *Semnopithecus entellus* comprised 97.6% of the biomass killed by Tigers. In contrast, I have found that the Spotted Deer alone was 80.1% of the biomass consumed by Tigers in the Sundarbans.

Non-food items in scats

Other than typical food items, soil and sungrass blades have been reported in Tiger scat samples (Powell 1957; Schaller 1967; Johnsingh 1983; Reza *et al.* 2001). During this study, soil was found in large quantities (more than 50% of the volume) in 51% of the scat samples, which is the highest proportion of soil-containing scats ever reported. Schaller (1967) reported that scats with soil and grass (more than 50% of the volume) represented 3.8% and 2.3% of all types of items eaten by Tigers in Kanha, India. He found most of the soil-containing scats during October-December, i.e., early winter, and suggested a seasonal incidence of soil-eating. A similar trend was found in this study, in which more than 80% of the soil-containing (more than 50% of the volume) scats were found in winter (October-March), with the peak in November-December (*c.* 15%). In Bandipur, India, Johnsingh (1983) found that out of 36 scats, three contained soil and two contained grass (more than 50% of the volume). Reza *et al.* (2001) mentioned the occurrence of an average 6% weight of scats composed of soil in the Sundarbans, but in this study, soil was found to constitute more than half of the volume of 51% of scat samples. This means that the percentage of weight of soil was definitely much higher than 6%. Other than soil, I have found significant amount of sungrass blades in one scat. The ingestion of soil and sungrass blades by Tigers is probably to meet mineral requirements, for better digestion and/or to scour the digestive system for internal parasites. In Kanha, India, one grass-blade-rich Tiger scat had a tapeworm (Schaller 1967).

Table 5: Age of Spotted Deer kills based on observation of kills and on the eruption of teeth in the lower jaw

Age based on kills			Age based on eruption of teeth		
Class	No.	%	Class	No.	%
Adult	26	56.5	Adult	26	76.5
Yearling	11	23.9	Yearling	6	17.6
Fawn	9	19.6	Fawn	2	5.9

Table 6: Condition of Spotted Deer kills

Condition		
Class	No.	%
Good	52	78.8
Moderate	14	21.2
Bad	0	0

Prey abundance versus prey selection

In Nagarhole, India, Karanth and Sunquist (1995) studied prey selection by Tiger, Leopard and Asiatic Wild Dog. They concluded that all three predators selected prey species non-randomly, which was mainly based on the prey size and encounter probability. In the Sundarbans, I have also found that Tigers non-randomly selected the prey species and the largest and commonest available ungulate (Spotted Deer) forms the bulk of the diet.

In Bandipur, India, Tiger scat and kill data reveal that proportionately fewer Spotted Deer were killed than were present in the population (Johnsingh 1983, 1993). This can be attributed to the anti-predator behaviour of the Spotted Deer, which assemble in open areas to spend the night, where they are relatively less vulnerable to Tiger predation. The Spotted Deer was virtually the only large prey in the Sundarbans, so it is difficult to compare my conclusions with those of Johnsingh (1983, 1993). In general, prey size together with the abundance is the most important factor driving the prey consumption. However, there are many other factors that might be involved in Tiger predation, such as anti-predator behaviour, detectability, and 'profitability' in terms of energy gain.

Based on prey selectivity in comparison to abundance, the index of selectivity of the six potential prey species in the Sundarbans East WS identified Wild Boar and Lesser Adjutant as the two highest-ranking species. These two species, however, contribute little in biomass abundance and biomass consumed by Tigers in the Sundarbans, so highest-ranking species should not be confused with commonly-preyed species. Since both Wild Boar and Lesser Adjutant are largely solitary, they are more vulnerable to Tiger predation. According to van Orsdol (1981), Lion *Panthera leo* hunting success varied with the size of prey group; single and paired prey were more easily caught than those in larger groups. Moreover, Tigers probably preferred Wild Boar and Lesser Adjutant as a change in common prey item (Spotted Deer). Although the Water Monitor was common, it has been identified as a non-used species (there was no trace of it in scats) probably because of its smaller size and aquatic habitation, and like most mammalian species, Tigers might be reluctant to hunt such a reptile.

Selectivity for age classes

Predators may preferentially select substandard (juveniles and young) animals, because they are less adapted to escape (Hornocker 1970; Mech 1970; Schaller 1972; Curio 1976; Vitale 1989). Karanth and Sunquist (1995), and Miquelle *et al.* (1996) reported that although Tigers predominantly kill adult prey, the young or substandard prey is killed in relatively high proportions.

In my study most of the Tiger kills were adult animals, which do not agree with the above-mentioned findings. There was no tendency to prefer young or substandard prey, probably because it may not be 'profitable' to hunt young Spotted Deer instead of the adult because of size. The adult Spotted Deer is not too big to pose any challenge to the Tiger and in the Sundarbans there is enough cover for the Tiger to ambush. My findings from Tiger kills and their jaws, however, could be adult-biased, because young and juvenile animals are smaller and they are more commonly eaten completely by predators (Schaller 1967; Sunquist 1981; Johnsingh *et al.* 1991). Moreover, the kill detectability by the researcher is normally large-animal-biased (Ruggiero 1991).

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PRELIMINARY STUDIES ON THE DIVERSITY OF SPIDER FAUNA (ARANEAE: ARACHNIDA) IN PARAMBIKULAM WILDLIFE SANCTUARY IN WESTERN GHATS, KERALA, INDIA

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147 species of spiders belonging to 82 genera and 22 families are recorded from Parambikulam. 51 species are new records for Kerala State and 5 species are new records for India. Moist deciduous forests exhibit higher diversity of spiders compared to evergreen forests. Spider fauna of Parambikulam exhibits affinities with Oriental and Palaearctic regions. 45 species recorded are endemic to the Indo-Sri Lankan region. Family Mimetidae is a new record from southern India. Key to different spider families found in Parambikulam also incorporates all the families so far recorded from Kerala. Distributional data based on literature of all the spiders recorded are included.

Key words: Parambikulam Wildlife Sanctuary, spiders, biodiversity, Western Ghats, endemism, affinities, zoogeography, India

INTRODUCTION

Though spiders form one of the most ubiquitous and diverse groups of organisms existing in Kerala, their study has remained largely neglected. Once completely enumerated, their species diversity will outnumber all groups other than insects. Due to high species endemism, the Western Ghats are listed among the twenty-five 'biodiversity hotspots' of the world. Parambikulam Wildlife Sanctuary is one of the thickest undisturbed forest patches existing in the Western Ghats. Inaccessibility of these forest areas has considerably facilitated their protection. Due to scarcity of workers much of the arthropodan diversity remains unexplored, and the disappearance of many species undocumented, so that any scope for their future utilization ceases. Considering the importance of spiders in the natural suppression of many insect pests, urgent efforts are needed to understand their diversity. Our knowledge about the spiders of Kerala remains confined to the works of Ferguson (1906), Gravely (1915, 1921a, 1931, 1935), Pocock (1900) and Sinha (1951a, b). The number of species previously recorded from Parambikulam is only 91 (Patel 2003); our study helps to raise this number to 147. Though the study of spiders from Parambikulam is still far from complete, the present study will form a basis for further investigations on this group.

STUDY AREA

Parambikulam Wildlife Sanctuary (10° 20'-10° 26' N; 76° 35'-76° 50' E) is situated between the Anamalai ranges of Tamil Nadu and the Nelliampathy ranges of Kerala. It comprises a total area of 285 sq. km with a reservoir area of 28 sq. km. Elevation ranges from 300 m to 1,430 m, with average elevation being 600 m. Annual rainfall is 1,720 mm, most rain being received in June-August while the eastern part of the Sanctuary adjoining Tamil Nadu receives most rain in October-November. The Sanctuary has both natural forest and plantations. Evergreen – semi-evergreen forest (about 80 sq. km) is found along the northern and north-western borders, moist deciduous forest (70 sq. km) is mostly in the central portion and small patches of dry deciduous forest in the drier parts adjoining Tamil Nadu. Plantation, mostly of Teak, occupies 90 sq. km of area. These plantations with a belt of deciduous forest interspersed with marshy areas (*vayals*) present a mosaic type of vegetation unique to Parambikulam. Temperature ranges from a maximum of 27-33 °C to a minimum of 20-24 °C.

METHODOLOGY

Spiders were studied following the methods of Tikader (1987). The study was of limited duration extending for six days from September 08, 2001 to September 13, 2001. Five areas (Fig. 1) were selected for study:

1) Moist Deciduous forest around Anappady (10° 26' 36.9" N; 76° 48' 50.1" E; 564 m),
2) Moist Deciduous forests at Kuriyarkutty, along the former forest Tram way (10° 24' 22.1" N; 76° 43' 16.9" E; 534 m),

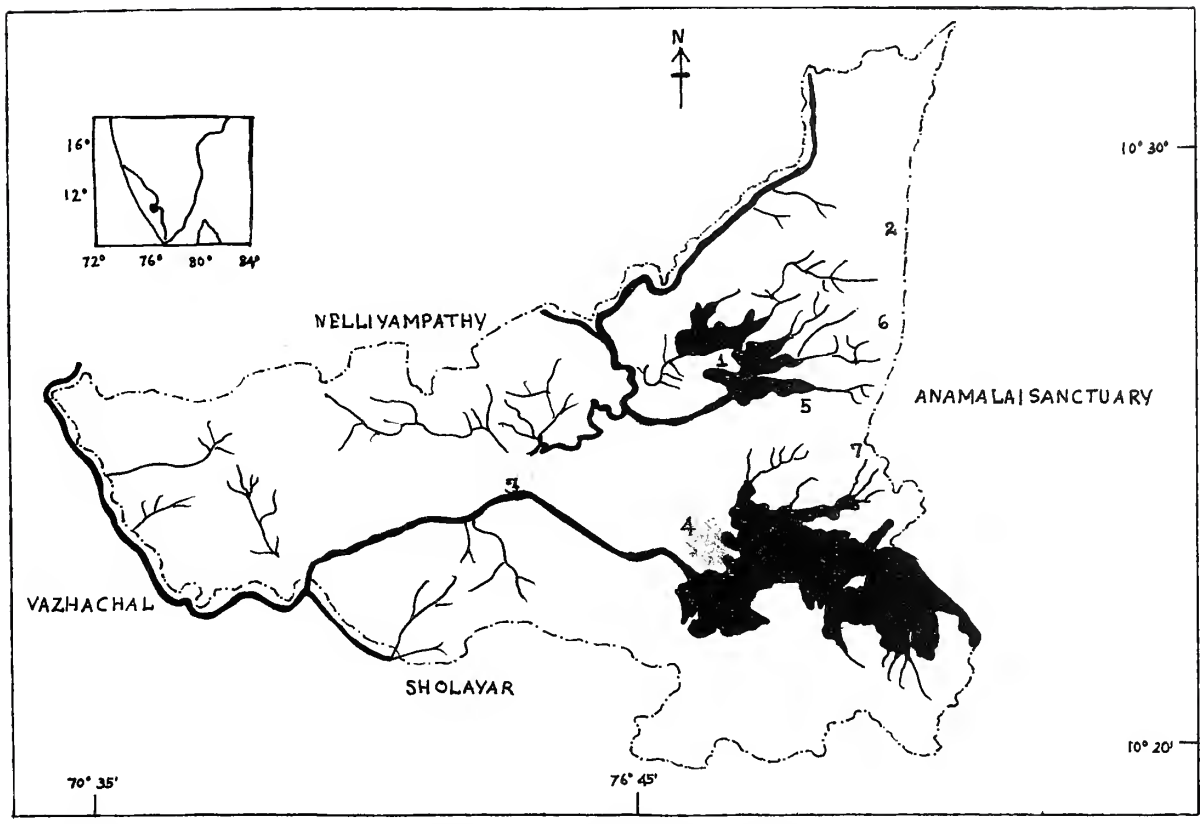

Fig. 1: Map of Parambikulam Wildlife Sanctuary: 1. Thunacadavu, 2. Karianshola, 3. Kuriarkutty, 4. Parambikulam, 5. Vengolimala, 6. Anappady, 7. Vengoli

3) Evergreen forest located at Karianshola (10° 27' 44.3" N; 76° 49' 39.2" E; 742 m),
4) Evergreen forest tread path from Karianshola to Vengolimalai,
5) Moist Deciduous forest at Vengoli (1,200 m) and Vengolimala (968 m), located east of the Sanctuary.

Bushes, tree trunks, forest floor and foliage were all searched for spiders. Observation was conducted in moist deciduous forest around Anappady, also at night. A hand unit of Global Positioning System (GPS) was used to determine the exact geographical locations. To indicate the differentiation diversity (Beta Diversity), Jaccard index was used. Jaccard Index cj = j / r x 100 where j = the number of species found at both sites, r = the number of species at one site.

The identification of spiders was done following Gravely (1915, 1921a, 1921b, 1924, 1931, 1935), Koh (1989), Majumder and Tikader (1991), Pocock (1900), Sherriffs (1919, 1927, 1928, 1929), Sinha (1951a,b), Tikader (1970, 1977, 1980, 1982). The families are arranged after Platnick (2001). Since many changes have occurred in the taxonomic names, older names are retained in brackets to avoid confusion. Data regarding the general distribution is taken from Platnick (2001) and Tikader (1980, 1982). Based on our observations, status of each species is indicated as 'rare' or 'common'. The key provided is modified from Ovtsharenko *et al.* (2001); some families that are not recorded from Parambikulam, but found in other regions of Kerala are also included in the key.

Small dash in the Table 1 indicates that the species was not collected during the present study, but has been previously reported from Parambikulam. ('-' is present in space corresponding to status and habit, eg. No. 15, 51, 56 etc.)

RESULTS

Key to spiders of Parambikulam

1	Eight eyes present	2
—	Six eyes present	30
2	Cribellum absent	3
—	Cribellum present	26
3	Chelicerae downward or downward and forward, cheliceral fangs directed towards each other	4
—	Chelicerae projecting forward, cheliceral fangs directed more or less parallel to the main body axis	Theraphosidae
4	Tarsi with three claws	5
—	Tarsi with two claws	16
5	Spiders with extremely long and thin legs, II legs 4-5 times longer than body	Pholcidae
—	Spiders without extremely long and thin legs	6

6 Tibia and metatarsi I & II with a row of long prolateral spines ..... Mimetidae
— Tibia and metatarsi I & II without a row of long prolateral spines 7
7 Tarsi IV with 6 to 10 serrated setae, forming a comb..... ..... Theridiidae
— Tarsi without such a comb 8
8 Eye group in hexagonal arrangement ..... Oxyopidae
— Eye group not in hexagonal arrangement 9
9 Tarsi with numerous trichobothria 10
— Tarsi without trichobothria 13
10 Tarsal trichobothria in single dorsal row 11
— Tarsal trichobothria irregular, in two dorsal rows 12
11 The six spinnerets in a more or less transverse row .... Hahniidae*
— The six spinnerets in three rows ..... Agelenidae*
12 Posterior row of eyes so strongly recurved that it may be considered to form two rows ..... Lycosidae
— Posterior row of eyes slightly recurved and not forming two distinct rows ..... Pisauridae
13 Chelicerae divergent from base, usually long and strong .. .. Tetragnathidae
— Chelicerae not divergent from base 14
14 Boss present on chelicerae ..... Araneidae
— Boss absent on chelicerae 15
15 Posterior spinnerets enormously long, usually longer than abdomen ..... Hersilidae
— Posterior spinnerets shorter and thicker, Tibia IV with 1 or 2 dorsal spines ..... Linyphiidae
16 Eyes in three rows; first row of two eyes, second row of four eyes, and third row of two eyes ..... Ctenidae
— Eyes in two rows 17
17 I & II legs enlarged and bearing scopulae 18
— I & II legs normal 19
18 Labium completeIy fused with sternum, two large anterior spinnerets and remnants of posterior four spinnerets present, carapace diamond shaped ..... Stenochilidae
— Labium not fused with sternum, only two spinnerets present, carapace oval ..... Palpimanidae*
19 Apex of metatarsus with a soft trilobate ..... Sparrassidae
— Apex of metatarsus otherwise 20
20 Chelicerae robust and provided with very long and slender fangs..... ..... Prodidomidae
— Chelicerae otherwise 21
21 Eyes arranged in three rows, the front or anterior median eyes much larger ..... Salticidae
— Eyes arranged in two rows, the front or anterior median eyes not larger 22
22 Colulus present, legs I & II much longer than III & IV, spiders crab-shaped ..... Thomisidae
— Colulus absent 23
23 Tarsi I & II with scopulae ..... Philodromidae*
— Tarsi I & II without scopulae 24
24 Anterior spinnerets cylindrical, widely separated at base .. .. Gnaphosidae*
— Anterior spinnerets conical, separated by a distance much closer than their diameter 25
25 Clypeus narrower than a diameter of anterior median eyes (AME); if it is so, posterior median eyes (PME) separated by a distance of their diameter ..... Clubionidae
— Clypeus not narrower than the diameter of anterior median eye (AME), usually twice or wider; anterior lateral eyes (ALE) larger than AME ..... Corinnidae
26 Posterior median eyes largest and directed forward .... Deinopidae
— Posterior median eyes of moderate size and not as above 27
27 Tarsi furnished with an ungual tufts and an inferior claw .. .. Psechridae
— Tarsi otherwise 28
28 Eyes homogeneous, light in colour, tarsi with a dorsal row of trichobothria ..... Amaurobiidae*
— Eyes homogeneous, dark in colour, or heterogeneous, light and dark in colour; tarsi without Trichobothria 29
29 Eyes homogeneous, dark; metatarsus IV compressed and concave above ..... Uloboridae
— Eyes heterogeneous, metatarsus IV of the usual shape (not compressed and concave above) ..... Dictynidae*
30 Six eyes, arranged in three separate groups 31
— Two, four or six eyes present and all arranged in one group 32
31 Carapace round and high behind, sternum round behind ..... Scytodidae*
— Carapace flat and depressed, sternum pointed behind ..... Loxoscelidae*
32 Eyes six; median eyes larger than laterals, located on anterior portion of carapace ..... Oonopidae*
— Eyes two, four or six, almost equal in size, located mostly on central portion of carapace ..... Tetrablemmidae*

*Not recorded from Parambikulam.

TAXONOMIC DIVERSITY

Family Diversity: Of the 59 families recorded in the Indian region, 22 families (38%) are found in Parambikulam Wildlife Sanctuary. Families Araneidae, Theridiidae, Tetragnathidae, Thomisidae, Salticidae and Theraphosidae exhibit maximum species diversity, which is closely associated with the diversity of habitats. Some rare families like Prodidomidae, Mimetidae, Deinopidae and Stenochilidae

are also recorded here. Mimetidae is a new record from southern India. Families consisting of hunting and wandering spiders (Lycosidae, Pisauridae, Oxyopidae, Sparrassidae, Clubionidae, Thomisidae, Philodromidae, Hersilidae and Ctenidae) represent 55% of the spiders found. Scytodidae, Loxoscelidae, Lyssomanidae, Gnaphosidae, Agelenidae which are collected from other regions of central Kerala, are not represented in our studies, perhaps because of the short study period.

Generic Diversity: Of the 252 genera recorded from the Indian region (Tikader 1987), 82 genera are found in Parambikulam. High generic diversity is found in Araneidae (11), Theridiidae (6), Thomisidae (10), Salticidae (7), Theraphosidae (6), and Tetragnathidae (7). The number of genera is higher than that of Andaman & Nicobar islands - 33 (Tikader 1970) Sikkim - 41 (Tikader 1977), and Calcutta (now Kolkata) - 47 (Tikader and Biswas 1981). Genera like *Arachnura* (Family: Araneidae); *Perenethis*, *Polyboeae* (Family: Pisauridae); *Pistius*, *Camaricus*, *Misumenops*, *Ozyptila*, *Tibellus*, *Xysticus*, *Strigoplus* (Family: Thomisidae); *Castianeira* (Family: Corinnidae); *Miagrammopes* (Family: Uloboridae); *Hyllus*, *Phintella*, *Telamonia* (Family: Salticidae); *Thelcticopis* (Family: Sparrassidae); *Chilobrachys*, *Thrigmopoeus* (Family: Theraphosidae); *Theridula*, *Argyrodes*, *Achaearanea*, *Theridion*, *Dipoena*, *Coleosoma* (Family: Theridiidae); *Linyphia* (Family: Linyphiidae); *Zimiris* (Family: Prodidomidae), *Deinopis* (Family: Deinopidae) are new records for Kerala.

Species Richness: 147 species were recorded from a limited area of 20 sq. km, a very high number compared to other regions like Andaman & Nicobar Islands - 65 (Tikader 1970), Sikkim - 55 (Tikader 1977) and Calcutta (now Kolkata) - 99 (Tikader and Biswas 1981). The three studies quoted above were conducted over a period of one to two years while the present study was limited to six days. Considering this, we believe that the diversity of spiders in Parambikulam is amongst the richest in India. A detailed survey will reveal much greater species diversity. Of the total species recorded, 112 are found in moist deciduous and 46 species in evergreen forests, and 29 in both habitats. Differentiation diversity index between the two habitats is 0.22, indicating high dissimilarity.

New Records: New species records for India are *Dipoena ruedai, Argyrodes flagellum* (Family: Theridiidae); *Hyllus diardi* (Family: Salticidae); *Perenethis unifasciata*, *Polyboea vulpina* (Family: Pisauridae). Species reported for the first time in Kerala are *Arachnura angura*, *Araneus nympha*, *Cyclosa bifida*, *C. confraga*, *C. hexatnberculata*, *C. quinqueguttata*, *C. spirifera*, *Cyrtophora bidenta*, *Eriovixia laglaizei*, *E. poonaensis*, *Gasteracantha dalyi*, *Neoscona vigilans* (Family: Araneidae); *Tylorida culta*, *Leucauge dorsotuberculata*, *L. pondae*, *Nephila kuhli*, *Tetragnatha andamanensis*, *T. vermiformis* (Family: Tetragnathidae); *Camaricus khandalaensis*, *Misnmenops andamanensis*, *Misumena decorata*, *M. silveryi*, *Strigoplns netravathi*, *Xysticus himalayensis* (Family: Thomisidae); *Phintella vittata, Telamonia dimidiata* (Family: Salticidae); *Argyrodes gazedes*, *A. ambalika*, *A. gazingensis*, *A. xiphias*, *A. andamanensis*, *A. flagellum*, *Achaeranea durgae*, *A. diglipuriensis*, *Theridnla angula*, *Theridion manjithar* (Family: Theridiidae); *Hippasa olivacea*, *H. lycosina* (Family: Lycosidae); *Oxyopes slnveta* (Family: Oxyopidae); *Linyphia urbasae* (Family: Linyphiidae); *Deinopis* sp. (Family: Deinopidae); *Zimiris* sp. (Family: Prodidomidae); *Thrigomopoeus parambikulamensis*, *Plesiophrictns* spp., *Chilobrachys* sp., (Family: Theraphosidae).

Mygalomorph spiders: These large spiders live in burrows in the ground or in deep cavities or holes in large tree trunks. After the work of early arachnologists like Pocock (1900), Gravely (1915, 1935), Hirst (1909), the group has been largely neglected. Of the seven species previously reported from Kerala, five were reported from Parambikulam; *Haploclastus kayi*, *Plesiophrictus raja*, *P. bhori*, *Anandaliella travancorica* and *Poecilotheria striata* (Family: Theraphosidae). *P. striata* was the only arboreal mygalomorph found in Parambikulam. In addition, four new species were found during our study: *Chilobrachys* sp., *Plesiophrictns* sp. 1, *Plesiophrictus* sp. 2, *Anandaliella* sp., *Chilobrachys* sp. were discovered from the Evergreen forest of Karianshola and the burrows of *Plesiophrictus* sp. and *Haploclastus kayi* were found on embankments on the side of the road to Sálim Ali Centre at Kuriyarkutty. Besides these, *Poecilotheria rufilata*, *Anandaliella travancorica* (Family: Theraphosidae) were also recorded in Kerala, but not in Parambikulam.

Zoogeographic analysis: 36 species recorded in Parambikulam are widely distributed in many places in South Asia; 4 of these are found only in the Indo-Sri Lankan region. Most of these species belong to Araneidae (14) and Tetragnathidae (11). Because of bright coloration and large orb webs, spiders of these two families are easily observed, hence they are well represented in the literature. About 47 species found in Parambikulam are widely distributed in Kerala. Since the distributional status of Indian spiders is poorly known, species that are found in two widely separated regions are considered widely distributed. 15 species recorded from Parambikulam have so far been reported only from Kerala.

Endemism: Intensive agriculture and human settlements have destroyed the habitat of many spider species. Due to the disappearance of suitable habitats many species formerly widely distributed are now restricted to forest; *Gasteracantha remifera*, *G. dalyi*, *G. haselltii* (Family:

Araneidae) were earlier present in semi urban areas (Subrahmanyam 1954). The threat posed by habitat destruction is far greater to endemic species. Fifteen species discovered in Parambikulam are endemic to the Western Ghats of Kerala, while 44 are reported only from India. 51 species have been identified only up to generic level, of which many may be new species. The endemic species found in Parambikulam are *Gasteracantha geminata* (Family: Araneidae); *Ctenus indicus*, *C. cochinensis*, *Acantheis indicus* (Family: Ctendiae); *Psechrus alticeps* (Family: Psechridae); *Strigoplus netravathi* (Family: Thomisidae); *Poecilotheria striata*, *Haploclastus kayi*, *Thrigmopoeus parambikulamensis*, *Plesiophrictus bhori*, *P. raja* (Family: Theraphosidae); *Tetragnatha cochinensis* (Family: Tetragnathidae); *Wadicosa (Lycosa) quadrifer* (Family: Lycosidae). Family Theraphosidae has three endemic genera: *Plesiophrictus* and *Poecilotheria* endemic to Indo-Sri Lankan region, and *Thrigmopoeus* found only in the Indian subcontinent. Of the 147 species found in Parambikulam, 45 are endemic to the Indo-Sri Lankan region.

Affinities: The spider fauna of Parambikulam bears affinities with Oriental and Palaearctic regions. Affinity with the island fauna of Sri Lanka is also pronounced. According to Holloway (1974), the Indian fauna was formed as a result of displacement by invaders from other regions of the Orient, after its separation from Gondwanaland and merger with Asia. Species having Sri Lankan affinities are *Argiope anasuja*, *Cyclosa bifida*, *C. insulana*, *Eriowixia laglaizei*, *Gasteracantha remifera* (Family: Araneidae); *Tylorida culta*, *T. ventralis*, *Opadometa fastigata*, *Nephila maculata*, *Tetragnatha ceylonica* (Family: Tetragnathidae); *Peceutia viridana* (Family: Oxyopidae); *Hersilia savigyni* (Family: Hersilidae); *Perenethis unifasciata* (Family: Pisauridae). Those with oriental affinities are *Argiope anasuja*, *Cyclosa bifida*, *C. confraga*, *Eriovixia laglaizei*, *E. poonaensis*, *Gasteracantha dalyi*, *G. haselltii*, *Neoscona rumphi* (Family: Araneidae); *Leucauge decorata*, *Nephila maculata*, *Tetragnatha ceylonica*, *T. andamanensis* (Family: Tetragnathidae); *Perenethis unifasciata*, *Polyboea vulpine* (Family: Pisauridae); *Dipoena ruedai* (Family: Theridiidae). A small fraction of species like *Araneus nympha*, *Eriovixia laglaizei*, *Gasteracantha hasseltti* (Family: Araneidae); *Nephila maculata* (Family: Tetragnathidae); show Palaearctic affinities.

DISCUSSION

The spider fauna of Parambikulam is rich and diversified. Of about 1,066 species reported from India (Tikader 1987), 147 species were recorded from Parambikulam. This high species diversity can be attributed to the high diversity of plants (1,300 species) and insects (1,000 species) Sudheendrakumar *et al.* (2000). A high floral diversity sustains a high faunal diversity of invertebrates. The complex interaction of climatic factors like high rainfall and humidity with topographical features creates many small environmental niches within evergreen forests, semi-evergreen forests, moist deciduous forests, dry deciduous forests, grasslands, bamboo areas and *vayals* (marshy areas). This makes Parambikulam an important centre of speciation in the Western Ghats.

Faunal similarity with other regions is also striking. *Artema atlanta* (Family: Pholcidae); *Argyrodes xiphias*, *A. andamanensis*, *Achaearanea diglipuriensis* (Family: Theridiidae); *Tetragnatha andamanensis*, *Nephila maculata* (Family: Tetragnathidae); *Hersilia savigyni* (Family: Hersilidae); *Pardosa sumatrana* (Family: Lycosidae); *Myrmarachne plateleoides* (Family: Salticidae) are also found in the spider fauna of Andaman and Nicobar islands (Tikader 1977). *Theridion manjithar*, *Argyrodes gazedes*, *Theridula angula* (Family: Theridiidae); *Cyrtophora bidenta*, *Cyclosa insulana*, *Gasteracantha hasseltii* (Family: Araneidae); *Leucauge decorata*, *L. tesellata*, *L. pondae*, *Nephila maculata* (Family: Tetragnathidae); *Oxyopes shweta* (Family: Oxyopidae) are species represented in the spider fauna of Sikkim (Tikader 1970). Species like *Artema atlanta*, *Crossopriza lyoni* (Family: Pholcidae); *Parawixia dehaanii*, *Cylosa insulana*, *Eriovixia poonaensis*, *Neoscona rumphi*, *Gasteracantha haselltii*, *Argiope pulchella* (Family: Araneidae); *Nephila maculata*, *Nephila kuhli*, *Tylorida ventralis*, *L.* decorata (Family: Tetragnathidae); *Pardosa sumatrana* (Family: Lycosidae); *Phintella vittata*, *Telamonia dimidiata* (Family: Salticidae) are also found in Kolkata (Tikader and Biswas 1981). Similarly, the collection of many South East Asian species from here indicates the close faunal relationship between the two regions. *Gasteracantha hasseltii*, *Eriovixia laglaizei*, *Parawixia dehaanii*, *Cyclosa bifida*, *C. insulana* (Family: Araneidae); *Nephila maculata*, *Leucauge decorata*, *Tylorida ventralis* (Family: Tetragnathidae); *Argyrodes flagellum* (Family: Theridiidae); *Crossoprioza lyoni* (Family: Pholcidae); *Polyboea vulpina*, *Perenethis unifasciata* (Family: Pisauridae); *Hyllus diardi*, *Phintella vittata*, *Telamonia dimidiata* (Family: Salticidae) are reported by Joseph Koh (1989) from Singapore. *Tetragnatha ceylonica*, *T. vermiformis*, *Nephila maculata*, *Leucauge decorata*, *Opadometa fastigata* (Family: Tetragnathidae); *Dipoena ruedai* (Family: Theridiidae); *Perenethis unifasciata* (Family: Pisauridae) *Hersilia savigyni* (Family: Hersilidae) are reported by Barrion and Litsinger (1995) from the Philippines.

Another feature of the spider fauna of Parambikulam is the occurrence of higher species and generic diversity in moist deciduous forests compared with evergreen forests.

Web-building families like Araneidae, Tetragnathidae, Psechridae, Theridiidae are more common in moist deciduous forests. We attribute this to the presence of rich undergrowth in moist deciduous forests, where spiders can construct webs, whereas absence of rich undergrowth in evergreen forests reduces the foliage area for web construction. The rich litter-covered surface in evergreen forests increases the abundance of ground dwelling spiders of families like Ctenidae, Pisauridae and Lycosidae. The paucity of spiders in the understorey of Evergreen forests may be due to their migration to the canopy. Since spiders are predators, they reside chiefly among foliage and flowers that attract flying insects. In evergreen forests, foliage and flowers of tall trees occur in the upper storey. No attempts were made to evaluate the spider fauna of canopies during the present study.

Parambikulam holds many endemic and rare species, like *Poecilotheria striata*, an arboreal mygalomorph spider that lives in the holes in the bark of tall trees. There are some unconfirmed reports that these spiders are now illegally trafficked out of the country in good numbers because of the growing demand by the pet trade to the West (Anon. 2000). Besides this, their specialized habitat is vulnerable to deforestation and logging. Ground dwelling mygalomorphs like *Haploclastus kayi*, *Plesiophrictus* sp., *Thigmopoeus* sp., *Chilobrachys* sp. may be destroyed by soil erosion or flooding. Conservation of natural habitats is essential for the survival of many species as well as adoption of appropriate conservation strategies for effectively safeguarding genetic diversity.

Although the widely distributed spiders are more numerous in Parambikulam, the characteristic faunal element is the high number (45) of endemic species, whose faunistic composition reflects the local character of the fauna. Many of the species are not reported from any region in India other than Kerala. This phenomenon can be explained by the relative isolation of Western Ghats provided by mountains in the East and the Arabian Sea in the West. The Western Ghats thus appear to represent a major centre of speciation in Asia. Holloway *et al.* (1992) observed that conversion of forest to plantation and other man-induced disturbances lead to reduction in the diversity of invertebrates, both in species richness and in the taxonomic and biogeographic quality. Teak plantations should therefore be replaced, in the sanctuary, with natural forest, and top priority must be given to the conservation of its rich diversity.

Table 1: List of spiders collected from Parambikulam Wildlife Sanctuary during the study

Scientific name	Habitat	Status	Distribution
Family: Theraphosidae			
1. *Anandaliella* sp.	M	R	
2. *Anandaliella travancorica*, Hirst 1909	M	R	IND: KL
3. *Chilobrachys* sp.	M	R	
4. *Haploclastus kayi* Gravely, 1915	M	R	IND: PBKL
5. *Plesiophrictus bhori* Gravely, 1915	M	R	IND: PBKL
6. *Plesiophrictus raja* Gravely, 1915	M	R	IND: PBKL
7. *Plesiophrictus* sp. 1	M	R	
8. *Plesiophrictus* sp. 2	M	R	
9. *Poecilotheria striata* Pocock, 1895	M	R	IND: PBKL
10. *Thrigmopoeus parambikulamensis*, Sanjay & Daniel, 2002	M	R	IND: PBKL
Family: Pholcidae			
11. *Artema atlanta* Walckenaer, 1837	M	R	PAN
12. *Crossopriza lyoni* (Blackwall, 1867)	M	R	COS
Family: Mimetidae			
13. *Mimetus* sp.	M	R	
Family: Hersilidae			
14. *Hersilia savigyni* Lucas, 1836	M	C	IND; SLK; PHL
15. *Tama gravelyi* Sinha, 1950	-	-	IND: PBKL
Family: Deinopidae			
16. *Deinopis* sp.	E	R	
Family: Uloboridae			
17. *Miagrammopes* sp.	E	R	
18. *Uloborus danolius* Tikader, 1969	M	C	IND: WB, AN, MH
19. *Uloborus krishnae* Tikader, 1970	M	C	IND: GJ, SI, AN
20. *Zosis geniculatus* (Oliver, 1789)	M	R	PAN
Family: Theridiidae			
21. *Achaearanea diglipuriensis* Tikader, 1977	M	R	IND: AN
22. *Achaearanea durgae* Tikader, 1970	M	C	IND: SI
23. *Achaearanea mundula* (L. Koch, 1872)	M	R	IND: NEC
24. *Achaearanea* sp.1	M	R	
25. *Argyrodes xiphias* Thorell, 1873 (*Argyrodes carnicobarensis* Tikader, 1977)	M	C	IND: AN; MYN; JAP; KRK
26. *Argyrodes ambalika* Tikader, 1970	M, E	R	IND: SI
27. *Argyrodes andamanensis* Tikader, 1970	M	R	IND: AN

Table 1: List of spiders collected from Parambikulam Wildlife Sanctuary during the study (*contd.*)

Scientific name	Habitat	Status	Distribution
28. *Argyrodes flagellum* Doleschall, 1857	E	R	SGP; MYN
29. *Argyrodes gazedes* Tikader, 1970	M	C	IND: SI
30. *Argyrodes gazingensis* Tikader, 1970	M	R	IND: SI
31. *Argyrodes* sp.	M	R	
32. *Coleosoma* sp.	M	R	
33. *Dipoena ruedai* Barrion & Litsinger, 1995	M	R	PHL
34. *Theridion manjithar* Tikader, 1970	M	R	IND: SI
35. *Theridula angula* Tikader, 1970	M	C	IND: SI
36. *Theridion* sp.	M	R	
Family: Linyphiidae			
37. *Atypena* sp.	M	R	
38. *Lephthyphantes* sp.	M	R	
39. *Linyphia urbasae* Tikader, 1970	M, E	R	IND: SI
40. *Linyphia* sp.	E	R	
41. *Linyphiidae* sp. 1	E	R	
42. *Linyphiidae* sp. 2	E	R	
Family: Tetragnathidae			
43. *Herennia ornatissima* (Doleschall, 1859)	M	R	IND: PBKL, TN; CHN; MAL; NEG
44. *Leucauge decorata* (Blackwall, 1864)	M, E	C	IND: KL, UP, SI, WB; PAL
45. *Leucauge dorsotuberculata* Tikader, 1980	M	C	IND: MH
46. *Leucauge pondae* Tikader, 1970	M, E	C	IND: SI
47. *Leucauge tesselata* (Thorell, 1887)	M	C	IND; MLC; TAW
48. *Nephila kuhli* Doleschall, 1859	M, E	C	IND: WB; SLW
49. *Nephila maculata* (Fabricius, 1793)	M, E	C	IND; BHT; MYN; CHN; JAP
50. *Opadometa fastigata* (Simon, 1877)	M, E	C	IND: PBKL, KL, OR, UP; SLK; PHL; SLW
51. *Orsinome marmorea* Pocock, 1901	-	-	IND: KL, TN, MH, KR
52. *Tetragnatha vermiformis* Emerton, 1884 (*Tetragnatha mackenziei* Gravely, 1921)	M	R	IND: KL, OR, KR, BI, WB; EAS
53. *Tetragnatha andamanensis* Tikader, 1977	M	R	IND: KL, AN
54. *Tetragnatha ceylonica* Cambridge, 1869 (*Tetragnatha gracilis* Pocock, 1900)	M	C	IND: KL, TN, KR; SLK; MYN; PHL
55. *Tetragnatha cochinensis* Gravely, 1921	M	R	IND: KL
56. *Tetragnatha maxillosa* Thorell, 1895 (*Tetragnatha listeri* Gravely, 1921)	-	-	IND: KL; SAF; BGL; PHL; NEH
57. *Tetragnatha sutherlandi* Gravely, 1921	M	R	IND: KL, WB, BI, MG
58. *Tylorida culta* (O.P. Cambridge, 1869) (*Leucauge culta* O.P. Cambridge, 1869)	M	R	IND: WB, KR, TN; SLK
59. *Tylorida ventralis* (Thorell, 1877) (*Leucauge ventralis* (Thorell, 1877)	M	C	IND: KL, WB; SLK; NEG; TAW
Family: Araneidae			
60. *Arachnura angura* Tikader, 1990	M, E	R	IND: SI
61. *Araneus nympha* Simon, 1899	M, E		IND: HIM; SLK; PAK; MAL
62. *Argiope anasuja* Thorell, 1887	M, E	C	IND: TN, MH, OR, WB; SLK; PAK; MAL
63. *Argiope pulchella* Thorell, 1881	E	C	IND: AN, LD, WB, MP, OR, AS, MH, TN; MYN; MAL
64. *Argiope* sp.	M	R	
65. *Chorizopes* sp.	M	R	
66. *Cyclosa bifida* (Doleschall, 1859)	E	R	IND: MG; MYN; SLK; NEG; MAL
67. *Cyclosa confraga* (Thorell, 1892)	M, E	R	IND: SI, AS, MH; MAL; BGL; MYN
68. *Cyclosa hexatuberculata* Tikader, 1982	M	R	IND: MH
69. *Cyclosa insulana* (Costa, 1834) (*C. moesta* Blackwall, 1865)	M	R	IND; SLK; MYN; PHL; AUS
70. *Cyclosa quinqueguttata* (Thorell, 1883) (*C. fissicauda* Simon, 1889)	M, E	R	IND: SI; BHT; MYN; CHN; TAW
71. *Cyclosa spirifera* Simon, 1889	M, E	R	IND
72. *Cyrtarachne* sp.	M, E	C	
73. *Cyrtophora bidenta* Tikader, 1970	M	R	IND: SI
74. *Eriovixia laglaizei* Simon, 1877 (*Neoscona laglaizei* (Simon, 1877)	M, E	C	IND: TN; MYN; CHN; SLK; AUS; MAL; NEG; PHL
75. *Eriovixia poonaensis* (Tikader & Bal, 1981) (*Neoscona poonaensis*, 1981)	M	R	IND: MH, WB
76. *Gasteracantha dalyi* Pocock, 1900	M	R	IND: TN; PAK
77. *Gasteracantha geminata* (Fabricius , 1798)	M, E	C	IND: KL, TN; SLK

Table 1: List of spiders collected from Parambikulam Wildlife Sanctuary during the study (*contd.*)

Scientific name	Habitat	Status	Distribution
78. *Gasteracantha hasselti* C.L. Koch, 1837	M, E	C	IND: KL, TN, WB, AS, SI; MYN; CHN; MOL
79. *Gasteracantha kuhli* C.L. Koch, 1837	M	R	IND; PHL; JAP
80. *Gasteracantha remifera* Butler, 1873	M	R	IND; SLK
81. *Gea* sp. 1	M	R	
82. *Neoscona mukerjei* Tikader, 1980	M	R	IND: WB, MH
83. *Neoscona nautica* (L. Koch, 1875)	M	R	IND: MH, GJ, WB; COS
84. *Neoscona pavida* (Simon, 1906)	M	R	IND: WB; PAK; CHN
85. *Neoscona vigilans* (Blackwall,1865) *Neoscona rumphi* (Thorell, 1887)	M	R	IND; MYN; PAK; SLK; AUS; MAL
86. *Parwixia dehaani* (Doleschall, 1859)	E	R	IND: KL; AUS; MAL
Family: Lycosidae			
87. *Evippa* sp.	M	R	
88. *Hippasa agelenoides* (Simon, 1884)	M, E	C	IND; TAW
89. *Hippasa greenalliae* (Blackwall, 1867) (*H. pantherina* Pocock, 1899)	M, E	C	IND; SLK; CHN
90. *Hippasa leucostigma* Simon, 1885	-	-	IND
91. *Hippasa lycosina* Pocock, 1900 (*H. nilgiriensis* Gravely, 1924) (*H. mahabaleshwarensis* Tikader & Malhotra, 1980)	-	-	IND; CHN
92. *Hippasa olivacea* (Thorell, 1887)	M, E	R	IND; MYN
93. *Lycosa madani* Pocock, 1901	-	-	IND: PBKL
94. *Pardosa sumatrana* (Thorell, 1890)	M, E	C	IND: TN, KR, WB, UT, BI, MH; NEP
95. *Pardosa atropalpis* (Gravely, 1924)	M	C	IND: TN, KL, AN, KR, OR, BI, WB
96. *Wadicosa quadrifer* (Gravely, 1924) (*Lycosa quadrifer* Gravely, 1924)	-	-	IND: PBKL
97. *Lycosa* sp. 1	M	R	
98. *Lycosa* sp. 2	M	R	
Family: Pisauridae			
99. *Perenethis unifasciata* (Doleschal, 1859)	M	R	SLK; MYN; SGP; NEG
100. *Pisaura* sp.	M	R	
101. *Polyboea vulpina* Thorell, 1895	E	C	MYN; THL; SGP; MAL

Table 1: List of spiders collected from Parambikulam Wildlife Sanctuary during the study (*contd.*)

Scientific name	Habitat	Status	Distribution
Family: Oxyopidae			
102. *Oxyopes ashae* Gajbe, 1999	E	R	IND
103. *Oxyopes birmanicus* Thorell, 1887	M	C	IND; CHN, SUM
104. *Oxyopes shweta* Tikader, 1970	M	C	IND: SI; TAW
105. *Oxyopes* sp. 1	M	C	
106. *Peucetia viridana* (Stoliczka, 1877)	M	R	IND: TN, WB, KL; SLK
Family: Stenochilidae			
107. *Stenochilus hobsoni* O.P. Cambridge, 1870	M	R	IND: TN, AP, MH, RJ
Family: Psechridae			
108. *Psechrus alticeps* (Pocock, 1899)	M, E	C	IND: KL
Family: Ctenidae			
109. *Ctenus indicus* Gravely, 1931	E	C	IND: KL
110. *Ctenus* sp. 1	E	R	IND: UT
111. *Ctenus* sp. 2	E	R	
112. *Ctenus cochinensis* Gravely, 1931	-	-	IND: PBKL
113. *Acanthies indicus* Gravely, 1931	-	-	IND: PBKL
Family: Clubiuonidae			
114. *Cheiracanthium* sp.	E	R	
115. *Oedignatha microsculata* Reimoser, 1934	-	-	IND: PBKL
116. *Oedignatha carli* Reimoser, 1934	-	-	IND: PBKL
Family: Corinnidae			
117. *Castineira* sp.	E	R	
Family: Prodidomidae			
118. *Zimiris* sp.	M	R	
Family: Sparrassidae			
119. *Heteropoda leprosa* Simon, 1884	M, E	C	IND; MAL; MYN
120. *Heteropoda* sp.	M	C	
121. *Palystes flavidus* Simon, 1897	M	R	IND: TN, OR, WB, UP
122. *Thelcticopis* sp.	M	R	
Family: Thomisidae			
123. *Camaricus khandalaensis* Tikader, 1980	M	R	IND: MH
124. *Misumena decorata* Tikader, 1963	M	R	IND: KR
125. *Misumena silveryi* Tikader, 1965	M	R	IND: MH
126. *Misumena* sp.	M	R	

Table 1: List of spiders collected from Parambikulam Wildlife Sanctuary during the study (*contd.*)

Scientific name	Habitat	Status	Distribution
127. *Misumenops andamanensis* Tikader, 1980	M	R	IND: AN
128. *Misumenops* sp.	M	R	
129. *Ozyptila* sp.	M	R	
130. *Pistius* sp.	M	R	
131. *Strigoplus netravathi* Tikader, 1963	M	R	IND: KR
132. Thomisidae sp. 1	M	R	
133. Thomisidae sp. 2	M	R	
134. *Tibellus* sp. 1	M	R	
135. *Tibellus* sp. 2	M	R	
136. *Xysticus himalayaensis* Tikader & Biswas, 1974	M	R	IND: WB
137. *Xysticus* sp.	M	R	
Family: Salticidae			
138. *Hyllus diardi* (Walckanaer, 1837)	M	C	MAL; IDS; THL; MYN; VET; SGP
139. *Hyllus* sp.	M	R	
140. *Myrmarachne plataleoides* Cambridge, 1869	M	C	IND: WB, BI, KL; SLK; THL; SGP
141. *Myrmarachne* sp. 1	M	C	
142. *Myrmarachne* sp. 2	M	R	
143. *Phintella vittata* C.L. Koch, 1845 (*Salticus ranjitus*, Tikader, 1967)	M	R	IND: SI, GJ; IDS; VET; CHN; MAL
144. Salticidae sp. 1	M	R	
145. Salticidae sp. 2	M	R	
146. Salticidae sp. 3	M	R	
147. *Telamonia dimidiata* (Simon, 1899) (*Phidippus pateli* Tikader, 1974)	M, E	C	IND; SGP

Abbreviations used in the table: AUS = Australia, BGL = Bangladesh, BHT = Bhutan, CHN = China, COS = Cosmopolitan, EAS = Eastern Asia, HIM = Himalaya, IDA = Indonesia, IND = India, JAP = Japan, KRK = Krakatau, MAL = Malaysia, MLC = Molucos, MLD = Maldives, MYN = Myanmar, NEB = New Britain, NEC = New Caledonia, NEG = New Guinea, NEH = New Hebrides, NEP = Nepal, PAK = Pakistan, PAL = Paleotropical, PAN = Pan tropical, PHL = Philippines, QSL = Queensland, SAF = South Africa, SGP = Singapore, SLK = Sri Lanka, SLW = Sulawesi, SUM = Sumatra, TAW = Taiwan, THL = Thailand, VET = Vietnam; AN = Andaman & Nicobar Islands, AS = Assam, BI = Bihar, GJ = Gujarat, KL = Kerala, KR = Karnataka, LD = Lakshadweep, MG = Meghalaya, MH = Maharashtra, MP = Madhya Pradesh, OR = Orissa, RJ = Rajasthan, SI = Sikkim, TN = Tamil Nadu, UP = Uttar Pradesh, UT = Uttarakhand, WB = West Bengal; R = Rare, C = Common; M = Moist Deciduous forest, E = Evergreen forest; PBKL = Parambikulam.

