JOURNAL
OF THE
BOMBAY NATURAL HISTORY SOCIETY

APRIL 2010 VOL. 107 (1)

BNHS INDIA CONSERVING NATURE SINCE 1883

JOURNAL OF THE BOMBAY NATURAL HISTORY SOCIETY

Hornbill House, Shaheed Bhagat Singh Marg, Mumbai 400 001.

VOLUME 107(1): APRIL 2010

CONTENTS

NEW DESCRIPTIONS

MISCELLANEOUS NOTES

Cover Photograph: Tiger
Panthera tigris
By Sachin Rai

ACKNOWLEDGEMENT

We are grateful to the Ministry of Science and Technology, Govt of India, for enhanced financial support for the publication of the Journal.

Editorial

Are we saving tigers for Chinese consumers?

Tiger is perhaps the most famous animal in the world. Everything about the tiger is written in superlative terms – its beauty, grace, aura, grandeur, strength, ecological role, iconic role, and even aphrodisiac potency of its body parts. Nothing is mundane about the tiger. Even some tiger conservationists consider themselves above all other conservationists. Earlier every tiger shot was a life-long memory of a hunter, now every tiger sighting by a tourist is a conversation topic among family and friends. Poaching of tigers makes the front-page in daily newspapers. There are more books on tiger than any other Indian animal. There are tourist agencies that survive solely on tiger tourism. Such is the aura of this grand animal, and rightly so. For me, the tiger is a spirit, literally and figuratively, of Indian conservation movement – a flagship species. It is the animal which inspires many of us to save our wilderness.

India has come a long way from the bad old days of tiger shooting as 'sport' to tiger tourism as a growing business. We even have a school of art based solely on tiger paintings. Instead of an ugly rug of a tiger skin or a decaying 'trophy' of a tiger head in some decrepit house of an aging former rajah or nawab, tiger paintings now proudly adore art galleries and board rooms of corporates. Visiting a tiger reserve is a fashion statement.

India has 39 tiger reserves scattered all over the tiger's range, covering about 40,000 sq. km of forest. Unfortunately, almost 50 per cent are in very bad shape, but they can be recovered with proper management. According to tiger experts, a male tiger requires about 100-160 sq. km territory and a tigress requires about 40-60 sq. km, which means we should have about 400 adult tigers and about 800 adult tigresses only in the tiger reserves. We also have about 100,000 sq. km forest, which can support tigers, may be in lower densities. In well-protected areas, such as the Corbett National Park, there are 20 adult and subadult tigers of both sexes per 100 sq. km. Similarly, in Kaziranga National Park the density is 26 tigers per 100 sq. km. Therefore, ideally India should have 2,400 to 3,000 tigers, perhaps more, as in good protected areas (e.g. Corbett, Kaziranga, Bandhavgarh, Ranthambore) tigers can live in much higher densities. We have less than 50 per cent of the rough estimated figures. Thanks to mismanagement, lack of funds and administrative support, and extensive poaching we have vast empty forests where the tiger and its prey have almost gone. Besides, our forests face constant threats of livestock overgrazing, encroachment, and mining.

While mining, livestock grazing and encroachments can be stopped by strong administrative and legal measures, the invidious threat of poaching is much more difficult to control, particularly when the tiger moves out of the protective cover of a tiger reserve or a national park. As long as there is demand in China for tiger parts, tigers will be poached. With 60 per cent of world's tigers in India, we have become the biggest supplier of tiger parts to the growing Chinese market.

BINGOS (big international NGOs), donors and tiger conservationists frequently go through the ritual meetings and conferences where the issue of protecting tiger through training of staff, giving them more guns and boots (!), getting stakeholders support etc. are discussed on the well-trodden lines, but not many are willing to take up China. As long as we have demand of tiger parts in China, all wild tigers of the world will be under constant threat.

We may have a million children writing to the Prime Minister of India to save the tiger, a retinue of celebrities endorsing tiger protection, large hoardings appealing to save our national animal, but a poacher is not going to listen to this; for him a dead tiger is money. The higher-up you are in illegal tiger trade, the more money you make. And as long as there are people willing to give any amount of money to have tiger-penis soup for purportedly aphrodisiac properties, as long as there are people willing to wear a tiger nail around their neck for good omen, and as long as there are people who consider tiger meat, fat and bones as cure-all, tiger poaching will continue.