Small dash indicates that the species was not collected during the present study, but has been previously reported from Parambikulam.

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CETACEAN SPECIES RICHNESS AND RELATIVE ABUNDANCE AROUND THE BAR REEF MARINE SANCTUARY, SRI LANKA

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The Bar Reef Marine Sanctuary, off north-western Sri Lanka, and its adjacent waters were suspected to be an important Cetacean habitat, but a dedicated survey had never been undertaken. Therefore, a one-year survey was carried out from April 2004 to May 2005 to fill the vacuum of knowledge on Cetacean species of the area, and to gather baseline data for management and conservation. Surveys were carried out twice every month. Thirty three sightings of eight cetacean species were documented. The species recorded were *Balaenoptera acutorostrata*, *Balaenoptera musculus*, *Physeter macrocephalus*, *Kogia sima*, *Peponocephala electra*, *Stenella longirostris*, *Tursiops truncatus* and *Sousa chinensis*. The first confirmed sighting of *S. chinensis* in Sri Lanka's waters was recorded while *K. sima* and *P. electra* were sighted off the west coast for the first time. The northern and central parts of the Sanctuary can be termed as 'cetacean hotspots' due to high species richness and year-round abundance. Baseline data from this survey can be used immediately for management purpose, though further research is recommended. *S. chinensis* needs special consideration as the newly discovered population is heavily dependent on the Puttalam Lagoon which is under intense human use, making these dolphins vulnerable to a multiplicity of anthropogenic threats.

Key words: Cetacean, species richness, relative abundance, *Sousa chinensis*, *Kogia sima*, *Peponocephala electra*, Sri Lanka

INTRODUCTION

The Bar Reef Marine Sanctuary (BRMS) is one of the few marine protected areas in the waters off the northern Indian Ocean island of Sri Lanka. This Sanctuary is 306.7 sq. km in area and is located between 8° 16' 00"-8° 32' 00" N and 79° 44' 00"-79° 46' 70" E off the Kalpitiya Peninsula on the north-western coast of Sri Lanka. It was demarcated under the countries Fauna and Flora Protection Ordinance in 1992, and is divided into a buffer zone and core area, within which varying degrees of human activity take place (Rajasuriya *et al.* 1995).

The BRMS and its surrounding waters were suspected to be important for cetaceans on the basis of opportunistic observations and sporadic sightings in the area (Leatherwood *et al.* 1984; Rajasuriya *et al.* 1995; Dayaratne *et al.* 1997; Ilangakoon 2002). Though some information was available for the area, a dedicated cetacean survey had never been carried out in this marine sanctuary or its immediate surroundings. Therefore, the waters within the BRMS, the Puttalam Lagoon immediately adjacent to it, and the deeper waters immediately seaward of it were selected as the study area for the present survey. The water depth within the Puttalam Lagoon varies from 1 to 5 m, while the waters within the BRMS straddle the 20 m contour towards its western boundary. Beyond the Sanctuary's western boundary, the depth increases rapidly, with the 20 m and 100 m contours located in close proximity to each other.

The present survey was undertaken to fill the information lacuna on cetacean fauna in and around BRMS. The survey was designed with the primary objective of gathering data on the species richness and relative abundance of cetaceans occurring in the area. This was deemed necessary in order to make informed management decisions based on scientific data, which would lead to a long-term conservation and rational management of important marine fauna.

METHODOLOGY

Vessel-based cetacean sighting surveys were conducted twice a month from April 2004 to March 2005. One survey was done within the Sanctuary, using a 25-hp outboard engine-powered fibreglass vessel and one offshore survey was done seaward of the Sanctuary boundary using a larger 3.5 ton motorised fishing boat. A pre-planned saw-tooth patterned transect line was covered each month in order to maximise the coverage area in the available time and resources.

Offshore surveys to look for cetaceans beyond the seaward boundary of BRMS were conducted during all months except in June 2004 when the survey had to be abandoned half way through due to adverse weather conditions. The Sanctuary survey was not conducted during May, June and July as the weather was very rough. In all, 21 days were spent at sea actively searching for cetaceans during the one-year survey period.

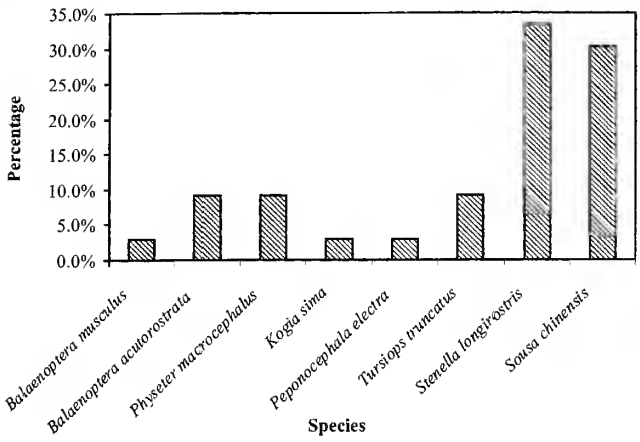

Fig. 1: Relative abundance of Cetaceans (N=33 sightings)

There were three observers on board to look for cetaceans. The observers rotated through three positions – port observer, bow observer and starboard observer – at 30-minute intervals. The port and starboard observers surveyed the area from the beam of the vessel to approximately 10 degree from the bow, while the bow observer surveyed the area directly ahead of the vessel in a 20 degree cone, and also acted as the data recorder. The survey effort was made when the sea state was below Beaufort 4 and visibility was good. When the sea state exceeded Beaufort 4 or heavy rain made visibility poor, the effort was suspended. Cetaceans or cetacean groups encountered were approached to a distance where species identification and group size estimates were possible. A pair of 7x50 binoculars was used to verify the distant sightings and determine species.

The data on cetaceans encountered was recorded on a standard data sheet with particular attention to position at sighting, species identification, group size, presence of calves and general behaviour. Other parameters such as environmental conditions and associated fauna were also recorded. Positions were recorded using a hand-held GARMIN e-trex global positioning system; photographs were taken once the cetaceans were approached.

RESULTS

The survey yielded a total of 33 sightings of eight cetacean species. The eight species of cetaceans included two species from Suborder Mysticeti, Family Balaenopteridae, namely Blue Whale *Balaenoptera musculus* and Minke Whale *Balaenoptera acutorostrata*. The other six species belonged to Suborder Odontoceti and included the Sperm Whale *Physeter macrocephalus* of Family Physeteridae, Dwarf Sperm Whale *Kogia sima* of Family Kogiidae, and Melon-headed Whale *Peponocephala electra*, Indo-Pacific Humpback Dolphin *Sousa chinensis*, Long-snouted Spinner Dolphin *Stenella longirostris* and Common Bottlenose Dolphin *Tursiops truncatus* all of Family Delphinidae.

Cetaceans were sighted in all months except June, when the survey was abandoned midway due to bad weather (Table 1). Species richness was high in February, April, August, and September. Approximately 50% of the sightings were within the BRMS (Fig. 2). Species richness was high within the Sanctuary, with six of the eight species sighted at least once. Most sightings were clustered around the western, seaward boundary of the northern and central parts of the

Table 1: Number of Cetacean sightings by month and species in and around the Bar Reef Marine Sanctuary

Month	*B. mus*	*B. acu*	*P. mac*	*K. sim*	*P. ele*	*T. tru*	*S. lon*	*S. chi*	Total
April	-	1	-	-	-	2	-	3	6
May	-	-	-	1	-	-	-	-	1
June	-	-	-	-	-	-	-	-	0
July	-	-	-	-	-	-	-	1	1
August	1	1	1	-	-	-	-	1	4
September	-	-	2	-	-	-	1	2	5
October	-	-	-	-	-	-	2	-	2
November	-	-	-	-	-	1	3	-	4
December	-	1	-	-	-	-	2	-	3
January	-	-	-	-	-	-	1	-	1
February	-	-	-	-	1	-	2	2	5
March	-	-	-	-	-	-	-	1	1

Note: Complete species names in column headings of the above Table
B. mus = Balaenoptera musculus, B. acu = Balaenoptera acutorostrata, P. mac = Physeter macrocephalus, K. sim = Kogia sima, P. ele = Peponocephala electra, T. tru = Tursiops truncatus, S. lon = Stenella longirostris, S. chi = Sousa chinensis

BRMS, with no sightings towards the southern boundary.

The most common cetacean encountered was Long-snouted Spinner Dolphin *Stenella longirostris* (33.3%) (Fig. 1). It also had the widest distribution and was recorded throughout the central part of the BRMS and in deeper waters seaward of the Sanctuary boundary. This species was also sighted in very large schools during February, April, August, and September, with some groups containing over 1,000 animals, including many juveniles. Sighting of the Indo-Pacific Humpback Dolphin *Sousa chinensis* (30.0%) was restricted to the Puttalam Lagoon and the north-western extremity of the Sanctuary (Fig. 2). These are the first scientifically documented sightings of this species in Sri Lankan waters.

Minke Whale *Balaenoptera acutorostrata*, Sperm Whale *Physter macrocephalus* and Common Bottlenose Dolphin *Tursiops truncatus* accounted for 9.0% each of the total recorded sightings. Minke Whale sightings were clustered in a small area within the north-central part of the BRMS (Fig. 2). Common Bottlenose Dolphin were sighted from north to south along the seaward (western) boundary of the Sanctuary, and Sperm Whale sightings were limited to deep offshore areas beyond the seaward boundary of the Sanctuary (Fig. 2).

Blue Whale, Dwarf-Sperm Whale, and Melon-headed Whale were recorded only once (3.0%) each. While Dwarf-Sperm Whale and Melon-headed Whale were sighted in deep waters, the Blue Whale sighting was within the BRMS where water depth ranges from shallow to moderate (Fig. 2).

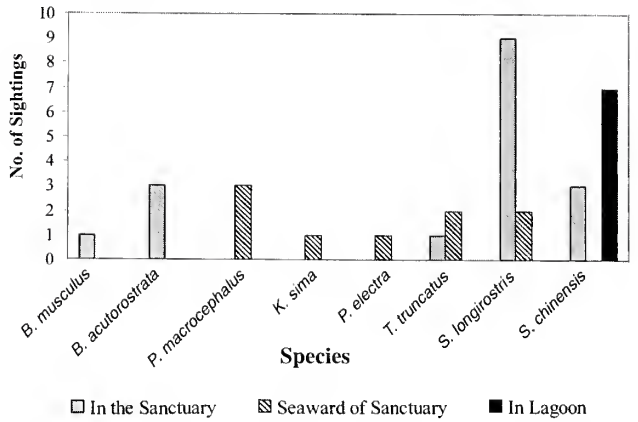

Fig. 2: Distribution of cetacean species in relation to sighting area

DISCUSSION

Twenty-seven cetacean species have been recorded from Sri Lanka's waters to-date (Ilangakoon 2002). The eight species recorded in this survey account for about 30% of all the species. It is noteworthy that a survey carried out over a short period of one year, with 21 field days, recorded almost 30% of all species in the Sri Lankan waters within this small survey area off the north-west coast.

The Long-snouted Spinner Dolphin was the most common species of cetacean in this area. This agrees with the other surveys conducted off Sri Lanka's west, south and east coasts in the 1980s and 1990s (Leatherwood *et al.* 1984; Alling 1986; Leatherwood and Reeves 1989; Ilangakoon *et al.* 2000; Ilangakoon 2002). However, the very large schools sighted during February, April, August, and September, often in association with the Yellow-fin Tuna *Thunnus albacares*, during the present survey have not been reported before. While this dolphin species has been documented in Tuna-Dolphin associations in other parts of the world, such as the Eastern Tropical Pacific, the association with the Yellow-fin Tuna in northern Indian Ocean has not been extensively documented (Ilangakoon 2002). While Ilangakoon (2000) mentions that some sightings during a 1994 study on the west coast indicated an association between these two species, the present survey shows a very strong association in which the occurrence of large schools of this dolphin coincides with the Tuna fishing season during September-October. Tuna fishermen in the BRMS study area were aware of this and actually looked for dolphins to find the Tuna. Despite containing many juveniles, these dolphin schools interacted freely with the tuna fishing boats and our survey vessel, bow-riding often and showing no fear.

Although the Indo-Pacific Humpback Dolphin accounted for 30% sighting during the present survey, the occurrence of this species has never before been documented in any part of Sri Lanka's waters. Although the species was known to be present around the west coast, based on two museum specimens collected in the 1880s and 1934 respectively (Blanford 1891; Deraniyagala 1945; Ilangakoon 2002) and a possible unconfirmed sighting from an aerial survey for dugongs in the early 1980s around Dutch Bay in the Puttalam Lagoon (Leatherwood *et al.* 1984), there have been no confirmed sightings of the Indo-Pacific Humpback Dolphin till the present survey. It is possible that the species is common only off the north-west coast of Sri Lanka including the shallow Puttalam Lagoon, and was never properly documented due to the lack of dedicated previous cetacean surveys in the area. This is substantiated by the fact that the skull collected in 1891 was from the Gulf of Mannar off north-west Sri Lanka and the unconfirmed sighting in the 1980s was also in the Puttalam Lagoon.

The Minke Whale accounted for 9% of the sightings in the present survey, but this species has not been commonly sighted during the surveys of other parts of Sri Lanka. Leatherwood *et al.* (1984) reported a single sighting off the

east coast, and Ilangakoon (2002) reported one sighting off the west coast and another off the north-west coast near Thalawila, just south of the present study area. Accordingly, the present results in conjunction with the previous observation by Ilangakoon (2002) indicate that the waters in and around the BRMS may be an important habitat for this species in Sri Lanka.

The Sperm Whale and the Common Bottlenose Dolphin also accounted for 9% each of the total number of sightings recorded in the present study. Several studies and surveys off Sri Lanka have reported that the Sperm Whales are common in deeper waters all around the islands and this has been particularly well-documented off the east coast (Alling *et al.* 1982; Whitehead *et al.* 1983; Leatherwood *et al.* 1984; Ilangakoon 2002). While Ilangakoon (2002) reported previous sightings off the north-west coast, more recently the Ocean Alliance research vessel *R/V Odyssey* reported large numbers in the deeper waters of the Gulf of Mannar off north-western Sri Lanka (Ocean Alliance 2003). The Common Bottlenose Dolphin was not as numerous or common in the present study area as has been reported for other areas off Sri Lanka. The species has been reported as being commonly sighted off the east coast (Alling 1986) and off the south and west coasts (Ilangakoon *et al.* 2000; Ilangakoon 2002). The present data is not sufficient to offer an explanation for the Common Bottlenose Dolphin being less common in the study area, but sightings along the seaward boundary of the BRMS, where there is a change in water depth, indicate that this may be a preferred feeding area for the species.

The Blue Whale, Dwarf-Sperm Whale and Melon-headed Whale were not commonly seen but were recorded only once each during this survey. However, the Blue Whale is common around Sri Lanka, especially off the east, south and west coasts (Ilangakoon 2002). It is of interest to note that the Blue Whale sighting during the present survey was within the BRMS in moderately shallow waters and not in the deeper waters beyond as would be expected. However, as stated by Ilangakoon (2002), the species has previously been sighted in near-shore continental shelf waters in other areas off the west coast of Sri Lanka. Both the Dwarf-Sperm Whale and the Melon-headed Whale are not commonly sighted species anywhere in Sri Lanka's waters, but have been frequently recorded in the fisheries by catch around the island (Leatherwood and Reeves 1989; Ilangakoon 1997, 2000; Ilangakoon *et al.* 2000). While there have been no previous sightings of either species off the west coast of the island, Alling (1986) reported a single sighting of the Dwarf-Sperm Whale from the east coast. A possible, but unconfirmed, sighting of the Melon-headed Whale was also previously reported from the north-east coast (Leatherwood *et al.* 1984). During the present survey both these species were encountered in deeper offshore waters beyond the BRMS, and sightings of both species were recorded off the west coast for the very first time.

To conclude, the survey succeeded in filling the lacunae on information on cetacean species richness and relative abundance in this area and added new knowledge on the distribution of the cetaceans in Sri Lanka's waters as a whole by documenting one species never sighted previously and two others that had not been sighted off the west coast of the island. While the entire study area off north-western Sri Lanka has a rich cetacean diversity, it is suggested that the area from the northern boundary of the BRMS to its central section be considered a 'cetacean hotspot' due to the high species richness and numerous sightings made throughout the year. This should also be taken into consideration while planning future conservation and management strategies for the BRMS, and ideally the core area should be extended in order to provide better protection to these cetaceans. The role of the Puttalam Lagoon in providing an essential habitat to the newly discovered population of the Indo-Pacific Humpback Dolphin should be investigated. Since this population was only discovered through the present survey, more detailed studies are needed to ensure its long-term survival through management measures based on sound scientific data. This is urgent and extremely important because the Puttalam Lagoon is under intensive human use posing a multiplicity of anthropogenic threats to these dolphins. Finally, it should be noted that the data from this survey have only provided a baseline upon which further studies could be undertaken on the cetacean fauna of the area. While these baseline data can be used immediately for management purposes more detailed studies are recommended as the area appears to provide a habitat for globally threatened species, such as Blue Whale and Sperm Whale.

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ECOLOGY AND BEHAVIOUR OF THE PIG-TAILED MACAQUE *MACACA NEMESTRINA LEONINA* IN SOME FORESTS OF ASSAM IN NORTH-EAST INDIA

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The Northern Pig-tailed Macaque *Macaca nemestrina leonina* is among the poorly studied primates of South-east Asia. Its ecology and behaviour in some rainforest pockets of Assam in north-eastern India are presented and discussed here. The study period extended between 1986 and 2006, but detailed observations were carried out during 1992-94 and in 2004 with 290 hours of direct contact. This dense forest-dwelling macaque is largely arboreal. Resting including roosting accounted for about 45% of their diurnal time. Feeding activity followed with 23.5%. Locomotion is a major activity accounting for 17 to 19.4% of their diurnal time. The Pig-tailed Macaque's diet included 65.9% fruits. During feeding, occasionally a group may split into two subgroups for a short period. They live in multi-male and multi-female groups. The group size ranged from 16 to 33. The sex ratio of the adults was 1:5.5. Interactions within group members and with other groups were largely peaceful. The home ranges were between 83 and 347 ha and the overlapping was 25 to 48%. The range length in a day varied between 690 and 2,240 m. Estrous females were observed from August to February. Newborns were observed from mid-January to early May. Females copulated with several males. The time taken for each mounting bout ranged from 2 to 16 seconds and the number of thrusts given by the male partner ranged from 3 to 23. The inter bout gap was 1 to 65 min. After copulation bouts, the male usually uttered a low bark. The female normally groomed the male after a copulation bout. The male remained completely lifted while copulating as his legs held those of the female. The gestation period was estimated to be 171-180 days.

Key words: *Macaca nemestrina leonina*, Northern Pig-tailed Macaque, Assam, ecology, social behaviour, feeding, ranging, reproduction

INTRODUCTION

The Pig-tailed Macaque *Macaca nemestrina* Linnaeus, 1766 is among the poorly studied primates of South-east Asia. Because of their elusiveness and furtive behaviour in the wild, their ecology and social behaviour are difficult to study (Bernstein 1967; Caldecott 1986). It is widely distributed throughout South-east Asia – in north-east India, south-west China, Bangladesh, Myanmar, Thailand, Laos, Cambodia, Vietnam, Malaya, Mergui Archipelago, Sumatra, Bangka Island, Pagai Island, Mentawai Islands and Borneo (Napier and Napier 1967; Yin 1967; Eudey 1987; Groves 1993, 2001; Le Xuan Canh *et al.* 1997; Duckworth *et al.* 1999; Choudhury 2003a).

In India, its distribution is restricted to the south of the Brahmaputra river where it occurs in all the states (Choudhury 1988a, 1989, 2003a). Anon (1997) had erroneously reported its occurrence to the north of the Brahmaputra. The Northern Pig-tailed Macaque is found in the forests, both in the plains and hills up to 2,000 m elevation (Choudhury 2003a). For quite a long period, the distribution of *leonina* in India was imperfectly known and vaguely referred to "eastern India (probably some districts east of the Ganges)" (Pocock 1939), and "Assam" (Roonwal and Mohnot 1977). Corbet and Hill (1992) did not include north-east India as well as Bangladesh within the range of this species although its occurrence has been mentioned in Ellerman and Morrison-Scott (1951), Choudhury (1988a, 1989, 1995a) and Khan (1981).

The subspecies found in north-east India is *leonina* (Fooden 1975). The subspecies *M.n. blythii* Pocock, 1931: 305, has been synonymised with *leonina* by Fooden (1975). Groves (2001) proposed full specific treatment for this subspecies.

Till the mid 1980s, the scanty literature available for *leonina* was restricted to publications by Pocock (1931, 1939, 1941) and McCann (1933). General information is also found in Blanford (1888-91), Finn (1929), Prater (1948), Ellerman and Morrison-Scott (1951), Gust *et al.* (1996), Napier and Napier (1967), and Roonwal and Mohnot (1977). Some studies were carried out since then in north-eastern India (Mukherjee 1982; Tilson 1982; Choudhury 1983, 1988a,b, 1989, 1995a,b, 1996a,b, 2001, 2002, 2003a,b), and in Bangladesh (Feeroz *et al.* 1994). A comprehensive account on its distribution and status in India is found in Choudhury (2003a) while its range in the region has also been mapped in detail by Choudhury (2003a,b). Elsewhere, the taxonomy and evolution of *M. nemestrina* have been reviewed by Fooden (1975). The Southern Pig-tailed Macaque *M. nemestrina nemestrina*, on the other hand, is relatively better studied in the field in Malaya (McClure 1964; Bernstein 1967, 1969; Medway 1969) and Sumatra (Oi 1990). Some other noteworthy publications are those of Crockett and Wilson (1980) and Caldecott (1986).

The ecology and behaviour of the Northern Pig-tailed Macaque as observed in the field are presented here in this paper.

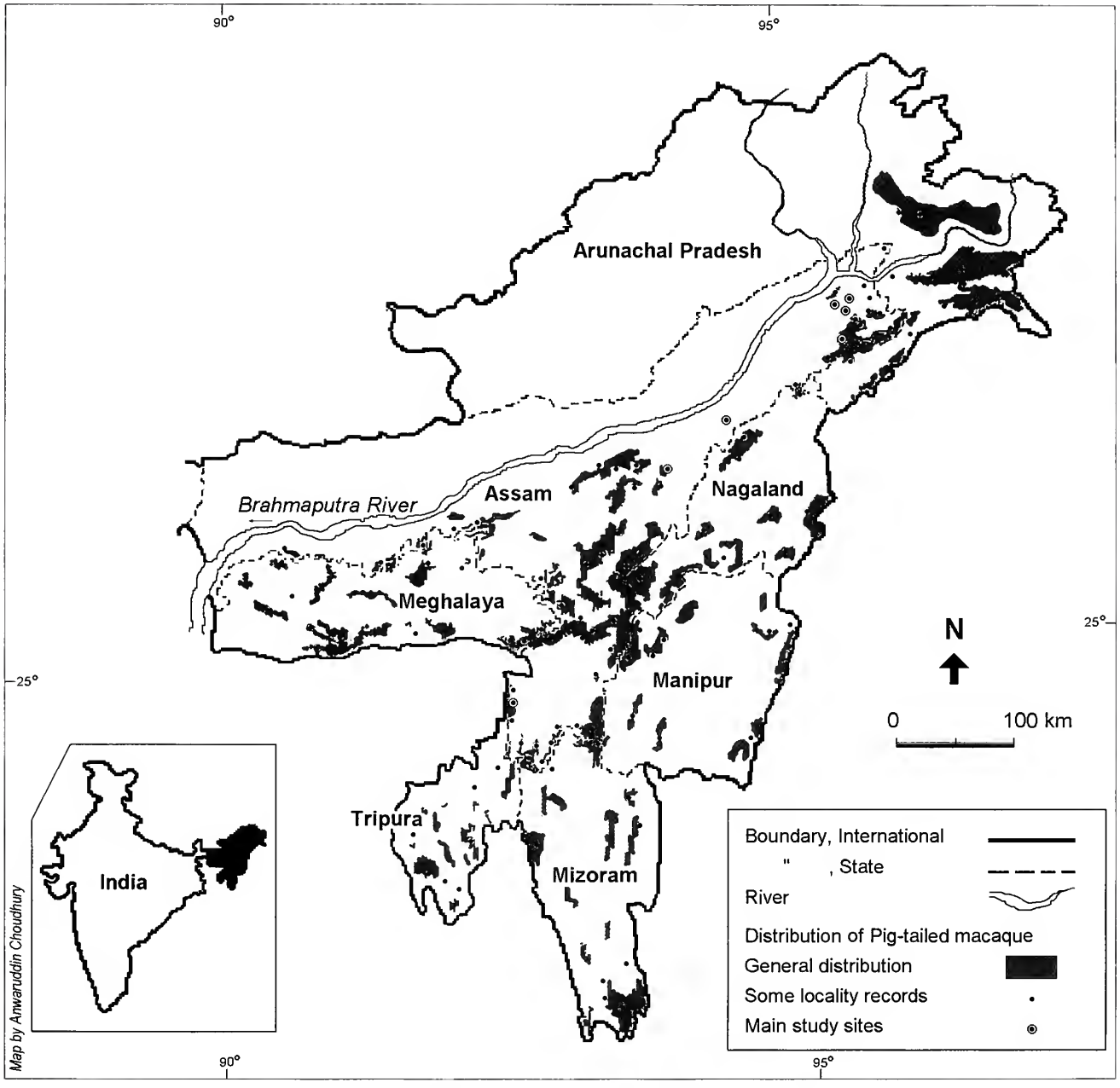

Fig. 1: Map showing the distribution of the Pig-tailed Macaque and the main study sites

METHODS

Study area

Although the general survey covered the north-eastern India, which comprises the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura (21° 58'-29° 27' N; 89° 42'-97° 24' E), the main observations were made in some forests of Assam (Fig. 1). The location, topography, vegetation and climate of these areas are given in Table 1.

Between February 1986 and May 2006, I was able to carry out field surveys in some potential habitats of the Northern Pig-tailed Macaque in north-east India as a part of a broader survey of wildlife. During 1992-94 and in 2004, I carried out some detailed observations on Northern Pig-tailed Macaque. While travelling widely in Assam, Arunachal Pradesh, Meghalaya, and Mizoram, I also visited Nagaland, Manipur, and Tripura. In July 2006, I made a brief visit to Thailand to observe the macaques for comparison of their external characters and human imprint.

Field procedures

During field study, the presence or absence of the macaque was ascertained by direct sighting, preserved skulls

in the tribal villages, and by interviewing local forest staff, villagers and hunters with the help of visuals (photos and drawings). Some of the skulls were identified at the Zoological Survey of India, Kolkata. For direct observation, foot-transects and elephant-transects (using trained elephants) along existing paths, newly cut paths and trails, vehicle-transects along roads and motorable tracks, boat-transects along *nullahs* and rivers were made. Total 290 hrs were spent in direct observation of the macaques (133 hrs in Bherjan, 40 hrs in Borajan, 31 hrs in Nambor-Garampani, 20 hrs in Podumoni, 13 hrs in Upper Dihing west block and 53 hrs elsewhere). Dense vegetation and elusiveness of the macaques were the main constraints in the field (for e.g., total time spent in a tiny forest such as Bherjan with 105.5 ha was 360 hrs; however, the macaques were in direct contact for only 133 hrs).

Detailed observations were made in select localities depending upon visibility, relative abundance and less shyness of the macaques. Daily activity budget was recorded by scan sampling at intervals of 5 mins (against 10 min interval of Martin and Bateson 1993) for greater details; however, any interesting behaviour and changes in activity in between was also recorded, from dawn to dusk. The home ranges were calculated from 1:50,000 scale maps enlarged photographically to about 1:20,000. All the sighting localities of a particular group observed at different times of the year were plotted on the map. The daily range is the distance covered by a group during its daily activity patterns while the home range was determined here by closed traverse made by joining the outermost traces of movement of a group during the period of observation (more than a year in the groups considered here). A closed traverse (polygon), made up of all the sites, was considered as the home range. The area of the home ranges was calculated by superimposing a scaled grid (1.25 ha per grid). The daily range was calculated by measuring the ground distance covered by a group from morning to evening. The data on food items were collected across groups and study areas, and not necessarily confined to the study groups. The proportion of feeding on fruits and other items was calculated on the basis of time spent on feeding on those items. Herbarium sheets were prepared for the food species, which could not be identified in the field. These were then identified at the Botanical Survey of India, Shillong. The book by Kanjilal *et al.* (1938) also helped identify some of the common species. For analysing the species diversity of vegetarian food items (Fig. 3b), a tree species providing two types of food items such as leaf and fruit, has been counted twice, once each under the category 'leaf' and 'fruit' to have a logical visual presentation in a diagram. Observations were done with the help of naked eye, a pair of binoculars, a 10 x 50 telescope and a 10 x 46 monocular. Photographs were taken with a Canon T50 camera with 200 mm tele and a Nikon FM2.

Table 1: Detailed features of the field study sites

Name of the area	Coordinates	Topography with elevation	Forest type	Rainfall	Temperature (°C)
Hollongapar Gibbon Sanctuary	(26°45' N, 94°25' E)	Plains; 100-110 m	Tropical wet semi-evergreen or rainforest	> 2,000 mm	7-35
Bherjan-Borajan-Podumoni WS	(27°25'-32' N, 95°19'-23' E)	Plains; 110-130 m	Tropical wet evergreen or rainforest and deciduous plantations	> 2,300 mm	7-35
Upper Dihing (west block) RF	(27°20' N, 95°30' E)	Plains and low undulating country, 100-200 m	Tropical wet evergreen or rainforest	> 2,300 mm	7-35
Garampani and Nambor WS	(26°23' N, 93°52' E)	Low undulating country, 170-250 m	Tropical wet semi-evergreen or rainforest	> 1,800 mm	7-35
Patharia Hill RF	(24°40' N, 92°15' E)	Low hilly, 20-150 m	Tropical wet evergreen or rainforest with degradation	> 3,000 mm	7-35

RF=reserved forest; WL=wildlife sanctuary

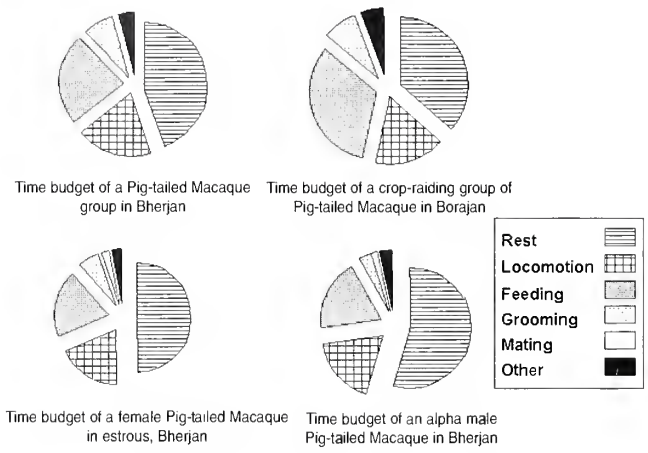

Fig. 2: Daily activity patterns in Pig-tailed Macaques

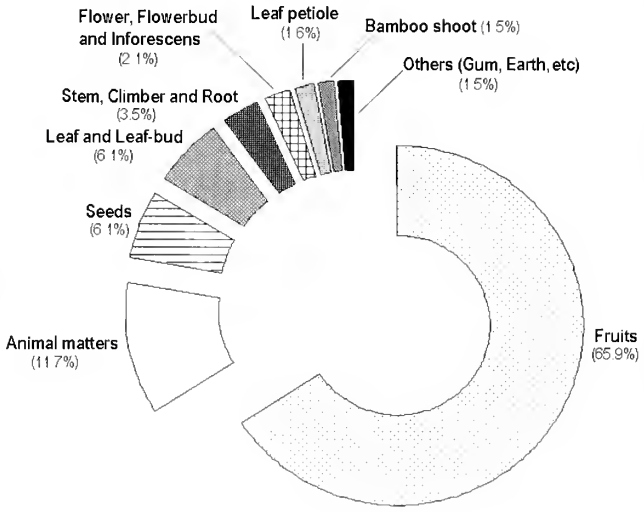

Fig. 3a: Proportion of food items of Pig-tailed Macaque

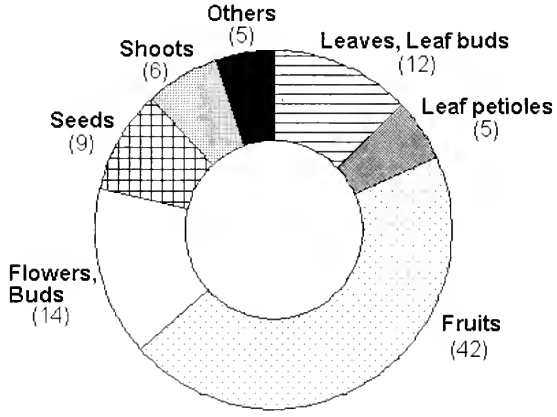

Fig. 3b: Species diversity of sources of vegetarian food item

RESULTS

The Northern Pig-tailed Macaque is among the most arboreal of the macaques found in north-east India. They come down to the ground for crossing clearings and also for foraging, especially in degraded areas. Of the total 133 hrs of observation in Bherjan, the macaques were observed for only 120 mins on the ground (mostly lone males; once a female with infant, and two immatures). The group may not come to the ground at all for many days in forests with relatively good canopy cover (e.g., Bherjan). However, in the nearby Borajan, where the canopy was broken, the macaques were frequently observed on the ground, crossing roads and clear-felled patches.

Daily activity pattern

Northern Pig-tailed Macaques become active just after dawn. The daily time budget of two groups in Bherjan showed an activity pattern with three peaks of feeding, and a long midday rest. There was a shorter spell of resting around mid-morning and late afternoon. In winter, most macaques went for basking in sun, and the mid-morning rest was often utilised for this activity. Resting including roosting (till dusk) accounted for about 45% of their diurnal time; feeding activity followed with 23.5%. In August, in Bherjan forests, three important feeding periods were from 0610 to 0640 hrs, 0900 to 0940 hrs and again from 1230 to 1400 hrs. In January in Borajan forests, the three important feeding periods of the crop-raiding group were from 0615 to 0650 hrs (in forest), 0800 to 0950 hrs and again from 1225 to 1405 hrs (both in the harvested paddy field).

The copulating alpha male of the Eastern Group in Bherjan spent as much as 54.4% of the diurnal time in resting and 19% feeding. During mating time, the alpha male and an estrous females respectively spent as much as 33.7% and 56.5% in copulation, and its related activities such as post-copulation grooming and resting between repeated copulations. It was more in case of the female as two males had copulated with it (Fig. 2).

Locomotion

Northern Pig-tailed Macaques were observed using both arboreal and terrestrial paths. They travel quadrupedally both on the ground and through trees. Occasionally they stand up on their hind legs to see any intruder. The crop raiding groups at Borajan forests were observed doing so while feeding on the ground. In closed canopy forest, they usually travel through trees leaping or jumping when the distance is not within reach, and walking on all fours on tree trunks. In broken habitat, they did not hesitate to come down to the ground and walked across. They jumped from tree to tree, bending and breaking branches under their weight. The groups

usually travel in single-file through trees, shrubs or bamboos, and each individual may pass along the same route or the same branches as the preceding ones (observed repeatedly in Bherjan forests). In the Western Group at Bherjan, the alpha male moved first followed by juveniles, subadults, other adults and lastly the females with infants. They communicate by uttering *pno*, *pno*, etc., while travelling. They may also travel in small subgroups, foraging as they move and keeping in contact with other subgroups through vocalizations *pno, po*.

Locomotion in Northern Pig-tailed Macaques accounted for 17 to 19.4% of their diurnal time (feeding and resting for short stints during locomotion have been included in those activities).

Food and feeding

Northern Pig-tailed Macaques were observed feeding on fruits, seeds, mature and tender leaves, leaf buds, leaf petioles, stems, climbers, roots, flowers, flower-buds, inflorescence, bamboo shoots, as well as gums, insects and larvae, termite eggs and spiders. They also take some earth occasionally (may be for minerals). At a few places, they raid crops for grain, fruits and vegetables. The dominance of fruits in its diet was very conspicuous whether it is number of species involved or the time spent on it. In the study groups of Bherjan forests, fruit comprised 65.9% of the macaque's diet (Fig. 3a). The Northern Pig-tailed Macaque eats more than 91 kinds of plants, many of which could not be identified. The different types of fruits, flowers and other items are shown in Fig. 3b. Appendix 1 lists the plant species with parts eaten.

Fruits were eaten either partially (e.g., *Lagerstroemia flosreginae*, *Artocarpus chaplasha*) or wholly (e.g., *Sapium baccatum*). In case of latter, they usually break the twigs with a large number of fruits (bunches) and actually consuming partially, thus wasting many. Flowers were eaten completely but in some cases only selected parts were consumed. It also licked from the branches for insects and larvae. Insects were also picked up from leaves and spider's web. Spiders were taken both from tree branches as well as webs. The only root taken was that of an epiphytic orchid while the tender tops of two unidentified climbers were also taken. Northern Pig-tailed Macaques feed on small leaves and figs by pulling branches towards them, and then plucking them directly off the branches. To remove a number of smaller leaves at a time, the macaque holds the twig in one hand, and with a single sweep of the other hand, takes off all the leaves. Larger leaves, fruits and flowers are pulled off the branches with either of the hands, and then eaten. Often the macaques were seen carrying a twig with fruits and taken to a comfortable branch for feeding. During feeding, occasionally a group may split into two subgroups for a short period. It spends nearly one fourth of the diurnal time in feeding (23.5% in August). A group in Borajan spent 32.9% of their diurnal time on feeding, mostly in the harvested paddy fields. The feeding time ranged from 158 to 229 minutes in a day. It has three peaks of feeding (for details of feeding periods, see 'daily activity pattern').

While feeding, the members of a group were loosely dispersed over a sizeable area and were observed to even split up into two subgroups. The maximum distance observed between two extreme individuals of foraging subgroup was about 150 m (Bherjan forests, August 21, 1992).

Social organization

Northern Pig-tailed Macaques have a multimale-multifemale social system. The normal group size varied from 16 to 33 (n=7). These were the groups where exact counting was possible and were repeatedly counted for several days. In most cases, exact counting was difficult due to dense forest.

Table 2: Group size and composition in Pig-tailed macaque

		Adult Male	Adult Female	Adolescent Male	Adolescent Female	Juvenile	Infant	Total	Remarks
February 1992	Garampani WS	2	15	1	4	6	5	33	
February 1992	Nambor WS	2	11	1	4	7	1	26	
January 1993	Borajan RF	1	12	1	4	6		24	Northern Group
January 1993	Borajan RF	1	10	1	3	5	1	21	Southern Group
July-Aug. 1992	Bherjan RF	2	7	1	1	3	6	20	Western Group
July-Aug. 1992	Bherjan RF	3	5	2	4	7	2	23	Eastern Group
January 1993	Podumoni RF	1	6	1	2	3	3	16	
	Mean	1.7	9.4	1.1	3.1	5.3	2.6	23.3	
	Range	1-3	5-15	1-2	1-4	3-7	1-6	16-33	
	%	7.4	40.5	4.9	13.5	22.7	11.0	100	

NB: At least another 15 groups in Innerline RF, Dhansiri RF, Upper Dihing (west block) RF, Dum Duma RF, Kumsong RF and Patharia Hill RF were recorded to have 20+ macaques but details are lacking

Hence, only seven groups were considered although partial count was possible for another six while many sightings were recorded when only partial count was possible. Single adult males have also been encountered in the forest. Table 2 lists the group size and composition of some troops where count / estimate were possible. The mean of seven groups was 23.3. In at least another 15 groups, the size was >20.

Six smaller groups were also encountered with size varying from 5 to 12 with a mean of 7.2 (Table 2), but detailed observation of 22 groups indicated that these were in all probability subgroups, formed temporarily for foraging. The proportion of adult females was 40.5% against 7.4% males. The sex ratio of the adults was 1:5.5.

Social behaviour

(i) Mother-infant relationship: Mother-infant relationship in Northern Pig-tailed Macaques is intimate. Mothers protect their infants from other group members and sympatric species. Until it is about a month old, the mother rarely broke contact with the infant. Then the infant began to leave the mother and explore the surroundings within a metre or so. The infant began to move out 2-4 m away by about 2 months of age. The infant also started foraging, however, still maintaining close contact with the mother. When about a year old, the infant (could be termed as juvenile) spent most of the time moving along with the group, only to return to its mother during resting and night roosting. Infant grooming by mother was common, especially during the midday resting period. The infant's vocalisation consisted mostly of squealing and screaming, usually when left alone by mother or inadvertently threatened by an adult or subadult. Adult males were observed to be rather indifferent to the infants.

(ii) Play: Play behaviour was observed mostly in infants and juveniles, and only occasionally in subadults. They indulged in play during morning resting, and during and after the midday resting period. Infants sometimes played with their mother. Friendly wrestling bouts among juveniles and subadults and short-distance chases were among the common plays. Some subadult and juveniles also mock mate as a part of play. The younger macaques spent maximum time of their total social behaviour in play. Infants and juveniles were observed to spend more time playing followed by subadults. Virtually no play was observed among the adults. Self-play was also observed among the juveniles and infants. Once a subadult female teased an infant by touching it and making frightening gesture, the infant screamed. The mother then chased the subadult.

(iii) Agonistic behaviour: This occurred infrequently and usually involved momentary squabbles over food between adult females, subadult males or both. However, aggressive threats and chasing of adult and subadult males by the alpha male was observed, especially when any female was in estrous. The other males were observed to submit without actually coming into conflict. No rigid dominance hierarchy was observed among the adult females of a group.

(iv) Grooming: Grooming was one of the major activities of social behaviour, with each grooming bout lasting from a few seconds to more than 60 mins, which forms nearly 6 to 8% of the total activity period. Males busy in copulation groomed less (3.5% of the total activity period). Grooming was usually done with one or both hands. Grooming took place between individuals of all age/sex classes, except infants who mostly received. During grooming, extraneous matters were removed by hands or with the mouth. The groomed individual sits relaxed often with the eyes closed. After mating, the female usually groomed the male. Grooming, except when performed after mating, was usually done during the midday resting period and late in the afternoon. Self grooming of tail, abdomen, limbs and genital portions (by male only) were also observed. The estrous females were groomed in their genital portion by adult males. Scratching of the body was done with hands and feet.

(v) Interaction within group members: Adult males were dominant over adult females while in the multimale groups, the alpha male was dominant over other males. Although in multiple male groups, the males coexisted peacefully, there was a linear dominance hierarchy, which was conspicuous in a group during sexual cycle. After an alpha male completed its copulation bouts and left for resting a little distance away, the second male came and copulated several times. Then a third adult male approached only to be chased away by the second male. On a few occasions, subadult males were seen copulating when the adult males were not around. The second adult male of Eastern Group in Bherjan once observed mock mounting the alpha male after latter stared at him following his copulation with a female in estrous. On a few occasions, the alpha male had copulation bouts when the second male was sitting close by (only a metre away).

Two infants, which were carried by their mothers, but which also foraged (less than a year old) had begged two adult females (not their mothers) for *Anthocephalus cadamba* fruits. The adults complied with, then both the infants left with fruits in their hand (Bherjan forests; July 30, 1992). Juveniles often curiously observed copulation bouts.

(vi) Interaction with other groups: On the whole, relations between Northern Pig-tailed Macaque groups were peaceful and actual fights were not seen. Two groups peacefully feeding within 60 to 100 m have been observed repeatedly in Bherjan and Borajan. In fact, their respective home ranges overlapped in the study sites. However,

occasional exchange of visual and vocal displays with chasing, usually by subordinate males, took place. Shaking of tree branches by the adult males was also observed. Two groups were observed on many occasions foraging and even copulating within 60 m with no agonism.

(vii) Interactions between groups and solitary male: Direct interaction between a solitary male and a troop was observed only once in Nambor Wildlife Sanctuary on March 02, 1992. A solitary male had approached a group feeding on sugarcane near the highway, when two adults, a male (not the alpha) and a female chased it to a tree with less foliage. Then they forced it to move to another tree with dense foliage while they remained in the tree with less foliage. When the solitary male again tried to come to the tree with less foliage, they again chased him by jumping to the tree with foliage. That time the solitary male had to flee from the scene. While chasing, the male was ahead of the female. Then the female groomed the male for about 3 mins in the tree with foliage. The pair was also observed copulating. After about 10 mins, the alpha male among the group that was feeding on sugarcane near the highway was silent when the earlier confrontation took place growled *hrrr-hrrr* and rushed towards the couple/ site of confrontation. The macaques were not visible due to dense vegetation and further developments could not be observed. At about 1600 hrs, the lone male was visible but at about 400 m away from the main group, and was moving about on the ground.

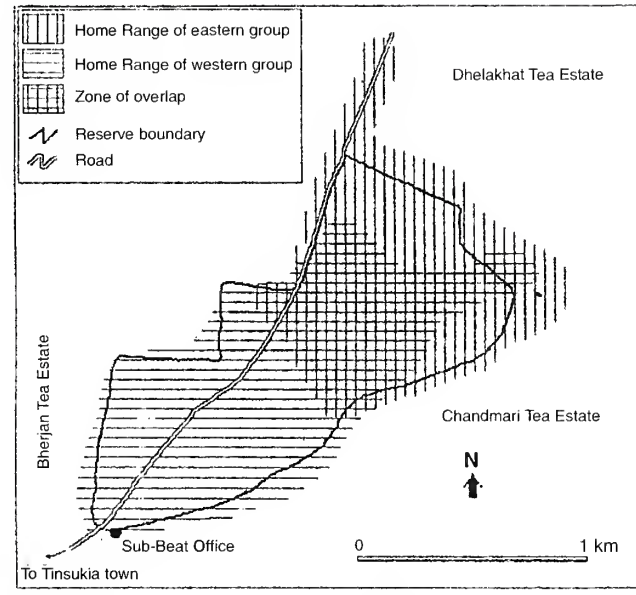

Fig. 4: Map of Bherjan forests and adjacent areas showing the home range of two Pig-tailed Macaque groups

Reproduction and sexual behaviour

In Bherjan forests, several females in estrous were observed from August to early December, and in Nambor till February.

When the female was ready to mate, the hairless area of her buttocks swelled up and turned red. During that period, copulation was a major activity for the adult males and females in estrous. Newborns were observed from mid-January to early May. The Northern Pig-tailed Macaque gave birth to a single offspring. For copulation, females were observed soliciting males by presenting their rump after approaching them from behind and standing in front of males mostly without any hint. On a few occasions the males were seen touching the rump of sitting or foraging females when the latter stood up and presented often looking back over one shoulder. Sometimes the female may run away also. Once after nine copulation bouts, the female ran away but the male followed it and mounted for another nine bouts.

A female was observed copulating with two adult males of the group, one in the forenoon another in the afternoon. With first (alpha male), she had seven copulations while with the second nine. A third male also tried to copulate but was chased away by the 2nd. However, on another day, a subadult took the opportunity of absence of adult males and copulated. It has been recorded that the copulations took place between 0700 hrs and 1440hrs in Bherjan forests. The time taken for each mounting bout ranged from 2 to 16 seconds and the number of thrusts given by the male partner ranged from 3 to 23. A female was observed having copulation bouts for 20 days (from November 10 to 30, 1992; Bherjan forests).

In the Eastern Group in Bherjan, the alpha male was observed having seven mounting bouts in the forenoon within 2 hr 23 mins. In between, once he refused to mount although insisted by the female. In the afternoon, the 2nd male copulated taking the advantage of absence of the alpha male, which was resting some distance away. It had nine bouts within a time span of just 20 mins. The gap between two bouts in alpha male ranged from 2 to 65 mins (mean=20.4 mins) while in case of second male 1 to 4 mins (mean=2.5 mins). On a subsequent day, the alpha male had 16 copulation bouts within a span of 30 mins. this time the inter-bout gap was 1 to 4 mins (mean= 1.9 mins). After that he refused twice despite presentation by the female.

The thrusts of the second male were relatively slower and gentler than the alpha male. After each copulation, the male in most cases uttered *khek-khek* or *ghek-ghek* or *agh-agh* or *kheh-kheh* (just after dismounting). During 42 copulations, the male uttered these on 15 occasions. Post-copulation grooming was observed on 21 occasions in 42 copulation bouts. Females were mostly silent except for one young female that made low scream. While mounting, the males may hold the thigh or waist of the female by one or

both arms. The male also remains completely lifted while copulating as his legs hold those of the females. All the copulation bouts in Bherjan forests were observed in trees, at height ranged from 5 to 23 m. In Borajan, copulation on the ground was also observed.

Despite best efforts the exact gestation period could not be found as the two pregnant females, which were under observation remained elusive for a few days when the young ones were delivered but gave a probable range of 171-180 days.

Ranging behaviour

Northern Pig-tailed Macaques made no effort to defend their home ranges. The overlapping of home ranges and tolerating other groups at close range also indicates the same. The home ranges of Northern Pig-tailed Macaque groups ranged between 83 and 347 ha; the home ranges overlapped by 25 to 48%. In Bherjan forests, the home ranges covered 83 (Western Group) and 101 ha (Eastern Group); the home ranges overlapped by 39 to 48%. In the home range of the western group, around 14% was outside the reserved forest, mainly in Chandmari Tea Estate. In case of the eastern group, around 35% was outside the reserved forest in Athelbari and Dhelakhat Tea Estates (Fig. 4). In Borajan forest, it was about 298 ha (Northern Group) and 347 ha (Southern Group) in 1992-94; home ranges overlapped by 25 to 29%. In the heavily degraded Podumoni forest, it was 150 ha. In Patharia Hill Reserved Forest, the partial home range of a group inside India was >110 ha the remaining being inside Bangladesh. The border fencing has disturbed their movement; however, they move across through select routes, either along rivulets through ground or through trees having canopy links.

The day range length varied between 690 and 2,240 m. The day range of the western group in Bherjan was between 690 and 1,400 m, that of eastern group between 830 and 1,850 m, southern group in Borajan between 780 and 2,240 m and northern group 750 and 2,190 m. The partial day range of a group in Nambor was >1,500 m, in Patharia Hill >900 m, and Dhansiri >2,200 m. Fast travelling of 160 m in 12 mins to slow one, 205 m in 70 mins were observed. A lone male not attached to any group had travelled >500 m in 45 mins in Nambor.

DISCUSSION

So far, this is the first comprehensive study on the ecology and behaviour of the Northern Pig-tailed Macaque *M.n. leonina*. Although this paper is the first such detailed account, its elusiveness and poor visibility had its sway by wasting invaluable time in the field. Earlier observers had also commented similarly (Bernstein 1967; Caldecott 1986). Although a dweller of dense forest, wherever degradation took place it adapted itself to a great extent (e.g., Podumoni forests). It also haunts tea plantations and vicinity of human settlements (Choudhury 2003a). Crop raids are rare unlike its southern counterpart (Crockett and Wilson 1980). The Northern Pig-tailed Macaque is mostly arboreal in dense forest although they do not hesitate to come down to the ground for crossing clearings and also for foraging, especially in degraded areas. The Southern Pig-tails were largely terrestrial (Cawthon Lang 2005). McCann (1933) also mentioned that it is more arboreal. In case of *leonina*, most of the longer duration terrestrial activity were found to be human induced, i.e., raiding crops and feeding on sugarcanes on the highway or crossing clear-felled areas. As a rule, the Northern Pig-tailed Macaque is not very shy, however, in areas where it is hunted for food, it was extremely so.

According to Bernstein (1967) and Medway (1969), when in flight from humans, the Southern Pig-tailed Macaque descends to the ground and flees, but in case of *leonina*, their flight was through trees, either canopy or other layers. Even when on the ground, *leonina* may flee through forest floor or climb trees and flee.

The daily time budget showed rest including roosting (till dusk) accounted for about 45% of their diurnal time. It should be noted that they take up roosting position well before dusk and hence, the proportion of 'inactive' time increases.

Female copulating with more than one male as well as subadults as has been found in *leonina* was also observed in the Southern Pig-tails by other observer (Oi 1996). Their locomotion is somewhat like the Southern Pig-tailed females, but they were not seen to lead the movement. In fact, alpha male was found to take lead at least in one of the intensively studied groups. Elsewhere, during sporadic observations, it was the alpha male that was ahead of others.

The dominance of fruits in diet was conspicuous (hence, frugivorous); however, it may not be out of the way to call the Northern Pig-tailed Macaque an "omnivore" as it takes innumerable small animal matters, most of which could not be identified, and an array of vegetables, gums and a bit of earth. Corner (1941) and Bernstein (1967) also listed the Pig-tailed Macaque as omnivorous. The dominance of fruit in the Pig-tailed Macaque's diet was evident in all the earlier studies, although all were on nominate subspecies (Fooden 1971; Crockett and Wilson 1980; Caldecott 1986). Some tree species play a particularly important role in Pig-tailed Macaque ecology, by providing a major component of food supply in certain seasons, e.g., *Anthocephalus cadamba* (fruit; in September, October, November, 15-20% of the observed feeding time was spent on this), *Sapium baccatum* (fruit; in August, September, October, 25-30%), *Artocarpus chaplasha*

(fruit; in June and July, 35%) and *Castanopsis indica* (fruit; in September, October, 15-20%). In two other interesting cases, which may not be applicable for most of the normal forest groups, sugarcane (stem; in February and March, 42% of the feeding time of the study groups was spent on this) and fallen paddy (grain or seed; in January, 65% of the feeding time was spent on this) formed major diet for certain periods.

According to McClure (1964) and Medway (1969, 1970), the group size in disturbed forests in Peninsular Malaysia was 3-15. Apparently, '3' was not a group but a splinter unit. Fooden (1971) found groups of 12-40 animals. The present study found that the mean of typical groups was 23.3 (range was 16-33). The mean of at least another 15 groups was also >20 where exact number and composition could not be counted. It appears that 20-33 is the ideal range (n=21). Tilson (1982) found 26 in a group at Hollongapar.

The 16 member group was from Podumoni forests, where three-fourth of the forests was in a degraded state and a few monkeys were reportedly killed by village dogs and leopards. The groups of 50-150 Northern Pig-tailed Macaques in Vietnam (Le Xuan Canh *et al.* 1997) and elsewhere, including Khao Yai National Park, Thailand (Duckworth *et al.* 1999), were in all probability of two or more groups feeding/foraging together. This researcher had observed two groups in Khao Yai where he encountered two groups with 25-35 animals. These groups often come closer (looked like a single group) looking for food when visitors stop their vehicles although located deep inside the Park with no opportunistic hunting. In Bherjan, Borajan and Nambor forests, consisting respectively of 59, 43 and 43 macaques were at the end of the day found to be six different groups having overlapping home ranges. Similar temporary 'congregation' was also observed in case of Assamese macaques, putting a casual observer into confusion.

The sex ratio was biased toward females. Females comprised of the major share of any group, 39.9% were adult females (n=7) in this study, while in case of Southern Pig-tails it was 30.4% (n=3) (Oi 1990).

Contact between members within a group or with other groups was largely peaceful, a feature also observed in Southern Pig-tails (Bernstein 1967).

The information on the home range and day range of *leonina* was poorly known prior to this study. It was 83-347 ha against 60-828 ha in Southern Pig-tails. In Nambor and Upper Dihing, the home range could be more than 400 ha (details could not be worked out) while in the colder subtropical forests of Nagaland, it could be much more. The overlapping in this study was up to 48%, which is almost similar to the 50% of southern pigtails (Sponsel *et al.* 2002). The day range length in present study varied between 690 and 2,240 m, which is also not much different from the Southern Pig-tail's 825 and 2,964 m (Caldecott 1986). Weather conditions and seasonal fruit availability had influenced the day ranges to a great extent. With easy food supplements available in large quantity at a fixed place such as paddy (in Borajan) and sugarcane left overs (in Nambor), the day ranges were shorter. During monsoon, often heavy shower also affected the day range to be shorter (the adults look for cover of dense foliage where they sit for quite sometime). In degraded forest, where the fruiting trees were located far apart, the day range increases significantly (e.g., Borajan forests and Patharia Hills).

McCann (1933) stated that the Northern Pig-tailed Macaque probably breeds in April and May, judging from the condition of embryos. Fooden (1971) found lactating and pregnant females in February (early pregnancy) and April (late pregnancy) in western Thailand. According to Crockett and Wilson (1980) and Rowe (1996), Southern Pig-tailed Macaques are not seasonal breeders and mating occurs year-round though there is a slight peak from January to May. The present study on *leonina* shows that several females in estrous were observed from August to December with a few till February while newborns were seen from mid January to May (few in June also). It could be inferred that climate, especially rainfall might have a role in case of *leonina*, which seems to have a marked winter-spring breeding season. This is contrary to the year-round breeding of southern subspecies.

Blanford (1888-91) believed that the gestation period was 210 days. Bernstein (in Roonwal and Mohnot 1977) stated that it is 175 days while Maestripieri (2002) has put it as 170 days. In captivity, it was 162-186 days (Kuehn *et al.* 1965) and 167-179 (Tokuda *et al.* 1968). The present study, although could not fix any day, but confirmed a probable range of 171-180 days (n=2).

Information on mounting in the wild of *leonina* has also been dealt with in details for the first time. Captive macaques were observed since long (Tokuda *et al.* 1968). They observed mounts that lasted for 2-18 seconds (in this study, it was 2-16 seconds); the mean interval between mounts was about 3 mins (in this study, it was variable greatly between individuals; 20.4 mins in alpha male while in case of second male 2.5 mins). The reason seemed to be that the alpha male is relaxed and it carried on copulation bouts at his will and often leisurely (once after a gap of 65 mins) but the second male was in a hurry. It had mounted only when the alpha male was away resting. The mean of pelvic thrusts per mount was recorded as 13 (in this study, it was 10). Oi (1996) and Gouzoules *et al.* (1998) found that the percentage of copulations followed by calls was 98.79% and 45% in two different studies of Pig-tailed Macaques. In this study, it was

36% in case of male only while females were mostly silent (only 2.5%), i.e., no post-copulatory vocalizations. Maestripieri and Roney (2005) put forth one of the hypothesis that copulation calls reflect an orgasm-like reaction.

In Khao Yai National Park, Thailand, a few groups have become habituated and a major part of their diet comes from biscuits, fruits, etc., offered by tourists. Although these groups (at least two groups were observed in July 2006) are deep inside the Park, somehow they developed this habit and are now depending upon it substantially. Despite habitat fragmentation and venturing near human habitations, the Pig-tailed Macaques in Assam and elsewhere in north-east India did not develop this habit although there are Rhesus *Macaca mulatta* and Assamese macaques doing this in some temples and in a few roadside localities (northern Bengal).

The forests of Bherjan, Borajan, Podumini, Hollongapar, Upper Dihing (west block), and Nambor, which were recommended for protected area status after this study (Choudhury 1989, 1995b, 1996c) have been declared as wildlife sanctuaries by the Government of Assam in 1997 (Hollongapar as Hollongapar Gibbon Sanctuary), 1999 (Bherjan, Borajan and Podumini as Bherjan-Borajan-Podumini Wildlife Sanctuary) and 2004 (part of Upper Dihing as Dihing Patkai Wildlife Sanctuary).

Habitat loss and fragmentation due to felling, *jhum* cultivation and expansion of agriculture, and hunting for meat are the main threats to *leonina* in its range in India (Choudhury 2003a). It is protected under Schedule II (part I) of The Wildlife (Protection) Act of India while IUCN has listed it as Vulnerable (IUCN 2004). At least 30 protected areas in north-east India (12 in Assam) have known population of *leonina*. Adequate protection of existing habitat, declaration of some key sites as protected (Dhansiri in Assam, and Narpuh in Meghalaya); and check on felling and *jhum* cultivation are the need of the hour.

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Appendix 1: Food plants and items eaten by Pig-tailed macaques (across groups and study areas)

Species (Family)	Leaves, leaf buds	Leaf petioles	Fruits	Flowers, Buds	Seeds	Shoots	Others
Aerides sp. (Orchidaceae)							+Stem / root
Albizzia lucidor (Mimosaceae)					+		
Amblyanthus sp. (Myrsinaceae)			+				
Amoora wallichii (Meliaceae)			+				
Anthocephalus chinensis / cadamba (Rubiaceae)			+				
Ardisia sp. 1 (Myrsineceae)			+				
Ardisia sp. 2 (Myrsineceae)			+				
Artocarpus chaplasha (Moraceae)	+		+				
Artocarpus lakoocha (Moraceae)			+				
Baccaurea ramiflora (Syn. *sapida*) (Euphorbiaceae)			+				
Bambusa tulda (Bambusaceae)		+				+	
Bambusa balcooa (Bambusaceae)		+				+	
Bauhinia purpurea (Caesalpiniaceae)					+		
Bauhinia variegata (Caesalpiniaceae)					+		
Bischofia javanica (Euphorbiaceae)			+				
Bombax ceiba (Bombasaceae)				+			
Carica papaya (Caricaceae)			+				
Castanopsis indica (Fagaceae)			+				
Cinnamomum glanduliferum (Lauraceae)			+				
Cinnamomum bejolghota (Syn. *C. obtusifolia*) (Lauraceae)			+				
Citrus reticulate (Rutaceae)			+				
Crateva magna var. *magna* (Syn. *Crateva nurvala*) (Capparidaceae)				+			
Croton joufra (Euphorbiaceae)					+		
Dendrocalamus hamiltonii (Bambusaceae)		+				+	
Dillenia indica (Dilleniaceae)	+ bud		+				
Dillenia scabrella (Dilleniaceae)			+				
Dysoxylum gobara (Syn. *D. procerum*) (Meliaceae)				+			
Ficus benjamina (Urticaceae)			+				
Ficus hispida (Moraceae)			+				
Ficus glaberrima (Urticaceae)			+				
Ficus hirta (Urticaceae)	+		+				
Ficus mysorensis (Urticaceae)			+				
Ficus nervosa (Urticaceae)			+				
Ficus religiosa (Urticaceae)			+				
Ficus rhododendrifolia (Urticaceae)			+				
Ficus rostrata (Syn. *sinnuata*) (Urticaceae)			+				
Ficus sp. 1 (Moraceae)			+				
Ficus sp. 2 (Moraceae)			+				
Garcinia morella (Guttiferea)			+				
Garuga pinnata (Burseraceae)	+		+				
Gmelina arborea (Verbenaceae)			+	+	+		
Gynocardia odorata (Flacourtiaceae/Bixaceae)			+				
Hoya parasitica (Asclepiadaceae)			+	+?			
Ipomoea sp. (Convolvulaceae)	+						
Jasminum dispermum (Oleaceae)	+						
Lagerstroemia flos-reginae (Syn. *speciosa*) (Lythraceae)			+				
Ligustum sp. (Oliaceae)				+			
Litsea polyantha (Lauraceae)					+		
Macrosolen cochinchinensis (Loranthaceae)			+				
Mallotus philippensis (Euphorbiaceae)					+		

Appendix 1: Food plants and items eaten by Pig-tailed macaques (across groups and study areas) (*contd.*)

Species (Family)	Leaves, leaf buds	Leaf petioles	Fruits	Flowers, Buds	Seeds	Shoots	Others
Malvastrum sp. (Malvaceae)				+			
Mangifera sylvatica (Anacardiaceae)				+			
Mangifera indica (Anacardiaceae)				+			
Melocanna baccifera (Syn. *bambusoides*) (Bambusaceae)		+				+	
Mesua ferrea (Clusiaceae)	+						
Mezoneurum cucullatum (Leguminaceae)				+			
Miliusa vetulina (Annonaceae)			+				
Musa spp. (Musaceae)			+	+			
Nephelium litchi (Sapindaceae)			+				
Oryza sativa (Oryzeae)					+		
Pelathanthera sp. (Orchidaceae)							+Stem / root
Picrasma sp. (Simaroubaceae)	+						
Premna bengalensis (Verbanaceae)			+				
Pseudostachyum polymorphism (Bambusaceae)		+				+	
Quercus listerni (Fagaceae)	+						
Saccharum officinarum (Poaceae)							Stem
Sapium baccatum (Euphorbiaceae)			+				
Schizostachyum dulloa (Poaceae)						+	
Smitinandia sp. (Orchidaceae)							+Stem / root
Spatholobus roxburghii (Fabaceae)				+			
Spondias pinnata (Syn. *mangifera*) (Anacardiaceae)			+	+			
Sterculia villosa (Sterculiaceae)	+ (tender)			+			
Symplocos spicata (Symplocosaceae)	+						
Terminalia chebula (Combretaceae)			+				
Terminalia belerica (Combretaceae)			+				
Uncifera sp. (Orchidaceae)							+Stem / root
Wrightia tomentosa (Apocynaceae)	+						
Zea mays (Poaceae)					+		

'+' - food items consumed
'?' - ambiguous whether consumed or not
[Synonyms are important as many authorities still use earlier names.
Two *Ficus* spp. could not be identified but were two distinct species and hence, listed to show the diversity]

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THE ICHTHYOFAUNAL DIVERSITY IN THE FRESHWATER RIVERS OF SOUTH DINAJPUR DISTRICT OF WEST BENGAL, INDIA

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A steady decline in fish catch per year through the past decades, and selective decline of certain prized small table fishes in the rivers of the district have not been addressed so far. This study, therefore, aims to estimate the present status of the annual fish catch of South Dinajpur district, West Bengal, with reference to the species composition of the rivers and *kharis* during pre-monsoon, monsoon and post-monsoon seasons. In this two-year long survey, we have identified 5 orders, 6 suborders, 17 families, 11 subfamilies, 40 genera and 49 fish species and a few rarely caught species from the rivers, *kharis* and *beels* of the district.

Key words: riverine ichthyofaunal diversity, South Dinajpur, species composition

INTRODUCTION

The aqua resources of India include 2.02 million sq. km of an Exclusive Economic Zone (EEZ) of surrounding seas, approximately 29,000 km length of rivers, *c.* 1,13,000 km of canals, *c.* 1.75 million ha of existing water-spread in the form of reservoirs, *c.* 1 million ha in the form of tanks and ponds, and *c.* 0.6 million ha of stagnant, derelict, swampy waterspread areas (Jhingran 1991). About 2,200 fin fish species have been recorded from different ecosystems of India, which is 11% of the world fish germplasm (Sinha 1998). Of these, 400 species are commercially important. These include cultured, cultivable and wild species. The ecosystem-wise distribution of fish germplasm resources of India are: cold water (73; 3.3%), warm waters of the plains (544; 24.73%), brackish water (143; 6.50%) and marine water (1440; 65.45%) (Anon 1992-93; Das 1994).

This study aims to estimate the species composition of the rivers, *kharis, khals* and *beels* of South Dinajpur district, West Bengal. The South Dinajpur district forms a part of the erstwhile undivided West Dinajpur, created out of the Dinajpur district in 1947 at the time of partition of India. It was then split into two districts in 1992 – one being Dakshin or South Dinajpur and the other Uttar or North Dinajpur (Table 1; Fig. 1).

The district has four north to south flowing major rivers, namely Atrai, Punarbhaba, Tangon and Jamuna. Atrai and Punarbhaba originate in India, at the foothills of the Himalayas and pass through Bangladesh to enter India again in South Dinajpur. These rivers have connections with Teesta drainage system, especially during the monsoon. Besides these rivers, there are a number of drainage channels, locally known as *kharis*, *khals*, or *beels* (Tables 2, 3, 4 and 5). The relevant details of resources available for development of fisheries in the district are shown in the Table 6 (Rao 2001). Almost all the rivers and streams enter the district from Bangladesh and leave the district to enter again to either Bangladesh or a neighbouring district. However, many rivers originate from other major river systems north of Bangladesh, and also from India.

The productivity of the cultured fish is less than 2 tons per hectare per year in the district, which can be enhanced considerably with the help of scientific extension programmes (Rao 2001). However, there is no concrete data regarding the status of fish catch from the open water bodies. A steady decline in fish catch per year through the past decades, and selective decline in the catch of certain prized, small table fishes in the rivers of the district have not been addressed so far. Therefore, the present study aims towards estimating the present status of the annual fish catch in capture fisheries of the district with reference to the species composition of the rivers and *kharis* during pre-monsoon, monsoon and post-monsoon seasons. To the best of our knowledge, no such study with regard to cataloguing the fish species has been undertaken prior to this study in this district. Therefore, this study gives an idea regarding the ichthyo-biodiversity status of the endemic fish stocks of the district. Two potential breeding grounds were also identified, namely the Danga *Beel*, near Balurghat aerodrome and Gochina *Beel*, near Trimohini, Hili block.

List of abbreviations used in text:

EEZ - Exclusive Economic Zone
ZSI - Zoological Survey of India

METHODOLOGY

Surveys in different rivers and *kharis* of the district

A two-year survey (2004-2006) was undertaken in major rivers, like Atrai, Punarbhaba, Tangan, Jamuna, in minor rivers,

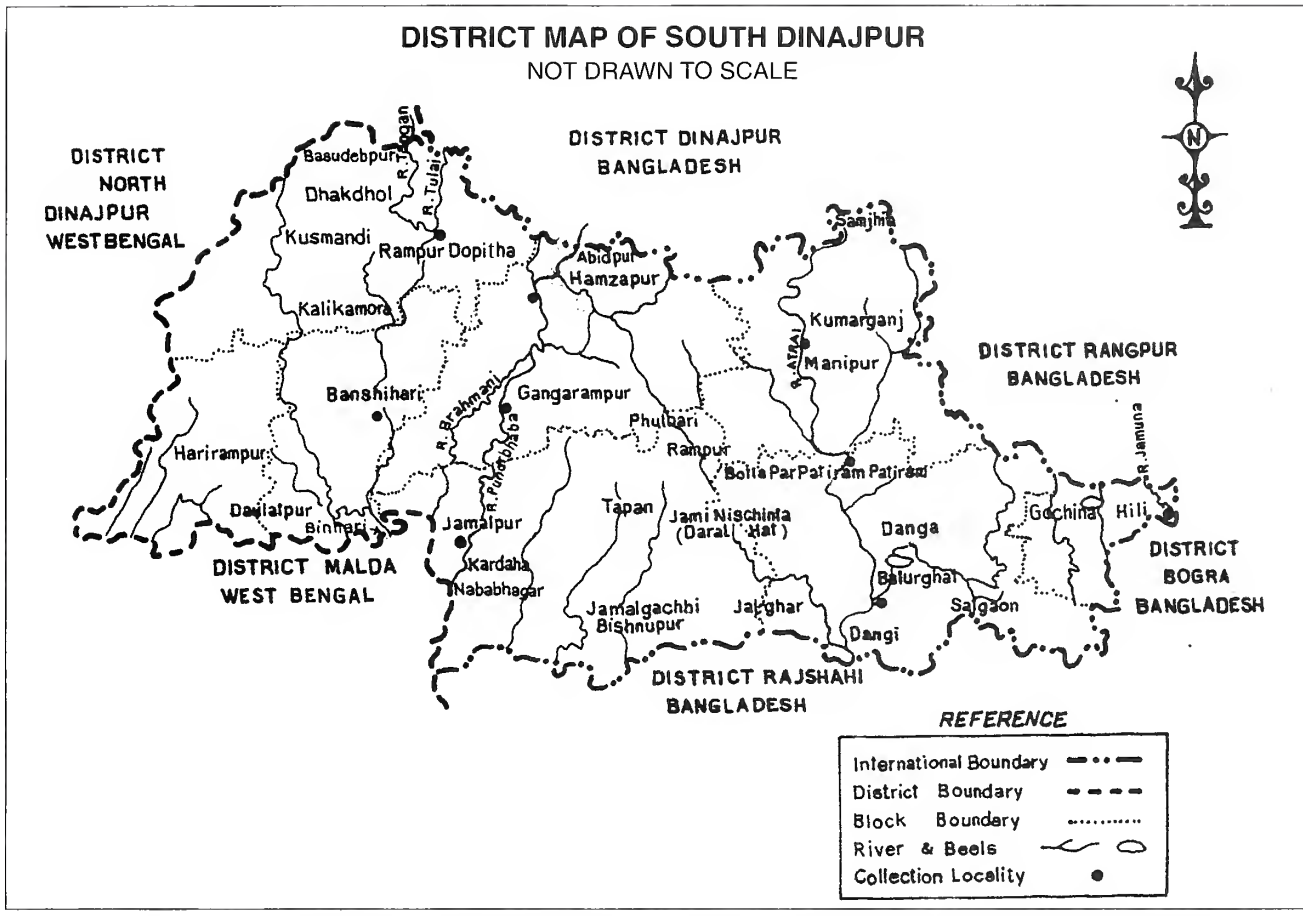

Fig. 1: District map of South Dinajpur, West Bengal. Map shows district blocks, major and minor rivers and adjoining districts of Bangladesh besides, two *Beels* namely, Danga and Gochina. Fish sample collection stations are marked as filled circles by the side of each major river (Map not drawn to scale)

like Ichhamoti, and in *kharis* like, Kalkali, Kashiani and Brahmani. *Beels* visited were Danga and Gochina. Surveys were also undertaken at different landing centers and fish markets.

Field Surveys

In total, forty-six field studies were undertaken in major rivers with assistance from fishermen (Haldars), who provided boats, and various types of nets and manpower. The rivers and *kharis* were divided into well-marked zones keeping in mind the flow patterns, average water depth, location of villages of local fishermen community and accessibility of the regions. Nettings were done extensively in these landing stations during three periods, namely pre-monsoon (February-May), monsoon (June-September) and post-monsoon (October-January). In case of habitat ground surveys, photographs of the area and streams in different seasons were taken.

Surveys were conducted at different markets and landing centers regularly in different seasons. Market surveys included important fish markets in big towns that are located by the sides of major rivers of the district. Fishes were also collected from various fishermen.

Fishes were collected and immediately kept in neutral 10% Formalin in a plastic jar, and then preserved in specimen jars containing 4-6% Formalin at the Zoology Department of Balurghat College, Balurghat. The specimen jars were labelled properly and stored for further studies. Local names of the fishes were recorded on site, and size, colour and any peculiarities, if present, were noted and the fishes photographed.

Table 1: District profile

Sub-Divisions: 2	Blocks: 8	Municipalities: 2
Balurghat (District Headquarter)	Balurghat	Balurghat
Gangarampur at Buniadpur	Hili Kumarganj Tapan Gangarampur Kushmandi Banshihari Harirampur	Gangarampur

(Source: Dakshin Dinajpur District Profile URL)

Table 2: Large rivers in South Dinajpur district

Name of Major Rivers	Enters Dakshin Dinajpur at	Leaves Dakshin Dinajpur at	Blocks Traversed
Atrai	Samjia	Dangi	Kumarganj + Balurghat
Punarbhaba	Abidpur	Nababhagar (Gangarampur)	Gangarampur + Tapan
Tangan	Basudebpur	Binhari	Kushmandi + Banshihari
Jamuna	Agra	Baikunthapur	Hili

Identification of breeding grounds

Two potential habitats – Danga *Beel*, near Balurghat aerodrome, and the Gochina *Beel*, near Trimohini, Hili block – identified in the first year of survey were taken up for more studies. Another prospective breeding ground was the Bhaluka beel in the Hili block.

Making of an inventry

Collected and preserved fishes were identified using standard taxonomic procedures following standard literature (Shaw and Shebbeare 1937; Menon 1974; Jhingran 1991; Talwar and Jhingran 1991; Menon 1999; Jayaram 1999) and with the help from the Fishery Division of ZSI, Department of Zoology, Calcutta University, and Meen Bhawan, Balurghat, South Dinajpur. In total, forty-nine species have been identified.

RESULTS

We have identified 5 orders, 6 suborders, 17 families, 11 subfamilies, 40 genera and 49 fish species from the rivers, *kharis* and *beels* of the district during the two-year long survey (Table 7).

Table 3: Small rivers in South Dinajpur district

Name of Major Rivers	Enters Dakshin Dinajpur at	Leaves Dakshin Dinajpur at	Blocks Traversed
Ichhamoti	North of Thalsama	Opens to Atrai	Kumarganj
Brahmani (*Khari* like)	Comes out of Punarbhaba at Debipur	North of Lakshmipur	Gangarampur + Tapan
Tulai	Suihara	Opens to Tangan at Chandpur	Kushmandi

Table 4: List of *Khari* and *Khals* in South Dinajpur district

Name of *Khari*/*Khal*	Name of *Khari*/*Khal*
River Ghagra	Bhonar
River Cheri	Kasiani
Ghukshiri	Barakharia
Pagliganj	Kochakona
Kalkali	Harbhanga
Shyamnagar	Balia

Fishes like Bhada *Badis badis* (Hamilton-Buchanan), Nandos *Nandus nandus* (Hamilton-Buchanan) and Khursa *Labeo dero* (Hamilton-Buchanan) have not been reported from the rivers of the South Dinajpur district for the last fifteen years. We report presence of two specimens of *Badis badis*, one each from Atrai and Jamuna rivers (Table 7). Hilsa [*Hilsa* (*Tenualosa*) *ilisha* (Hamilton-Buchanan)] earlier reported from Atrai river (local fishermen's catches) during late monsoon was not found in this study.

Another interesting find was a single specimen of *Amblyceps mangois* (Hamilton-Buchanan) (local name: Tele Tengra) from Jamuna river of Hili Block (Table 7). This fish is found usually on the pebbly beds of fast flowing rivers at the base of hills (Talwar and Jhingran 1991). Shaw and Shebbeare (1937) have also reported this fish from Jamuna river. A single specimen of *Acanthophthalmus pangia* (Hamilton-Buchanan) (local name: Pahari Puye) was collected from Jamuna river (Table 7). This fish is reported from the terai and duars area of north West Bengal (Shaw and Shebbeare 1937; Talwar and Jhingran 1991). We collected a few specimens of *Conta conta* (Hamilton-Buchanan) from Atrai river; it is usually found in the rocky streams of north West Bengal at the base of the Himalayas (Talwar and Jhingran 1991).

Waterbody-wise categorization and documentation of available fishes has been depicted in Table 7.

DISCUSSION

Over the past few years, there has been a steady and un-replenishable decline in the fish catch. A few species have become rare in the markets over the past couple of decades. This decline can be attributed to a few apparent causes: rising river beds, less precipitation and water flow, rampant use of drag nets made up of mosquito nets and degradation of the breeding grounds, in the district or probably in the upstream regions of the neighbouring country Bangladesh. There was also a possibility of the presence of polluting substances from the agricultural run-offs entering the riverine system, which contributed to the decline of fish population. In order to take measures to conserve the fish germplasm and replenish

Table 5: List of *Beels*

Name of *Beel*	Position
Danga	Between Kalkali Khari
Bhaluka	Near the international border, *c.* 1.5 km north of Trimohini
Gochina	Jamalpur mouza, Chagaldanga, Hili Block

Table 6: Details of resources of the district

1.	Net Water Area		8,260 ha
	(i) of which	a) Culturable	2,260 ha
		b) Derelict	2,603 ha
		c) Semi-derelict	3,397 ha
	(ii) of which	a) Private	6,177 ha
		b) Vested	1,543 ha
2.	Number of persons engaged in the profession		31,265 (12,322 families)
3.	Approximate annual production		9,151 tons
4.	Number of Hatcheries		11 (Govt.-1, Private-10)
5.	Cooperative Societies :-		
	(i) Central Fishermen Coop. Societies		1
	(ii) Primary Fishermen Coop. Societies		10
	(iii) Membership of the Coop. Societies		3,147

(Source: Rao 2001)

the dwindling natural fish population, it is imperative that we assess the current status of the ichthyofaunal diversity of the rivers and natural water bodies of the district. Since no known published data regarding the diversity of riverine fishes of the district was available, we intended to build up the initial inventory, through a two-year long survey (2004-2006).

During this survey, we assessed the total number of fish species present in the major and minor rivers of the South Dinajpur district. A few species like *Salmostoma bacaila*, *Amblypharyngodon mola*, *Barilius barna*, *Barilius shacra*, *Esomus danricus*, *Lepidocephalus guntea*, *Botia dario*, *Danio devario*, *Mystus bleekeri*, *Mystus vittatus*, *Ailia punctata*, *Eutropiichthys murius*, *Eutropiichthys vacha*, *Xenentodon cancila*, *Chanda nama*, *Glossogobius giuris*, *Channa punctatus*, *Macrognathus pancalus* and *Mastacembelus armatus* were numerous. However, species like *Badis badis*, *Amblyceps mangois*, *Acanthopthalmus pangia*, *Conta conta*, and *Crossocheilus latius latius* were rare and only one or two specimens of each were caught.

Some of the fish species may be accidental finds in this area, like *Amblyceps*, *Acanthophthalmus* and *Conta* which are adapted to and reported from the fast flowing rivers and streams of the Himalayan foothills. Indian Torrent Catfish (*Billi Fish*) *Amblyceps mangois* (local name: *Tele Tengra*) is distributed along the foothills of Himalayas from the Kangra Valley (Himachal Pradesh) to Assam in India and attains a length of about 12.5 cm (Talwar and Jhingran 1991). The specimen obtained by us from Jamuna river of Hili Block, is a juvenile of about 6.35 cm. *Acanthopthalmus pangia* (local name: *Pahari Puye*) is distributed in north-eastern West Bengal and Manipur, and attains a length of about 6.5 cm (Talwar and Jhingran 1991). The single specimen obtained by us from Jamuna river of Hili Block is about 5.08 cm. Conta Catfish or *Conta conta* (local name: unknown) is reported to be distributed at the base of Himalaya in north West Bengal, Assam and Meghalaya and attains a length of 7.8 cm (Talwar and Jhingran 1991). Conta Catfishes collected from Atrai river are of various sizes, attaining about 7.62 cm. Further ecological and genetical studies are needed to compare these species with those found in the northern regions and to explore the possibility of their adaptive radiation.

Table 7: River-wise categorization of fish catch

Species	Atrai	Punarbhaba	Tangon	Jamuna
Class Osteichthyes				
Subclass Actinopterygii				
Subdivision Teleostei				
Order Cypriniformes				
Family Cyprinidae				
Subfamily Cyprininae				
1. *Catla catla* (Hamilton-Buchanan)	+	+	+	+
2. *Cirrhinus mrigala* (Hamilton-Buchanan)	+	+	+	+
3. *Cirrhinus reba* (Hamilton-Buchanan)	+	+	-	+
4. *Labeo bata* (Hamilton-Buchanan)	+	+	+	+
5. *Labeo calbasu* (Hamilton-Buchanan)	+	+	+	+
6. *Labeo rohita* (Hamilton-Buchanan)	+	+	+	+
7. *Puntius conchonius* (Hamilton-Buchanan)	+	+	+	+
8. *Puntius sarana sarana* (Hamilton-Buchanan)	+	+	+	+
9. *Puntius sophore* (Hamilton-Buchanan)	+	+	+	+
10. *Puntius ticto* (Hamilton-Buchanan)	+	-	-	-

Table 7: River-wise categorization of fish catch (*contd.*)

Species	Atrai	Punarbhaba	Tangon	Jamuna
Subfamily Cultrinae				
11. *Salmostoma bacaila* (Hamilton-Buchanan)	+	+	+	+
Subfamily Rasborinae				
12. *Amblypharyngodon mola* (Hamilton-Buchanan)	+	+	+	+
13. *Aspidoparia morar* (Hamilton-Buchanan)	+	+	-	-
14. *Barilius barna* (Hamilton-Buchanan)	+	+	+	+
15. *Barilius shacra* (Hamilton-Buchanan)	+	+	+	+
16. *Danio devario* (Hamilton-Buchanan)	+	+	+	+
17. *Esomus danricus* (Hamilton-Buchanan)	+	+	+	+
Subfamily Garrinae				
18. *Crossocheilus latius latius* (Hamilton-Buchanan)	-	-	-	+
Family Psilorhynnchidae				
19. *Psilorhynchus sucatio* (Hamilton-Buchanan)	+	+	+	+
Family Cobitidae				
Subfamily Cobitinae				
20. *Lepidocephalus guntea* (Hamilton-Buchanan)	+	+	-	+
21. *Acanthophthalmus pangia* (Hamilton-Buchanan)	-	-	-	+
22. *Somileptus gongota* (Hamilton-Buchanan)	+	+	+	+
Subfamily Botiinae				
23. *Botia dario* (Hamilton-Buchanan)	+	+	-	+
Order 2 Siluriformes				
Family Bagridae				
24. *Mystus bleekeri* (Day)	+	+	+	+
25. *Mystus vittatus* (Bloch)	+	+	+	+
26. *Rita rita* (Hamilton-Buchanan)	+	+	+	+
Family Siluridae				
27. *Ompok pabda* (Hamilton-Buchanan)	+	+	+	+
28. *Wallago attu* (Schneider)	+	+	+	+
Subfamily Ailiinae				
29. *Ailia punctata* (Day)	+	+	-	-
Subfamily Schilbeinae				
30. *Clupisoma garua* (Hamilton-Buchanan)	+	+	+	+
31. *Eutropiichthys murius* (Hamilton-Buchanan)	+	+	-	-
32. *Eutropiichthys vacha* (Hamilton-Buchanan)	+	+	-	-
Family Pangasiidae				
33. *Pangasius pangasius* (Hamilton-Buchanan)	+	+	+	+
34. *Amblyceps mangois* (Hamilton-Buchanan)	-	-	-	+
Family Sisoridae				
35. *Conta conta* (Hamilton-Buchanan)	+	-	-	-
36. *Erethistes pussilus* Muller & Troschel	+	-	-	-
37. *Erethistoides montana montana* Hora	+	-	-	-
38. *Sisor rhabdophorus* Hamilton-Buchanan	+	-	-	+
Family Clariidae				
39. *Clarias batrachus* (Linnaeus)	+	+	+	+

Table 7: River-wise categorization of fish catch (*contd.*)

Species	Atrai	Punarbhaba	Tangon	Jamuna
Order Cyprinodontiformes				
Suborder Exocoetoidei				
Family Belonidae				
40. *Xenentodon cancila* (Hamilton-Buchanan)	+	+	+	+
Order Perciformes				
Suborder Percoidei				
Family Chandidae				
41. *Chanda nama* Hamilton-Buchanan	+	+	+	+
Family Nandidae				
Subfamily Badinae				
42. *Badis badis* (Hamilton-Buchanan)	+	-	-	+
Suborder Gobioidei				
Family Gobiidae				
Subfamily Gobiinae				
43. *Glossogobius giuris* (Hamilton-Buchanan)	+	+	-	+
Suborder Anabantoidei				
Family Anabantidae				
44. *Anabas testudineus* (Bloch)	+	+	+	+
Family Belontidae				
Subfamily Trichogasterinae				
45. *Colisa fasciatus* (Schneider)	+	+	+	+
Suborder Channoidei				
Family Channidae				
46. *Channa punctatus* (Bloch)	+	+	+	+
Suborder Mastacembeloidei				
Family Mastacembelidae				
47. *Macrognathus pancalus* Hamilton-Buchanan	+	+	+	+
48. *Mastacembelus armatus* (Lacepede)	+	+	+	+
Order Tetraodontiformes				
Family Tetraodontidae				
49. *Tetraodon cutcutia* Hamilton-Buchanan	+	+	-	+
Total Fish Species	46	40	31	41

(+): Found; (-): Not Found

In the habitat ground surveys, we have found numerous small hatchlings and fries of minor carps, spiny eels, snake heads, gobies and perches during the early monsoon. Prospective breeding ground, like Danga *beel* remains almost dry during the dry periods with only a thin stream (Kalkali *Khari*) flowing through it. The area is used for cultivation during this period, which often gets over flooded during monsoon. The fish fries are carried along the *khari* that opens to Atrai river at Balurghat town. The habitat survey with regards to physico-chemical parameters and water quality assessment vis-à-vis fish species availability will be published later.

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NOTE ON A COLLECTION OF SNAKES FROM SOUTH INDIA, WITH EMPHASIS ON THE SNAKE FAUNA OF THE MEGHAMALAI HILLS (HIGH WAVY MOUNTAINS)

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This paper deals with two collections of snakes obtained in south India by the senior author in the years 1946-48 and 1949-52 respectively. Specimens were obtained from the Meghamalai Hills, also known as the High Wavy Mountains, from the Anaimalai Hills, located in the State of Tamil Nadu, and in Wayanad district, Kerala, at the northern edge of Nilgiri Hills. A total of 39 snake species are recorded from Meghamalai Hills. This area, now mostly planted with tea, includes Cloudlands, Highwavys and Manalaar estates, the access to which is now largely restricted, still includes large untouched remnants of evergreen forest. The description of a rare Hutton's Pitviper *Tropidolaemus huttoni* Smith (1949) is completed on the basis of unpublished notes from the senior author.

Keywords: Serpentes, *Tropidolaemus huttoni*, India, High Wavy Mountains, Meghamalai Hills, Tamil Nadu, Anaimalai Hills, Nilgiri Hills, Collection

INTRODUCTION

Hutton (1949a) reported on a collection of snakes obtained in the High Wavy Mountains, south-west of Madurai, in the State of Tamil Nadu, South India (see below for the exact position of this range). Subsequently, Hutton (1949b) described the mammals of this poorly known area. The paper on snakes was based on collections and observations made in 1946-48. This earlier collection contained two specimens of new species of pitviper previously mentioned as a *nomen nudum* by Hutton (1949a), which was later described by Smith (1949a) as *Trimeresurus huttoni*. Since its description, no other specimens have ever been collected. On the basis of the sole holotype, David and Vogel (1998) concluded that this species shares most characters with *Tropidolaemus wagleri* (Boie 1827) and referred it to the genus *Tropidolaemus* Wagler, 1830. Nevertheless, *Tropidolaemus huttoni* remains the most poorly known Hutton's pitviper and one of the rarest of all snake species.