Before tiger hunting was banned in 1969, we used to have about 30 shikar companies exclusively for the so-called sport hunting of tiger in India. As one of India's greatest living conservationists, Dr. M.K. Ranjitsinh tells that in his younger days, when one saw a tiger, it was shot, what else would one do? Now, when we see a tiger, we still shoot, but with a camera. When we Indians can change our way of living in one generation, from tiger hunters to tiger lovers, why can't the Chinese stop using tiger parts? When they have death penalty for killing a Giant Panda – their conservation symbol – why can't they protect the tiger in their own country and stop smuggling of tiger parts from other tiger-range countries? I remember the old slogan of WildAid, "When the Buying Stops, the Killing Can Too". This is the basic issue of tiger conservation. When the main problem lies in China, the solution also lies there. We have to see that consumption of tiger parts is stopped in China and other countries through strong legislative and administrative actions and national and international pressure – otherwise we will continue breeding tigers in India, spending crores of rupees and with great sacrifice by the local people (e.g. shifting villages), for the Chinese market. 'Guns and boots' and well-intentioned petitions cannot save tiger as a free-ranging wild animal in India.

Asad R. Rahmani

FEEDING ECOLOGY OF THE ASIAN ELEPHANT *ELEPHAS MAXIMUS* LINNAEUS IN THE NILGIRI BIOSPHERE RESERVE, SOUTHERN INDIA

N. Baskaran[1,2], M. Balasubramanian[1,3], S. Swaminathan[4] and Ajay A. Desai[1,5]

[1]Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk, S.B. Singh Road, Mumbai 400 001, Maharashtra, India.
[2]Present address: Asian Nature Conservation Foundation, Innovation Centre, First Floor, Indian Institute of Science, Bengaluru 560 012, Karnataka, India. Email: nagarajan.baskaran@gmail.com
[3]Present address: The Periyar Foundation, Thekkady 685 536, Kerala, India. Email: wildbala@gmail.com
[4]No. 5, Perumal Kovil Street, Porayar 609 307, Tamil Nadu, India.
[5]84 BC Camp, Belgaum 590 001, Karnataka, India. Email: ajaydesai.1@gmail.com

We studied the activity patterns and feeding ecology of Asian Elephants *Elephas maximus* in deciduous and dry thorn forests of the Nilgiri Biosphere Reserve, southern India. Over 20,000 instantaneous scan samplings on elephants revealed that 60% of the daylight hours were devoted to feeding. Feeding patterns were strongly bimodal, with peaks in the morning and evening. Elephants spent less time feeding during the dry season than in the wet season, both in dry deciduous and dry thorn forests. Feeding decreased with increasing ambient temperature and its influence is more pronounced during the dry season in all the habitats. The time spent on feeding was less in dry thorn (53%) than in dry deciduous forests (68%), attributed to higher ambient temperatures coupled with poor shade availability and higher human disturbances in dry thorn forest. The diet of elephants constituted more species of browse (59) than grass (29), but grass formed the bulk of the annual diet (84.6%) than browse (15.4%). Elephants fed on more diverse food plants during the dry than the two wet seasons, and in the dry thorn than dry deciduous forests, which is discussed in the light of availability of grass biomass. The proportion of browsing was significantly more during the dry season in dry thorn forest, coinciding with poor availability of grass. These observations indicate that grass forms the principal diet of elephants in this area.

Key words: Asian elephant, *Elephas maximus*, activity, feeding, seasonal variation, temperature, browse, grass biomass

INTRODUCTION

Both living species of proboscideans, the Asian Elephant *Elephas maximus* and African Elephant *Loxodonta africana*, are well adapted to living in diverse habitats by exploiting a wide spectrum of plant species. Their physiological adaptations, like the large prehensile trunk, dentition and digestive system, which help to collect and process vast quantities of diverse plant food required to compensate for an extremely poor digestive ability and the nutritional demands of the elephant's large body mass, are undoubtedly critical to the survival of the species (Sukumar 2003). However, such physiological adaptations alone are unlikely to be sufficient, especially in tropical ecosystems, which show large spatio-temporal variance in climate, and food quality and quantity. Additional behavioural adaptations may also be necessary for both the species to efficiently exploit the highly changing heterogeneous tropical environments.

The Nilgiri Biosphere Reserve (NBR) in southern India, along with its adjoining contiguous areas in the Western and Eastern Ghats, supports the largest elephant population in Asia (Daniel *et al.* 1995). The Reserve encompasses a wide range of habitats ranging from semi-evergreen to tropical dry thorn forests and shows distinct seasonality – dry versus wet – making it an ideal system to study the effects of the spatial and environmental factors on the activity and feeding behaviour of the Asian Elephant. This paper documents the seasonal influences of ambient temperature and the availability of grass on the activity pattern and feeding behaviour of elephants in the tropical deciduous and dry thorn forests of NBR. Though the study was carried out over a decade back (1992-95), the findings are still important as there exist no detailed published data on the feeding ecology of elephants from optimal habitats (like Mudumalai, Bandipur, Nagarahole and Wayanad) of NBR, which support the major population of elephants in southern India. Additionally, it would provide baseline data to know the impact of the recent changes taking place on the vegetation physiognomy of elephant habitats due to proliferation of exotic weeds like *Lantana camara* and *Eupatorium odoratum* and the reported decline of preferred food plant species (Sivaganesan and Sathyanarayana 1995), and their impact on elephant feeding.