In the present paper, largely on the basis of Angus Hutton's notes, we present a general description of the High Wavy Mts., one of the least known places in south India, as far as zoology is concerned, but now definitely not as remote and forgotten as suggested in David and Vogel (1998). We publish data on specimens of snakes of this second collection. We take this opportunity to present new data on *Tropidolaemus huttoni*.

In contrast to the information published in David and Vogel (1998), the paratype of this species retained by Hutton was not lost but had been donated personally by him in 1962, while on his way to Australia, to Dr. V. Chari, Curator of Reptiles at the Prince of Wales Museum (now Chhatrapati Shivaji Maharaj Vastu Sangrahalaya [CSMVS]), Bombay (now Mumbai), as instructed by Mr. Humayan Abdulali, the then Honorary Secretary of the Bombay Natural History Society (BNHS), Mumbai. The specimen was sighted in 1973 by Hutton (and his wife), while on a holiday, and he advised the new Curator that the spirit had evaporated and it needed urgent attention. He examined it again in 1986 while on a UN / FAO Consultancy for the GoI and UN, and was disappointed that it had not been attended to!

Although this specimen is in bad condition, it allowed us to expand the variation in this species. On the basis of the 1946-48 and 1949-52 collections, which contain a total of 39 snake species, we tentatively compare the fauna of this isolated range with the known fauna of three other ranges of south India.

MATERIAL AND METHODS

The following list is based on preserved specimens deposited in the Natural History Museum, London in 1952, namely the second collection of the senior author examined by the second author. Some other snakes were deposited in the collection of the BNHS, Mumbai and CSMVS, Mumbai.

The exact localities of collect are as follows:

Anaimalai Hills: Injapara and Monica Tea Estates, Coimbatore district, Tamil Nadu, 1949-51; High Wavy Mts.: Meghamalai Hills, (1946/48) see above; Mysore: Kadamane Estate, near Sakleshpur, Hassan district, Karnataka, 1951; Nilgiri-Wayanad: Rockwood Estate, Wayanad district, Kerala (1952).

Interesting specimens are described in detail below. Biological notes are exclusively based on Angus Hutton's

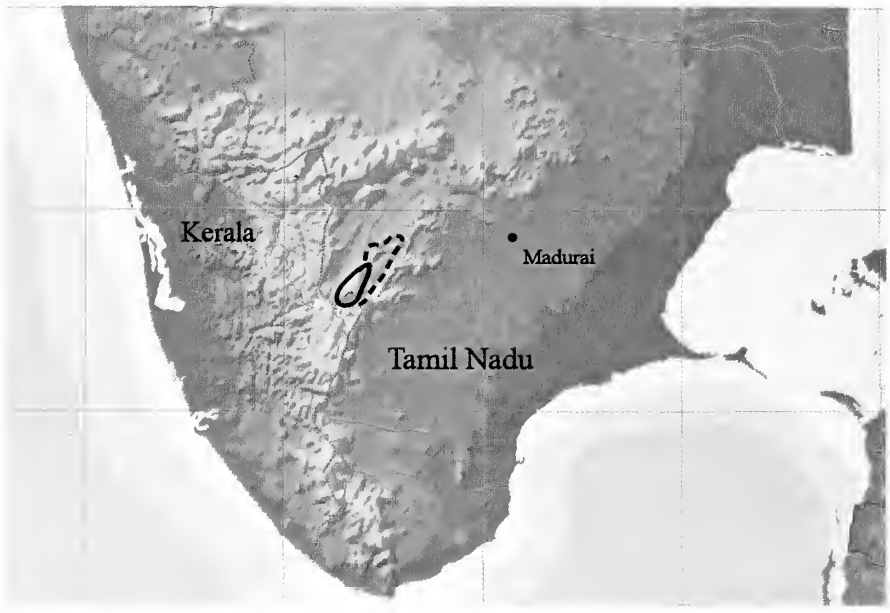

Fig. 1: Map of South India showing the general position of the Meghamalai Hills. Thick line on the South: general limit of the Meghamalai Hills; Thin line on the North: the Varushanad Hills

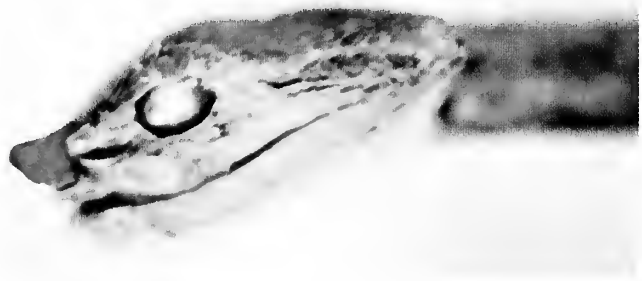

Fig. 2: *Tropidolaemus huttoni* (Smith, 1949), lateral view of the head of the paratype. Colorised view based on a B&W photograph dating from 1947. In life the red hue of the snout was slightly more brown (brick red). Note upturned snout and the yellow mental shield and postocular streak

Fig. 3: A composite panorama taken in October 1993 of part of the Manalaar Tea Estate just below the junction of Manalaar and Chinna Manalaar rivers. Downstream of the confluence the stream becomes the Suruli river. Note the jungle corridors left in place. Manalaar is at the extreme right of the panorama; Mt. Pakkadi Mettu, *c.* 1,898 m, is at the centre of the picture

field data. The spelling of Indian names of localities follows Ravi (2001).

Measurements were measured to the nearest millimetre. Ventral scales were counted according to Dowling (1951). The terminal scute is excluded from the number of subcaudals. The number of dorsal scale rows at mid-body is counted at the level of the ventral plate corresponding to half of the total ventral number. Values for symmetric head characters are given in left / right order. The number of examined specimens appearing under each species details may differ in tables, as specimens in bad condition were not examined in details.

Abbreviations: SVL: Snout-vent length; TaL: Tail length; TaL/TL: ratio tail length/total length; TL: total length.

Scalation characters: ATem: anterior temporals; C-SL3: number of scale(s) between the 3rd supralabial scale and the subocular; CEP: number of cephalic scales on a line between the eyes; DSR: dorsal scale rows; IL: infralabial scales; Lor: loreal scales; MSR: number of dorsal scale rows at midbody; PreOc: preocular scales; PSR: number of dorsal scale rows before vent; SC: subcaudals; SL: supralabials; SL-orb: number of supralabial(s) entering orbit; Tem: temporal scales; VEN: ventral scales.

Museum abbreviations: BMNH: The Natural History Museum, London, UK; BNHS: Bombay Natural History Society, Mumbai, India.

RESULTS

Historical background

The first herpetological paper by Hutton (1949a) was based on collections and observations made in 1946-48. At that time, the senior author of this paper, then aged 18 who was born in Mysore State (now Karnataka state) and had the advantage of being fluent in Tamil and several dialects, had commenced work in the High Wavy Mts. as Assistant Manager with Tea Estates (India) Ltd, a subsidiary company of Brooke Bonds of England, one of the leading Tea producing companies of the time in India.

His work involved surveying and clearing the jungle for planting up a thousand acre Cinchona and Tea estate, leaving the natural vegetation on the river systems untouched and also preserving essential jungle corridors for migrating Elephants and other wildlife. Windbreaks were left intact on the ridges as protection from the South West monsoon winds. This work provided a unique opportunity for collecting specimens of flora and fauna, as upwards of 500 contract workers were employed at any one time. He also assisted the manager and engineers with the survey and construction by some 300 workers of the access ghat road from Chinnamanur, in the Kambam valley, that took two years to build and this provided even more opportunities for collecting.

As the '*tappal*' (Mail) runner complained about the weight of pickled snake specimens, sealed in tins of spirit, that he had to carry for 8 hours to the Kambam Post Office, Angus Hutton ascertained from the BNHS that, provided the head and tail ends were preserved intact, it was quite acceptable to skin out the intermediate section to save weight. It is for this reason that such a large number of specimens are described as skinned!

In August 1948 Hutton went to the UK on four months furlough with more snake and lizard specimens, which were deposited with Dr. Malcolm A. Smith in the collection of the then BMNH, now the Natural History Museum, London, to add to others preserved in spirit, which had been forwarded by the BNHS for identification.

Hutton's 1948 collection also included the second known specimen of the Skink *Dasia subcaerulea* (Boulenger 1891) collected in the High Wavy Mts., 1,798 m above msl, some 16 km from the type locality of this species located near Bodinaikkanur, *c.* 335 m (Boulenger 1891). This second specimen was described by Smith (1949b).

On returning to India in January 1949 Hutton was transferred to the Anaimalai Hills to the Company's Monica and Injapara tea estates as senior assistant, for 2 years, followed by 6 months relieving on Kadamane tea estate in Mysore and finally appointed manager of Rockwood tea estate in the Nilgiri Wynaad where he remained till July 1952 where he completed his contract.

Each year in India, during his 2 weeks local leave he visited the High Wavy Mts., now known as the Meghamalai Hills, Teni district, Tamil Nadu hoping to obtain more specimens of *T. huttoni*, alas without success, though the patch of Bamboo at the confluence of the Manalaar and Chinna Manalaar rivers where the original capture was made was totally intact as it was in one of the jungle corridors that had been left for migrating elephants.

The author collected a good number of reptile specimens both in the High Wavy Mts. and also in two other ranges of South India, the Nilgiri Wayanad (now the Wayanad district, Kerala) and the Anaimalai Hills (Coimbatore district, also in Tamil Nadu) and took these specimens with him to UK and deposited them in the BMNH, London in July 1952. Specimens were identified by the curator, J.C. Battersby (*in litteris*, dated November 29, 1954). This collection is rich with 6 lizard species, all common species, and 136 snake specimens, of which 129 are still in the collections of the BMNH. Up to now, the contents of this second collection had never been published in detail.

The High Wavy Mts. received little attention prior to the publications of Angus Hutton. Blatter and Hallberg (1917)

reported on a botanical tour, whereas Wroughton (1917) published data on the mammals. These authors put emphasis on the poor knowledge of this hilly range, the top of which was then still covered with dense evergreen forests.

It should be pointed out that, at that time and up to the establishment of Tea estates that first commenced at Cloudlands, just before World War II, to around 1946, the High Wavy Mts. were still a remote area. It took the senior author an 8 hour walk or ride on a horse to reach the estates from the nearby city of Kambam prior to the construction of the vehicular ghat road.

A description of the High Wavy Mountains

A short description of the High Wavy Mountains was provided by David and Vogel (1998), but it was both incomplete and erroneous: this plateau is definitely no longer the remote, unexplored and uninhabited area described by earlier naturalists who visited this mountain range!

The High Wavy Mountains are now known as the Meghamalai Hills (Fig. 1), from the Tamil words *Megha*, a cloud, and *Malai*, a hill. During A. Hutton's service days, this name only applied to the eastern end where Cloudland Estate was the earliest planted area. The High Wavy Mts. area was always called Patchakumachi, from the Tamil word *Patcha*, green, and *Kumachi*, a jungle, which may be loosely translated as "Green jungle". The name "High Wavy Mountains" was applied by the earlier explorers who just noted the appearance from the then Cumbum (Kambam) valley - that is just how they appear. In those days, the 198 m drop of the Suruli river waterfall was a scenic beauty, though the Hydro Electric Scheme dam above the falls has now cut the flow of water to a small trickle.

This elevated plateau constitutes a spur from the Cardamom Hills oriented southwest-northwest on the south-western edge of the Varushanad Hills (or Varusanadu Hills). The Varushanad hills extend in a north-east direction; east near Thekkadi from the junction of Cardamom Hills and Pandalam Hills towards the Andipatti Hills just west of Madurai. The Meghamalai Hills constitute the western edge of the Varushanad Hills along the deep Kambam Valley. The city of Kambam (formerly Cumbum; 9° 43' 60" N; 77° 17' 60" E) is about 15 km north-west of the Meghamalai Hills, whereas Gudalur is closer, at about 10 km east of the southern part of the range. The Meghamalai range is located in Teni (or Theni) district of the state of Tamil Nadu, in southern India. The southern tip of this range is located very close to the limit between the limit of the State of Kerala. The south westernmost edge of the Meghamalai Hills borders the Idukki district of Kerala. Lastly, the south-western part of the range is adjacent to the famous Periyar lake and Tiger Reserve in Kerala.

The Meghamalai Hills are made of steep slopes and precipitous hills, which culminate by a cool and misty plateau approximately only 45 sq. km in area, with undulating hills at an average elevation of about 1,550 m above sea level. The highest point of the range, Brook's Peak, top at 1,965 m above sea level.

According to ancient reports such as Blatter and Hallberg (1917) and Wroughton (1917), the High Wavy Mts. were heavily covered with dense, dark evergreen forests with thick undergrowth. Only a few patches of ground remained bare.

Nowadays, the Meghamalai Hills are subject to much pressure. This plateau has become quite a tourist spot, for some parts open to the public, especially around the Suruli river waterfall. Other parts have been cleared since 1946 and extensive plantations established.

Most of the cultivated area is now covered with Tea estates of which the access is highly restricted. This area has about 12.15 sq. km of the world's finest tea and two ultra modern Tea factories. For example, the locality where specimens of *Tropidolaemus huttoni* were collected is at about one kilometre east of Brook's Peak. This area is now enclosed in the Manalaar Tea estate, which produces one of the most famous Teas in India, a clonal selected high yielding Tea. According to the website *www.teabungalows.com* (accessed on May 02, 2008), the largest Tea plantation, the Highwavys Group, is owned by the Woodbriar group. Other plantations nearby include Cardamom, Pepper and Coffee. However, the southernmost part of the Meghamalai Hills, close to the Periyar Reserve, is still covered with dense forests.

Currently, the vegetation ranges from dry scrub forests on the foothills up to about 915 m above msl, then to the plantations cited above on the plateau, which replaced the evergreen forests of the past. Ridges overlooking the valleys are covered with grass whereas the hill-bamboo *Ochlandra travancorica* edges the tracts of evergreen forest. Large patches of evergreen forests are still present only on the higher summits. However, even within the extensive Tea estates, extensive tracts of undisturbed forests and of bamboo have been deliberately left and preserved as windbreaks and to protect the rivers and preserve natural wildlife corridors. These natural corridors allow the annual migration of wild elephants, which are still abundant, across the range (Fig. 3) and are used by monkeys, deers (Sambar) and birds. All natural ridges, as well as watercourses were left.

Description of the collection of 1952

The senior author took this collection to the BMNH

(London) in 1952, but specimens were entered in collection in 1955.

Uropeltidae Müller, 1831

***Melanophidium punctatum* Beddome, 1871**

Material Examined: 3 specimens; BMNH 1955.1.2.93-94 (2 females), "Anamallies", now Anaimalai Hills. BMNH 1955.1.2.95 (female), "High Wavy Mts.", now Meghamalai Hills.

Biology: Collected at 1,066 m above msl in the Meghamalai Hills.

Note: These specimens agree well with the descriptions provided in Smith (1943) and Whitaker and Captain (2004).

Description: BMNH 1955.1.2.93: SVL 457 mm, TaL 23 mm; VEN 177, SC 16; 16-15-13 DSR. Ochre-brown above, with scales edged with brown on their lower part (Table 1).

***Plecturus perroteti* Duméril, Bibron & Duméril, 1854**

Material Examined: 1 specimen; BMNH 1955.1.2.92 (female), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu.

Biology: Collected at 1,066 m above msl.

Note: This specimen agrees well with the descriptions provided in Smith (1943), Rajendran (1985) and Whitaker and Captain (2004).

Description: SVL 217 mm, TaL 8 mm; VEN 168, SC 8; 15-15-15 DSR. Ochre-brown above, with scales edged with brown on their lower part.

***Uropeltis ceylanicus* Cuvier, 1829**

Material Examined: 10 specimens; BMNH 1955.1.2.82-83, BMNH 1955.1.2.90 (3 males), BMNH 1955.1.2.81, BMNH 1955.1.2.84-85, BMNH 1955.1.2.91 (4 females), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu. BMNH 1955.1.2.86 (1 female), High Wavy Mts. BMNH 1955.1.2.87-88 (2 females), "Anamallies", now Anaimalai Hills.

Biology: Collected at 1,066 m above msl in the Nilgiri Hills, between 914 and 1,066 m in the High Wavy Mts. and between 609 and 1,981 m in the Anaimalai Hills.

Note: These specimens agree well with the descriptions provided by Smith (1943) and Whitaker and Captain (2004). Main morphological characters are summarized in Table 2. In all specimens, the portion of the rostral visible from above is distinctly shorter than the distance rostral-frontal. The venter is yellow, either only speckled with dark brown (BMNH 1955.1.2.81) or with dark brown spots, or largely barred with black crossbars wider than the yellow areas (BMNH 1955.1.2.82 and BMNH 1955.1.2.86).

We could not find any previous published record of this species from the Nilgiri Hills, either in Smith (1943), in Rajendran (1985) or Murthy (1990).

***Uropeltis maculatus* (Beddome, 1878)**

Material Examined: 1 specimen; BMNH 1955.1.2.73 (female), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu.

Biology: Collected at 1,066 m above msl.

Note: This specimen agrees well with the descriptions provided in Rajendran (1985) and Whitaker and Captain (2004). Main morphological characters are summarized in Table 2. Two large coral spots are present on each side of the tail.

***Uropeltis ocellatus* (Beddome, 1863)**

Material examined: 7 specimens; BMNH 1955.1.2.74, BMNH 1955.1.2.76, BMNH 1955.1.2.78 (3 males), BMNH 1955.1.2.75, BMNH 1955.1.2.77 (2 females), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu. BMNH 1955.1.2.79 (female), BMNH 1955.1.2.80 (sex unknown; bad condition), "Anamallies", now Anaimalai Hills.

Biology: Specimens from the Nilgiri Hills were collected at 1,066 m above msl. Those from the Anaimalai Hills were obtained between 609 and 1,981 m.

Note: These specimens agree well with the descriptions provided in Rajendran (1985) and Whitaker and Captain (2004). Main morphological characters are summarized in Table 2. Two large coral spots are present on each side of the tail. Specimens from the Nilgiri are brown above, whereas those from the Anaimalai Hills are light greyish-green.

***Uropeltis pulneyensis* (Beddome, 1863)**

Material Examined: 7 specimens; BMNH 1955.1.2.68-69, BMNH 1955.1.2.72 (3 males), BMNH 1955.1.2.70-71

Table 1: Main characters of specimens of *Melanophidium punctatum*

Number	Sex	SVL	TaL	TaL/TL	VEN	SC	DSR
BMNH 1955.1.2.93	F	457	23	0.048	177	16	16-15-13
BMNH 1955.1.2.94	F	-	-	-	176	15	16-15-13
BMNH 1955.1.2.95	F	440	27	0.058	186	14	16-15-13

(2 females), "High Wavy Mts.", now Meghamalai Hills.

Biology: Collected between 914 and 1,066 m above msl.

Note: These specimens agree well with the descriptions provided in Smith (1943), Rajendran (1985), and Whitaker and Captain (2004). Main morphological characters are summarized in Table 2. Two large coral spots are present on each side of the tail.

Uropeltis rubromaculatus **(Beddome, 1867)**

Material Examined: 1 specimen; BMNH 1955.1.2.89 (1 male), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu.

Biology: Collected around 1,066 m above msl.

Note: This specimen agrees well with the descriptions provided in Smith (1943) and Whitaker and Captain (2004). Main morphological characters are summarized in Table 2. Pattern: above dark brown with each scale tinged with yellow; six coral red blotches on each side of the anterior part of the body; one elongated, curved, boomerang-like blotch on each side of the tail; venter yellow with scales speckled with brown on their anterior margin.

Boidae Gray, 1825

Eryx johnii **(Russell, 1801)**

Material Examined: 1 specimen; BMNH 1955.1.2.66 (male; SVL 577 mm, TaL 43 mm; skin only), "Anamallies", now Anaimalai Hills.

Biology: Collected between 609 and 1,981 m above msl. Nothing else recorded.

Note: This specimen agrees well with the descriptions provided in Smith (1943).

Gongylophis conicus **(Schneider, 1801)**

Material Examined: 1 specimen; BMNH 1955.1.2.67 (female; SVL 604 mm, TaL 38 mm; skin only), "Nilgiri-

Table 2: Main morphological characters of examined specimens of the genus *Uropeltis* Cuvier, 1829

Number	Sex	SVL	TaL	TaL/TL	VEN	SC	MSR	PSR
				Uropeltis ceylanicus				
BMNH 1955.1.2.82	M	224	16	0.067	121	10	17	17
BMNH 1955.1.2.83	M	206	14	0.064	131	10	17	17
BMNH 1955.1.2.84	M	180	11	0.058	133	8	17	17
BMNH 1955.1.2.90	M	245	16	0.062	134	10	17	17
BMNH 1955.1.2.81	F	288	16	0.053	127	9	17	17
BMNH 1955.1.2.85	F	238	12	0.048	129	8	17	17
BMNH 1955.1.2.86	F	188	9	0.046	132	8	17	17
BMNH 1955.1.2.87	F	229	14	0.058	122	9	17	17
BMNH 1955.1.2.88	F	254	9	0.034	124	8	17	17
BMNH 1955.1.2.91	F	262	12	0.044	134	8	17	17
				Uropeltis maculatus				
BMNH 1955.1.2.73	F	282	8	0.028	159	6	17	17
				Uropeltis ocellatus				
BMNH 1955.1.2.74	M	231	11	0.045	207	9	17	17
BMNH 1955.1.2.76	M	222	8	0.035	207	10	17	17
BMNH 1955.1.2.78	M	151	5	0.032	212	8	17	17
BMNH 1955.1.2.73	F	282	8	0.028	209	6	17	17
BMNH 1955.1.2.75	F	281	9	0.031	206	8	17	17
BMNH 1955.1.2.77	F	224	6	0.026	210	6	17	17
				Uropeltis pulneyensis				
BMNH 1955.1.2.68	M	204	10.5	0.049	173	11	17	17
BMNH 1955.1.2.69	M	188	10	0.051	173	12	17	17
BMNH 1955.1.2.72	M	199	10.5	0.050	176	12	17	17
BMNH 1955.1.2.70	F	258	8	0.030	180	7	17	17
BMNH 1955.1.2.71	F	227	8	0.034	179	7	17	17
				Uropeltis rubromaculatus				
BMNH 1955.1.2.89	F	279	17	0.057	128	9	17	17

Wynaad", now Wayanad District, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu.

Biology: Collected at 1,066 m above msl. Nothing else recorded.

Note: This specimen agrees well with the descriptions provided in Smith (1943).

Colubridae Oppel, 1811

Ahaetulla dispar (Günther, 1864)

Material Examined: 8 specimens; BMNH 1955.1.3.50 (female; Table 3), BMNH 1955.1.3.51-52 (2 males), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu. BMNH 1955.1.3.53-55 (3 males), BMNH 1955.1.3.56-57 (2 females), "Anamallies", now Anaimalai Hills.

Biology: Collected at 914-1,066 m above msl in the Nilgiri Hills, and between 609 and 1,981 m in the Anaimalai Hills.

Note: These specimens agree well with the description provided in Smith (1943) and Whitaker and Captain (2004).

Ahaetulla nasuta (Lacepède, 1789)

Material Examined: 2 specimens; BMNH 1955.1.3.58 (male; SVL 650, TaL 398 mm), Mysore. BMNH 1955.1.3.59 (female; SVL 682 mm, TaL 368 mm), Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu.

Biology: Collected at 1,066 m in both localities.

Note: These specimens agree well with the description provided in Smith (1943) and Whitaker and Captain (2004).

Boiga ceylonensis (Günther, 1858)

Material Examined: 8 specimens; BMNH 1955.1.3.42 (female; see Table 4), BMNH 1.3.43-45 (3 males), "High Wavy Mts.", now Meghamalai Hills. BMNH 1955.1.3.46, BMNH 1955.1.3.49 (2 females), BMNH 1955.1.3.47-48 (2 skins), "Anamallies", now Anaimalai Hills.

Biology: Collected at 914-1,066 m above msl in the Meghamalai Hills and between 609 and 1,981 m in the Anamalai Hills.

Note: These specimens agree well with the description provided in Smith (1943) and Whitaker and Captain (2004). Main characters are summarized in Table 4.

Coelognathus helena monticollaris (Schulz, 1992)

Material Examined: 7 specimens; BMNH 1955.1.3.25 (male; SVL 540 mm, TaL 147 mm), "Anamallies", now Anaimalai Hills. BMNH 1955.1.3.26-27 (2 females; SVL 511 & 257 mm, TaL 104 & 66 mm), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu. BMNH 1955.1.3.28 (male; SVL 770 mm, TaL 228 mm; skin only), BMNH 1955.1.3.29 (female; SVL 1,188 mm, TaL 226 mm; skin only), Mysore. BMNH 1955.1.3.30-31 (2 males; SVL 376 & 256 mm, TaL 89 mm & tail broken), "High Wavy Mts.", now Meghamalai Hills.

Biology: Collected at 1,066 m in the Nilgiri Mts., between 609 and 1,981 m in the Anamalai Hills and at 914-1,066 m in the Meghamalai Hills.

Note: This species was previously placed in the genus *Elaphe*. It was transferred to the genus *Coelognathus* Fitzinger, 1843 by Helfenberger (2001) and Utiger *et al.* (2002).

These specimens agree well with the description provided in Schulz (1996). All have 25 dorsal scale rows at mid-body. Crossbars with the typical white ocelli are present only on the anterior half of the body on a rather dark background. These specimens are typical of *Coelognathus helena monticollaris* (Schulz, 1992), endemic to the Western Ghats, whereas the nominate subspecies *Coelognathus helena helena* (Daudin, 1803) inhabits other parts of India and Sri Lanka.

Dendrelaphis pictus (Gmelin, 1789)

Material Examined: 2 specimens; BMNH 1955.1.3.32-33 (2 females; SVL 642 & 368 mm, TaL 425 & 246 mm),

Table 3: Main morphological characters of examined specimens of *Ahaetulla dispar*

Number	Sex	SVL	TaL	TaL/TL	VEN	SC	MSR	PSR	SL	PreOc	Tem
BMNH 1955.1.3.51	M	520	249	0.324	157	110	15	13	8 / 8	2 / 2	2+2 / 2+2
BMNH 1955.1.3.52	M	269	-	-	151	-	15	13	8 / 8	2 / 2	2+2 / 2+2
BMNH 1955.1.3.53	M	468	248	0.346	149	115	15	13	8 / 8	2 / 2	2+2 / 2+2
BMNH 1955.1.3.54	M	430	216	0.334	148	109	15	13	8 / 8	1 / 1	2+2 / 2+2
BMNH 1955.1.3.55	M	431	227	0.345	153	116	15	13	8 / 8	0 / 0	2+2 / 2+2
BMNH 1955.1.2.50	F	540	242	0.309	146	98	15	13	8 / 8	2 / 2	2+2 / 2+2
BMNH 1955.1.2.56	F	415	165	0.284	146	99	15	13	8 / 8	2 / 2	2+2 / 2+2
BMNH 1955.1.3.57	F	307	131	0.299	145	86	15	13	8 / 8	2 / 1	2+2 / 2+2

"Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu.

Biology: Collected at 1,066 m above msl.

Note: These specimens agree well with the description provided in Smith (1943) and Van Rooijen and Vogel (2008). They are dark coloured and rather uniform in pattern at the exception of the dark postocular stripes.

***Lycodon aulicus* (Linnaeus, 1758)**

Material Examined: 2 specimens; BMNH 1955.1.3.11 (female; SVL 238 mm, TaL 42 mm), Mysore. BMNH 1955.1.3.12 (male; skin only), "Anamallies", now Anaimalai Hills.

Biology: Collected at 1,066 m above msl. Nothing else was recorded.

Note: These specimens agree well with the description provided in Smith (1943). Both have 17 MSR and the typical dorsal pattern.

***Lycodon travancoricus* (Beddome, 1870)**

Material Examined: 8 specimens; BMNH 1955.1.3.13-14 (2 females; SVL 342 & 486 mm, TaL 83 & 108 mm), BMNH 1955.1.3.15 (juvenile; SVL 151, TaL 38 mm), "Anamallies", now Anaimalai Hills. BMNH 1955.1.3.16 (male; SVL 405 mm, TaL 101 mm), BMNH 1955.1.3.17 (female; body partly cut), "Nilgiri - Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu. BMNH 1955.1.3.18 (female; SVL 255, TaL 66 mm), BMNH 1955.1.3.19 (male; SVL 142 mm, TaL 36 mm), BMNH 1955.1.3.20 (unsexed juvenile), "High Wavy Mts.", now Meghamalai Hills. Another specimen, BMNH 1955.1.3.21, was exchanged in 1955 and is no longer present in the BMNH's collections.

Biology: All specimens were collected between 914 and 1,066 m.

Note: This specimen agrees well with the descriptions provided in Smith (1943) and Whitaker and Captain (2004). They do not belong to *Lycodon flavicollis* Mukherjee and Bhupathy (2007) as defined by these latter authors.

***Oligodon taeniolatus* (Jerdon, 1853)**

Material Examined: 1 specimen; Unnumbered specimen (female; dessicated and damaged; Table 3), no locality.

Biology: No data.

Note: These specimens agree well with the Form IV of Smith (1943).

***Oligodon travancoricus* Beddome, 1877**

Material Examined: 6 specimens; BMNH 1955.1.3.35 (male; Table 3), BMNH 1955.1.3.36-39 (4 females), BMNH 1955.1.3.41 (sex only, head and neck only), "High Wavy Mts.", now Meghamalai Hills. Another specimen, BMNH 1955.1.3.40, was exchanged in 1955, and is no longer present in the BMNH's collections.

Biology: Collected between 914 and 1,828 m.

Note: These specimens agree well with the description provided in Smith (1943). Their main characters are summarized in Table 5.

***Oligodon venustus* (Jerdon, 1853)**

Material Examined: 1 specimen; BMNH 1955.1.3.34 (male; Table 5; badly damaged), "Anamallies", now Anaimalai Hills.

Biology: Collected between 609 and 1,981 m above msl.

Note: Main characters are summarised in Table 5. This identification is only tentative as, if specimen agree well in scalation and pattern with the description provided in Smith (1943), it has only 15 MSR due to a reduction at the levels of VEN 66 & 67 at right and left respectively. Its pattern is made of dark purple dorsal blotches and a venter chequered with white and black.

We could not find any previous published record of this species from the Anaimalai Hills, either in Smith (1943) or Murthy (1990).

Table 4: Main morphological characters of examined specimens of *Boiga ceylonensis*

Number	Sex	SVL	TaL	TaL/TL	VEN	SC	MSR	PSR	ATem
BMNH 1955.1.3.43	M	809	236	0.226	223	118	21	17	3 / 3
BMNH 1955.1.3.44	M	828	248	0.230	218	122	21	17	3 / 3
BMNH 1955.1.3.45	M	751	218	0.225	233	119	21	17	3 / 3
BMNH 1955.1.3.47	F	806	233	0.224	244	104	21	17	3 / 3
BMNH 1955.1.3.48	F	796	236	0.229	242	106	21	17	3 / 3
BMNH 1955.1.3.42	F	598	158	0.209	215	76	19	17	3 / 3
BMNH 1955.1.3.46	F	502	133	0.209	232	102	21	17	3 / 3
BMNH 1955.1.3.49	F	812	-	-	241	-	21	17	3 / 3

Fig. 4: The senior author in December 1946 with the skins of two very large specimens of *Naja naja*

***Ptyas mucosa* (Linnaeus, 1758)**

Material Examined: 4 specimens; BMNH 1955.1.3.22 (female; SVL 365 mm, TaL 126 mm), BMNH 1955.1.3.23 (male; SVL 330 mm, TaL 129 mm), "Anamallies", now Anaimalai Hills. BMNH 1955.1.3.24 (male; SVL 325 mm, TaL 131 mm), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu. Unnumbered specimen (female; SVL 360 mm, TaL 138 mm), no locality.

Biology: Collected at 1,066 m above msl in the Nilgiri Mts., between 609 and 1,981 m in the Anaimalai Hills.

Note: These specimens agree well with the description provided in Smith (1943).

Natricidae Bonaparte, 18401

***Amphiesma beddomei* (Günther, 1864)**

Material Examined: 11 specimens; BMNH 1955.1.2.96-97 (2 females), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu. BMNH 1955.1.2.98-99 (2 males), Mysore. BMNH 1955.1.3.1 (male), BMNH 1955.1.3.2 (female), "High Wavy Mts.", now Meghamalai Hills. BMNH 1955.1.3.3-4 (3 males), BMNH 1955.1.3.5-6 (2 females), "Anamallies", now Anaimalai Hills. Another specimen, BMNH 1955.1.3.7, was exchanged in 1955 and is no longer present in the BMNH's collections. Unnumbered specimen (female; SVL 412 mm, TaL > 128 mm, part of tail missing), no locality.

Biology: All specimens were collected between 609 and 1,981 m. The unnumbered specimen contains a toad in its stomach.

Note: This specimen agrees well with the descriptions provided in Smith (1943) and Whitaker and Captain (2004). Main morphological characters are summarised in Table 6. Other characters include: divided nasals; dorsal scales keeled above. Body more or less distinctly patterned, with all intermediates; a white postocular streak, edged with black above in all specimens.

***Amphiesma stolatum* (Linnaeus, 1758)**

Material Examined: 1 specimen; Unnumbered specimen (female; SVL 390 mm, TaL 119 mm), no locality.

Table 5: Main morphological characters of examined specimens of *Oligodon* Boie, 1827

Number	Sex	SVL	TaL	TaL/TL	VEN	SC	DSR	Anal	SL	Lor
				Oligodon taeniolatus						
BMNH unnumbered	F	283	49	0.148	-	-	15-15-15	2	7 / 7	1 / 1
				Oligodon travancoricus						
BMNH 1955.1.3.35	M	330	62	0.158	141	34	17-17-15	2	7 / 7	0 / 0
BMNH 1955.1.3.36	F	332	52	0.135	152	31	17-17-15	2	7/ 7	0 / 0
BMNH 1955.1.3.37	F	292	41	0.141	158	29	17-17-15	2	7 / 7	0 / 0
BMNH 1955.1.2.39	F	128	21	0.141	159	30	17-17-15	2	7 / 7	0 / 0
				Oligodon venustus						
BMNH 1955.1.3.34	M	295	55	0.157	141	32	17-15-15	2	7 / 7	1 / 1

Biology: No data.

Note: This specimen is typical of the species.

Macropisthodon plumbicolor **(Cantor, 1839)**

Material Examined: 2 specimens; BMNH 1955.1.3.8-9 (2 females; skins only), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu.

Biology: Collected at 1,066 m above msl. Nothing else recorded.

Note: Only the skins of these specimens were preserved. They agree well with the description provided in Smith (1943).

Xenodermatidae Gray, 1849

Xylophis perroteti **Reinhardt, 1836**

Material Examined: 1 specimen; BMNH 1955.1.3.10 (male; skull removed), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu.

Biology: This specimen was collected at 1,066 m.

Note: This specimen agrees well with the description provided in Smith (1943).

Elapidae Boie, 1827

Bungarus caeruleus **Schneider, 1801**

Material Examined: 2 specimens; BMNH 1955.1.3.61-62 (2 males; SVL 762 and 880 mm, TaL > 95 and 120 mm), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu.

Biology: These specimens were collected at 1,066 m.

Note: Both specimens agree well with the description provided in Smith (1943).

Calliophis nigrescens **(Günther, 1862)**

Material Examined: 6 specimens; BMNH 1955.1.3.63-65 (3 females; SVL 405, 235 and 162 mm, TaL 45, 23 and 18 mm), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu. BMNH 1955.1.3.66-68 (3 males; SVL 412, 360 and 460 mm, TaL 51, 42 and 49 mm), "Anamallies", now Anaimalai Hills.

Biology: Collected at 1,066 m above msl. Specimen BMNH 1955.1.3.68 contains an adult *Limnonectes limnocharis* (Gravenhorst, 1829) in its stomach.

Note: The generic position follows Slovinski *et al.* (2001). All specimens agree well with the description provided in Smith (1943). Specimens BMNH 1955.1.3.63, BMNH 1955.1.3.64, BMNH 1955.1.3.66, and BMNH 1955.1.3.67 belong to the Form 1 of Smith (1943), whereas others belong to Form 2.

Naja naja **(Linnaeus, 1758)**

Material Examined: (Fig. 4): 2 specimens; Two skins of the 1946' collection, High Wavy Ghat Road, "High Wavy Mts.", now Meghamalai Hills.

Biology: These specimens were not previously discussed. Both skins are conserved in the private collection of the senior author. However, they are worth being mentioned here due to their size. One specimen was 179 cm long, the other one 229 cm long.

Ophiophagus hannah **(Cantor, 1836)**

While no specimens were examined, this species was encountered a few times in the High Wavy Mts. during the construction of the Ghat Road in the lower altitude section between Chinnamanur and the Varushanad Valley.

The senior author came across the species in all the Tea plantation areas where he worked but never collected a specimen of such a well known and dangerous snake, which usually preferred to get out of the way.

Table 6: Main morphological characters of specimens of *Amphiesma beddomei*

Number	Sex	SVL	TaL	TaL/TL	VEN	SC	MSR	PSR	SL	SL-orb	Tem
BMNH 1955.1.2.98	M	380	-	-	143	-	19	17	8/8	4-5/4-5	1+1/1+1
BMNH 1955.1.2.99	M	370	134	0.266	139	69	19	17	9/9	4-6/4-6	1+2/1+2
BMNH 1955.1.3.1	M	420	148	0.261	140	68	19	17	8/8	3-5/3-5	1+2/1+2
BMNH 1955.1.3.3	M	402	129	0.243	145	61	19	17	8/8	3-5/3-5	1+2/1+2
BMNH 1955.1.3.4	M	413	140	0.253	146	62	19	17	8/9	3-5/4-6	1+2/1+2
BMNH 1955.1.2.96	F	321	102	0.241	146	66	19	17	9/9	4-6/4-6	1+2/1+2
BMNH 1955.1.2.97	F	336	106	0.240	144	62	19	17	8/8	3-5/3-5	1+1/1+1
BMNH 1955.1.3.2	F	382	-	-	142	-	19	17	8/8	3-5/3-5	1+1/1+2
BMNH 1955.1.3.5	F	290	102	0.260	144	67	19	17	8/8	3-5/3-5	1+2/1+2
BMNH 1955.1.3.6	F	251	85	0.253	140	65	19	17	8/8	3-5/3-5	1+2/1+2

It is worth recording that in 1921 Angus Hutton's father accidentally caught a King Cobra alive that was lying on the overhead shade in a Tea nursery, mistaking it for a common Rat Snake that he had planned to put in the Rice Store! He was lucky to get out of the situation alive, after the labourers had all fled, thanks to help by the foreman with a large stone. The senior author still has the skin in his personal collection. It is 325 cm long.

Viperidae Oppel, 1811

Trimeresurus (Peltopelor) macrolepis (Beddome, 1862)

Material Examined: 14 specimens; BMNH 1955.1.3.82, Unnumbered specimen 1 (2 males; Table 7; skin), BMNH 1955.1.3.83-85, Unnumbered specimens 2-3 (5 females), "Anamallies", now Anaimalai Hills. BMNH 1955.1.3.86, BMNH 1955.1.3.88-90 (4 females; see Table 7), BMNH 1955.1.3.87 (male), BMNH 1955.1.3.91-92 (2 unsexed, juvenile specimens; damaged, scales not counted), "South India", no precise locality. Three other specimens, BMNH 1955.1.3.93-95, were exchanged in 1955 and are no longer present in the BMNH's collections.

Biology: Specimens of Anaimalai Hills were collected between 609 and 1,981 m above msl. Specimen BMNH 1955.1.3.88 contains a rodent in its stomach.

Note: This species was referred to the genus *Peltopelor* Günther, 1864 by Malhotra and Thorpe (2004). For reasons explained elsewhere (David *et al.* 2009), we regard the genera recognized by these authors as subgenera of the genus *Trimeresurus* Lacepède, 1804.

Trimeresurus (Trimeresurus) malabaricus (Jerdon, 1854)

Material Examined: 12 specimens; BMNH 1955.1.3.69 (male), BMNH 1955.1.3.70-71 (2 females; Table 7; specimen BMNH 1955.1.3.71 as a skin only), "Nilgiri-Wynaad", now Wayanad district, Kerala, at the border between the states of Kerala, Karnataka and Tamil Nadu. BMNH 1955.1.3.72-73, BMNH 1955.1.3.75 (3 females; skins only), BMNH 1955.1.3.74 (male; skin only), "Anamallies", now Anaimalai Hills. BMNH 1955.1.3.76, BMNH 1955.1.3.80 (2 males; skins only), BMNH 1955.13.77-79 (3 females; skins only), Mysore. Another specimen, BMNH 1955.1.3.81, was exchanged in 1955 and is no longer present in the BMNH's collections.

Table 7: Main morphological characters of specimens of *Trimeresurus* Lacepède, 1804

Number	Sex	SVL	TaL	TaL/TL	VEN	SC	DSR	CEP	SL	C-SL3
					Trimeresurus macrolepis					
BMNH 1955.1.2.82	M	479	109	0.185	139	51	17-13-9	1	8 / 8	0 / 0
BMNH 1955.1.2.87	M	482	139	0.224	133	56	16-13-10	1	8 / 8	0 / 0
BMNH 1955.1.3.89	M	480	120	0.200	136	50	16-13-11	2	7 / 7	0 / 0
BMNH Specimen 1	M	422	104	0.198	136	52	16-13-10	3	8 / 8	0 / 0
BMNH 1955.1.3.83	F	472	92	0.163	143	48	16-13-10	1	8 / 7	0 / 0
BMNH 1955.1.3.84	F	467	95	0.169	143	50	16-15-11	1	8 / 8	0 / 0
BMNH 1955.1.2.85	F	572	116	0.169	140	47	17-14-11	3	8 / 8	0 / 0
BMNH 1955.1.2.86	F	690	141	0.170	138	48	19-13-11	1	8 / 8	0 / 0
BMNH 1955.1.3.88	F	381	73	0.161	140	50	15-13-9	3	7 / 8	0 / 0
BMNH 1955.1.3.90	F	409	88	0.177	138	47	14-13-10	3	8 / 8	0 / 0
BMNH Specimen 2	F	428	-	-	141	49	16-13-11	3	8 / 8	0 / 0
BMNH Specimen 3	F	395	88	0.182	147	46	16-13-11	3	8 / 8	0 / 0
					Trimeresurus malabaricus					
BMNH 1955.1.3.69	M	316	62	0.164	151	58	21-21-15	9	9 / 9	1 / 1
BMNH 1955.1.3.74	M	489	103	0.174	146	58	21-21-15	7	8 / 9	1 / 1
BMNH 1955.1.3.76	M	-	-	-	143	57	21-21-15	9	9 / 9	1 / 1
BMNH 1955.1.3.80	M	208	42	0.168	145	54	21-21-15	10	11 / 10	2 / 2
BMNH 1955.1.3.70	F	204	36	0.150	147	51	23-21-15	10	10 / 10	1 / 1
BMNH 1955.1.3.71	F	408	71	0.148	144	52	21-21-15	11	9 / 10	1 / 1
BMNH 1955.1.3.72	F	662	-	-	148	-	25-21-15	8	10 / 10	1 / 1
BMNH 1955.1.3.73	F	621	107	0.147	149	49	25-21-15	8	9 / 9	1 / 1
BMNH 1955.1.3.75	F	323	48	0.129	149	49	21-21-15	8	10 / 9	1 / 1
BMNH 1955.1.3.77	F	377	54	0.125	150	45	25-21-15	9	11 / 11	1 / 2
BMNH 1955.1.3.78	F	364	52	0.125	150	47	25-21-15	10	9 / 11	2 / 2
BMNH 1955.1.3.79	F	391	57	0.127	146	45	23-21-15	9	9 / 10	1 / 1

Biology: Specimens from Nilgiri Hills and Mysore were collected at 1,066 m above msl, those of the Anaimalai Hills between 609 and 1,981 m.

Note: These specimens agree well with the description provided in Smith (1943).

DISCUSSION

The examination of this new collection allows us to extend the composition of the snake fauna of the "High Wavy Mts." or Meghamalai Hills. We also take this opportunity to present unpublished data on specimens of *Tropidolaemus huttoni*.

A list of snake species of the Meghamalai Hills

On the basis of Hutton (1949a) and of the present collection, we establish a preliminary list of snake species recorded from this area as defined above in the Introduction. A total of 39 species is listed.

We have not recorded in detail morphological characters of the collection of 1946-48, but the determination of the included species were checked. Morphological ecological data of specimens of the 1946-48' collection were given by Hutton (1949a).

Uropeltidae Müller, 1831

Melanophidium punctatum Beddome, 1871
Plecturus perroteti Duméril, Bibron & Duméril, 1854
Rhinophis sanguineus Beddome, 1863
Rhinophis travancoricus Boulenger, 1892
Uropeltis arcticeps (Günther, 1875)
Uropeltis ceylanicus Cuvier, 1829
Uropeltis ellioti (Gray, 1858)
Uropeltis pulneyensis (Beddome, 1863)
Uropeltis rubromaculatus (Beddome, 1867)
Uropeltis woodmasoni (Theobald, 1876)

Pythonidae Fitzinger, 1826

Python molurus molurus (Linnaeus, 1758)

Colubridae Oppel, 1811

Ahaetulla dispar (Günther, 1864)
Ahaetulla perroteti (Duméril, Bibron & Duméril, 1854)
Ahaetulla pulverulenta (Duméril, Bibron & Duméril, 1854)
Argyrogena fasciolata (Shaw, 1802)
Boiga ceylonensis (Günther, 1858)
Coelognathus helena (Daudin, 1803)
Dryocalamus nympha (Daudin, 1803)
Lycodon striatus (Shaw, 1802)
Lycodon travancoricus (Beddome, 1870)
Oligodon brevicauda Günther, 1862
Oligodon taeniolatus (Jerdon, 1853)
Oligodon travancoricus Beddome, 1877
Oligodon venustus (Jerdon, 1853)
Ptyas mucosa (Linnaeus, 1758)

Natricidae Bonaparte, 1840

Amphiesma beddomei (Günther, 1864)
Amphiesma stolatum (Linnaeus, 1758)
Atretium schistosum (Daudin, 1803)
Macropisthodon plumbicolor (Cantor, 1839)
Xenochrophis piscator (Schneider, 1799)

Elapidae Boie, 1827

Calliophis nigrescens (Günther, 1862)
Naja naja (Linnaeus, 1758)
Ophiophagus hannah (Cantor, 1836)

Viperidae Oppel, 1811

Viperinae Oppel, 1811
Daboia russelii (Shaw & Nodder, 1797)
Crotalinae Oppel, 1811
Trimeresurus (*Trimeresurus*) *gramineus* (Shaw, 1802)
Trimeresurus (*Peltopelor*) *macrolepis* (Beddome, 1862)
Trimeresurus (*Trimeresurus*) *malabaricus* (Jerdon, 1754)
Tropidolaemus huttoni (Smith, 1949)

An updated account on *Tropidolaemus huttoni* (Smith, 1949)

David and Vogel (1998) expanded the description of *Trimeresurus huttoni* Smith, 1949 and referred this species to the genus *Tropidolaemus* Wagler, 1830. However, the description provided in this paper was rather incomplete. The paratype of *Trimeresurus huttoni* Smith, 1949, BNHS 2658, has been traced and examined. It had been deposited in 1962 in the collection of the then Prince of Wales Museum, Bombay now CSMVS, Mumbai and (presumably) later transferred to the Bombay Natural History Society. The senior author could also provide a description of the pattern of these specimens recorded while they were alive. The most important new character is the bright brick red colour of the snout (Fig. 2), a feature unknown in other species of the genus *Tropidolaemus* as defined in Vogel *et al.* (2007). Precise biological data of these specimens, which remain the sole known specimens, are also made available below.

Morphology

On the basis of this new information, we expand the description of *Tropidolaemus huttoni* as follows:

Material: BMNH 1948.1.8.75 (male; holotype) and BNHS 2658 (female; paratype), both from "The High Wavy Mountains, Madura district, South India; altitude 1,854 m", a locality here précised as: a patch of bamboo at the confluence of the Manalaar and Chinna Manalaar rivers, Manalaar Tea Estate, about 1 airline kilometre full east of Brooks Peak, very close to the border with Kerala, Meghamalai Hills, Teni district, Tamil Nadu. Collected by Angus Hutton on November 09, 1947.

Main morphological characters are summarized in Table 8. Other characters are:

Body: Both juvenile snakes; body moderately stout. Head short and wide at its base, about 1.6 times longer than wide, triangular, clearly distinct from neck, thick, flattened in front of the eye and depressed on the middle of the snout; very sharp jaw angle posteriorly; snout short, flattened, about 2x as long as the diameter of the eye, slightly protracted with its tip slightly raised, rounded and narrow when seen from above, angulous and prominent when seen from the side, with a sharp *canthus rostralis*; eye large (juvenile), diameter similar to the distance between its inferior margin and upper lip edge; tapering tail, cylindrical, long and prehensile. Dorsal scales rhombohedral, all smooth at mid-body, some feebly keeled on the posterior part of body.

Head: Rostral as high as wide, triangular, barely visible from above; nasal triangular, undivided, with nostril in its middle; no nasal pore visible; 1 pair of enlarged, narrow internasals, about twice longer but barely wider than adjacent scales on upper snout surface, separated from one another by 1 or 2 small scales that are about half as wide as the internasals. 4 canthal scales bordering the *canthus rostralis* between the internasal and the corresponding supraocular, slightly enlarged compared with adjacent snout scales; 1 small triangular loreal; 2 upper preoculars above the loreal pit, the lower one bordering the upper margin of the loreal pit, the upper one visible from above, both elongated and in contact with the loreal; the lower preocular that borders the lower margin of the loreal pit is divided into two small scales; 2 postoculars on both sides of both specimens; 1 supraocular, entire, long and narrow, barely larger than the adjacent upper head scales and 0.8-0.9 time as large as internasals, largely indented on its inner margin; upper snout and cephalic scales relatively large, irregular and unequal, barely imbricate, flat, distinctly keeled both on the snout, and on the middle and posterior part of the head, strongly keeled and imbricate on posterior part of head; 9 cephalic scales on a line between the supraoculars; temporals on three rows, the lower ones enlarged, as large as the supralabials, all strongly keeled; 1 thin, elongated, crescent-like subocular; 9 supralabials on each side in both specimens, third largest; 1st supralabial completely separated from the nasal; 2nd not bordering the anterior margin of the loreal pit and topped by a prefoveal, namely the scale above the supralabial bordering the pit that borders the whole of the anterior margin of the loreal pit, 1 or 2 minute scales on each side between the nasal and the 2nd supralabial; 3rd supralabial large, rather low and elongated, about 2.3 times as long as high, separated both from the posterior lower preocular scale and from the subocular by one small scale; 4th supralabial nearly as high as long than the third one, separated from the subocular by 1 small scale; 5th and other posterior supralabials much smaller than preceding ones, not larger than lower temporals, but smooth; 5th supralabial separated from the subocular by two scale rows and in contact with the first and second lower temporals; 10 pairs of infralabials in both specimens, those of the first pair in contact with each other and obtusely but distinctly keeled, infralabials of the first, second and third pairs in contact with the chin shield; one pair of elongated, keeled chin shields; 6 or 7 rows of gular scales, distinctly keeled.

Pattern in preservative (holotype only, as the paratype is desiccated and turned brown): Dorsal and upper tail surfaces dull green, slightly paler on the body sides, with on each side a series of small, vertically elongated white spots located on the 2nd and 3rd scale rows from the vertebral row, separated each other by about 3-5 scales; no ventrolateral stripes; end of tail dull reddish on a length equivalent to the 25 posterior subcaudal scales. Venter pale green.

Head dull green above and on its sides; a white temporal streak running on the 3rd and 4th rows of temporals from eye to the neck, edged below with a dull, rather indistinct red streak; another white streak extending on the upper preocular and loreal forward the eye, not reaching the nasal; this forward white streak is bordered below with a reddish-brown, indistinct streak that makes the snout tip rather red.

Pattern in life: Body grass green, with on each side a series of small, vertically elongated white spots; interstitial skin yellow. Tail green, with the last inch bright red. Venter

Table 8: Main characters of known specimens of *Tropidolaemus huttoni* (Smith, 1949)

Number	Sex	SVL	TaL	TaL/TL	VEN	SC	DSR	CEP	InS	SL	C-SL3	C-SL4
BMNH 1948.1.8.75	M	98	38	0.279	146	52	25-23-19	9	1	9/9	1/1	1/1
BNHS 1955.1.2.87	F	184	35	0.160	140	48	23-21-17	9	2	9/9	1/1	2/2

light green with white flecks and yellow tinge on their outer margins.

Head green as the body, with a pale yellow temporal streak edged below with a touch of red, brighter in front of the eye than backwards; snout distinctly brick red on its sides and above. Below, lower labials, chin and throat pale green, with the mental scale golden yellow.

The pattern of the head in life is depicted in Fig. 2. This illustration was reconstructed from a black & white picture colourized by the senior author from his own notes.

Biology

Both snakes were caught during day time through a clump of *Ochlandra travancorica*, a local bamboo named *Eeta* in Tamil on the side of an elephant track. The *Shikari* assistant of the senior author, a jungle expert, had never seen such a snake previously. The red, upturned snout and the red wiggling tail distinguished immediately these two snakes from the hundreds of babies of *T. malabaricus*, *T. gramineus* and *T. macrolepis* seen by the senior author. These three latter species are still common in the Tea and Coffee plantations, where they adapted to the leaf litter at the base of the bushes.

When the Tea estate was being surveyed and planned it was decided to leave intact corridors of forests in which elephants could move from the Meghamalai Hills to Periyar lake. These tracts of dense jungle were still extant in 1993. However, this species has never been seen again.

Visits to the area made by the first author between 1949 and 1993

In addition to visits made in 1949, 1950, 1951 and 1952, Angus Hutton revisited the High Wavy Mts. in 1972 when on holiday with his wife and again in 1986 during the course of a UN/FAO Consultancy, and most recently in 1993. On each and every occasion he searched a wide area surrounding the, still standing, Bamboo clump where the initial capture was made in 1946. He also thoroughly questioned the plantation labourers (many of whom remembered him), and showed them pictures and offered a reward and also made arrangements with the management should a specimen turn up. However, though one labourer claimed to have killed a similarly coloured pitviper in the nearby Tea some years before, nothing has eventuated. Sadly, several collecting trips made by Rom Whitaker to the precise area by Hutton indicated have also proved fruitless.

Comparison with *Tropidolaemus wagleri* (Boie, 1827)

A comparison between *Trimeresurus huttoni* and *Tropidolaemus wagleri* was provided in David and Vogel (1998). These species sharing important characters, such as (1) absence of a nasal pore, (2) second supralabial not bordering the loreal pit, (3) strongly keeled upper snout and cephalic scales, (4) strongly keeled gular scales, (5) strongly keeled temporal scales, (6) white or red and white dorsal spots, and (7) bicolour pre- and postocular streaks. On this basis, *Trimeresurus huttoni* was referred to the genus *Tropidolaemus*.

Vogel *et al.* (2007) provided an extensive discussion on variation of *Tropidolaemus wagleri* based on more specimens than those available to David and Vogel (1998). On this basis, *T. wagleri* and *T. huttoni* differ by (1) an upturned snout in *T. huttoni*, (2) a longer tail in males of similar size (150-250 mm), with a ratio TaL/TL of 0.279 for the male of *T. huttoni* vs. 0.179-0.196 in 5 juvenile males of *T. wagleri*, (3) a shorter tail in female of *T. huttoni*, with a ratio of 0.160 vs. 0.176-0.178 in 2 juvenile females of *T. wagleri*, (4) internasals separated in *T. huttoni*, always in contact in T. *wagleri*, (5) a deep red snout in *T. huttoni*, whereas the red hue is present only on the lower edge of the preocular streak in *T. wagleri*, and (6) a mental scale bright golden yellow in *T. huttoni*, whereas it is pale green in *T. wagleri*. As pointed out in David and Vogel (1998), main scalation characters of these two species are identical.

The differences between *Tropidolaemus huttoni* and *Tropidolaemus subannulatus* (Gray, 1842), as defined in Vogel *et al.* (2007), are similar in points (1), (2), with a ratio TaL/TL in males *T. subannulatus* of 0.157-0.173, (5) and (6) Internasals are separated by 1-2 scales in both species.

According to these data, there is no doubt about both the generic belonging and distinct specific status of *Tropidolaemus huttoni*. The occurrence of *Tropidolaemus huttoni* in southern India therefore extends considerably westwards the range of the genus *Tropidolaemus*, previously regarded as typically Indo-Malayan and limited northwards (and westwards) to the Phang-Nga Province of Thailand (Pauwels *et al.* 2000), namely 2,400 airline kilometres across the Bay of Bengal and many more following the mainland.

Biogeographical implications

There is really no possibility for an erroneous type locality of *Tropidolaemus huttoni*. The puzzling occurrence of this Indo-Malayan genus in South India was discussed by David and Vogel (1998). However, there are other reptile genera that show similar distributional pattern, occurring both in Southeast Asia (Indo-China, West Malaysia and the Indo-Malayan Archipelago), and southern India and Sri Lanka, with an apparent distributional gap in Myanmar and most of Peninsular India. According to Das (1996), there are 42 genera of Indo-Malayan reptiles represented in the Indian region. Some snake genera of southern India with Indo-Malayan affinities have been discussed by Hora and Jayaram (1949),

the most striking examples being the genera *Cylindrophis* and *Chrysopelea*. The latter genus has three Indo-Malayan species and one Sri Lankan endemic, in addition to a widespread species (*Chrysopelea ornata*) with a discontinuous range, being found in eastern India to southern China, southwards to Malaya, with populations in south-western India and Sri Lanka (Welch 1988).

These and other snake genera discussed by Hora and Jayaram (1949) share a common characteristic in being absent from the area between the Indo-Chinese region and southern Peninsular India. Das (1996) showed that the reptile faunas of the Western Ghats and of north-east India were not similar. He concluded that the occurrence of Indo-Malayan elements in the fauna of southern India and Sri Lanka is the remnants of an ancient, much wider distribution of plants and animal groups. The wet mountains of southern India provided then the sole refuge to many Indo-Malayan forest-dweller elements, now absent from the dry adjacent lowlands, when the Indian climate and flora dramatically changed following the Eocene with a recession of tropical evergreen forests and their replacement by dry savannas. Indian populations would be relictual, being ecologically trapped, and would have evolved independently from original Indo-Malayan taxa. The presence suggested by Das (1996) of a more widespread distribution of species than now fits well with the presence of *Tropidolaemus* in India.

Interestingly, Blatter (1929) recorded 26 species of mosses, of which one was previously only found in Ceylon (now Sri Lanka), and two previously known from Ceylon and West Malaysia.

A better knowledge of the distribution of *Tropidolaemus huttoni* through further collections would throw light on the zoogeography of the genus. Unfortunately, one has to wait for additional, adult specimens of this species, which still remain unknown.

A BIOGEOGRAPHICAL ANALYSIS OF THE SNAKE FAUNA OF THE MEGHAMALAI HILLS

We compare in Table 9 the known snake fauna of the Meghamalai Hills with the faunas of three other mountain ranges of South India. Two are located farther north, the Anaimalai Hills, which belong to the same system of mountain ranges, and the Nilgiri Hills in the Western Ghats. The third range, the Cardamom Hills, is located south of the Meghamalai Hills. References are given in Table 9. It should however be understood that the faunas of these two latter ranges are much better known than the fauna of the High Wavy Mountains. So this comparison should be considered to be preliminary at best.

It might be surprising to have a higher percentage of species inhabiting the Meghamalai Hills shared with the Nilgiri Hills, a distant range separated from the southern system of hills and plateau by the Palghat gap. In contrast, the nearby Anaimalai Hills have the lowest number of shared species. These figures seem especially to suggest a lack of systematic collecting in the Anaimalai and the Cardamom Hills.

The Meghamalai Hills constitute a rather isolated spur of highlands along the south-eastern edge of the Kamban Valley figures, but do not seem to host a peculiar reptilian fauna with the exception of *Tropidolaemus huttoni* and the second known specimen of the Skink *Dasia subcaerulea*.

CONCLUSION

As explained above, this survey is highly preliminary. The strictly restricted access of the Tea estates covering much

Table 9: Comparison between the snake fauna of three South Indian ranges

Species	Meghamalai Hills	Anaimalai Hills	Nilgiri Mts.	Cardamom Hills	Sources
Uropeltidae					
Melanophidium punctatum	x	x		x	Smith (1943); Murthy (1990); Whitaker & Captain (2004)
Plecturus perroteti	x	x	x		Smith (1943); Murthy (1990) ; Whitaker & Captain (2004)
Rhinophis sanguineus	x		x	x	Smith (1943); Murthy (1990)
Rhinophis travancoricus	x			x	Smith (1943); Murthy (1990)
Uropeltis arcticeps	x			x	Smith (1943); Murthy (1990); Whitaker & Captain (2004)
Uropeltis ceylanicus	x	x	x	x	Smith (1943); Rajendran (1985); Murthy (1990); this work
Uropeltis ellioti	x			x	Smith (1943); Murthy (1990)
Uropeltis pulneyensis	x			x	Smith (1943); Murthy (1990)
Uropeltis rubromaculatus	x	x	x		Smith (1943); Murthy (1990)
Uropeltis woodmasoni	x	x	x	x	Smith (1943); Murthy (1990)

Table 9: Comparison between the snake fauna of three South Indian ranges (*contd.*)

Species	Meghamalai Hills	Anaimalai Hills	Nilgiri Mts.	Cardamom Hills	Sources
Pythonidae					
Python molurus	x	x	x	x	Whitaker & Captain (2004)
Colubridae					
Ahaetulla dispar	x	x	x	x	Smith (1943); Murthy (1990); Whitaker & Captain (2004)
Ahaetulla perroteti	x		x		Smith (1943); Murthy (1990)
Ahaetulla pulverulenta	x		x	x	Smith (1943); Murthy (1990)
Argyrogena fasciolata	x	x			Murthy (1990)
Boiga ceylonensis	x		x		Murthy (1990); Whitaker & Captain (2004); this work
Coelognatus helena	x	x	x	x	Murthy (1990); Whitaker & Captain (2004); this work
Dryocalamus nympha	x		x	x	Hutton (1949a); Whitaker & Captain (2004)
Lycodon striatus	x	x	x	x	Whitaker & Captain (2004)
Lycodon travancoricus	x	x	x	x	Smith (1943); Murthy (1990); Whitaker & Captain (2004)
Oligodon brevicauda	x	x	x	x	Smith (1943); Murthy (1990)
Oligodon taeniolatus	x		x		Smith (1943); Murthy (1990); Whitaker & Captain (2004)
Oligodon travancoricus	x		x	x	Smith (1943); Murthy (1990)
Oligodon venustus	x	x	x	x	Smith (1943); Murthy (1990); this work
Ptyas mucosa	x	x	x		This work
Natricidae					
Amphiesma beddomei	x	x	x	x	Smith (1943); Murthy (1990); Whitaker & Captain (2004); this work
Amphiesma stolatum	x	x	x	x	Smith (1943); Murthy (2001)
Atretium schistosum	x	x	x		Smith (1943); Whitaker & Captain (2004)
Macropisthodon plumbicolor	x		x		Smith (1943); Murthy (2001); this work
Xenochrophis piscator	x	x	x	x	Smith (1943); Murthy (2001); PD's unpublished data
Xenodermatidae					
Xylophis perroteti	x		x	x	Murthy (1990); Whitaker & Captain (2004)
Elapidae					
Calliophis nigrescens	x	x	x	x	Smith (1943); Murthy (1990)
Naja naja	x	x	x	x	Murthy (1990); Whitaker & Captain (2004)
Ophiophagus hannah	x	x	x	x	Smith (1943); Whitaker & Captain (2004)
Viperidae					
Daboia russelii	x	x	x	x	Smith (1943); Whitaker & Captain (2004)
Trimeresurus gramineus	x	x	x		Wall (1919); Pope & Pope (1933)
Trimeresurus macrolepis	x	x	x	x	Smith (1943); Murthy (1990)
Trimeresurus malabaricus	x	x	x	x	Smith (1943); Murthy (1990); Whitaker & Captain (2004)
Tropidolaemus huttoni	x			-	This work
TOTAL	39	25	32	28	
% of the High Wavy fauna	—	64.1	82.1	71.8	

of the Meghamalai Hills does not make it easy for any herpetological investigations in this area. Yet this isolated system of high hills seems to host remnants of undisturbed forests, thanks to the principle of conserving tracts of undisturbed forests for the largest mammals as surveyed by the first author when the Tea estates were being planned.

The survey of these tracts in the protected areas included in restricted tea estates might bring to light new data on the relationships of the herpetological faunas inhabiting the hilly systems of southern India.

Numerous questions have yet to be resolved, the most puzzling of it being the presence in this area of members of the Indo-Malayan fauna (David and Vogel 1998), especially of a pitviper of which nearly nothing is known exactly 60 years after its discovery by the first author. Although covered with tea plantations, this area is still very rich in flora and fauna.

Elephants, Sambar, Barking Deer, Nilgiri Thar, and Gaur are numerous. Recently, the very rare Fruit Bat *Latidens salimalii* Thonglongya, 1972, discovered in 1947 by the first author of this paper, and listed in the 1995 Guinness Book of Records as the world's rarest bat, has been rediscovered (Muni 1994) in this area.

It should be a matter of time, opportunity and chance to rediscover *Tropidolaemus huttoni*.

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THE ROLE OF PERCHES IN ACCELERATING SEED ARRIVAL IN HUMAN-ABANDONED CLEARINGS WITHIN BHADRA TIGER RESERVE, INDIA

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Seed arrival is often the primary limitation to forest regeneration in denuded landscapes, with the number of seeds arriving diminishing rapidly with increase in distance from remnant seed sources. We compared seed rain collected at different distances from the forest edge in seed rain traps with and without introduced bamboo perches in human-abandoned agricultural clearings in Bhadra Tiger Reserve. The number of seeds collected per trap below perches was 38 times greater than the number of seeds collected in traps without perches. The species richness of seeds collected per trap below perches was ten-fold greater than in traps without perches. Our study showed that introducing artificial perches is an effective method to improve seed arrival into tree-less habitats, as has been found in studies elsewhere.

Keywords: Agricultural clearings, bird-perches, regeneration, seed rain

INTRODUCTION

Vegetation recovery in human-abandoned agricultural fields and pastures, especially in the initial stages, has been shown to be severely impeded by factors such as the unavailability of seeds, harsh micro-climatic conditions, degraded soil, competition with existing vegetation, and high rates of seed and seedling predation. Primary amongst these factors is the lack of seed arrival from adjoining forests (Aide and Cavelier 1994; Duncan and Chapman 1999; Holl 1999; Cubiña and Aide 2001). In tropical forests, more than 70-80% tree species are animal-dispersed and their dispersal is likely to be adversely affected by habitat modification as animals are less likely to traverse open habitats (Howe and Smallwood 1982).

Remnant trees in clearings foster regeneration by aiding arrival of bat- and bird-dispersed seeds by providing perch-sites as well as micro-habitats for regeneration of shade-loving species (Willson and Crome 1989; Duncan and Chapman 1999; Toh *et al.* 1999; Galindo-Gonzalez *et al.* 2000; Guevara *et al.* 2004). Restoring disturbed habitats by planting seedlings may often be expensive in terms of money and labour (McClanahan and Wolfe 1993). Alternate measures such as introducing artificial perches to simulate remnant trees in clearings have resulted in an increase in seed arrival and in some cases, a slight increase in seedling densities as well (McClanahan and Wolfe 1993; Aide and Cavelier 1994; Holl 1998; Shiels and Walker 2003).

We investigated whether introducing bamboo-perches improves arrival of bird-dispersed seeds in agricultural clearings within Bhadra Tiger Reserve (Bhadra TR). These clearings were abandoned following a voluntary relocation programme in 2002. We investigated patterns in arrival of wind- and bird-dispersed seeds in seed traps below bamboo perches, and in control traps, at different distances from the forest edge, in 5 out of the 13 abandoned clearings in Bhadra TR.

METHODS

Study area

Bhadra TR (13° 22'-13° 47' N; 75° 29'-75° 47' S, area: 492 sq. km) is located within the Western Ghats biodiversity hotspot in India (Conservation International 2005, Fig. 1). Bhadra was notified as a Tiger Reserve in 1998, and the reserve is rich in faunal and floral diversity (Karanth 1982; Jathanna 2001). The Reserve is composed of moist deciduous forests in the southern portion, with dry deciduous forests towards the north (Meher-Homji 1990). The present study was carried out in the abandoned village sites of Madla, Vadihaddi, Hipla, Kesavé and Karvani. The clearings in the five abandoned villages aggregate to about 130 ha of riparian habitat.

Field methods

A 350 m long forest-field edge was selected in each of the five clearings. Along this edge, five points were marked at random and transects radiating into the clearing were established at each of these points for recording arrival of wind-dispersed seeds. Each transect consisted of seven traps radiating into the clearings at distances of 0, 2, 4, 8, 16, 32

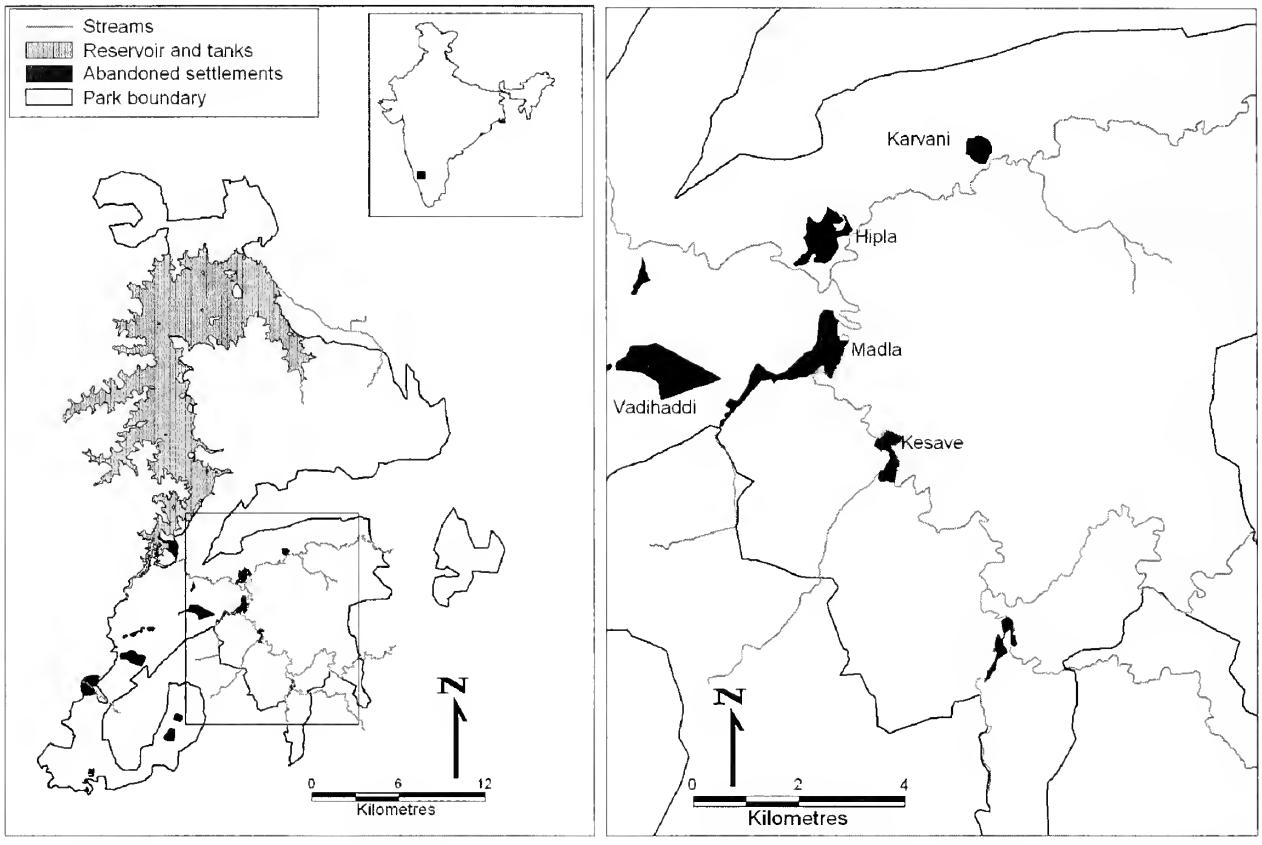

Fig. 1: On left: Map of Bhadra showing the Bhadra reservoir to the north-west, and the location of abandoned settlements (Inset map shows location of Bhadra within peninsular India). On right: (enlarged view of the area demarcated in the figure on left): Five of the 13 abandoned settlements in Bhadra that were chosen as replicate sites for this study

and 64 m from the forest edge. Seed traps consisted of pits, 0.1 m deep and 1 x 1 m wide, lined with cloth to enable detection of small seeds. Seed traps were visited fortnightly (five visits) between March 15 and May 31, 2006. During each visit, the pits were emptied and seeds of tree species counted and collected in numbered bags. Since most trees in Bhadra flower and fruit during the February-May dry season, the sampling period coincided with the main window of seed dispersal in this forest.

Bird perches were erected along one of the five transects established in each clearing, chosen at random (Fig. 2). Perches were bamboo poles (*Bambusa arundinacea*) about 7 m tall, and had at least ten lateral branches. Seed traps below the perches trapped both wind- and bird-dispersed seeds. Seed rain below the bird-perches was also collected fortnightly, with five collections between March 15 and May 31, 2006.

Analytical methods

Sites (i.e. village clearings) were considered as replicates and seed rain data from transects within each site were pooled for analysis, after compositing by distance. Seed rain density was log-transformed to achieve normal distribution of errors, and to remove heteroscedasticity in the data. Few bird-dispersed seeds (about 0.1 seed / 5 fortnights/ sq. m) were collected beneath perches in Hipla (a clearing with many remnant trees – more than 50 in the *c.* 1.6 ha sampled for seeds) and data from this clearing were not included in the analysis. The effects of perches and distance from edge on seed arrival were investigated using generalised linear models (GLMs [McCullagh and Nelder 1989]). Log-transformed seed rain was used as the response variable. The presence of perches (i.e., 'perch / no perch,' a categorical variable) and distance from the forest-field edge (a continuous variable) were used as the predictor variables. Intercept and slope parameters were estimated for the following models: (a) seed rain as a function of perches, (b) seed rain as a function of distance from the edge, (c) seed rain as a function of perches + distance from the edge, and (d) seed rain as a function of perches + distance from the edge + an interaction between perches and distance from the edge. These models were compared using AIC_C (Akaike's Information Corrected Criterion), and the relative importance of the different models was assessed based on AIC_C weights (Burnham and Anderson 1998; Johnson and Omland 2004). Statistical analysis was carried out using software R, version 2.5.0.

Fig. 2: Bamboo bird-perches (height: 7 m) erected at 0, 2, 4, 8, 16, 32, 64 m from the forest edge in Karvani, one of the abandoned clearings within Bhadra

RESULTS AND DISCUSSION

Effect of perches on seed arrival into clearings

Frugivorous birds observed frequenting the perches included Jungle Myna (*Acridotheres fuscus*), Common Myna (*A. tristis*), Grey-headed Starling (*Sturnia malabarica*) and Red-whiskered Bulbul (*Pycnonotus jocosus*). A total of 4,051 wind-dispersed seeds of 19 tree species were collected from 175 seed rain traps over five fortnightly collections. A total of 3,715 bird-dispersed seeds of 10 tree species were collected from 35 traps below perches in comparison with 390 bird-dispersed seeds of 7 tree species collected from 140 traps without perches over the same sampling period (refer Appendix).

The results of GLMs suggested that the perches had strongest effect on seed arrival (Table 1, Fig. 3). Distance from the forest-field edge had little-to-no effect on numbers of bird-dispersed seeds that arrived below perches. At any given distance from the forest-field edge, the mean density of bird-dispersed seeds collected under perches (seeds / 5 fortnights / sq. m) was about 38 times that of seeds collected from traps without perches (106.2 ±95.0 cf. 2.8 ± 3.8), whereas the mean density of wind- and bird-dispersed seeds that arrived below perches were about 25 times that of seeds collected from traps without perches (128.86 ±155.85 cf. 5.09 ± 3.95). Perches not only enhanced the numbers of seeds arriving, but also augmented the mean number of species arriving into plots in clearings by a factor of 10.

The genus *Ficus* accounted for three of the ten species (and 95% of all seeds) collected below perches. *Ficus* species are of considerable value to forests in Asia as keystone resources due to their large crop size and asynchronous phenology (Borges 1993; Shanahan *et al.* 2001). About 40% of the *Ficus* seeds were from species such as *F. religiosa* and *F. mysorensis*, which are often cultivated in villages in India. Seed arrival was as low as 0.1 seed / sq. m during the study period in Hipla, a clearing with many remnant trees, indicating that perches are likely to be effective only in tree-less sites where birds are perch-limited, and not in sites with remnant trees.

Artificial perches have been introduced in other clearings adjoining forests (McClanahan and Wolfe 1993) with varying disturbance histories, such as grazing (Aide and Cavelier 1994; Holl 1998), and landslides (Shiels and Walker 2003). These studies have shown that seed arrival below

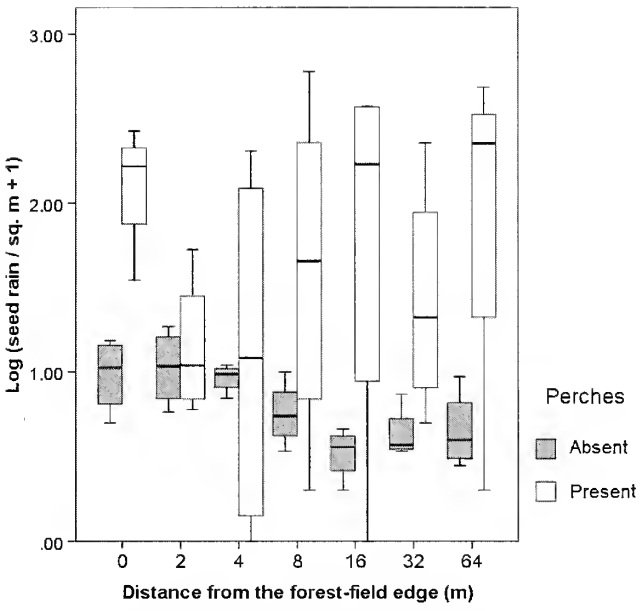

Fig. 3: Number of seeds collected in seed traps with and without bird-perches in five abandoned clearings within Bhadra at different distances from the forest edge. Data are number of seeds (bird- and wind-dispersed) collected between March 15 and May 31, 2006

perches is higher by a factor of 20 (Holl 1998; Shiels and Walker 2003) to 150 (McClanahan and Wolfe 1993) than in sites without perches. However, the effectiveness of perches in increasing seed rain was not reflected in seedling establishment; only one of these studies reported an increase in seedling establishment (McClanahan and Wolfe 1993). The lack of improved seedling establishment in these studies was attributed to factors such as harsh micro-climatic conditions, seed predation, lack of nutrients in the soil and competition from existing vegetation in the clearings.

Factors such as perch height and design may also affect the number of bird visits: seed arrival has been reported to be higher below relatively taller trees, because they tend to attract more species of birds; taller perches, similarly, are likely to attract a greater number of bird species (Duncan and Chapman 1999; Toh *et al.* 1999). Holl (1998) found higher bird visit rates to, and seed dispersal below, branch perches compared with crossbar perches. The height of perches used in this study (about 7 m compared with average canopy height of 25-30 m in Bhadra) and the relatively thin lateral branches of bamboo perches may have deterred larger-bodied frugivores, such as barbets (*Megalaima* spp.) and green pigeons (*Treron* spp.) from visiting the perches.

Implications for restoration

Clearings within forests help maintain high densities of herbivores (and consequently, large carnivores), and thus management interventions frequently focus on maintaining such clearings (Schaller 1967; Karanth and Sunquist 1992). In the case of Bhadra, the abandoned agricultural fields may be maintained as clearings, akin to management practiced in other protected areas in India (e.g., Kanha and Nagarahole National Parks). However, findings from our study provide insights for restoration of slash-and-burn fallows, abandoned tea and coffee plantations, and other degraded lands where

Table 1: Effect of perches compared with that of distance from the forest edge, the combined effect of both, and interaction between the two, on number of bird-dispersed seeds that arrived below perches in five abandoned clearings within Bhadra TR

Model	Estimated parameters (SE)				△ AIC_c	Model likelihood	AIC_c weights
Perch	Intercept			Perch	0	1	0.73
	0.713 (0.125)			0.847 (0.176)			
Perch + Distance	Intercept	Distance		Perch	1.99	0.37	0.27
	0.689 (0.146)	0.001 (0.004)		0.847 (0.178)			
Perch + Distance + Perch * Distance	Intercept	Distance	Perch	Distance x Perch	2.83	0.24	0
	0.762 (0.165)	-0.003 (0.006)	0.701 (0.233)	0.008 (0.008)			
Distance	Intercept			Distance			
	1.112 (0.138)			0.001 (0.005)	18.26	0	0

Perch * Distance denotes interaction between the two predictor variables

the management objective is clearly to restore the original vegetation.

We found that introducing perches is a simple and practical method to overcome the primary limitation of seed arrival into clearings and deforested land adjacent to forests, especially in relatively open sites where birds are perch-limited. Improved seed arrival does not necessarily translate into an increase in regeneration, however. In order to foster regeneration, augmenting seed arrival may need to go hand-in-hand with interventions to overcome other barriers to regeneration such as harsh micro-climatic conditions, competition with existing shrubs and grasses, and seed and seedling predation.

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Appendix

List of tree species, seeds of which were collected from seeds traps in this study in Bhadra. Also given are the location where each species was encountered (i.e., whether in clearings, C, or in the adjoining forests, F), and the species' dispersal mode (A = animal-, B = bird- & W = wind-dispersed)

Tree species	Family	Clearing / Forest	Mode of dispersal
Semecarpus anacardium	Anacardiaceae	C	B / A
Alstonia scholaris	Apocynaceae	C / F	W
Stereospermum personatum	Bignoniaceae	C / F	W
Terminalia alata	Combretaceae	C / F	W
Terminalia paniculata	Combretaceae	C / F	W
Albizzia lebbeck	Fabaceae	C / F	W
Albizzia odoratissima	Fabaceae	C / F	W
Butea monosperma	Fabaceae	C / F	W
Cassia spp.	Fabaceae	C / F	W
Cassia tora	Fabaceae	C / F	W
Dalbergia latifolia	Fabaceae	C / F	W
Erythrina indica	Fabaceae	C / F	W
Erythrina spp.	Fabaceae	C / F	W
Pongamia pinnata	Fabaceae	C / F	W
Pterocarpus marsupium	Fabaceae	F	W
Lagerstroemia lanceolata	Lythraceae	C / F	W
Cipadessa baccifera	Meliaceae	C	B / A
Ficus racemosa	Moraceae	C	B / A
Ficus mysorensis	Moraceae	C	B / A
Ficus religiosa	Moraceae	C	B / A
Olea dioica	Oleaceae	C	B / A
Ziziphus xylopyrus	Rhamnaceae	C	B / A
Atalantia monophylla	Rutaceae	C	B / A
Santalum album	Santalaceae	C	B / A
Grewia tiliaefolia	Tiliaceae	C	B / A
Tectona grandis	Verbenaceae	C	W / A

Bird-dispersed seeds were collected below bamboo perches erected in the clearings

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NEW DESCRIPTION

A NEW TRIBE AND A NEW GENUS OF OSCINELLINAE (DIPTERA: CHLOROPIDAE) FROM INDIA

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A new tribe, Indonellini with type genus *Indonella* Cherian gen. nov. of Subfamily Oscinellinae (Chloropidae) is described. Salient features and affinities of *Indonella* are given and the type species *I. intermedia* sp. nov. from Kerala is also described.

Key words: Diptera, Chloropidae, Oscinellinae, new tribe, genus and species, India

INTRODUCTION

Chloropidae is a medium-sized family of Diptera comprising of small flies represented in all the faunal regions of the world. Nartshuk (1983, 1987) gave Family Chloropidae the status of a superfamily, Chloropoidea and divided it into families Siphonellopsidae and Chloropidae, the former comprising genera dealt with earlier under the Subfamily Siphonellopsinae of the undivided Family Chloropidae, and the latter the rest of *Chloropid* genera. However, Cherian (2002) based on his studies on the close affinities shown by many species and genera belonging to the two families relegated Siphonellopsidae to the rank of a subfamily of Chloropidae as traditionally followed.

During the course of revision of Chloropidae of India and adjacent countries, the authors came across a new species, belonging to Subfamily Oscinellinae, which shows close affinities to some genera of Siphonellopsinae. Because of some intermediate and also combination of characters the species possesses, it does not fit elsewhere in any of the genera of 22 recognized tribes of Chloropidae. Hence, this new species, *Indonella intermedia* from Kerala, is placed in a new tribe, Indonellini with type genus *Indonella* gen. nov. under Subfamily Oscinellinae. The new tribe, genus and species are described here.

Type specimens are retained in the collections of the University of Kerala and shall later be deposited in the National Collections of Zoological Survey of India, Kolkata.

Abbreviations used:

*ant*3 - third antennal segment; *as* - apical scutellar bristle; 1 *dc* - first dorsocentral bristle; 2 *dc* - second dorsocentral bristle; *fr* - frontal hair; *h* - humeral bristle; *if* - interfrontal bristle; *ivt* - inner vertical bristle; *kepst* - katepisternum; *m-m* - medical cross-vein; *npl* - notopleural bristle; *oc* - ocellar bristle; *orb* - fronto-orbital bristle; *ovt* - outer vertical bristle; *pa* - postalar bristle; *prs* - prescutellar bristle; *pvt* - postvertical bristle; *r* - radial vein; *r-m* - radio-medial vein; *sa* - supraalar bristle; *ss* - subapical scutellar bristle.

Indonellini Cherian, tribe. nov.
Type genus: *Indonella* Cherian gen. nov.

A small tribe having long and reclinate *orb* and *oc*, long *ivt*, broad gena, 2 *h*, and 2 *dc* bristles, subsquarish scutellum with *as* widely separated at base, long *r* 2+3 and vestigial but somewhat distinct anal vein.

Head higher than long; frons greatly widened at vertex, projecting beyond the anterior margin of eye; frontal triangle large and tomentose, with depressions; face deeply concave with low facial carina; arista long and finely pubescent; gena wider than *ant*3 with lower shiny part bearing many punctate hairs and long oral setae; eyes pubescent with horizontal long axis; cephalic bristles very well-developed; *ivt* longer than *ovt* and subequal to *pvt*; *oc* reclinate; *orb* and *if* 4 each, the former reclinate; scutum finely tomentose with evenly distributed dense hairs; pleura with *kepst* hairy; scutellum subsquarish, much wider than long; *as* arising from posterolateral corners of scutellum and borne on warts; base of *ss* 1 nearer to base of scutellum than to *as*; *h* 2, inner shorter and slightly turned mesad; *npl* 1+1, equal to outer *h*, *pa* 1 and 1 *dc*; *dc* 2 short, slender and presutural wing broad with well-developed anal area, oblique *m-m*, and vestigial, but slightly distinct anal vein; legs without tibial and femoral organs.

Distribution: Oriental Region

Remarks: Indonellini shows affinities to both the subfamilies Siphonellopsinae and Oscinellinae and is intermediate between the two. In the general development of frons, gena and antennae, appearance of head and in having *ivt* longer than *ovt*, 2 *h* and 2 *dc* bristles and such other characters, Indonellini superficially resembles some of the genera of Siphonellopsinae like *Apotropina* Hendel, *Protohippalates* Andersson and others. However, in

possessing reclinate *oc* and *orb*, in the absence of additional bristles like *sa*, *prs* and a bristle on *kepst* and in the nature of general chaetotaxy, thoracic pubescence and build of wing and wing venation, this tribe differs from Siphonellopsinae and exhibits close affinities to other tribes and genera of Oscinellinae. But a combination of characters like anteriorly projecting frons, long cephalic bristles with *ivt* longer than *ovt*, presence of 2 *h* and 2 *dc* bristles, nearly subtruncate scutellum with widely separated *as* borne on warts and a vestigial anal vein are not found together in any other Chloropid tribe or genus so far known, though a few of these characters are very rarely found in different combinations in some of the other tribes and genera of Oscinellinae. Hence, a new tribe Indonellini with type genus *Indonella* gen. nov. is proposed under which the new species is placed.

Genus ***Indonella*** Cherian gen. nov.
Type species: *Indonella intermedia* sp. nov.

Medium sized black flies with anteriorly projecting frons, large, subshiny and dark tomentose frontal triangle, broad gena, long *ivt*, flattened scutum, nearly subsquarish scutellum with *as* borne on short warts, 1+1 *npl* and 2 *h* and 2 *dc* bristles.

Head: Higher than long. Frons projecting beyond anterior margin of eye, widened at vertex and gradually narrowing anteriorly as in most genera of Siphonellopsinae, with well-developed black *fr*; frontal triangle large, with convex side margins, subshiny, finely dark tomentose, partly with complex depressions as in some species of *Euthyridium* Frey; *if* long, reclinate, in a row along margin of frontal triangle. Face much narrower than frons, deeply concave; facial carina triangular between antennae and running as a low, narrow ridge to depressed epistomal margin. Basal antennal segments partly covered by projecting frons; *ant*3 wider than long; arista slender with fine pubescence. Gena narrowing anteriorly, wider than *ant*3, divided into narrow upper tomentose part and much broad glabrous lower part, the latter with punctate hairs and a row of well-developed oral setae; vibrissal corner blunt, not reaching anterior margin of eye; postgena wide. Eye of medium size, oval with nearly horizontal long axis. Parafacialia not developed. Palpi cylindrical and proboscis of medium size, both with well-developed black hairs. Head bristles long, stout, black; *ovt* a trifle shorter than *ivt*, the latter subequal to *pvt* which are parallel and turned caudad; *oc* very well-developed, erect, subparallel, reclinate; *orb* 4, reclinate.

Thorax: Scutum wider than long with almost flattened, very finely dark tomentose, nearly shiny disc-bearing uniformly distributed punctate hairs. Scutellum much broader than long, nearly subsquarish, pubescent like but more coarsely punctate than scutum. Pleura glabrous with short hairs on *kepst*. Thoracic bristles very well-developed; *h* 2, of which outer is long and subequal to *npl* and inner nearly half as long as outer; *npl* 1+1, subequal; *pa* 1 and 1 *dc* equal to *npl* and *pa* 2 shorter than *pa* 1; apart from normally developed 1 *dc* there is a short and slender presutural 2 *dc* which is only a little longer than scutal hairs; *as* widely separated at base, longer than scutellum, borne on short wart; *ss* 1 located nearer to the base of scutellum than to base of *as*.

Wing: Hyaline with deeply brown veins; costal break developed; second sector of costa more than 2x as long as third sector; terminal sector of m 1+2 joining costa very slightly beyond apex of wing; m-m cross-vein oblique; terminal sector of m 3+4 distinctly convex below in basal half. Anal area very well-developed. Haltere yellow.

Legs: Partly yellow and partly dark brown with well-developed black hairs; midtibia with 2-3 short, black subterminal spines apart from normally developed spine; tibial and femoral organs not developed.

Abdomen: Suboval, finely dark tomentose with numerous well-developed hairs, especially at sides, and longer, bristly hairs on distal segments. Female ovipositor slender, of medium size.

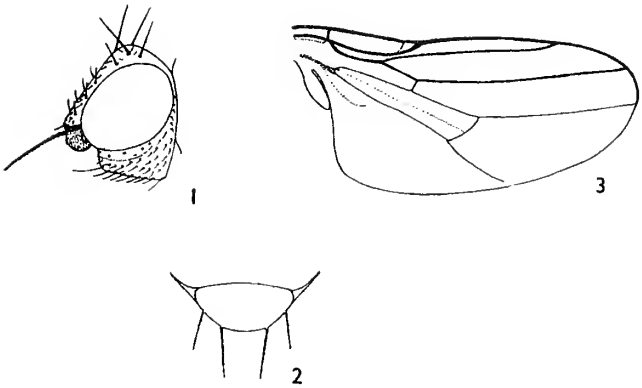
Distribution: Oriental Region.