STUDY AREA

Nilgiri Biosphere Reserve (12° 15'-10° 45' N; 76° 0'-77° 15' E), spread over an area of 5,520 sq. km is situated at the junction of three southern states — Tamil Nadu, Karnataka and Kerala. It has an undulating terrain with an average elevation of 1,000 m above msl. Rivers such as Nugu, Moyar and Bhavani, and most of their tributaries, are perennial and drain the area. The Reserve has a diverse climate due to its

varied reliefs and topography. The temperature ranges from 7°C in December to 37°C in April, and receives rainfall both from the Southwest (May to August) and Northeast (September to December) monsoons. The mean annual rainfall varies from 600 (in the eastern side) to 2,000 mm (in the western side). The dry season is from January to April. Corresponding to the gradient in rainfall, the vegetation varies from southern tropical dry thorn forest in the east to moist deciduous forest in the west with dry deciduous forest in between the two forest types (Champion and Seth 1968). NBR along with its adjoining natural habitats has remarkable faunal diversity and is well-known for supporting the largest population of Asian elephants with an estimated population of 5,750 individuals (Project Elephant 2007). Overgrazing by domestic cattle and firewood collection are serious problems in the eastern fringes of NBR (Baskaran *et al.* 2004).

METHODS

Grass biomass

The abundance of grass, in terms of biomass, was estimated twice in a season for three seasons from stratified transects of one to two kilometres in dry deciduous (7 transects of total length of 10 km) and dry thorn forest (6 transects of total length of 10 km). The grass biomass could not be assessed in moist deciduous forest due to inadequate manpower. At 200 m intervals along these transects, two 1 sq. m quadrats were placed at a 5 m distance on either side of the transect. All the grass species were clipped at the ground level from each quadrat and weighed to estimate the grass biomass (wet weight). The biomass estimates using dry weight is more appropriate than wet weight method, due to varied water content in plant samples in different season. However, given the manpower and infrastructure facilities, dry weight method could not be used. Mean grass biomass for grazed and un-grazed (by domestic cattle) areas for each habitat was also estimated, as there were remarkable differences in grazing pressure across habitats. All transect were restricted to areas where direct observations on feeding of elephants was carried out.

Activity and feeding behaviour

Observations were made on elephant clans and bulls using instantaneous scan sampling method (Altmann 1974). Using radio-collared elephant clans and bull, a minimum of two clans and a bull were observed for a period of 2 days/ month. Non-collared elephant clans and bulls were also observed, especially during months when radio-collared elephants were not recorded within a habitat. Daylight hours from 06:00 to 18:00 hrs were divided into 12 one-hour blocks for sampling and an attempt was made to sample each one-hour block at least once a month. Scan sampling was made at 15-minute intervals (four scans per hour) presuming that this interval would rule out over-sampling of any particular behaviour. Observations were made on foot (ground) or from a tree, depending on the topography, wind direction and visibility. Care was taken to ensure that the target animal or target group did not detect the observer's presence. During the sampling, animals were systematically scanned and information such as age, sex and activity (feeding, resting, moving and others) were recorded. If the animal was feeding, data on plant species eaten was also recorded. Additionally, the ambient temperature was recorded at every 30-minute intervals using digital thermometer at the observation site.

Data analyses

The frequency of activities and plant species eaten was estimated season-wise for each habitat. The data blocks in the morning (06:00-08:00 hrs) and evening (16:00-18:00 hrs) were less compared to other sample blocks primarily due to delay in radio-locating the animals because of weather conditions (mist, rain, etc.) and the remoteness of certain areas. Since the activity of elephants changes according to daylight hours (McKay 1973), any bias in observation at particular hours of the day would result in over- or under-estimation of a particular activity. To standardize such bias, the percentages of various activities/hour was derived from observed hourly-pooled data, and from this percentage, the mean time spent on various activities (weighted average) was calculated for the season. Data on activity pattern and grass, and browse ratio collected from the radio-collared tuskless bull, a habitual crop raider, were not included into the analysis, as its activities and feeding habits were skewed due to crop raiding behaviour. However, its data on food species eaten were included into the analysis mainly to capture the wide spectrum of food species eaten by elephants in this area. All the data were analyzed using non-parametric statistical tests and analyses were done using 'Statistical Package for Social Studies' (Norusis 1990). Kruskal-Wallis' one-way ANOVA and the Man-Whitney U tests were used to test the differences in activity pattern. Chi-square analysis was used to test the differences in the selected browsing and grazing plant species. The relationship between ambient temperature and activities (feeding and resting) was tested using Spearman Rank Correlation.