Etymology: The genus has been named after India, the country of its distribution with the suffix *nella*.

Remarks: Because of the combination of characters discussed earlier which *Indonella* possesses it is considered a distinct genus intermediate between Siphonellopsinae and Oscinellinae. Though it shows closer affinities to Oscinellinae yet it cannot be placed under any other tribe or genus of the subfamily so far known. Hence, it is placed under the new tribe Indonellini of which it is the type genus.

Indonella intermedia Cherian sp. nov. (Figs 1-3)

Male and Female: Head (Fig. 1): Higher than long, length, height and width ratio 16:19:24 (eyes are collapsed in both the types, and hence width of head cannot be measured with exactitude). Frons greatly widened at vertex as in most species of Siphonellopsinae, width at vertex margin more than twice that behind apex, projecting distinctly beyond anterior margin of eye, subshiny black along three-fourths its length, yellowish-brown in rugulose anterior part, longitudinally depressed at sides of frontal triangle and with well-developed black *fr*; frontal triangle large, subshiny black except for brownish area around apex, finely dark tomentose, reaching anterior margin of frons, ending with slightly obtuse apex and with a large, oblong, median shallow depression in



Figs 1-3: *Indonella intermedia* Cherian sp. nov.
1. Head; 2. Scutellum; 3. Wing

anterior part and with more depressions, which are discernable only in certain angles of illumination, and appear somewhat like suborbicular to rectangular pits on either side of ocellar triangle, recalling partly the condition in some species of *Euthyridium* Frey. Face deeply concave, much narrower than frons; facial carina triangular between antennae and running as low ridge to epistomal margin which is depressed, deeply concave in middle and silvery white tomentose. Basal antennal segments deeply infuscated, partly hidden by projecting frons; *ant*3, 1.4x as wide as long, yellowish brown with dark tinge along dorso-distal margin; arista long, located sub-basally, slender, dark brown with fine, but distinct, fairly dense pubescence. Gena well-developed, narrowing anteriorly, width in the middle 1.25x that of *ant*3, divided into upper narrow grey tomentose part and lower much broader, shiny, brownish black part bearing fairly dense, well-developed, punctate black hairs; oral margin with a row of 8-10 black, prominent and erect setae; vibrissal corner blunt, not reaching anterior margin of eye, with one vibrissal bristle; postgena well-developed, brownish-black with well-developed hairs; parafacialia not developed. Eye suboval, appearing to be densely short pubescent (but not very distinct because of collapsed eyes in both the types), with horizontal long axis. Palpi cylindrical and proboscis of medium size, both with well-developed black hairs. Head bristles very well-developed, black; *ivt* a little longer than *ovt*; *pvt* subequal to *ivt*, parallel, turned caudad; *oc* long, erect, subparallel, reclinate; *orb* 4, anterior 3 reclinate, posteriormost reclinate and slightly lateroclinate; *if* 4, reclinate, in a row along margin of frontal triangle.

Thorax: Wholly black. Scutum 1.1x as wide as long, with nearly flattened, finely dark tomentose shiny disc bearing fairly dense, finely punctate evenly distributed black hairs; humeral callus moderately developed. Scutellum (Fig. 2) subsquarish, 1.7x as wide as long with almost flattened disc which is pubescent like but more coarsely punctate than scutum. Pleura glabrous with slender fairly dense black hairs on *kepst*. Thoracic bristles very well-developed; *h* 2, outer long and equal to *npl*, inner slender, nearly half as long as outer, slightly turned mesad; *npl* 1+1, long, subequal and equal to *pa* 1 and 1 *dc*; dc 2 presutural, short and slender, only 2x as long as scutal hairs; *pa* 2 about three-fifths as long as *pa* 1; *as* widely separated at base, 1.2x as long as scutellum, arising from posterolateral corner of scutellum, borne on short wart; *ss* 1, 0.7x as long as *as*, arising laterally from nearer to base of scutellum than to base of *as*.

Wing: (Fig. 3): 2.43x as long as wide, hyaline with yellowish brown veins and brown hairs; proportions of costal sectors 2 to 4 in the ratio 19:9:6; terminal sectors of *r* 4+5 and *m* 1+2 parallel; *r-m* cross vein distad of middle of discal cell, opposite 0.52 of its length; *m-m* cross vein oblique; terminal sector of *m* 3+4 convex below in basal half; a vestigial anal vein is present; anal area well-developed. Haltere oval, yellow, pointed at apex.

Legs: Medium size, with well-developed dark hairs; coxae yellow; fore femur along more than three-fourths its length basally, and mid and hind femora along nearly one third their lengths, basally yellow and remaining areas gradually becoming infuscated and blackish especially on mid and hind femora; fore tibia and all tarsi almost wholly yellow; mid and hind tibiae brownish-black except for their yellow bases and apices; mid-tibia with two to three short, additional subterminal spines apart from the normal spine; tibial and femoral organs absent.

Abdomen: Suboval, subshiny, finely dark tomentose, brownish black except for a large yellowish-brown rugulose, subsquarish area covering median part of dorsum of two basal segments and with numerous well-developed dark hairs especially along sides, and longer bristly hairs on distal segments. Female ovipositor slender of medium size with dark hairs. Male genitalia could not be studied because of partly damaged terminal part of abdomen in the male specimen.

Length: Male: 1.77 mm; wing 1.88 mm. Female: 1.81 mm; wing 1.85 mm.

Holotype: Male, INDIA: Kerala: Trivandrum dt., Sreekaryam, 25 m, 2.viii.2006, collected from tuber of *Amorphophallus*, Coll. P. Rajamma.

Paratype: 1 female (some body parts including wings partly crumbled), collection data same as of holotype.

Etymology: The species links the two subfamilies Siphonellopsinae and Oscinellinae, and hence the name *intermedia*.

Remarks: The flies were found resting on freshly dug out tuber of *Amorphophallns* and were collected along with those of *Apotropina* Hendel.

ACKNOWLEDGEMENTS

The authors are grateful to the Ministry of Environment and Forests, Government of India for financial support under its AICOPTAX project and to Prof. Oommen V. Oommen, Head of the Department of Zoology, University of Kerala for facilities for work and encouragement. We are also thankful to Dr. P. Rajamma, Senior Scientist, Central Tuber Crops Research Institute, Trivandrum for collecting and providing the specimens for study.

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REVIEWS

1. SPECIATION IN BIRDS by Trevor Price. Published by Roberts and Company Publishers, USA. 2008. Pp. 470. Size: 25.5 cm x 17.5 cm. Paperback. Price: US $59.95/-.

This is a very specialized book written by a professional ornithologist who has extensively worked in the USA and Asia on sympatric warblers.

He starts the book with the question, 'What is a bird species?'. As without knowing the concept of species, it would be difficult to understand (and appreciate) this book. The concept of species itself has undergone changes in recent years, thanks to DNA sequencing. From earlier classification, based mainly on morphological differences, birds are now classified based on DNA sequence, and some times even on song characteristics, particularly in sympatric species (Isler *et al.* 1998). In the Indian subcontinent, Rasmussen and Anderton (2005) in their famous book BIRDS OF SOUTH ASIA, THE RIPLEY GUIDE have classified 83 pairs of subspecies as full species based on their geographical separation.

Based on vocalization, structure and plumage, mtDNA sequences, Chiffchaff *Phylloscopus collybita* is now distinguished into four species: Common Chiffchaff *P. collybita*, Iberian Chiffchaff *P. brehmii*, Canary Island Chiffchaff *P. canariensis* (polytypic) and Mountain Chiffchaff *P. sindianus* (polytypic).

There are five species concepts: Evolutionary Species Concept, General Lineage Concept, Biological Species Concept, Recognition Species Concept, and Phylogenetic Species Concept. A detailed description of these classifications is beyond the scope of this review. As we explore the finer details of into the concept of a species, it becomes more complicated as can be understood from this book. Trevor Price has followed the bird species classification of Sibley and Monroe (1990), mainly on plumage, shape and size differences or the biological species concept for sympatric taxa.

The book is divided into 16 main chapters, excluding the Conclusion which summarizes the concept of this book. As it is a technical book, it is not for an amateur birdwatcher because it needs a sound biological background. Many terms are used presuming that the readers would know them. However, a Glossary of seven pages is given in the end. This authoritative book is mostly for post-graduate and research students who are interested in the concepts of evolution of birds. I highly recommend this book to all students of ornithology.

■ ASAD R. RAHMANI

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2. A FIELD GUIDE TO THE BIRDS OF THE INDIAN SUBCONTINENT by Krys Kazmierczak, illustrations by Ber van Perlo. 2008 (Reprint). Christopher Helm, London. Pp. 352. Size: 21 cm x 14.5 cm. Paperback. Price not stated.

For almost 20 years, the PICTORIAL GUIDE by Sálim Ali and S.D. Ripley was the standard field guide for birdwatchers in the Indian subcontinent, despite its awkward size and 'lifeless' illustrations. In 1999 and 2000, two books brought Indian bird guides to the international standard. First came the monumental BIRDS OF THE INDIAN SUBCONTINENT by Richard Grimmett, Carol Inskipp and Tim Inskipp (1998), quickly followed by the more field-friendly POCKET GUIDE TO THE BIRDS OF THE INDIAN SUBCONTINENT (1999) by the same authors. As we were still savouring these two books, in 2000 Krys Kazmierczak brought out A FIELD GUIDE TO THE BIRDS OF THE INDIAN SUBCONTINENT. Many of us who were not happy with the classification of Grimmett *et al.* were relieved to see that Krys had used the old classification in Ali and Ripley's book. I will leave the comparison here as it is not fair for me to compare these books as all of them have their merits and demerits. It is also a personal choice of liking or not liking a book.

Krys and Christopher Helm should be congratulated for bringing out a reprint of this popular book. Illustrations by Ber van Perlo are mostly good, but sometimes they appear too gaudy (Plate 70, Babblers) or pale (Plate 78, Reed and 'Tree' warblers). While there are differences among ornithologists about distribution of different species, I find the maps in this book to be quite accurate and updated. The distribution maps again prove that we still have to collect and collate bird data from various parts of India, particularly

central India where we do not have many birdwatchers. With the threats of climate change, habitat destruction and habitat modification, distribution of birds will change. Unless we have good site-specific data from all over the country, we may not be able to take corrective measures to save many bird species. It is extremely important to collect and share bird data through a system such as World BirdWatch. Books like this will certainly help in popularizing bird watching and data collection. I recommend this book to birdwatchers in India. If you had missed buying this book in the early 2000s, here is another chance to enjoy bird watching by accurately identifying your feathered friends.

■ ASAD R. RAHMANI

3. A CELEBRATION OF INDIAN TREES by Dr. Ashok Kothari. Published by National Society of the Friends of the Trees, India, in association with Márg Publications, India. 2007. 196 pp. Size: 34 cm x 25 cm. Hardback. Price: 2,500/- (INR).

Since ancient times, the rich tree diversity in India and their enchanting beauty, have invoked a vast number of authors to make their contributions in the immense task of its documentation. Hundreds of books covering one or more aspects of the theme "Trees of India" are available today. What makes each of these special and unique is the diversity in presentation of information of the book. This presentation is not only scientific in nature as a pictorial field guide, but can also act as a spectacular coffee table book that interests an amateur.

A CELEBRATION OF INDIAN TREES, a book by Dr. Ashok Kothari showcasing more than 140 tree species of India has been published by the National Society of the Friends of the Trees as a souvenir to commemorate its Golden Jubilee Year 2007. This 196-page book contains vivid descriptions and spectacular pictures of trees. The book features indigenous as well as introduced trees species that have become an integral part of the Indian landscape, deliberately keeping the notorious exotics outside the scope of the book. Each tree profile starts with the English common name and scientific name of the tree followed by its names in various Indian languages and dialects. It covers interesting facts and Indian traditional beliefs about the tree wherever relevant, and also the geographic distribution. Morphological details and key characters of each of the trees featured in this book such as growth form, bark, leaves, flowers, fruits and phenology along with selective photographs complimenting these descriptions, make the publication a very handy identification guide. The author also comments on the medicinal and other commercial use values of each tree species.

Detailed glossary and separarte indices of common names and scientific names at the end the book make it more user friendly. End papers with a double spread collage of paintings reproduced from SOME BEAUTIFUL INDIAN TREES by E. Blatter and W.S. Millard look splendid. A few relevant verse lines collected through the sources all over the world, appear on some of the pages and make the entire reading experience very poetic and mythical.

The attractive publications depicting natural wealth of the country are the need of time, which can reach a wider range of target group and help spreading a message of protecting it. The book will certainly be the one to inspire the readers to appreciate the living tree specimens around and experience the richness of their beauty.

■ SWAPNA PRABHU

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MISCELLANEOUS NOTES

1. A NOTE ON THE OBSERVATION OF A PALM SQUIRREL IN THEKKADY, PERIYAR TIGER RESERVE, SOUTHERN INDIA

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I have regularly seen Jungle Striped Squirrels *Funambulus tristriatus* in semi-evergreen/moist deciduous habitat at Thekkady in the Tourist Zone of the Periyar Tiger Reserve, southern India.

On June 02, 2008, when I was watching a pair of Jungle Striped Squirrels that had descended to the ground in search of food scraps left by tourists, a Palm Squirrel appeared suddenly. It chased off one of the Jungle Striped Squirrels and disappeared as quickly as it had appeared. The Palm Squirrel I saw was probably of the three-striped species, *Funambulus palmarum*, which is found in Tamil Nadu to the east of Periyar Tiger Reserve.

Seeing the two species close together provided an opportunity to appreciate how distinct they are. The Palm Squirrel was much brighter in appearance than the Jungle Striped Squirrel. About the difference between the two squirrels, Wroughton (1905) observed, "*F. tristriatus* is much the darker of the two, the palest specimen I have seen being darker than the darkest *palmarum*; the rufous vertex of the head which is without exception in *tristriatus* is often absent in *palmarum*..."

I have not seen palm squirrels at Thekkady previously. Dr. P.O. Nameer (pers. comm.) writes that my recent observation is interesting and that he has not seen the two squirrels co-existing.

ACKNOWLEDGEMENT

I thank Dr. Nameer for his comments on this note.

REFERENCE

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2. BURROW STRUCTURE OF INDIAN BUSH RAT *GOLUNDA ELLIOTI* AND BROWN SPINY MOUSE *MUS PLATYTHRIX* IN TIRUCHIRAPPALLI DISTRICT, TAMIL NADU

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Rodents occur in virtually every terrestrial environment that supports life (wild, agricultural or urban). Most rodents are inhabitants of burrows. The subterranean mode of living provides the rodents home, protection from predators and also helps in thermoregulation (Prakash *et al.* 1965). Studies on the burrowing habit of rodent pests are required to understand their social organization and behaviour of dominance (Barnett and Prakash 1975; Prakash and Mathur 1987). Further, they also help to distinguish rodents from other burrowing animals, for population estimation, placing poison baits and physical control (Neelanarayanan *et al.* 1996). The nature and internal structure of burrows of field rodents have been reported for *Bandicota bengalensis* (Barnett and Prakash 1975; Sivaprakasam and Durairaj 1995; Neelanarayanan *et al.* 1996), *Mus booduga* (Sivaprakasam and Durairaj 1995; Neelanarayanan *et al.* 1996), *Millardia meltada* (Urs 1968; Sivaprakasam and Durairaj 1995; Neelanarayanan *et al.* 1996), and *Tatera indica* (Chandrahas and Krishnaswamy 1974; Barnett and Prakash 1975; Goyal and Ghosh 1993; Sivaprakasam and Durairaj 1995; Neelanarayanan *et al.* 1996).

There is not much published information available on the nature of burrow patterns of the Indian Bush Rat *Golunda ellioti* and Brown Spiny Mouse *Mus platythrix*.

Therefore, the present study was undertaken to examine the burrow structure with reference to the morphology and anatomy along with its dimensions, of these two species in Tamil Nadu.

Study area

The present study was carried out in Puthanampatti, Vellakkalpatti, Thirupattur and Siruganur villages of Tiruchirappalli district (10° 00'-11° 30' N; 77° 45'-78° 50' E). Most areas where we studied the burrow patterns of *G. ellioti* and *M. platythrix* were dry interspersed with forest and cultivated lands. The Tiruchirappalli district has both fertile and comparatively dry tracts for crop cultivation. The present study was carried out in the dry tracts of Tiruchirappalli district. The terrain of the study area is slightly undulating. The ground water is utilized for irrigating the cultivated crops.

Material and methods

The burrows of *G. ellioti* and *M. platythrix* were searched with the help of local and experienced rodent trappers. The identified burrows were studied visually for their structure and nature of burrow entrance, and noted as suggested by Neelanarayanan *et al.* (1996). The crops nearest to the burrows, diameter of the entrance, horizontal length of the burrow (whether the main and emergency entrances are clearly seen or not), number of main and emergency exits were recorded. Thereafter, the burrows were dug out and their routes, number of blind alleys, number of internal and external soil plugging, number of brood and food chambers and the type of nesting materials were recorded as suggested by Sivaprakasam and Durairaj (1995). The diameter of the brood chamber was also measured and recorded. All measurements were taken using a thread and later calibrated with a measuring tape. Data are given as mean with standard deviation (SD).

Table 1: Morphometric measurements (cm) and other characteristics of burrows of *Golunda ellioti* (*n* = 40)

Parameters	Mean ±S.D.
Main burrow entrance diameter	8.3 ±2.4 (4.5-13.0)
Emergency burrow entrance diameter	5.8 ±1.3 (4.5-8.0)
Vertical depth of the burrow from the ground level	46.8 ±25.3 (11.5 - 98.5)
Horizontal width of burrow	56.4 ±37.1 (20.0-127.0)
Number of burrow openings*	
Main Entrance	1.0 ±0
Emergency openings	1.0 ±0
Number of soil plugging*	
External	NIL
Internal	NIL
Number of blind alleys*	1.2 ±0.4 (1.0-2.0)
Number of food chambers*	NIL
Number of brood chambers*	2
Diameter of the brood chambers	13.2 ±3.4 (6.0-16.5)
Male*	1.0 ±0
Female*	1.0 ±0
Litter*	3.6 ±1.9 (1.0-7.0)

Values in parentheses indicate range
*Values are not measurements

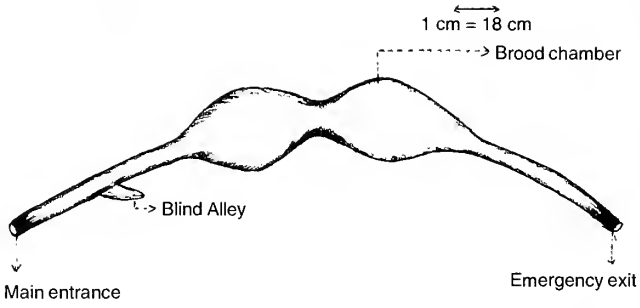

Fig. 1: Burrow structure of *Golunda ellioti*

Results and discussion

The burrows of rodents provide a relatively stable microclimate, suitable breeding site and protection from weather extremes and predators. Burrows and their structure (length, depth and diameter) depend upon the species' biological requirements and soil properties like texture, moisture, aeration and chemical composition (Parshad and Tripathi 2004). According to Parshad and Tripathi (2004), rodents dig elongated, deep, and complex burrows in clay and loamy soils, which persist for longer periods whereas, burrows in sandy soils are less deep and complex because of the limited stability and integrity of their tunnels and chambers.

Burrows of *G. ellioti* were observed in the barren lands to agricultural fields with crops of groundnut (*Arachis hypogea*) and red gram (*Cajanus cajan*). The burrow system of *G. ellioti* was simple and characterized by the absence of heap of soil and its entrance always remained open (Fig. 1). The number of burrow openings per burrow system was two. Similar descriptions have been made for *G. ellioti* by Prater (1971). The main burrow entrance diameter of *G. ellioti* ranged from 4.5 to 13.0 cm with a mean (± S.D) of 8.3 ±2.4 cm. The mean emergency burrow entrance diameter of *G. ellioti* was found to be 5.8 ±1.3 cm (Table 1).

G. ellioti digs its burrow at the ground level. The mean (± SD) vertical depth of burrows of *G. ellioti* was

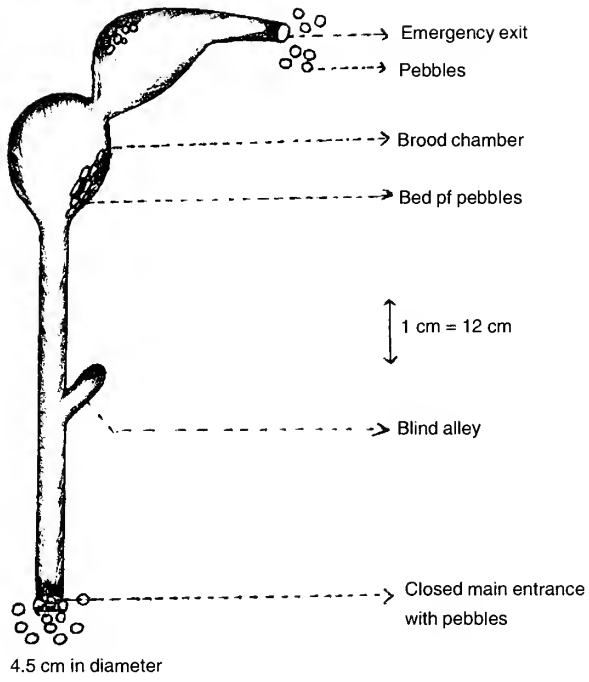

Fig. 2: Burrow structure of *Mus platythrix*

46.8 ±25.3 cm. The mean horizontal length of burrow system was 56.4 ±37.1 cm. There was no external and internal soil plugging in the burrow system of *G. ellioti*. It is generally observed that the mean number of blind alleys in a burrow of *G. ellioti* was 1.2 ±0.4 (Table 1). Food chambers and food hoarding behaviour were not observed in the burrows of *G. ellioti*. Earlier, Barnett and Prakash (1975), and Prakash and Mathur (1987) described the burrows of this species as simple.

Invariably all the burrows (n = 40) excavated had two brood chambers. The mean diameter of the brood chambers was found to be 13.2 ±3.4 cm. The mean number of individuals in a burrow was one male, one female and 3.6 ±1.9 litters for *G. ellioti*. Further, a study on the diet of *G. ellioti* is required to conclude whether this species is a pest of agricultural crops or not.

The Brown Spiny Mouse *Mus platythrix* had a unique pattern of burrow entrance. The burrow entrance of *M. platythrix* had a small to medium quantity of heap of more or less uniform sized pebbles (Fig. 2). Prater (1971), and Soni and Idris (2005) also describe the presence of the heap of pebbles at the burrow entrances of *M. platythrix*. Besides, the burrows of this species were located in the barren lands near to agricultural lands. Parshad and Tripathi (2004) reported the occurrence of *M. platythrix* burrows in sandy and gravel plains. This rodent species closes its burrow entrance after entering. This is in confirmation of earlier descriptions of Prater (1971). The observed behaviour of this rodent pest might be to prevent the entry of predators.

M. platythrix burrows had two openings. To confirm the presence of animals in burrows with closed entrances, the burrow entrances were excavated (n=18) and an occupant (*M. platythrix*, n=18) was present in all of them. Thus, it is inferred that the burrow entrances of the *M. platythrix* are highly species-specific. Further, with the help of this key one can identify the occupant *M. platythrix* under field conditions.

The burrow system of *M. platythrix* was simple. In general, the burrow system of *M. platythrix* had an entrance hole and an emergency opening. The mean (± SD) diameter of main and emergency burrow entrance of *M. platythrix* was 6.9 ±1.4 cm and 5.6 ±0.9 cm, respectively. Mean vertical depth of burrows of *M. platythrix* was 36.9 ±24.1 cm. The mean horizontal length of burrow systems was 76 ±43 cm. The number of external and internal soil pluggings in the burrow system of *M. platythrix* was 1 (n=15) and 2 (n=3) respectively. We observed mean number of blind alleys in a burrow of *M. platythrix* was 1.4 ±0.06. Food chambers and

Table 2: Morphometric measurements (cm) and other characteristics of burrows of *Mus platythrix* (n = 18)

Parameters	Mean ±S.D.
Main burrow entrance diameter	6.9 ±1.4
	(5.0-9.5)
Emergency burrow entrance diameter	5.6 ±0.9
	(4.0-7.5)
Vertical depth of the burrow from the ground level	36.9 ±24.1
	(17.0-92.0)
Horizontal width of burrow	76.0 ±43.0
	(22.0-183.5)
Number of burrow openings*	
Main Entrance	1.0 ±0
Emergency openings	1.0 ±0
Number of soil plugging*	
External	1.0 ±0
	(n=15)
Internal	2.0 ±0
	(n=3)
Number of blind alleys*	1.4 ±0.06
	(1.0-3.0)
Number of food chambers*	NIL
Number of Brood chambers*	1.3 ±0.5
	(1.0-2.0)
Diameter of the Brood chambers	12.1 ±2.2
	(9.5-20.0)
Male*	1.1 ±0.3
	(1.0-2.0)
Female*	1.0 ±0
Litter*	3.0 ±2.1
	(1.0-6.0)

Values in parentheses indicate range
*Values are not measurements

food hoarding behaviour was not observed in the burrows of *M. platythrix* (Table 2).

Burrows of *M. platythrix* had one to two brood chambers (1.3 ±0.5). The mean diameter of the brood chambers was 12.1 ±2.2 cm. The brood chambers were furnished with a bed of pebbles. The present observation is in accordance with the report of Prater (1971). The mean number of individuals in a burrow was 1.1 ±0.3 (male), 1 ±0 (Female), and 3 ±2.1 (litter).

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3. DISTRIBUTION AND STATUS OF THE WILD WATER BUFFALO *BUBALUS ARNEE* IN BHUTAN

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The Asiatic Wild Water Buffalo *Bubalus arnee* Kerr (*bubalis* Linn.), henceforth Wild Water Buffalo, is a globally threatened species and has been listed as 'Endangered' (IUCN 2007). Once widespread over large parts of South and South-east Asia, this rare bovine is now mainly confined to north-eastern India with small numbers in Nepal and Indo-China (Corbet and Hill 1992; Choudhury 1994). The occurrence in southern Bhutan has been mentioned by Blower (1986), Choudhury (1994) and Wangchuk *et al.* (2004).

I had visited parts of southern Bhutan since October 1985 (not frequently); from September 2004 to June 2007, I made frequent visits as part of my official work as Deputy Commissioner of Baksa district in Assam (having common border with Bhutan). During these visits, I had the opportunity to observe wild buffaloes. In this note, the distribution, habitat and status of the wild water buffalo in Bhutan have been discussed.

Bhutan being mountainous does not have much habitat for the Wild Water Buffalo, which requires grassland with water bodies, preferably on flat terrain. Owing to its occurrence in the Manas National Park in Assam, India (Gee 1964; Choudhury 1994), which is located on the international boundary, there was always chance of animals' crossing over. The observations made so far indicates that there are nine areas in Bhutan where the Wild Water Buffalo is still seen or seen till the recent past. These are: (1) Gabhorukunda (Gobarkanda) (26° 46'-48' N; 90°49-53' E), (it is not a point location but a stretch of grassy area) (2) Mathanguri (Matharguri) (26° 47' N; 90° 58' E), (3) Nunmati (26° 47' N; 90° 59'E), (4) Rabang nullah (26° 49' N; 91° 04' E), (5) East of Doimari (26° 49' N; 91° 06' E), (6) Kukulong (26° 47' N; 90° 45' E), (7) Kalamati (26° 47' N; 90° 40' E), (8) Saralbhanga (26° 52' N; 90° 15' E) and (9) Jamduar (26° 44' N; 89° 52' E).

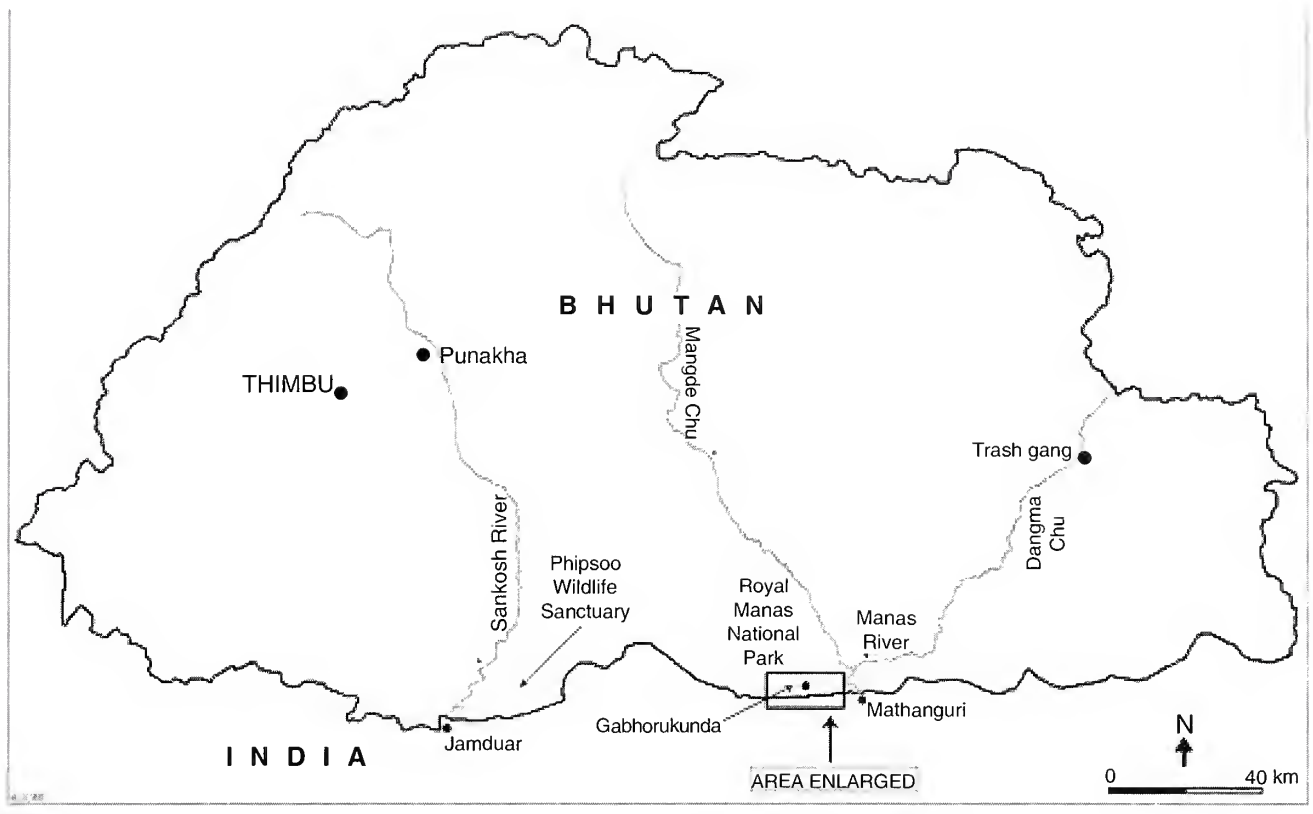

Fig. 1: Map of Bhutan showing the main features and the places mentioned in the text

Blower (1986) saw a small herd in Gabhorukunda area in September 1985. During my several visits to Gabhorukunda in 2006 and 2007, I saw footprints of lone bulls as well as small herds. The Forest Department staff and conservation volunteers of Assam's Manas National Park had reportedly observed several lone bulls and 2-3 herds totalling 20-30 animals during the same period. A census operation carried out jointly by the Project Tiger authorities and Rhino Foundation for Nature in NE India (NGO) on April 16-17, 2008, had counted 32 animals in three herds in Gabhorukunda area on the Indian side (Choudhury *et al.* 2008). Although the Bhutan side of Gabhorukunda was outside the purview of census operation, bulk of the area was visible and no buffalo could be seen. On the Bhutan side of Gabhorukunda, the animals mostly go for water as water bodies are limited in this Bhabar tract. There is water in the river only at the spot where it debouched onto the flat ground and the buffaloes visit the site normally after sunset. Daytime sightings are rare. The local reports by Forest staff and old hunters indicated that during the disturbed period in Manas for a decade from 1989 onwards (Choudhury 1989, 2006), many buffaloes were killed by poachers in Gabhorukunda area; the animals still avoid the wide open area with no cover during daytime. The animals also graze along the left bank of the River Gabhorukunda up to River Suidener, and also early in the morning or after dusk in some areas of the bed where there is grass. This is by far the only habitat of the Wild Buffalo in Bhutan.

At Mathanguri, I had observed a bull on the banks of River Manas in October 1985. Subsequently, one small herd (up to 14 animals) was also sighted on several occasions, besides lone bulls (up to two), in the same area crossing the border to Bhutan only to come back. I observed a small herd of seven animals' at the border on March 09, 2007. Since early 1990s, a buffalo *khuti* (*khuti*=camp) came to the Bhutan side of Mathanguri with several domestic female buffaloes. This prompted a large lone bull to regularly visit the camp everyday. Occasionally one more bull would come nearby, but only one remained with the cows in the *khuti*. This bull is perhaps the only wild buffalo that actually spends bulk of its time inside Bhutan territory.

'Nunmati' is a salt lick towards east of Mathanguri just north of the India-Bhutan international boundary. This was a favourite spot for the Indian One-horned Rhinoceros *Rhinoceros unicornis* till early 1990s when bulk of these pachyderms were eliminated by the poachers from Manas. Lone bulls as well as small herds of wild buffaloes regularly

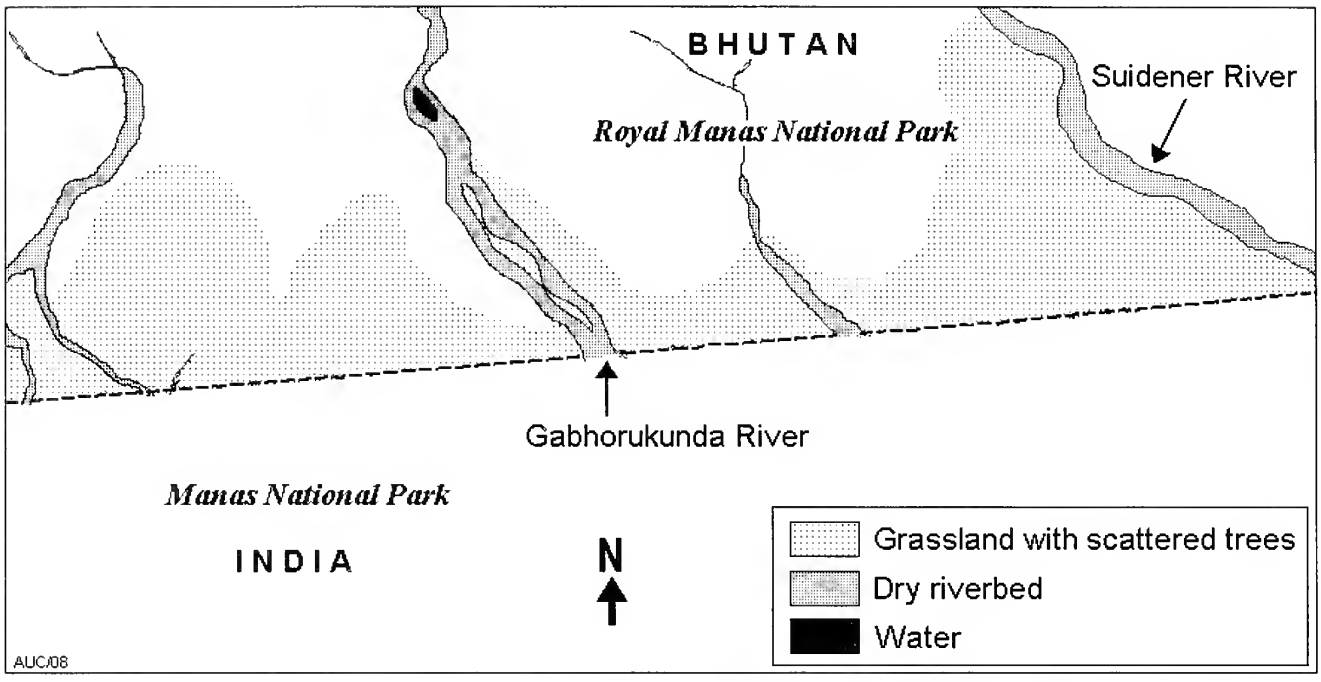

Fig. 2: Gabhorukunda (Gobarkanda) area is the main habitat of Wild Buffalo in Bhutan

visit the site. In fact, they just cross over to Bhutan to the lick and come back.

At Rabang nullah, there is grass on the bed of the river where an occasional animal is seen. Footprints of lone animals were seen in 2006-07 within a kilometre inside Bhutan. Similarly, towards east of Doimari, the animals are occasional visitors although here a patch of grassland is found where till early 1990s, even small herds used to visit.

Towards west of Gabhorukunda there are small tracts of grassland interspersed with trees up to Kukulong river. There is a linear patch along the left bank of Kukolong river, which is occasionally visited by buffaloes. Farther west is another site of salty earth called 'Kalamati' on the Kanamakra river. The buffalo is an occasional visitor to the area, which is on the border.

Farther west, there was no significant grassland till the Saralbhanga and Sankosh rivers. The site where the Saralbhanga river debouches into the plains had some grassland, which, however, is now under human occupation and a township in the form of Sarpang – a district headquarter, has come up in the area. Just south is the border with India where also a large human settlement (Saralpara Forest Village) came up. It was here, i.e, at the international boundary, that three Wild Water Buffaloes out of a herd of six were hunted down by a *shikar* party of the then ruler of Cooch Behar on March 07, 1900 (The Maharajah of Cooch Behar 1908). On the Bhutan side near Jamduar in Assam, the wild buffalo is no longer found (also in Assam area). The last animals were recorded in 1970s. The animals used to cross over for short distance inside Bhutan, just north and north-east of Jamduar and occasionally crossing the river towards Kalikhola.

From the above it is clear that Bhutan does not have a resident population of Wild Water Buffaloes, mainly because of its limited habitat. However, more than 30 animals could be inside Bhutan at any time (e.g., Gabhorukunda). Till 1989, the local staff and old hunters reported that the number often exceeded 50 when several herds used to loosely congregate for water and grazing. The daily range of the herds and lone bulls that occur in Bhutan spreads over both sides of the border.

The total grassland habitat available for the animal inside Bhutan is little over 10 sq. km (Fig. 1). Bulk of the grassland is located around Gabhorukunda area (Fig. 2). All but two locations are inside Royal Manas National Park while the area near Jamduar is a part of Phipsoo Wildlife Sanctuary.

Poaching for meat was the main reason for killing of Wild Water Buffalo since 1989 (Choudhury 1989, 2006) and the situation worsened when the anti-poaching camp at Gabhorukunda on Assam side was abandoned by staff due to attack by underground extremists. An unspecified number of buffaloes were killed in Gabhorukunda area (both sides of the border) and meat was sold in the markets often mixed up with deer meat (as latter fetches more money).

Situation has improved a lot in Assam's Manas

National Park and there was no significant poaching of buffalo since 2004. On Bhutan side, patrolling has started in recent years thus providing some security. A well-equipped and active anti-poaching camp at Gabhorukunda on the Bhutan side is strongly recommended, which should not be near the water spot (to avoid disturbance to the animals) so that in future the wild buffaloes can be seen again in large herds during daytime coming to the waterbody.

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4. TWO NEW RECORDS OF DISTRIBUTION OF FOUR-HORNED ANTELOPE *TETRACERUS QUADRICORNIS*

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The Four-horned Antelope or Chowsingha *Tetracerus quadricornis* is a lesser known antelope endemic to the Indian subcontinent (Krishna *et al.* 2008), and is one of the six antelope species found in India (Rahmani 2001). It is listed under Schedule I of the Wildlife Protection Act, 1972, and also declared as Vulnerable under the IUCN Red list (IUCN 2008). Rice (1991) carried out a questionnaire survey to assess its range and distribution, and reported the species from 83 sites in India. Further, in a literature review Krishna *et al.* (2009) report it from 104 sites from India. Another study by Sharma (2006) reports the distribution of Four-horned Antelope from 122 sites. Within Karnataka, it was already confirmed to be found in Nagarahole, Bandipur, Biligiri Rangaswamy Temple sanctuaries and other areas (Karanth 1986; Karanth and Nichols 2000; Sharma 2006; Krishna *et al.* 2008). Here we present two observations of the Four-horned Antelope from areas where it is not reported in previous literature (Karanth 1986; Rice 1991; Karanth and Nichols 2000; Sharma 2006; Krishna *et al.* 2009) in the state of Karnataka.

The first observation is from Jogimatti Reserve Forest (JRF) (14° 9' 53" N; 76° 24' 54" E, 107.18 sq. km) in Chitradurga district and the second report is from Rangayyanadurga State Forest (RSF) (14° 39' 30" N; 76° 10' 10" E, 77.23 sq. km) in Davanagere district. Both the locations fall in southern Karnataka and are dominated by tropical dry deciduous and thorny open scrub forests.

At JRF an individual was seen and was clearly identified by us by its body colour, size and behaviour. The animal had a dull reddish-brown colour above and was white below. The white rings above hooves were distinct. We observed the animal for about thirty minutes from an adjacent small hillock. The animal initially in an open patch moved into thickets browsing on leaves of short shrubs. The animal would move continuously and not be stationary. Our previous field knowledge and observations of Four-horned Antelope helped in identifying the animal and distinguish it from the Barking deer *Muntiacus muntjak* with which it is generally mistaken. The animal was later confirmed by referring to Prater (1998).

At RSF, droppings of Four-horned Antelope were seen and distinguished by its oblong shape and heaped middens. The locals identified the droppings as belonging to '*Kondu kuri*', Kannada name for Four-horned Antelope. The droppings were small and elongated, and were likely of the Four-horned Antelope. Extensive interactions with locals and forest department staff confirmed the absence of Chinkara (*Gazella gazella*) and Barking deer in the area. The middens were found in scantily forested habitat. During another visit, a midden with droppings of two distinct sizes, possibly belonging to an adult and a juvenile Four-horned Antelope, was observed at RSF. Due to its undulating terrain, the area is unlikely to support Blackbuck that need open grasslands and avoid thick cover (Jhala 1993, 1997). A few days later the second author, along with another wildlife enthusiast witnessed an individual Four-horned Antelope that had strayed into a village, confirming the presence of Four-horned Antelope at RSF. These sightings contribute towards the distribution knowledge of this species.

Changes in habitat and invasive plant species, especially Lantana *Lantana camara* can affect the presence of Four-horned Antelope (Krishna *et al.* 2008). Four-horned Antelope is also reported to be hunted at other sites and in RSF. Protection from anthropogenic pressures, appropriate management of human-induced fire and forest-extraction activities could all be critical for conservation of this species (Sharma 2006; Krishna *et al.* 2008).

The isolated reserved forests of Karnataka are fast being degraded by developmental activities, especially wind farms. Hence, these areas need to be conserved if species such as Four-horned Antelope are to be protected on long-term basis, and both these locations have potential for sustaining small populations. However, JRF is already fragmented due to installation of 118 wind turbines. Wind farms alter wildlife habitats through linear fragmentation, such as roads, electric lines, increased human movement and noise pollution (Abbasi and Abbasi 2000). Loss and fragmentation of habitats are known to be serious threats to Four-horned Antelope (Sharma 2006; Krishna *et al.* 2008). Though there is no documented evidence of direct impacts of wind turbines on Four-horned Antelope, the species being cryptic and shy (Sharma 2006) can be affected by noise of wind turbines and increased human activity.

In this background, it is more relevant that RSF is given the status of a wildlife sanctuary, as Protected Areas have greater prospect to protect threatened species (van Schaik *et al.* 2002; Hilborn *et al.* 2006). There are a few protected areas dedicated for the purpose of saving species of the drier plains, and this move could be a unique initiative in Karnataka.

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5. FIRST RECORD OF MERLIN *FALCO COLUMBARIUS PALLIDUS* FROM MAHARASHTRA, INDIA

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The Merlin *Falco columbarius* was first described by Linnaeus in 1758. The Merlin is a rare bird in India (Grimmett *et al.* 1998) and a rare winter migrant to north India (Naoroji 2006), but is classed globally as Least Concern (BirdLife International 2001).

There are two races of this species occurring in India: *insignis* and *pallidus* (Naoroji 2006). Both the races are rare winter visitors to northern India, specifically Jammu and Kashmir, Punjab, Rajasthan, Haryana, Gujarat, and Arunachal Pradesh (Naoroji 2006). Race *pallidus* is rarer than *insignis* (Naoroji 2006), reported as winter visitor to Jammu and Kashmir, passage migrant and scarce winter visitor to western and central Ladakh (Meinertzhagen 1927; Williams and Delany 1986; Mallon, 1987). It was observed in late August 2000 in the Nubra valley near Diskit on Hunda road and in Changthang between Demchok and Fukche in mid-August 2002 (Naoroji and Sangha 2004).

Little is known about the Merlin in the Subcontinent, except its famous hunting methods (Naoroji 2006). It has been described as a bold and dashing falcon inhabiting open country habitats (Grimmett *et al.* 1998).

We report here sighting of the Merlin, race *pallidus* (immature female), in an uninhabited open country just outside Bhimashankar Wildlife Sanctuary in Maharashtra. We were birding around that area on February 16, 2007, at 0930 hrs, and came across a small raptor perched on an electric pole, overlooking open scrub vegetation and a rocky terrain. We mistook the bird for a Common Kestrel, till we noticed a pale collar on the hind neck and buff bars on the uppertail. We noticed it scanning the area, sometimes bobbing the head up and down, disturbed by our presence it shifted its perch and flew to another electric pole.

The habitat here was mostly scrub vegetation, there were many rocks and a few clumps of grass. There were electric wires over this patch of open land, which served as a perch for many birds of prey.

This is the first record of the Merlin from Maharashtra. We can only speculate whether it was a vagrant, a passage migrant or a resident. But it is sure that some sincere work needs to be done on the raptors of Bhimashankar to ensure their long term survival.

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6. BROAD-BILLED SANDPIPER *LIMICOLA FALCINELLUS*: AN ADDITION TO THE AVIFAUNA OF INDIA'S WESTERN SEABOARD, SOUTH OF JAMNAGAR AREA

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The tide was coming in at 1000 hrs on November 29, 2008, at the Sewri waterfront leaving only a football sized area in front of the Colgate factory above water. The muddy area was packed with small waders of all types, i.e., stints, plovers, sandpipers. As I scanned the area with my spotting scope (85 mm objective and 40x eyepiece) I noticed two birds, one of which I identified positively as a Curlew Sandpiper *Calidris ferruginea* and another which looked like a smaller version of the Curlew Sandpiper. Both the birds were feeding actively and with almost identical pecking action. On continued observation it was evident that the smaller bird was a different species, probably a Dunlin *Calidris alpina* or a Broad-billed Sandpiper *Limicola falcinellus*, the latter having never been identified positively by me before. I saw numerous such pairs cross my field of view through the spotting scope. Viewed with binoculars (8 x 40) I could see the smaller version of the Curlew Sandpiper spread over a large area, numbering several dozens, but impossible to judge accurately, given the high density of small waders moving and feeding actively before the tide submerged the remaining visible ground.

The terminal kink in the bill was well-appreciated in profile, as also it's prominent white supercilium; the split supercilium could not be appreciated in the field as it was camouflaged by the apparent striped pattern of the crown. The split supercilium was clearly evident in the images captured, when viewed magnified. A streaked breast band was present. The belly and flanks were white.

The Broad-billed Sandpiper has not been reported in literature or documented from Mumbai (Varma *et al.* 2004) or Maharashtra in the recent past. Some authors consider it as an occasional winter passage migrant (Grimmett *et al.* 1999; Kazmierczak and van Perlo 2006) while others list it as a winter visitor (Hayman *et al.* 1986; Rasmussen and Anderton 2005) along the entire western seaboard. Search of the ENVIS database showed two reports of sightings from different parts of India (Balachandran and Natarajan 1997; Sangha and Kulshretha 2004). The OBI (orientalbirdimages.org) database had images of the bird from Jamnagar. The migratory pattern of this bird is also not well understood (Gavrilov *et al.* 1995).

An interesting finding of site fidelity (Balachandran and Natarajan 1997) among this species mandates a more thorough search for this bird in Sewri and other suitable nearby sites in late November and early December. This will also help settle the question whether this species is a passage migrant or a winter visitor to Mumbai and India's western seaboard or a combination thereof.

Possible reasons for the scarcity of reports of its sighting are: 1) low degree of awareness / suspicion 2) difficulty in field identification 3) low number of birds 4) visits of a nature of passage migrants rather than winter residents 5) confusion with other species of small waders 6) Paucity of observers and suitable photo documentation equipment.

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7. HIGH-ALTITUDE RECORDS OF THE HOUSE CROW *CORVUS SPLENDENS* IN WESTERN ARUNACHAL PRADESH, INDIA

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In October and November 2008, we observed House Crows *Corvus splendens* at high altitudes on several occasions in different sites of western Arunachal Pradesh, India. The species was recorded in the Lumpo village (27° 43' 07.2" N; 91° 42' 57.7" E) at 2,544 m in a pair, then a single individual near Geypo-Namse lake of Bangajang wetland complex (27° 30' 02.8" N; 92° 01' 45.9" E) at 4,230 m of Tawang district and other single sightings were recorded from Thungri area (27° 26' 50.3" N; 92° 22' 44.6" E) at 3,190 m, Potak area near Chomu lake (27° 37' 19.4" N; 92° 22' 07.7" E) at 4,374 m of West Kameng district of Arunachal Pradesh, India, which are probably among the highest altitude record for this species.

According to Kazmierczak and van Perlo (2000) the species is chiefly found below 1,600 m but sometimes up to 2,400 m. Grimmett *et al.* (1998) noted it occurs up to 2,100 m in India and up to 2,500 m in summer in Bhutan. In Nepal, it is found below 1,525 m, with only one report from a higher altitude: 2,100 m at Nagarkot on February 09, 1993 (Inskipp and Inskipp 1991). In Sikkim, an individual was recorded by F.N. Betts at 2,600 m in May 1943 (Ali 1962). Sangha and Naoroji (2003) recorded the species from human settlements of Koksar at 3,200 m and Dracha at 3,370 m of Himachal Pradesh and from Karu and Hanle of Ladakh at *c.* 3,500 m and 4,240 m respectively, which was previously reported to be the highest altitude record of House Crows.

Like the House Sparrow *Passer domesticus*, the House Crow is a commensal species. Increased tourism, development of permanent army camps and exploration of new grazing sites in different high altitude areas of Arunachal Pradesh seems to have facilitated its spread to higher areas recently. Additional observations on the sighting of the species in such altitudes would be useful to understand: i) whether it is a more common distributional pattern than has been previously observed and ii) the contribution of the species in high altitude ecosystems.

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8. STATUS AND CONSERVATION OF BRISTLED GRASSBIRD *CHAETORNIS STRIATA* IN CORBETT NATIONAL PARK

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Bristled Grassbird *Chaetornis striata* is one of the largest warblers of the world and a globally-threatened species with IUCN status Vulnerable. It occurs rather erratically throughout a range that encompasses lowland Pakistan, much of India, the Nepal terai and historically Bangladesh (BirdLife International 2001). It is a resident species and distributed over most of the Indian subcontinent, but is very local in its occurrence (Ali and Ripley 1997). The rare endemic appears to be closely tied to swampy areas (Roberts 1992). Historical records indicate that the species was fairly common, but it

seems to have declined drastically in recent years (Inskipp 1996). There is very little information available about its status, ecology and behaviour (Baral 1997). The species has recent records from India and Nepal only (Grimmett *et al.* 1998). This grassland specialist has a small, rapidly declining population owing to loss and degradation of its habitat, primarily drainage and conversion to agriculture (BirdLife International 2001). The bird is very secretive in its habits and difficult to both see and identify, outside the breeding season. During its breeding season, heat, non-accessibility and monsoon flooding in some sites has resulted in very few recent records (Baral 1997).

Status in Corbett National Park

I noticed the presence of this species for the first time in Corbett National Park on June 16, 2004, when four singing males were seen in the grassland close to Leed Khalia area near Dhikala. The males were singing from exposed perches and during flight display. There is, however, an earlier undated and anonymous record indicated in the comprehensive review in BirdLife International (2001) for the reserve.

During a survey conducted on June 14 and 15, 2006, at least 11 birds with a minimum of 6 singing males were seen, and another 5-6 birds were heard near the jeep track in a roughly 2 sq. km area; but from the calls and display it is estimated that probably 30-40 breeding pairs were present in 8-10 sq. km of grassland (Sharma 2007). During the same period Nayan Khanolkar collected a photographic record of the species for the first time from Corbett National Park.

On June 15 and 16, 2007, another survey was conducted at Dhikala grassland and at least 40 birds with a minimum of 27 singing males were counted. All the activity was found in the grassland patches along Sher Bhuji road, and along the lower half of the Car road (towards Leed Khalia). On a subsequent survey, conducted on July 29 and 30, 2007, this population was found to be augmented by the presence of many juvenile birds. On May 22, 2008, a male was seen on the Car road close to Leed Khalia, and on June 15 and 16, 2008, in the same area, at least 8-10 birds with a minimum of 6 displaying males were observed.

Conservation

As a part of the grassland management policy, the Park authorities' burn or cut patches of grassland in January and February. There is no set pattern and in certain years the complete grassland is burnt, leaving no suitable habitat for grassland species. During 2000 and 2001, instead of burning or cutting, the Dhikala grassland was harrowed using tractors. This resulted in the degradation of grassland, loss of top soil and invasion of exotic species. For the last few years, large patches of grassland are being left uncut or unburnt for the benefit of various grassland-dependent species. The whole area is divided in various patches and these are alternatively cut, burnt and left alone over a three-year cycle. *Chaetornis striata* is an important indicator of grassland habitat. Any sudden change in the grassland management policy can alter the habitat, rendering it unsuitable for the breeding or occurrence of this grassland specialist. The numbers observed at Dhikala grassland indicate that the breeding population of Corbett National Park is the largest known population, recorded in recent times, of this globally-threatened species. The grassland management policy for Dhikala grassland should always be formulated by keeping in mind the habitat preferences of this species. For some unknown reason, in Dhikala grassland, the Bristled Grassbird prefers to breed in the grassland patches along Sher Bhuji road and along the lower half of Car road (towards Leed Khalia). The areas preferred for breeding by the species should not be cut or burnt during the same year. It is suggested to divide these areas into patches and burn these in a pattern that every patch is left unburnt for a period of at least three years. This will ensure sufficient habitat for the species during each successive breeding cycle.

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9. OCCURRENCE OF *SALEA ANAMALLAYANA* BEDDOME, 1878 IN HIGH WAVY MOUNTAINS, WESTERN GHATS, INDIA

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Two species of spiny lizards, *Salea horsfieldii* and *Salea anamallayana*, have been reported from the Western Ghats of south-western India. Unequal and strongly imbricate dorsal scales and compressed body distinguish these lizards from other agamids of the Western Ghats. The Anamalai Spiny Lizard, *S. anamallayana* could be distinguished from Nilgiri Spiny Lizard, *S. horsfieldii* based on the presence of a fold on the shoulder, and continuous nuchal and dorsal crest in males (Smith 1935). While *S. horsfieldii* is reported both from north and south of the Palghat gap, *S. anamallayana* is restricted to south of Palghat (Smith 1935). However, Bhupathy and Kannan (1997) suggested the need for further investigations to confirm the occurrence of *S. horsfieldii*south of Palghat.

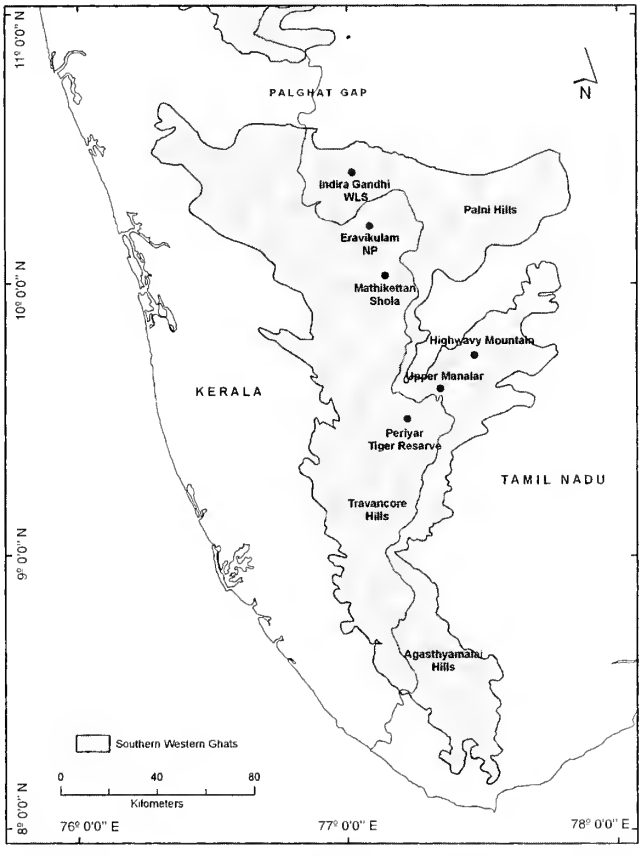

Fig. 1: Map of Southern Western Ghats, south-western India showing the locality records of *Salea anamallayana*

The Sálim Ali Centre for Ornithology and Natural History (SACON), Coimbatore is conducting ecological investigations on the herpetofauna of High Wavy Mountains, Theni Forest Division, Western Ghats since April 2006, and the following agamid lizards have been recorded; *Sitana ponticeriana*, *Calotes versicolor*, *C. calotes*, *C. grandisquamis*, *C. rouxii*, *C. elliotti* and *Psammophilus* sp. till December 2007. On April 20, 2007, while sampling in the Plateau of High Wavy Mountains, we came across an agamid lizard and it has been identified as a male *Salea anamallayana* based on the presence of unequal dorsal scales, fold on shoulder and continuous nuchal and dorsal crests. Snout-vent length and tail length of the lizard measured 40.2 mm and 60.3 mm respectively. Precise locality of this record is upper Manalar (9° 36' N; 77° 21' E), High Wavy Mountains, Western Ghats in Theni Forest Division, Tamil Nadu. This area (1,700 m above mean sea level) has remnants of evergreen forests, and is located on the border of Tamil Nadu and Kerala states. The boundary of Periyar Tiger Reserve, Kerala was in close vicinity (about 500 m) from the observation site of this agamid lizard.

It reported that *S. anamallayana* is restricted to the higher altitudes of the southern Western Ghats, especially in Anamalai, Palni (*Palani*) and Travancore Hills (Smith 1935). However, precise locality records for this species are scanty, which include Indira Gandhi Wildlife Sanctuary, Eravikulam National Park (Anamalai Hills), Mathikettan Shola and Mariyanshola in Palni Hills (Smith 1935; Bhupathy and

Kannan 1997; Bhupathy and Nixon 2004, Fig. 1). Even though, the present locality lies within the general Travancore Hills, it is perhaps, the only precise locality record available for this species south of Anamalai and Palni Hills, and is about 50 km (in straight line) from the nearest known site (i.e. Mathikettan shola). This record also indicates the possibility of the occurrence of *S. anamallayana* in Periyar Tiger Reserve, Kerala and on other hill tops such as Agasthiayamalai located further south. Further intensive surveys may yield new locality records and insights on the distribution pattern of this rare and endemic agamid species.

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10. RECORDS OF *ERYX JOHNII* (RUSSELL, 1801) (OPHIDIA: BOIDAE) AND *ECHIS CARINATUS* (SCHNEIDER, 1801) (OPHIDIA: VIPERIDAE) FROM THE THAR DESERT, RAJASTHAN, INDIA, WITH DISTRIBUTIONAL NOTES ON OTHER SNAKES

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During the course of a routine survey of the Thar Desert of Rajasthan, as a part of the assessment of impacts of the Indira Gandhi Nahar Project on biodiversity, two snakes, *Eryx johnii* and *Echis carinatus*, were encountered. Indian Sand Boa *Eryx johnii* was observed at 2245 hrs on August 15, 2000, in an agricultural field near the Desert National Park (DNP) guest house at Sudansari, Jaisalmer. The venomous Saw-scaled Viper *Echis carinatus* was observed at 2150 hrs on August 17, 2000, in a hard rocky area with sparse vegetation, *c.* 8 km towards Barmer on the road from Jaisalmer. The subspecies status of this reptile was not determined, i.e., whether the snake was *Echis carinatus carinatus* or *Echis carinatus sochureki* (some taxonomists consider the two to be distinct species – *Echis carinatus* and *Echis sochureki*).

A marked difference in behaviour was observed between the two species. The Indian Sand Boa on being disturbed was not aggressive, instead it tried to escape. The Saw-scaled Viper on the other hand, adopted a defensive posture.

Both the snake species have been reported to occur throughout the dry arid regions of India. The Thar Desert covers 13 districts of western Rajasthan. So far, a total of 20 snake species have been reported from the Thar Desert (Sharma 1996; Bhide *et al.* 2004). However, a look at their district-wise distribution reveals that they are not uniformly distributed. Maximum concentration occurs in Jodhpur district (15 species), while not a single species has been reported from Barmer, Churu, Ganganagar, Hanumangarh, Jalore and Jhunjhunu districts. In our opinion, as all the 13 districts of western Rajasthan lie within the Thar Desert and have similar environmental conditions, 60-70% of the snake species recorded in the Thar Desert may be present in all the districts. The present status of report may be due to the biased nature of earlier surveys. Thus, there exists plenty of scope in the distributional study of snakes within all 13 districts of the Thar Desert.

Previously, the Indian Sand Boa has been reported from two districts and the Saw-scaled Viper from five districts of western Rajasthan (Table 1). The present report adds to the existing knowledge of distribution of snake fauna in Jaisalmer district of the Thar Desert, Rajasthan, India.

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Table 1: Status of Snake fauna in the Thar Desert of Rajasthan

SN	Common name	Scientific name	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Brahminy Blind Snake	*Ramphotyphlops braminus*		+							+				
2.	Rough-tailed Sand Boa	*Gongylophis conicus*									+		+		
3.	Indian Sand Boa	*Eryx johnii*		+				*			+				
4.	Trinket Snake	*Coelognathus helena*													+
5.	Oriental Rat Snake	*Ptyas mucosa*									+		+		
6.	Hardwicke's Rat Snake	*Platyceps ventromaculatus*		+				+			+				
7.	Diadem Snake	*Spalerosophis diadema*									+	+			
8.	Royal Snake	*Spalerosophis atriceps*										+			
9.	Red-spotted Royal Snake	*Spalerosophis arenarius*		+							+				
10.	Sind Longnose Sand Snake	*Lytorhynchus paradoxus*												+	
11.	Indian Wolf Snake	*Lycodon aulicus*									+				
12.	Asiatic Water Snake	*Xenochrophis piscator*									+		+		+
13.	Lead Keelback	*Macropisthodon plumbicolor*													+
14.	Indian Gamma Snake	*Boiga trigonata*									+				
15.	Schokari Sand Racer	*Psammophis schokari*		+							+				
16.	Green Whip Snake	*Ahaetulla nasuta*													+
17.	Indian Krait	*Bungarus caeruleus*		+				+			+				
18.	Indian Cobra	*Naja naja*						+			+				
19.	Russell's Viper	*Daboia russelii*									+				
20.	Saw-scaled Viper	*Echis carinatus*		+				*			+	+	+		+

1 - Barmer; 2 - Bikaner; 3 - Churu; 4 - Ganganagar; 5 - Hanumangarh; 6 - Jaisalmer; 7 - Jalore; 8 - Jhunjhunu; 9 - Jodhpur; 10 - Nagaur; 11 - Pali; 12 - Sikar; 13 - Sirohi; '+' - Earlier record; '*' - Present record

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11. HARDWICK'S SPINY-TAILED LIZARD (*UROMASTYX HARDWICKII*, GRAY 1827) PREYED ON BY INDIAN SAND BOA (*ERYX JOHNII*, RUSSELL 1801)

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The Narayan Sarowar Sanctuary (NSS) is located (23° 27'-23° 42' N; 68° 30'-68° 57' E) in the westernmost part of the Kachchh district of the Gujarat State, India. NSS is a unique arid thorn forest ecosystem of the country which supports 15 threatened species of wildlife belonging to Schedule I of the Wildlife (Protection) Act, 1972 (Singh 2001). In which, a lizard *Uromastyx hardwickii* is found locally common (Vyas 2002) and is also categorized as Vulnerable (Molur and Walker 1998).

A recent observation of *Eryx johnii* predating on *U. hardwickii* was observed at NSS on September 10, 2008, at 0940 hrs in the reserve forest (Grassland) of Bhojpur village

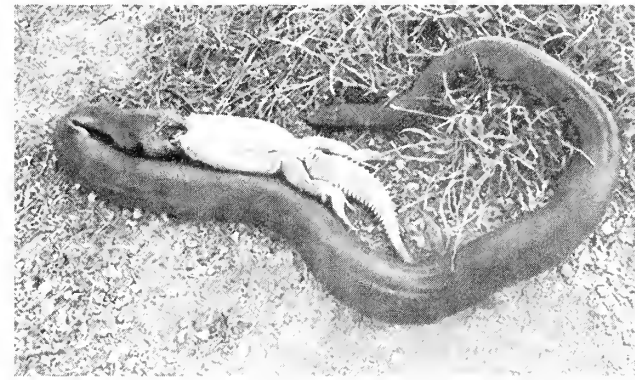

Fig. 1: *Eryx johnii* holding *Uromastyx hardwickii* in its mouth

(Abdasa taluka). We sighted *Eryx johnii* with a *U. hardwickii* in its mouth (Fig. 1). In the beginning, I was unable to identify the lizard as only the head of the lizard was caught by the snake, and the rest of the body was inside the burrow. However, it was easily identified when the Sand Boa (*E. johnii*) threw out the entire body of the lizard. This act tired the *E. johnii* and it rested for 40-55 seconds. It then threw out the entire body, and ate the lizard in 12 minutes and moved off slowly under the bushes of *Prosopis juliflora.*

Since *E. johnii* and *U. hardwickii* are common species in the sanctuary, both species (prey and predator) were easily identified by sight.

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12. DISCUSSION ON THE SNAKE FAUNA OF GUJARAT STATE, WITH SOME NOTABLE RECORDS

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A literature survey indicates that the snake fauna of Gujarat State consists of 63 species and subspecies belonging to 41 genera and 8 families (Appendix 1) (Vyas 2000, 2006), indicating a diversified fauna. This richness and diversity of the snake fauna of the state is due to the diversity of habitat types in the state, from desert to moist deciduous forests, mudflats to mangrove forests and natural fresh water wetlands to saline gulfs. Gujarat is the place where all major hill complexes (from north to south: Aravali, Vindhya, Satpuda and Sahyadri) meet within relatively short distances. Such hill complexes and various types of habitat and microhabitats offer suitable habitat conditions for many living organisms, including snake species.

SNAKES OF INDIA – THE FIELD GUIDE by Whitaker and Captain (2004) covers a large number of species inhabiting India, and provides high quality illustrations, descriptions, and natural history with updated information of distribution of 157 snake species. In the book, the authors have not incorporated information on distribution of a few species of snakes, which have been recorded from Gujarat State, or have questioned the records of others.

In this paper, I enumerate records that are not incorporated in that publication or are incorporated as of doubtful occurrence in inhabiting the state.

1. *Grypotyphlops acutus* (Duméril & Bibron, 1844)

The published records of the species indicate that it is widely distributed in the state from Dangs (Daniel and Shull 1963), Navsari district (Navtad, Vansda National Park; Vyas 2004) in south Gujarat; Surendranagar district (Dhangadhra; Sharma 1982); Bhavnagar district (Bhavnagar) and Porbander district (Barda Wildlife Sanctuary) of Saurashtra (Vyas *et al.* 2000): Anand (Vallabh Vidhyanagar) and Ahmedabad (Gayen 1999: ZSI Reg. no 16.6.1920) of central Gujarat.

However, Whitaker and Captain (2004) show the distribution of the species as "south of the Ganges Basin and south of Rajasthan. Range extends west to Baroda and east to Calcutta". Emendation required in noting its distribution in entire Gujarat (except Kachchh).

2. *Uropeltis ellioti* (Gray, 1858)

The distribution of this species is restricted to the high hills of southern Dangs, south Gujarat. During the monsoons of 1987, I collected a number of specimens of the species at Sunset point of Saputara (20° 33' 58" N; 73° 44' 39" E) and Piplai Devi (Dangs) (Vyas 1988).

According to Whitaker and Captain (2004), this species is distributed in the Western Ghats, mostly to the south of Goa Gap, to Tirunelveli, with scattered records from Bengaluru, Gujarat, Maharashtra, and recently, from Madhya Pradesh (Panchmarhi), and also the Eastern Ghats up to Ganjam on the Andhra Pradesh-Orissa border. Here, an addition of Dangs, Gujarat State, is needed.

3. *Uropeltis macrolepis* (Peters, 1862)

I have been able to collect a 26.6 cm specimen of *U. macrolepis* along with *U. ellioti* from Sunset point of Saputara (20° 33' 58" N; 73° 44' 39" E), Dangs (Vyas and Jala 1988). This species was mentioned by Whitaker and Captain (2004), with the comment that 'the Dangs, Gujarat is probably the northern-most limit of its distribution'.

4. *Coelognathus helena monticollaris* (Schulz, 1992)

This subspecies is commonly found in the districts (Dangs, Surat, Nasari and Valsad) of south Gujarat (extreme

northern end of Western Ghats). Whitaker and Captain (2004) mentioned that it is distributed in Western Ghats (from Kerala, Tamil Nadu, Karnataka, Goa and Maharashtra) only.

5. *Platyceps ventromaculatus* (Gray, 1834)

According to Whitaker and Captain (2004), this species is distributed in the Indian states of Jammu & Kashmir, Rajasthan and Gujarat, where the accompanying map shows its distribution in the entire Gujarat state. I have found it only at Banaskanth (Jassor Wildlife Sanctuary) and Kachchh (Kachchh Desert Sanctuary) districts.

6. *Argyrogena fasciolata* (Shaw, 1802)

According to Whitaker and Captain (2004), this species is distributed throughout most of the peninsular plains (from Baroda to Gwalior) to the Himalayas. Unfortunately, the accompanying map does not show the distribution in Gujarat, where the species is abundant, and large size and numbers of specimens have been recorded from Bhavnagar (Vyas 1987) and Rajkot (Buch 1989) districts.

7. *Chrysopelea ornata* (Shaw, 1802)

This species has been recorded from three different locations of the State - Satpura (Dangs; Vyas 1990), Purna Wildlife Sanctuary (Dangs; Vyas 2000), and Rajkot (Buch 1999). However, Whitaker and Captain (2004) mentioned the distribution of the species from forested hills of the South-west, Bihar, Orissa, West Bengal, forest of north-east India with the possibility from Maharashtra and Gujarat.

8. *Lycodon flavomaculatus* (Wall, 1907)

Whitaker and Captain (2004) stated that the species record from Gujarat needs confirmation. Earlier, the species is recorded from Bhavnagar district (Bhavnagar City and Velavader National Park) (Vyas 1987; Vyas and Gadhvi 2003). Recently, a specimen was collected from Padra, Vadodara district and voucher specimen is available at the Museum of the Bombay Natural History Society, Mumbai (3434 BNHS).

9. *Macropisthodon plumbicolor* (Cantor, 1839)

The species distributional map indicates the species is distributed only in southern Gujarat (Whitaker and Captain 2004). The species is found in the state from Banaskantha (Jassore Wildlife Sanctuary – adjoining border of Rajasthan) to Valsad districts of south Gujarat. Also, Gayen (1999) reported the species from Ahmedabad on the basis of ZSI Reg. No. 19203.

10. *Boiga forsteni* (Duméril, Bibron & Duméril, 1854)

According to Whitaker and Captain (2004), the species is distributed in the Western Ghats from Gujarat to Kerala; Peninsular India – Ganges valley, Orissa, West Bengal and Uttarakhand. Unfortunately, the accompanying map does not show its occurrence in the State. In Gujarat, this species has been recorded from Dangs (Saputara), Panchmahal (Pavagadh), Junagadh (Girnar hills) and Banaskantha (Jassore hills). Also, recorded from Abu hills of Rajasthan (Daniel 1962, 2002).

11. *Calliophis melanurus* (Shaw, 1802)

The distribution is scattered throughout the State, being reported from the Dangs and Valsad districts of south Gujarat (Daniel and Shull 1963); Bhavnagar (Victoria Park and Hathab), Junagadh (Junagadh and Sasan) and Rajkot (Hingolgadh) districts in Saurashtra region. Whitaker and Captain (2004) mentioned its distribution in peninsular India with the comment 'not clearly known'. However, the accompanying map shows its distribution up to eastern Gujarat. I have never found the species from eastern Gujarat, and no records from the area are available till date.

12. *Naja oxiana* (Eichwald, 1831)

According to Whitaker and Captain (2004), the authentic records are from India: Jammu & Kashmir, Himachal Pradesh, and probably Punjab. Though reported from Rajasthan and Gujarat, these records need confirmation, as they were possibly black, pattern less forms of *Naja naja*. Records from Kachchh (Chhari Dhandh; Akhtar and Tiwari 1991) and Banaskantha districts (Dhanera: Vyas 1998), Gujarat. These require authentication.

13. *Trimeresurus gramineus* (Shaw, 1802)

According to Whitaker and Captain (2004), this species is distributed in the Western Ghats and its northernmost limit probably being the Dangs in Gujarat. However, I have been able to collect the species from Ratanmahal Wildlife Sanctuary, Dahod district further north from the known northern limits of the species. Also, the species occurs in dry deciduous forest areas of Chota Udaipur (Vadodara district) and Devgadh Bariya (Dahod district).

Whitaker (1978) supported the above distribution range and mentioned the species is distributed in the 'Hills of India below a line drawn from Calcutta (now Kolkata) (in West Bengal) to Baroda (= Vadodara) (in Gujarat)'.

I believe, providing a voucher specimen or photograph of specimen is essential for establishing an authentic record else the record is deemed and is not considered as valid. Without any concrete evidence the particular record is considered as "suspicious".

The above mentioned species are not incorporated unambiguously and some of the records are incorporated with a question of probability. This might be due to the lacuna of establishing authenticity of record by recorders in the form of deposition of voucher specimen. But, the record of species

(from particular areas) cannot always be rejected on the ground of missing voucher specimen. Because obtaining a voucher specimen (for museum) is not possible if the species is recorded from Protected Areas or is under legal protection. Most of the Indian herpetologists (especially taxonomists) acknowledge that obtaining permission for such a collection is not so easy, especially when work in the above situation is along typical Indian bureaucratic scenarios.

However, here I have tried to establish that the above discussed species are recorded from the state, and vouchers of some of the species (Appendix 2) are available at museum of the Bombay Natural History Society, Mumbai and Zoological Survey of India, Kolkata.

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Appendix 1

List of snake species recorded from Gujarat State, India

Family: Typhlopidae
1. *Ramphotyphlops braminus*
2. *Grypotyphlops acutus*
3. *Typhlops porrectus*

Family: Uropeltidae
4. *Uropeltis ellioti*
5. *Uropeltis macrolepis macrolepis*
6. *Uropeltis ocellatus**

Family: Boidae
7. *Gongylophis conicus*
8. *Eryx johnii johnii*

Family: Pythonidae
9. *Python molurus molurus*

Family: Acrochordiae
10. *Acrochordus granulatus*

Family: Colubridae
11. *Ahaetulla nasuta*
12. *Ahaetulla pulverulenta**
13. *Amphiesma stolatum*
14. *Argyrogena fasciolata*
15. *Atretium schistosum**
16. *Boiga forsteni*
17. *Boiga trigonata*
18. *Cerberus rynchops*
19. *Chrysopelea ornata*
20. *Platyceps ventromaculatus*
21. *Coronella brachyura*
22. *Dendrelaphis pictus**
23. *Dendrelaphis tristis*
24. *Elachistodon westermanni*
25. *Coelognathus helena helena*
26. *Coelognathus helena monticollaris*
27. *Gerarda prevostiana*
28. *Lycodon aulicus*
29. *Lycodon flavomaculatus*
30. *Lycodon striatus*
31. *Macropisthodon plumbicolor*
32. *Oligodon arnensis*
33. *Oligodon taeniolatus*
34. *Oligodon venustus**
35. *Psammophis condanarus**
36. *Psammophis leithii*
37. *Psammophis longifrons*
38. *Psammophis schokari**
39. *Ptyas mucosa*
40. *Sibynophis subpunctatus*
41. *Spalerosophis diadema*
42. *Xenochrophis piscator*

Family: Elapidae
43. *Bungarus caeruleus*
44. *Bungarus sindanus*
45. *Calliophis melanurus*
46. *Calliophis nigrescens*
47. *Naja naja*
48. *Naja oxiana**
49. *Ophiophagus hannah**

Family: Hydrophidae
50. *Enhydrina schistosa*
51. *Hydrophis caerulescens*
52. *Hydrophis cantoris*
53. *Hydrophis cyanocinctus*
54. *Hydrophis gracilis*
55. *Hydrophis lapemoides*
56. *Hydrophis mamillaris*
57. *Hydrophis spiralis*
58. *Lapemis curtus*
59. *Pelamis platura*

Family: Viperidae
60. *Daboia russelii*
61. *Echis carinatus*
62. *Echis carinatus sochurki*
63. *Trimeresurus gramineus*

*Species need confirmation

Appendix 2: List of some important snake specimens in the BNHS Collection

Species Name	*G. acutus*	*U. ellioti*	*U. macrolepis*	*P. ventromaculatus*	*A. fasciolata*	*C. ornata*	*L. flavomaculatus*	*M. plumbicolor*	*C. melanurus*
Museum Registration No.	BNHS 3226	BNHS 3430	BNHS 3431	BNHS 3406	BNHS 2253	BNHS 3433	BNHS 3433	BNHS 3436	BNHS 3435
Collection Locality	Purna WS, Dangs	Saputara, Dangs	Saputara, Dangs	Karja, JWS, Banaskantha	Old Port, Bhavnagar	Purna WS, Dangs	Padara, Vadodara	Jassore WS, Banaskantha	Victoria Park, Bhavnagar
Snout to Vent Length	62.39	25.50	27.50	70.50	144.50	56.50	35.50	24.50	23.00
Tail Length	0.70	0.90	0.50	27.00	25.50	21.00	7.20	3.70	2.80
Total Body Length	63.09	26.40	28.00	97.50	180.00	77.50	42.70	28.20	25.80
Number of Body Rows	28	17	15	19:19:15	18:23:21	15:17:14	17:17:15	23:25:17	13:13:13
Number of Ventrals	458	157	126	208	225	220	181	145	244
Number of Sub-caudals	-	6	8	98	92	128	60	40	28
Supralabials	-	-	-	9	8	10	9	7	6
Number of Scales Touching	-	-	-	5th & 6th	4th & 5th	4th, 5th & 6th	3rd, 4th & 5th	3rd & 4th	3rd & 4th
Infralabials	-	-	-	9	9	9	10	10	7
Sex	N.D.	N.D.	N.D.	Female	Female	Male	N.D.	Female	N.D.

G. acutus: Grypotyphlops acutus; U. ellioti: Uropeltis ellioti; U. macrolepis: Uropeltis macrolepis; P. ventromaculatus: Platyceps ventromaculatus; A. fasciolata: Argyrogena fasciolata; *C. ornata: Chrysopelea ornata; L. flavomaculatus: Lycodon flavomaculatus; M. plumbicolor: Macropisthodon plumbicolor; C. melanurus: Calliophis melanurus*

(measurements in cm; N.D. = Sex not determined; - = Value not taken)

13. OCCURRENCE OF WHITE SUCKERFISH *REMORINA ALBESCENS* ON THE SOUTH-EAST COAST OF INDIA

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Zoological Survey of India, Marine Biological Station, Chennai is maintaining a marine aquarium which is stocked with ornamental fishes brought by local fishermen from the Chennai Coast. During the first week of March 2006, a live White Sucker fish was brought which had not been collected earlier. It was alive for 25 days in the aquarium. After close observation, it was identified as *Remorina albescens*. This species was collected 15 km off the village Nochikuppam, Chennai (13° 06' N; 80° 18' E). *Remorina albescens* is generally called White Suckerfish because of its white colour. Perusal of literature shows that this species has not been reported from the East Coast of Peninsular India. Previously this species was caught at Thalayi, 50 miles north of Calicut (now Kozhikode) in the west coast of India by the Madras Fisheries Department. This is the first report of the species from the East Coast of India. The specimen has been included in the registered collections of the Marine Biological Station.

Material examined: 1 ex., 214 mm, SL F. 5226 ZSI/ MBS, Nochikuppam, Chennai, 06.iii.06.

[Class: Actinopterygii; Order: Perciformes; Suborder: Percoidei; Family: Echeneidae; Species: *Remorina albescens* (Temminck & Schlegel 1850); (Fig.1)]

Echeneis albescens Temminck & Schlegel, Fauna Japonica Pisces, Part 6, 1850, p. 272.

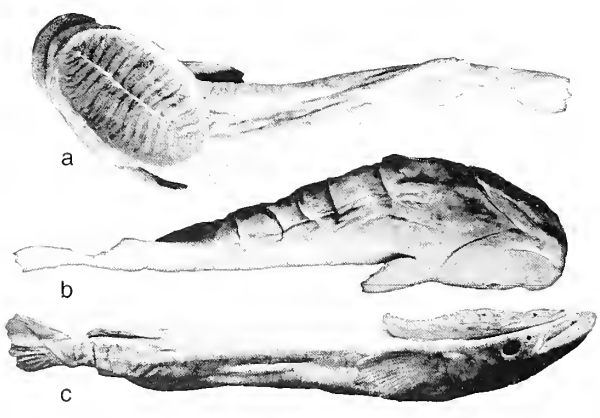

Fig. 1: *Remorina albescens* (Temminck & Schlegel 1850)
a. Ventral view; b. Dorsal view; c. Lateral view

Echeneis albescens Day, Fishes of India, Part II, 1876, p. 258.

Remorina albescens Maul, Bol. Mus. Municipal. Funchal. IX, Art 23, 1956, p.66.

Description: DI. 3; D2. 21; A. 20; P. 19; V. 1/.5; C. 15

Head: Head is rather long and flattened, its length 3.57, width 4.12, depth 8.23 in standard length (SL); head width 1.10, Head depth 2.19, Snout length 2.28, inter orbital width 1.16, width of sucker 1.16, length of sucker 0.79, sucker laminae 4.38 times in head length (HL).

Body: It is wide anteriorly with depth 9.30, width 4.76 in SL, pre-dorsal distance 1.38, pre pelvic distance 2.93, pre anal distance 1.34, caudal peduncle length 23.78 times in SL. **Colour**: Body is white and pectoral fin pale grey to white. *Remora* has no swim bladder and uses the sucking disc on the top of its head to obtain rides from other animals such as large sharks, and sea turtles. The sucking disk, developed from a transformed spinous dorsal fin, contains 16-20 transverse movable lamina which create a partial vaccuum permitting the *Remora* to obtain rides on the larger animals (Nelson 1984). The lower jaw projects past the upper jaw and the teeth, located in jaws and vomer are in a villiform patch, are pointed and recurved slightly inward. The morphological characters of *Remorina albescens* are given in Table 1.

The *Remorina* is a pelagic marine fish that is usually found in the warmer parts of most oceans clinging on to large sharks, sea turtles, bony fishes and marine mammals (Marshall 1965). Based on observations of the species in captivity (Bohlke and Chaplin 1993), *Remora remora* requires a swift passage of water over the gills and cannot survive in stagnant waters. The *Remorina* is not considered to be a parasite, despite it being attached to the host. Instead they are considered to have a commensal relationship with their host, since they do not hurt the host and just cling for the ride (McClane 1998). It has also been suggested (McClane 1998) that the relationship is symbiotic since the *Remorina* can obtain its food acting as a cleaner fish and removing parasites from the host, thus benefitting both. It is not known whether the Sharks tolerate the *Remorina's* presence or are just unable to catch them, but no *Remorina* has ever been found in a

Table 1: Morphological characters of *Remorina albescens*

Characters	Measurements (mm)
Total length	240
Standard length	214
Head length	57
Snout length	25
Inter-orbital width	49
Body depth	23
Sucker width	49
Sucker length	72
Sucker laminae	13
Predorsal distance	155
Caudal peduncle length	9.0
Body width	45
Head width	52
Head depth	26
Pre pelvic distance	72
Pre anal distance	160

Shark's stomach (McClane 1998). Instead, some small specimens have been found in the inside of sharks mouth, clinging to the roof (McClane 1998).

Discussion: Day (1889) reported its occurrence in the seas of India, but no specimen has so far been reported from the East Coast. Kapoor *et al.* (2002) listed this species in fish biodiversity of India but he did not mention the exact location. Munro (2000) also reported this species in the coastal waters of Sri Lanka. Rajan (2003) studied the marine food fishes of Andaman and Nicobar Islands, but he did not record this species. Based on the study of the various morphometric and meristic characters this species was confirmed as *Remorina albescens* and based on the available literature it is observed that this species has not been reported from the East coast of India.

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14. SEXUAL DIMORPHISM IN 'SPOTTED SCAT' – *SCATOPHAGUS ARGUS* (LINNAEUS)

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Introduction

Sexual dimorphism is widespread in nature and can be influenced by sex-specific natural selection resulting from ecological differences between sexes (Reimchen and Nosil 2004) and it is an important component of the morphological variations in biological populations. Differences in the selective pressures experienced by the sexes can ultimately result in the evolution of sexual dimorphism of morphological traits (Andersson 1994).

Such studies are of great significance in taxonomy, bionomics, reproductive biology, unisex culture of fishes, hybridization experiments, hormonal sex control, identification of maturity stage, identification of hybrids, breeding season, induced breeding, seedling production technology and also in the observation of courtship and mating, mate selection and preference.

The study on sexual dimorphism has been carried out only in a very few species of fishes like *Puntius filamentosus* (Thobias 1974), *Tetraodon travancoricus* Hora & Nair (Inasu 1993), *Ompok bimaculatus* and *Horabagrus brachysoma*

Table 1: Average morphometric details of *S. argus*

Measurements (mm)	Average (mm)		Range (mm)	
	Male	Female	Male	Female
Total length	145.2	151.8	124-176	125-179
Maximum width	78.3	85.6	70-92	75-97
Eye diameter	10.5	10.9	10-11	10-12
Inter-orbital space	16.9	18.4	15-19	16-21
Caudal peduncle length	9.8	10.5	9.5-10.5	9.5-11.0
Head length	38.3	40.8	35-45	36-48
Total weight (gm)	82.8	97.3	51.5-126.2	57.8-168.7

(Molly and Inasu 1997), *Priacanthus hamrur* (Tessy and Inasu 1998) and *Leiognathus bevirostris* (Honey *et al.* 2005).

The present work deals with the sexual dimorphism of *Scatophagus argus* belonging to the Order Perciformes and Family Scatophagidae. It is commonly called 'argus fish', 'spotted scat', or 'butterfish'. This peaceful shoaling fish is distributed in the Indo-Pacific ocean and also inhabits natural embayment, salt and brackish estuaries, lower reaches of freshwater streams, frequently occurring among mangroves. They spawn in the neighbourhood of coral reefs but the young ones reach the river mouths and go back to the sea when they grow large. While young it makes a handsome aquarium fish (Talwar and Jhingran 1991). Even though brackish in nature, it easily acclimatizes in fresh water. On account of its food and ornamental value, *Scatophagus argus* is a potential fish for induced maturation and breeding technologies. So the study on sexual dimorphism is of great significance as it is a preliminary step to distinguish the gender.

Material and Methods

Two hundred and eighty-five adult specimens (males 163 and females 122) were collected in fresh condition during February to July 2005 from the estuarine region of Ernakulum in Kerala. They were sorted into various length groups. The colour pattern in sexes was noted in fresh condition itself before preserving them in 7% formalin for morphometry. Various measurements in mm namely, total length, head length, maximum width, caudal peduncle length, inter-orbital space and eye diameter were taken for each fish using a vernier caliper. The total weight (gm) for each fish also was recorded.

Result and Discussion

Even though the males and females *S. argus* look alike, a close observation and the morphometry showed the existence of sexual dimorphism (Tables 1 and 2). Females are larger and heavier than the males of the same length group. No female fish 110-119 mm long with a developing ovary was observed. At the same time 12 males with developing gonad were observed in this length group. Similarly no males were recorded in the highest size group 180-189 mm, as against 8 females. Most of the females were in ripe condition and a few, spent. Maximum number of males belonged to 120-129 mm size group.

S. argus males are more ornamental than females. Mature males acquire a pinkish hue on the body especially on the basal portion of second dorsal fin, anal fin and caudal fin whereas in females the base of above mentioned fins are tinched with a pale greenish blue colour. In females the tip of the ventral fin is black while in male such coloration is not noticed (photographic evidence provided).

In the bulls eye, *Priacanthus hamrur* (Tessy and Inasu 1998), and in a silver belly *Leiognathus brevirostris* (Honey *et al.* 2005) and in an inland catfish *Ompok bimaculatus* (Molly and Inasu 1997) the females have been found to dominate males in morphometric measurements. The large body size of female fish can be explained by the fecundity of the fish. Andersson (1994) reported that females tend to have

Table 2: Average length (mm) and weight (gm) of *S. argus*

Size group (mm)	Sample size		Avg. Lt. (mm)		Avg. Wt. (gm)	
	Male	Female	Male	Female	Male	Female
110-119	12	-	121.1	-	52.0	-
120-129	48	12	124.6	128.4	57.3	61.2
130-139	26	18	133.0	134.4	70.9	73.1
140-149	25	19	143.0	146.0	82.2	88.6
150-159	20	10	154.5	156.5	94.1	98.0
160-169	18	20	165.2	169.8	100.4	16.5
170-179	14	35	176.4	177.0	126.7	137.3
180-189	-	8	-	185.3	-	148.1

larger gonads than males with large energy rich eggs, whereas males have much smaller gonads that produce numerous relatively inexpensive sperm.

This study has focused on the ultimate explanations of the observed sexual dimorphism in *S. argus*, yet it would be interesting to further examine the proximate causes of these differences.

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15. MOTION CAMOUFLAGE AND SPINNING WHEELS

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Acharya (1961) and Worth (1962) noted the strange behaviour of dragonflies in relation to spinning bicycle wheels. Acharya (1961) noted that near a particular lake in Gujarat, up to 50 dragonflies of an undetermined species belonging to Anisoptera would fly parallel with the rear wheel of his bicycle, moving when he moved and stopping when he stopped. They would maintain their fixed position even in response to a burst of speed or sudden slowing.

Worth (1962) noted that South African dragonflies of the same suborder also maintained a constant position with respect to the spinning front wheel of his bicycle. He also mentioned that the dragonflies would keep pace with his feet when he walked along sunny trails.

I have on a few occasions had the same thing happen with the large dragonfly *Anax guttatus* (Burmeister) and the front wheel of my motorcycle, moving at 30 kmph in the Bhimtal valley in Uttarakhand. Once, one of these dragonflies accompanied me for about 200 m on a winding hill road. On another occasion I noticed the dragonfly by the flashing reflections of the evening sun off its wings, which looked very much like the light reflected from the spokes of spinning motorcycle or, indeed, bicycle wheels.

Both of the previous authors could not offer a satisfactory explanation. Acharya (1961) suggested that dragonflies are fun loving and constantly sport with each other. "Perhaps the habit of continuous movement may be responsible for the peculiar behaviour referred to above, being attracted by the moving wheels."

Worth (1962) suggested that dragonflies use hunting tactics similar to those used by Cattle Egrets, who attend large mammals in order to catch the insects disturbed and put to flight by these mammals.

Mizutani *et al.* (2003) throw more light on this matter. They suggest that dragonflies utilize motion camouflage as a means of catching highly manoeuvrable prey. In this, the dragonfly moves in such a way that it imitates the trajectory of a distant stationary object on the retina of its potential prey by maintaining a certain position in relation to the retina of the potential prey. This is achieved by precise flight control and positional sensing. That is if Acharya's and Worth's rear and front wheels respectively or my motorcycle's front wheel had retinas, they would have observed a stationary dragonfly while we, the riders, with a different trajectory, noticed and wondered about the moving dragonflies practising their inborn, so far unexplained, ability to appear motionless and, therefore, harmless, to the spinning wheels.

This, then, is a rather clever way of stalking prey. This

implies that the dragonflies considered the spinning wheels as something worth stalking or, at least, pursuing. In one of my experiences, the reflections from the transparent wings of the accompanying *Anax* dragonfly reminded me very much of a spinning wheel. Perhaps the flashes of light reflected from the spinning spokes resemble a dragonfly's wings' flashes on the retina of the stalking dragonfly.

In the case of the large, solitary *Anax* species, which are active even at dusk, this could be a preliminary means of mate recognition.

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16. ABUNDANCE AND DIVERSITY OF ODONATA (INSECTA) IN SOME HILLY REGIONS OF TAMIL NADU

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Introduction

Fraser (1933, 1934, 1936) recorded 116 species of Odonata (Insecta) from the hilly regions of India. A perusal of literature (Miller 1992; Gunathilagaraj *et al.* 1999; Palot and Soniya 2000a,b; Asaithambi and Manickavasagam 2002; Emiliyamma and Radhakrishnan 2003; Kandibane *et al.* 2005; Sharma *et al.* 2007) showed that there has been no comprehensive study on the abundance and diversity of this group from the hilly regions of Tamil Nadu. Hence, the present study was conducted to assess the diversity and abundance of Odonata in five hilly regions of Salem district in Tamil Nadu.

Methodology

Five hilly regions, namely Yercaud, Karunkaradu, Pallikaradu, Periakaradu and Poonaikundru were surveyed to assess the Odonata diversity and abundance. The place of sampling and coordinates of the hilly regions are given in Table 1. Collections were made once after the North-east monsoon (January to April, 2006), and only adults were collected with the aid of sweep net (35 cm dia. and 70 cm ht.). In Yercaud, collections were made from small streams, tributaries of Kiliyanur River and from boat house lake. Karunkaradu, Pallikaradu, Periakaradu and Poonaikundru were devoid of water bodies and collections were made with a sweep net by slowly walking around the hills. The identity of collected Odonata was fixed using the keys developed by Fraser (1933, 1934, 1936), Kumar and Prasad (1981), Ram *et al.* (1982), Barrion and Litsinger (1994), and Emiliyamma and Radhakrishnan (2000). Odonata diversity was computed using the Simpson's index (Simpson 1949).

$$\text{Simpson's index } (\lambda) = \sum_{i=1}^{s} ni\,(ni-1) / N\,(N-1)$$

Where, ni is the number of individuals of the i^{th} species, and

N is the total number of individuals in the sample

Simpson's index (λ) varies from 0 to 1. Increase in the value of the index indicates decrease in the diversity of species and vice-versa.

Abbreviations used: dia. - diameter; ht. - height

Table 1: Coordinates of the hilly regions sampled in the present study

Hill	District	Altitude (m)	Latitude	Longitude	Shade cover	Water bodies
Yercaud	Salem	1,500	11° 48' N	76° 13' E	High	Present
Karunkaradu	Bukkampatty, Salem	220	11° 19' N	77° 40' E	Low	Absent
Poonaikundru	Bukkampatty, Salem	200	11° 19' N	77° 40' E	Low	Absent
Pallikaradu	Bukkampatty, Salem	200	11° 19' N	77° 40' E	Low	Absent
Periakaradu	Bukkampatty, Salem	250	11° 19' N	77° 40' E	Low	Absent

Table 2: Distribution of Odonata in hill regions of Tamil Nadu

Name of the species	Hills					
	A	B	C	D	E	Total
Suborder: Anisoptera						
Libellulidae						
Brachythemis contaminata	7	-	-	-	-	7
Bradinopyga geminata	3	-	8	-	-	11
Crocothemis servilia	3	-	-	-	-	3
Diplacodes nebulosa	1	-	-	-	-	1
Diplacodes trivialis	12	8	12	12	15	59
Lathrecista asiatica	-	1	-	-	1	2
Orthetrum sabina	7	9	7	9	9	41
Pantala flavescens	9	4	4	3	6	26
Potamarcha congener	-	2	-	-	-	2
Rhodothemis rufa	2	-	-	-	-	2
Tholymis tillarga	4	-	-	-	-	4
Tramea basilaris	3	3	1	1	1	9
Tramea limbata	2	4	2	1	1	10
Trithemis aurora	3	-	-	-	-	3
Suborder: Zygoptera						
Coenagrionidae						
Agriocnemis pygmaea	4	-	-	-	-	4
Ceriagrion coromandelianum	6	3	-	-	-	9
Ischnura aurora	7	4	-	-	-	11
Ischnura senegalensis	4	-	-	-	-	4
Pseudagrion decorum	5	-	-	-	-	5
Pseudagrion microcephalum	4	-	-	-	-	4
Pseudagrion rubriceps	2	-	-	-	-	2
Lestidae						
Lestes elatus	-	15	-	-	-	15
Platycnemididae						
Copera vittata	17	-	-	-	-	17
Total	102	53	34	26	33	248

A : Yercaud C : Poonaikundru E : Periakaradu
B : Karunkaradu D : Pallikaradu

Table 3: Diversity of Odonata (Simpson's index) in hilly regions of Tamil Nadu

Hilly region	Simpson's index
Yercaud	0.07
Karunkaradu	0.14
Poonaikundru	0.22
Pallikaradu	0.32
Periakaradu	0.30

Results

Odonata collected from 5 hilly regions comprised 23 species of Odonata (14 species of Anisoptera and 9 species of Zygoptera) belonging to 18 genera under 4 families (Table 2). Among the 23 species, *Diplacodes trivialis* (Rambur) (Libellulidae) and *Copera vittata* Selys (Platycnemididae) were the most abundant Anisoptera and Zygoptera respectively. Except Yercaud, all other hilly regions sampled were dominated by Anisoptera (dragonflies); Yercaud had both Anisoptera and Zygoptera in nearly equal proportions. No Zygoptera was recorded in Pallikaradu, Periakaradu and Poonaikundru. Libellulidae (Anisoptera) was the only family present in all hilly regions, whereas Zygoptera was represented by three families, namely Coenagrionidae, Lestidae and Platycnemididae. Libellulidae had maximum number of individuals (180) and species (14), followed by Coenagrionidae (39 individuals and 7 species), Platycnemididae and Lestidae (1 species each; 17 and 15 individuals respectively). Of the five hilly regions sampled, Odonata abundance was maximum in Yercaud followed by Karunkaradu, Poonaikundru, Periakaradu and Pallikaradu. *Copera vittata* Selys (Platycnemididae) and *Lestes elatus* Hagen in Selys (Lestidae) were dominant in Yercaud and Karunkaradu hills respectively, and *Diplacodes trivialis* (Rambur) (Libellulidae) was dominant in the rest.

Brachythemis contaminata (Fabricius), *Crocothemis servilia* (Drury), *Diplacodes nebulosa* (Fabricius), *Tholymis tillarga* (Fabricius), *Trithemis aurora* (Burmeister), *Rhodothemis rufa* (Rambur) (Libellulidae), *Agriocnemis pygmaea* (Rambur), *Ischnura senegalensis* (Rambur), *Pseudagrion decorum* (Rambur), *Pseudagrion microcephalum* (Rambur), *Pseudagrion rubriceps* Selys (Coenagrionidae) and *Copera vittata* (Platycnemididae) were unique to Yercaud, whereas *Potamarcha congener* (Rambur) (Libellulidae) and *Lestes elatus* (Lestidae) were confined to Karunkaradu hill. *Diplacodes trivialis* (Rambur), *Orthetrum sabina* (Drury), *Pantala flavescens* (Fabricius), *Tramea basilaris* (Palisot de Beauvois) and *Tramea limbata* (Desjardins) (Libellulidae) were found in all hilly regions sampled. Odonata diversity was higher in Yercaud and lower in Pallikaradu according to Simpson's index (Table 3).

Discussion

Odonata in hill ecosystem is restricted when compared to those in plains, because only those species that can tolerate erratic environment would colonise hilly regions (Samways 1989; Carchini *et al.* 2005). Oppel (2005a,b) reported that Zygoptera was abundant in hilly regions than Anisoptera, which is in contrast with the present study which shows dominance of Anisoptera in the hilly regions, except Yercaud.

High shade cover and presence of water bodies favour the zygopteran population than Anisoptera (Schindler *et al.* 2003; Oppel 2005a). This might be the possible reason for

the abundance of Zygoptera in Yercaud and the reverse may be true for the abundance of Anisoptera in other hilly regions. Odonata of Family Libellulidae (Anisoptera) are common in plains and their diversity decreases with increase in altitude because fast flowing streams and rivers are not suitable for Libellulidae naiads, which require sluggish and weedy ponds (Samways, 1989). But Libellulidae was dominant at higher altitudes in the present study. Eurytopic (wide habitat tolerance) nature of Libellulidae (Stewart and Samways 1998; Clausnitzer 2003; Oppel 2005a,b) might be responsible for their abundance when compared to other families, namely Coenagrionidae, Lestidae and Platycnemididae recorded in the present study.

Higher species richness and diversity of Odonata in Yercaud could be attributed to the vast area, variety of biotopes (temporary water bodies, river, stream, cascade) and high shade cover. This is in agreement with the findings of Samways (1989) in South Africa and Oppel (2005a) in Papua New Guinea.

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17. STATUS AND DISTRIBUTION OF *APPIAS LALAGE* BUTTERFLY (LEPIDOPTERA: PIERIDAE) IN THE WESTERN GHATS, SOUTH-WESTERN INDIA

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Much confusion surrounds the occurrence of *Appias lalage* Doubleday, 1842 (Lepidoptera: Pieridae: Pierinae), also known as the Spot Puffin butterfly, in the Western Ghats. The Western Ghats is a mountain chain that runs along the western coast of southern India, and it is one of the globally recognized biodiversity hotspots. Its evergreen forest flora and fauna are isolated from the nearest Himalayan and north-east Indian forests by over 1,500 km of dry, mixed deciduous forests on the Deccan Plateau. Hence, the Western Ghats is a key feature of peninsular India from biogeographic,

biodiversity and conservation perspectives (Gadgil 1996). In this note we present our observations on *A. lalage* to clarify its status and distribution within this mountain range.

The type specimen of *A. lalage* was taken from Khasi Hills in north-eastern India, which were previously included in Assam, but now belong to the state of Meghalaya, bordering Bangladesh. The currently well-known distribution of the nominate subspecies is throughout the Himalayas (Himachal Pradesh and Uttarakhand to Nepal, Sikkim, northern West Bengal, Bhutan and Arunachal Pradesh), the Khasi, Garo, Jaintia, Cachar and Lushai Hills of the Patkai Range (covering the entire north-eastern India) and the mountainous region of Myanmar (Evans 1932; Talbot 1939; Wynter-Blyth 1957; Smith 1989; Haribal 1992; Larsen 2004). Throughout its range it occurs between 550 m and 2,500 m above msl, but is partial to higher elevations; inhabits evergreen forests, and it may be seasonally common (Evans 1932; Parsons and Cantlie 1948; Wynter-Blyth 1957; Smith 1989; Haribal 1992; Larsen 2004). Two other subspecies have been listed under *A. lalage*: (a) *A. lalage lageloides* Crowley, 1900 occurs in Hainan, China (Io 2000), and (b) *A. lalage lagela* Moore, 1878 occurs in southern Myanmar, Thailand and Peninsular Malaysia (Evans 1932; Talbot 1939; Pinratana 1983; Corbet *et al.* 1992); although *lagela* is now widely recognized as a subspecies of *A. pandione* Geyer, 1832 rather than of *A. lalage* (Pinratana 1983; Corbet *et al.* 1992).

The occurrence of *A. lalage* in the Western Ghats, however, has been confirmed only recently. Early references on Indian butterflies do not mention the southern Indian range of the species, probably because the British collectors apparently did not collect it from the Western Ghats (Evans 1910; Antram 1924; Evans 1932; Talbot 1939; Wynter-Blyth 1957). Some of the specimens collected by these collectors were initially identified as *A. lalage*, but they turned out to be misidentified *Appias indra shiva* Swinhoe, 1885, the Sahyadri Plain Puffin (Harish Gaonkar, pers. comm.). Perhaps due to this, claims of occurrence of this species in the Western Ghats were largely discredited, and there was no explanation for a single specimen deposited in the collection of the Madras Government Museum, Chennai. This male specimen, collected from Kalakad Forest (now Kalakad-Mundanthurai Tiger Reserve and neighbouring forest tracts in south-western Tamil Nadu; henceforth KMTR), was a wet season form (Satyamurti 1966). Although Satyamurti recognized that this was the first record of the species from southern India, he did not report any other details of this specimen or of the species in this area.

In 1990s there were three important reports of the species from the Western Ghats. First, in 1995 a single male of a wet season form was reported mud-puddling at the Gudampara Estate, Idukki district, Kerala, at 1,200 m above msl (Nalini and Lomov 1996). Shortly afterwards, two entire

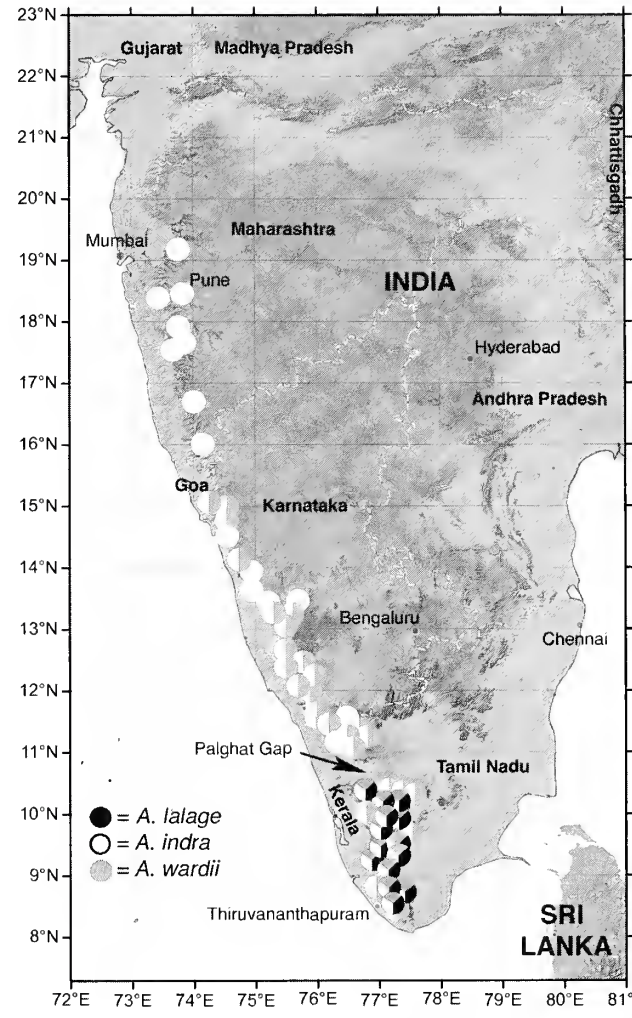

Fig. 1: Distribution of *Appias lalage lalage*, *A. indra shiva* and *A. wardii* in the Western Ghats
Each circle represents a spot record for the species, which are colour-coded as shown in the map. Half-split white-grey circles represent localities where *A. indra shiva* and *A. wardii* have been recorded together. Three-way split white-grey-black circles indicate that all three species co-occur at the localities surveyed. Data from Kunte (unpublished manuscript).

populations of the species were simultaneously reported from southern Western Ghats, one from KMTR, and the other from Eravikulam National Park, Kerala (Devy 1998; Kunhikrishnan 1998). These confirmed for the first time that the *A. lalage* specimens reported by Satyamurti, Nalini and Lomov were not stray and of unknown origin, but part of thriving populations within the southern Western Ghats. In his paper Kunhikrishnan attempted to describe in detail the status of this species in the Western Ghats. We extend that effort here with much more extensive observations that we have accumulated over the past 10 years.

In subsequent years since Soubadra Devy and Kunhikrishnan's reports, we have seen *A. lalage* in almost all

the major mountains in the states of Tamil Nadu and Kerala in the Western Ghats south of the Palghat Gap (Fig. 1). Particularly, we have seen large numbers at higher elevations in Eravikulam National Park, Grass Hills (the Anamalais), Periyar Tiger Reserve, Chemmunji Hills and Athirumala Hills in the Peppara Wildlife Sanctuary (WLS) in the Kerala part of the Ashambu Hills, KMTR, Schendurney WLS, Ponmudi Hills, Venkulamedu Hills and Agasthya Koodam Peak (border between Neyyar WLS and KMTR). All our sightings are from 600 m to 2,600 m above msl. We have, however, failed to locate *A. lalage* north of the Palghat Gap in spite of years of observations in these parts. This is interesting since the Palghat Gap is a biogeographic barrier that isolates many endemic butterflies on its northern and southern sides (Gaonkar 1996; Kunte 2008). It is up to a 40 km wide low-lying area that forms a major break among the tall mountains of the southern Western Ghats. The Nilgiri Mountains just north of the Palghat Gap have historically been extensively studied for their butterfly fauna and earlier workers in that region had never sighted *A. lalage* (see Larsen 1987-1988 and references therein). Mathew and Rahmathulla, however, reported *A.p. lagela* from Silent Valley National Park in Kerala, which is north of the Palghat Gap (Mathew and Rahamathulla 1993). This record is doubtful because *A.p. lagela* occurs in southern Myanmar, Thailand and Malaysia (see above), and is unlikely to occur in southern India. Dr. George Mathew of Kerala Forest Research Institute at Peechi, first author of the 1994 report, informed us that the record was probably based on just one or two specimens collected, which could not be located when we contacted him, and felt that more material was needed to verify the previous record. Our suspicion is that this would turn out to be *A. indra shiva*, although we do not rule out the possibility that it was a stray *A. lalage* that might have been blown across the Palghat Gap by strong winds. At present, from our failure to find the species north of the Palghat Gap and in absence of any other proof, we conclude that in the Western Ghats *A. lalage* is confined to the hills south of the Palghat Gap. We have observed it on both eastern and western slopes of the Western Ghats.

Our observations indicate that even in the Western Ghats *A. lalage* is partial to evergreen forests at higher elevations. At lower elevations (*c.* 600 m-1,000 m) in the Western Ghats, where it is very rare and co-occurs with *A. indra shiva* and *A. wardii* Moore, 1884 (the Lesser Albatross), the latter two usually far outnumber it. At higher elevations (*c.* 1,200 m-2,200 m), however, *A. lalage* becomes much more numerous than other *Appias*. Especially above *c.* 1,500 m, *A. wardii* becomes scarce and *A. indra* and *A. lalage* are the only species of *Appias* that are common, where *A. lalage* outnumbers *A. indra*. It is common along evergreen forest paths and edges, on plateaus and steep slopes. Males mud-puddle frequently and several dozen may congregate on a good patch, either forming their own species group or joining congregations of other *Appias*.

There seem to be two flight periods: pre-monsoon and post-monsoon. At *c.* 700-900 m in KMTR we have observed very fresh specimens in fair numbers (up to a dozen individuals every day) in May and early June. However, the post-monsoon (October-November) seems to be the better season, during which dozens of individuals may be seen in a single day. At Eravikulam-Grass Hills it is plentiful in October, flying even along the main tourist road that passes through shola forests and tea plantations around Rajamalai. We have also occasionally observed individuals flying at an altitude of *c.* 2,600 m along the slopes of Anaimudi Peak (the Anaimudi Peak, at an elevation of 2,695 m, is the highest point in southern India and included in the Eravikulam National Park). From December the populations decline gradually, the species becoming a rare sight in summer (March-April).

We hope that this note clarifies the status of *A. lalage* in southern India. We tentatively assign the Western Ghats populations to the nominate subspecies, *A.l. lalage*. Although we have reported seasonal occurrence and some habits of the species and delineated its distribution within the Western Ghats, we do not know its early stages and other natural history. This is particularly important because host plants and early stages of *A. lalage* are unknown even from the northern populations (Robinson *et al.* 2001). We hope that this information becomes available soon.

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18. A NEW RECORD OF HOST PLANT *EMBELIA ACUTIPETALUM* OF ATLAS MOTH *ATTACUS ATLAS* LINNAEUS FROM KONKAN

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Atlas moth *Attacus atlas* Linnaeus of Family Saturniidae is commonly seen in monsoon in Konkan region. On July 25, 2008, I found five final instar caterpillars of Atlas moth *Attacus atlas* Linnaeus near a small village Kasba, Taluka Sangameshwar, District Ratnagiri. Caterpillars were 110 mm long. All caterpillars were feeding on leaves of *Embelia acutipetalum* (Family Myrsinaceae), a common plant in Konkan (Fig. 1). Local Marathi name of this plant is '*Vavding*'. Many food plants of Atlas moth *Attacus atlas* Linnaeus are known, but there is no reference of this plant and is being reported here as the first record.

Fig. 1: Final instar caterpillar of *Attacus atlas* feeding on the leaves of *Embelia acutipetalum*

19. ABUNDANCE OF THREE SPECIES OF THE HORSESHOE CRAB ALONG THE COAST OF MALAYSIA

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Horseshoe crabs, popularly known as a 'living fossil', are one of the best-known living animals on Earth. They are important for the pharmaceutical, clinical and food industries, besides being good indicator organisms for monitoring the health of coastal zones. The blue blood of the horseshoe crab has been proved to be of great value medically for the production of lectin (Saito *et al.* 1997) and tachyplesin I (Morvan *et al.* 1997).

In some Asian countries like Singapore, Malaysia, Borneo, the eggs of horseshoe crab are considered as a

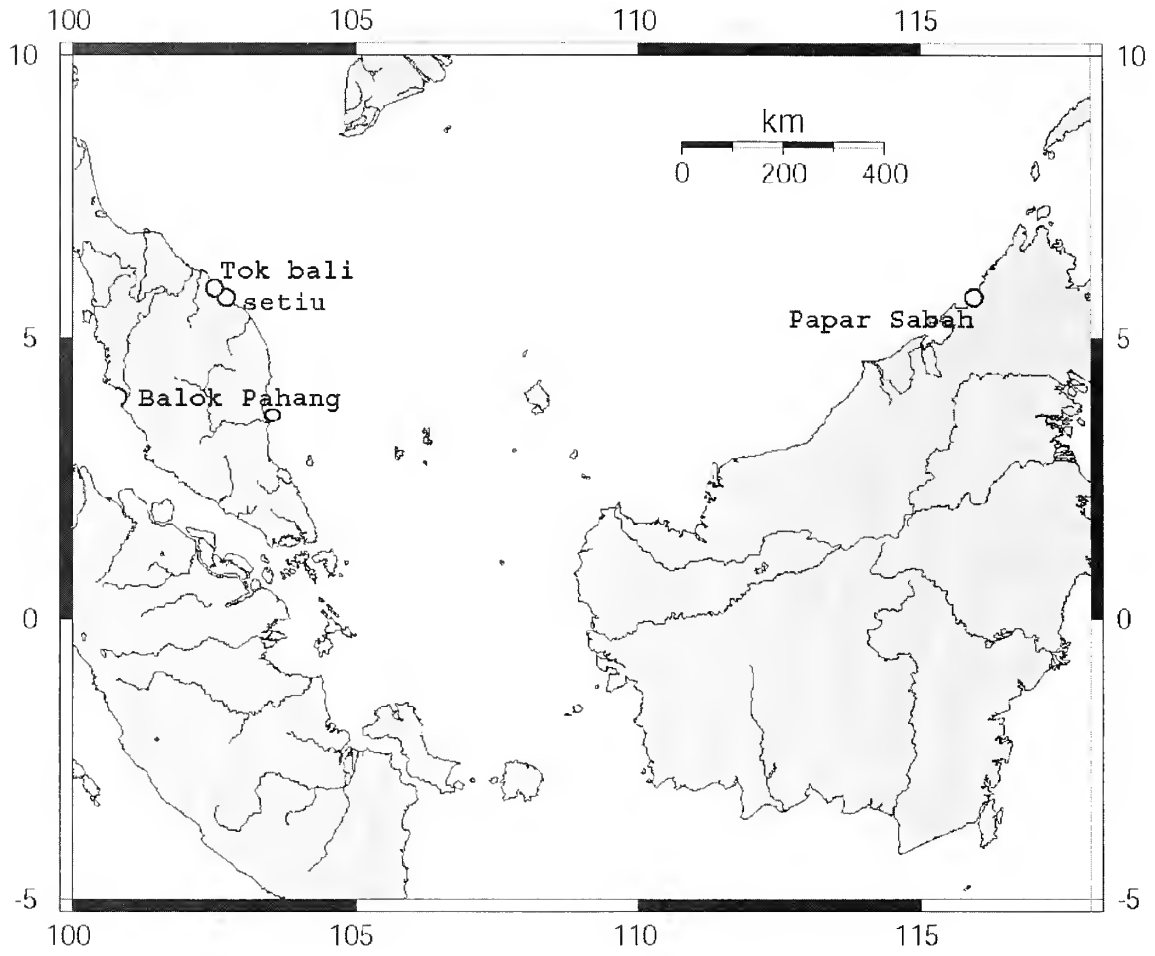

Fig. 1: Location of the collection of Horseshoe Crab specimens

delicacy (Chatterji 1994). The Malaysian Horseshoe Crab, popularly known as '*belangkas*', does not represent a multiple use resource like *Limulus polyphemus* (L) of Delaware, USA. However, they have potential to become important at least for biomedical compounds and eco-tourism industry. In the past, the Malaysian Horseshoe Crab was a neglected animal but due to the committed efforts of the scientists associated with the Institute of Tropical Aquaculture, University Malaysia Terengganu, the scientific value of the horseshoe crab has gone up far more than before. The distribution pattern of the four species of horseshoe crab in the world is discussed in detail by Sekiguchi *et al.* (1976), Botton and Haskin (1984), Chatterji *et al.* (1992) and Chatterji (1994). However, except for one record on co-existence of two species of horseshoe crab along the Indian coast (Chatterji 1999), no report has so far been available that showed the occurrence of three species of horseshoe crab together along the coast of any country. The present communication deals on a report of occurrence of three extant species of the horseshoe crab along the coast of Malaysia.

Live specimens of *Carcinoscorpius rotundicauda* (Latreille) and *Tachypleus gigas* (Müller) were collected from Setiu (5° 42' 60" N; 102° 42' 0" E); Balok (3° 57' 0" N; 100° 48' 0" E) and Tok Bali (5° 53' 11" N; 102° 29' 28" E) respectively (Fig. 1). Live specimens of *Tachypleus tridentatus* (Leach) were collected from Paper Sabah (5° 43' 48" N; 15° 55' 48" E). The specimens were brought to the laboratory and their carapace length (CL), carapace width (CW) and telson length (TL) were recorded up to the nearest mm for both the sexes separately. The average body weights in gram for both males and females of all the three species were also recorded.

Most of the body parts of *T. tridentatus* were approximately 2 times greater than the carapace length, carapace width and telson length of *C. rotundicauda* and *T. gigas* respectively (Table 1). However, body weight of females of *T. tridentatus* was 48.81 and 39.87 times more as compared to *C. rotundicauda* and *T. gigas* respectively (Table 1).

Horseshoe crabs have been reported to follow a uni-species distribution pattern (Botton and Haskin 1984), which may be due to habitat preference. Chatterji (1999) reported for the first time a sympatric distribution of *C. rotundicauda* and *T. gigas* along the north-east coast of Orissa in India. Mikkelsen (1988) reported the sympatric

Table 1: A comparison of different average body parts and body weight of *T. tridentatus* with *C. rotundicauda* and *T. gigas*

Name of species	Sex	Carapace length (mm)	Carapace width (mm)	Telson length (mm)	Body weight (gm)
C. rotundicauda	Male	242	311	240	184.1
	Female	303	292	211	488.1
T. gigas	Male	199	205	169	145.6
	Female	248	219	146	398.7
T. tridentatus	Male	365	410	280	2,410.5
	Female	510	500	340	6,900.6

distribution of *T. tridentatus* and *T. gigas* in Hong Kong, whereas Chiu and Morton (1999) observed the occurrence of *T. tridentatus* and *C. rotundicauda* along these coasts. The mature pairs of all the extant species of the horseshoe crab come to the shore for breeding purpose (Sekiguchi *et al.* 1977).

C. rotundicauda was found along all the three sampling sites, with maximum population along the coast of Tok Bali. The maximum congregation of *T. gigas* was reported along the coast of Balok (Dr. Annie Christianus pers. comm.). It is surprising to note that though the density of *T. tridentatus* was reported to deplete considerably in Japan (Dr. Glenn Gauvry pers. comm.), a high density of this species was found along the coast of Sabah in eastern Malaysia. The depletion of *T. tridentatus* population along the coast of Japan might be due to destruction and reclamation of breeding beaches causing significant migration of this species towards other undisturbed suitable beaches. Our suggestion is also supported by Shuster *et al.* (2003). This could be one of the reasons for *T. tridentatus* for changing their breeding grounds and migrating towards undisturbed beaches of Malaysia for their active spawning. The present information will help environmentalists to implement suitable policies to protect the important breeding beaches for the survival of these three species of horseshoe crab along the Malaysian coast.

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20. FIRST RECORD OF THE MANGROVE ASSOCIATE *DERRIS TRIFOLIATA* LOUR. FROM GUJARAT

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During recent investigations on the mangrove diversity in southern Gujarat, a climber was found growing within the mangrove vegetation of Purna and Varoli estuaries (Fig. 1). Specimens collected from the locations were identified as *Derris trifoliata* Lour. It was sent to experts who confirmed its identity and is thus being reported as the first record of its distribution from the mangrove forests of Gujarat.

Derris trifoliata Lour. is an erect shrub or a rambling climber growing to a length of up to 15 m. The leaves are compound with mostly 3 leaflets with a rounded base and

shortly acuminate apex. Flowers are pink, 1.0-1.2 cm and are borne on axillary racemes which are up to 15 cm long. The pods which are an important identification character, are single seeded, glabrous, reticulately veined and distinctly winged. It usually requires sufficient amount of freshwater to survive and has its coastal distribution from East Africa, Madagascar, and throughout tropical and subtropical Asia to tropical Australia. It is recorded in several coastal communities and is a frequent constituent of the back mangrove community (Tomlinson 1986). In India, it is reported to occur in the intertidal forests of all the coastal states except Gujarat (Thothathiri 1982; Banerjee *et al.* 1989; Rajendran and Sanjeevi 2004).

The mangrove forests in Gujarat have generally been described as being shrubby in nature and having low diversity compared to the other states of India (Anon 1987; Singh 2006). The mangrove forests of Kachchh and Jamnagar have received much attention of researchers, whereas mangrove forests in southern Gujarat have received comparatively little attention and hence the diversity of these mangroves remain uninvestigated. A recent report (February 2007) of several individuals of *Excoecaria agallocha* from the Varoli estuary (Dr. Sachin Chavan pers. comm.) is also an addition to the mangrove flora of Gujarat. A thorough investigation into the mangrove diversity of southern Gujarat could lead to further additions.

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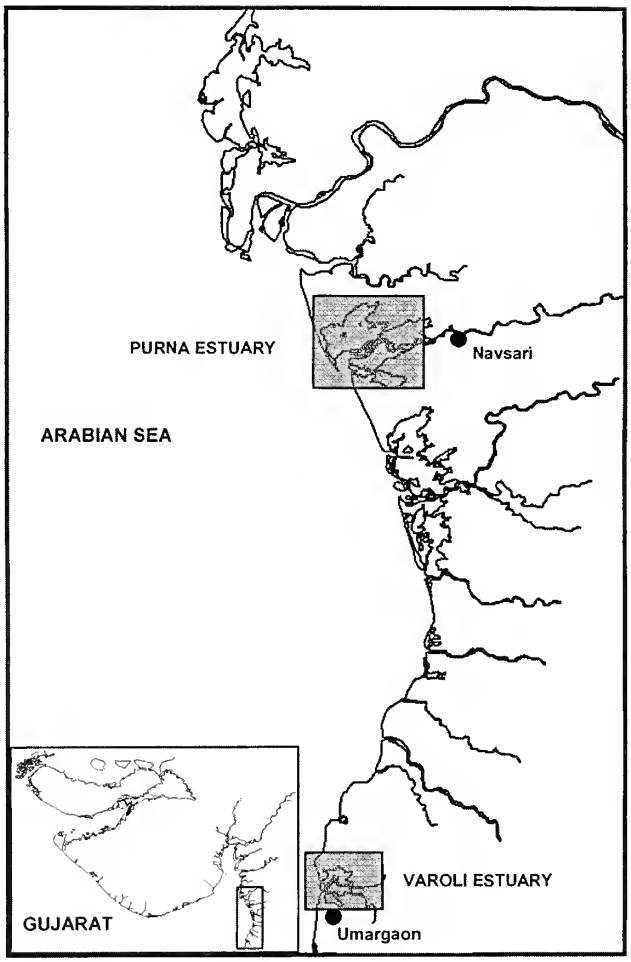

Fig. 1: Location of Purna and Varoli Estuaries

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21. PRELIMINARY OBSERVATIONS ON YELLOW MORNING GLORY *IPOMOEA HEDERIFOLIA* LINN. (CONVOLVULACEAE)

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Occurrence of yellow coloured flowers is recorded for the first time in Indian species of *Ipomoea hederifolia* Linn. of Family Convolvulaceae. Plants were growing naturally as a part of natural vegetation in Sinhachalum hillocks of

Visakhapatnam district of Andhra Pradesh. On critical identification and detailed study, the specimen turned out to be *Ipomoea hederifolia* Linn. When compared with red/orange coloured flowers, there were slight variations in the specimens in most of the characters except the inflorescence type, colour of the flower and size of the fruit. The details of the morphological feature are as follows: an annual twiner, 3-6 m in height; stems glabrous or sparsely pubescent; leaves ovate to suborbicular, 2.5-8.0 x 1.5-8.5 cm, acute to acuminate apex, cordate at base, entire or 3-lobed, glabrous; flowered cymes; pedicles 10-12 mm long; sepals oblong to elliptic, 3-6 mm long, obtuse to truncate; outer sepals with 1.5-2.0 mm long, subterminal, fleshy arista, glabrous; corolla yellow, hypocrateriform, 3.4-5.0 cm long; capsules subglobose, 7-9 mm long; seeds pyriform, dark brown, glabrous.

On consultation to Dr. M.J. Parmar, Dy. Director of BSI, Arid zone Circle Jodhpur, it has been noted that no yellow flowered Morning Glory from the Indian subcontinent is available. For further clarification, we also consulted Dr. Steven Jensen, Jordell Laboratory, Royal Botanical Garden Kew; he communicated that there was only one specimen of *I. hederifolia*, which had been collected from Asia (i.e. in Jiangsu-China). Perusal of literature (Cooke 1901-1909, Bentham and Hooker 1862-83; Shah 1978) has revealed that there is no record of yellow flowered specimens in *Ipomoea hederifolia*. This is therefore, the first record from India. Acc. No. VMR/ 523, 547.

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22. *ORNITHOGALUM ERYTHRAEUM* (WEBB & BERTHEL.) MANNING AND GOLDBLATT (HYACINTHACEAE) – A NEW RECORD FOR MAHARASHTRA

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Introduction

Morphological, phytochemical, microstructural and molecular data on members of Hyacinthaceae has resulted in the recognition of four subfamilies, the new world Oziroeoideae and the old world Hyacinthoideae, Ornithogaloidae and Urginoideae (Speta 1998a,b; Pfosser and Septa 1999; Manning *et al.* 2004). Subfamily Ornithogaloideae, characterized by flattened or angular seeds with tightly adhering testa, is considered to include the single genus *Ornithogalum* L., [Sp. pl.: 306 (1753). Type: *Ornithogalum arabicum* L.], which is expanded to include the genera *Albuca* L., *Dipcadi* Medik., *Galtonia* Decne., *Neopatersonia* Schonland, and *Pseudogaltonia* (Kuntze) Engl. According to Manning *et al.* (2004), the generic segregates of distinctive floral forms are morphological syndromes developed in association with diverse pollination strategies. It opens the way to accept that they reflect adaptive modes that were exploited by groups of related species rather than representing generic boundaries. Thus, the species previously placed in *Dipcadi* are now treated under *Ornithogalum* L. Manning *et al.* (2004).

All the 9 species and two varieties of *Dipcadi* in India are now treated under the genus *Ornithogalum* by Manning *et al.* (2004). The Indian species include *Ornithogalum concaneuse* (Dalzell) J.C. Manning and Goldblatt, *O. erythraeum* (Webb & Berthel.) Manning and Goldblatt, *O. maharashtrense* (Deb. & S. Dasgupta) J.C.Manning and Goldblatt, *O. minor* (Hook.f.) J.C. Manning and Goldblatt, *O. reidii* (Deb. & S. Dasgupta) J.C. Manning and Goldblatt, *O. saxorum* (Blatt.) J.C. Manning and Goldblatt, *O. serotinum* (L.) J.C. Manning and Goldblatt, *O. turbinatum* J.C.Manning and Goldblatt, *O. turbinatum* var. *madrasicum* (E. Barnes & C.E.C. Fisch) J.C.Manning and Goldblatt, *O. ursulae* (Blatt.) J.C. Manning and Goldblatt and *O. ursulae* var. *longiracemosum* (Deb. & S. Dasgupta)

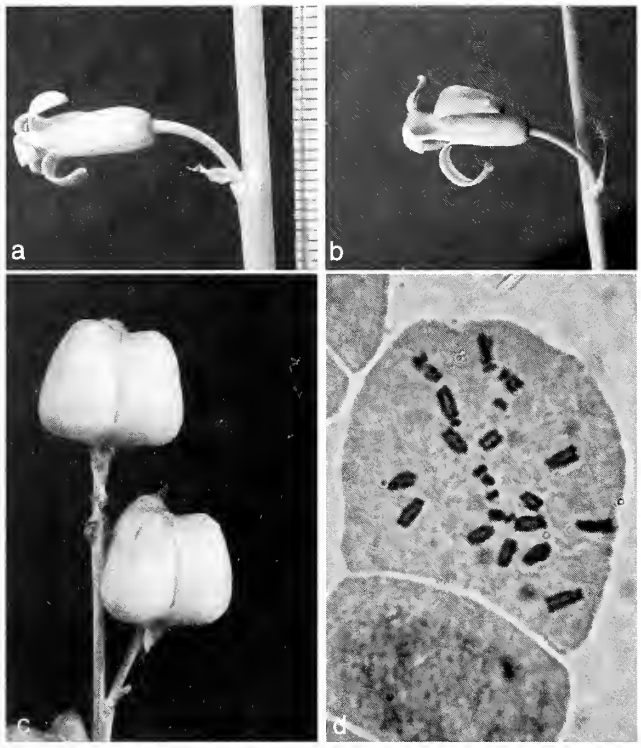

Fig. 1: *Ornithogalum erythraeum*
a. flower from Jodhpur; b. flower from Dhulia; c. fruits; d. somatic chromosomes (2n=22)

J.C. Manning and Goldblatt. *Ornithogalum maharashtrense* and *O. ursulae* var. *longiracemosum* are variants of *O. ursulae* do not deserve any taxonomic status and have been reduced to synonyms of *O. ursulae*.

Of the remaining eight species, six are recorded for the state of Maharashtra. *Ornithogalum erythraeum* is known to occur in Egypt, Afghanistan, Baluchistan, Pakistan and India. In India, it is so far reported from Bhairaswara, Jaisalmer and Jodhpur region of Rajasthan.

During August 2006, some specimens of *Ornithogalum* were collected from Laling ghat in Dhulia district of Maharashtra. On detailed analysis, the specimens turned out to be of *Ornithogalum erythraeum*. Somatic chromosome number 2n=22 was observed in the specimen, which has also been reported for the species by earlier workers (Jakhi *et al.* 1994). An occurrence of *O. erythraeum* in Dhulia district forms a new record for the state of Maharashtra. The present paper reports on morphology, somatic chromosome number and an extended distribution of *O. erythraeum*.

Ornithogalum erythraeum (Webb & Berthel.) J.C. Manning and Goldblatt. [Edinb. Jour. Bot. 60(3): 533-568 (2004)]. *Dipcadi erythraeum* Webb & Berthel., Hist. nat. Illes Canaries 2 (3): 341. 1848; Cooke, Fl. Pres. Bomb. 2:770. 1907 (Repr. ed 3: 278.1958); Bhandari, Fl. Indian desert 352.1978; Shetty and Singh in Fl. Raj. 2. 843.1991. *Hyacinthus serotinus* Forsskal, Fl. Aegyptiaco – Arabica 209.1775. *Uropetalum unicolor* Stocks in Journ. Bot. 4: 180. 1852. *Dipcadi unicolor* (Stocks) Baker in Journ. Linn. Soc. 11: 397. 1871; Hook. Fl. Brit. India 6: 346. 1892. Fig. 1.

Bulbous perennial herb; bulbs globose, 1.5-2.0 x 1.5-2.0 cm, tunicated; roots fibrous from basal disc. Leaves 2-3 per bulb, 25-35 x 0.5-1.5 cm, linear, flat, 6-7 nerved, acute at apex, margin curved upwards. Scapes short, 15-25 x 0.2-0.3 cm, erect, stout, glabrous; racemes 1-3 flowered, 4-5 cm long. Flowers 15-18 mm in length, greenish-white, drooping while blooming, bracteate; bracts 5-8 x 2 mm, deltoid, membranous to scarious, acuminate; pedicels 10-15 x 1 mm, slender, green. Perianth 15-18 mm in length, greenish-white, united to 1/3 of the length; outer perianth lobes 9-11 x 3 mm, 6-7 nerved, broadly lanceolate, recurved while blooming of flower; inner perianth lobes 10-11 x 2.5 mm, 5-nerved, recurved from the tips. Stamens 6, 6.5-7 mm long; filaments 5.5 x 0.7 mm; anthers 2.5 x 0.6 mm. Gynoecium 11-12 x 2.5 mm; ovary 6-6.5 x 2.5 mm; style 5 x 1 mm, stipe short, upto1 mm long, Capsule 12-15 x 10-12 mm, Seeds 6-7 mm in dia., rotund, black.

Flowering & Fruiting: August-September.

Distribution: INDIA: Rajasthan (North-West Rajasthan), Maharashtra (Dhulia); Egypt; Afghanistan; Baluchistan; Pakistan

Chromosome number (2n): 22

Plants collected from Dhulia are under cultivation in Botanical Garden, Shivaji University Kolhapur.

Note: It grows on the hills of the arid region in Rajasthan after rains. In Maharashtra, it grows in terrain with rocky substratum around Dhulia region (Laling ghat). The population found at Dhulia region differs from the population growing at Jodhpur only in its greenish-white flowers (Fig. 1b) and just 2-3 flowers per scape. The somatic chromosome number observed was 2n=22 (Fig. 1d). This diploid number 2n=22 of the species in population from Rajasthan region has also been reported by Jakhi *et al.* (1994).

Uses: Bulbs are eaten in Sind and Baluchistan.

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23. *HABENARIA COMMELINIFOLIA* WALL. (ORCHIDACEAE) – A NEW ADDITION TO THE FLORA OF ANDHRA PRADESH

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Introduction

Habenaria is one of the largest genera in the Family Orchidaceae, which comprises of about 750 species world-wide. Usually this genus are tuberous rooted, terrestrial, a few of them epiphytic and lithophytic, herbaceous annual in nature. In India, about 59 species of *Habenaria* have been reported mainly from the foothills of Himalayas, Western Ghats and Eastern Ghats (Bose *et al.* 1999). *H. commelinifolia* Wall. has been reported from central India northwards up to Western Himalayas. The report of this species is an addition to the flora of Andhra Pradesh. The previous floristic accounts of Andhra Pradesh have reported 11 species of *Habenaria* (Pullaiah 1999).

Habenaria commelinifolia Wall. ex Lindl. Gen. Sp. Orch. 325. 1835; Hook.f. Fl. Brit. India 6: 143. 1890; Haines, Bot Bihar & Orissa 3: 1157. 1924; Fischer in Gamble, Fl. Madras Pres. 3: 1470. 1928; Sant. & Kapadia, Orch. Bombay 25.t.4.f.11-12. 1966.

Robust tuberous herb. Stem up to 90 cm tall, sheathed below, leafy above; tubers one or two, ellipsoid. Leaves oblong-lanceolate, finely acuminate up to 10 cm long and 2.5 cm broad. Inflorescence 20 cm long, many flowered spikes. Flowers white, 2 cm across; bracts linear-lanceolate 1.6 cm long; lateral sepals gibbous, hatchet-shaped, dorsal orbicular, hooded; petals oblong, lip linear at base, trilobed, side lobes filiform, mid lobe shorter; spur *ca.* 6 cm long, slender, incurved.

Flowering & Fruiting: October-December.

Distribution: India: Western Himalaya, Garhwal, Kumaon, central India, West Bengal, Chota Nagpur, Karnataka, Andhra Pradesh; Nepal; Myanmar; Vietnam; Thailand.

Specimen examined: Andhra Pradesh, Chittoor district, Mudendlakorava in Tirumala hills, S. Karuppusamy, 31663 (SKU).

Ecology: Plants of this taxon appear only in monsoon among the *Cymbopogon* dominated grassland at above 1000 m altitude. The population of this taxon is very scarce in Andhra Pradesh, due to over grazing and seasonal forest fire.

Conservation status: Rare in Andhra Pradesh. It needs further ecological assessments to conserve this taxon.

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For the standardised common and scientific names of the birds of the Indian subcontinent refer to *Buceros* Vol. 6, No. 1 (2001).

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