RESULTS

Overall time activity pattern

Overall, during daylight hours, elephants showed two peaks in feeding, one in the morning (06:00-09:00 hrs) and

another in the evening (15:00-17:00 hrs) (Fig. 1a). Time spent on resting was more around midday than in mornings and evenings. Elephants frequently engaged in other activities such as mud-bath, sand-bath, salt-licking and play during 14:00-16:00 hrs. As the temperature increased from morning with a peak between 12:00 and 13:00 hrs, resting became more common. However, comparisons of feeding and resting with ambient temperature, with pooled data over habitats and seasons, showed no significant correlation. Overall, the activity budget revealed that elephants spent 60% of the daylight hours (06:00-18:00 hrs) on feeding and 20% on resting. Time spent on moving was 14% and 6% on other activities

Seasonal difference in time activity in different habitats

Dry deciduous forest: During the dry season, elephants showed a bimodal feeding activity with a peak each at 07:00 hrs and 18:00 hrs in dry deciduous forests (Fig. 1b). Elephants mainly rested during midday between 11:00 and 14:00 hrs. Feeding decreased significantly with increasing ambient temperature (r_s = - 0.7671, df = 12, P = 0.01), while resting increased positively (r_s = 0.8581, df = 12, P = 0.01). Movement was mostly restricted to the mornings and evenings. Unlike the dry season, elephants spent a minimum of 50% of time on feeding in all the hours of day during the first wet season, and resting being considerably less (Fig. 1c). Feeding and resting showed no significant correlation with temperature during the first wet season, as the ambient temperature during this season was relatively lower than the dry season. During the second wet season, the pattern of elephant activities observed was similar to the first wet season (Fig. 1d), but resting positively increased with temperature (r_s = 0.5874, df =12, P = 0.04), as ambient temperature increased gradually in this season unlike the first wet season.

Activity budget data show that in dry deciduous forest, elephants spent a major part (68%) of the annual daylight hours feeding (Table 1). However, time spent on feeding and resting varied among the three seasons. During the dry season, elephants fed for significantly less time than the first (M-W U = 14475, P = 0.01) and the second (M-W U = 14503, P = 0.01) wet seasons. Time spent on resting was significantly more during the dry season than the first (M-W U = 15402, P = 0.01) and second (M-W U=14864.5, P = 0.01) wet seasons.

Moist deciduous forest: In moist deciduous forest, the activity pattern shown (Fig. 1e) for the first wet season was based on a small number of observations (n = 221) collected over a short period of three days in a disturbed area around human settlements, and may therefore not accurately represent a picture for the entire season. Similarly, as the observations made on elephants were limited during dry season (n = 35) and nil during second wet season, the time activity pattern of elephants could not be constructed.

Dry thorn forest: The pattern of elephant feeding and resting observed in thorn forest during the dry season was similar to the pattern observed in dry deciduous forest (Fig. 1f-h), but there was a sharp rise in time spent on movement between 11:00 and 12:00 hrs. The peak temperature recorded during midday hours coincided with peak resting time. Resting increased positively with temperature (r_s= 0.7273, df =11, P = 0.01), while feeding decreased (r_s= - 0.7091, df = 11, P = 0.01). During the first and second wet seasons, the activities observed among elephants were similar, except for an unusually longer time (>55%) spent in resting in the morning hours (06:00-07:00 hrs) observed during second wet season (November and December), which is similar to that observed in the early dry season (January). No significant correlation was observed between ambient temperature and feeding, and resting during first and second wet seasons.

Data on activity budget showed that annually, elephants in thorn forest devoted significantly less time for feeding and more time for resting compared to dry deciduous forest (Table 1). On a seasonal basis, elephants in thorn forest also spent significantly less time on feeding (M-W U = 3838, P = 0.03) and more on resting during the dry season than the first wet season (M-W U = 2936, P = 0.01). The time spent on various activities did not vary much between the dry and

Table 1: Time spent (%) in various activities by elephants in the different habitats in Nilgiri Biosphere Reserve

Habitat and Activity	Season			Annual
	Dry	First wet	Second wet	
Dry deciduous	(n = 4603)	(n = 3310)	(n = 3203)	(n= 11,116)
Feeding	59.55	72.25	72.16	67.99
Moving	11.54	11.06	12.06	11.55
Resting	24.49	12.02	10.57	15.69
Others	4.42	4.66	5.2	4.76
Moist deciduous	(n = 35)	(n = 221)	(n = 0)	(n = 256)
Feeding	22.2	60.0	-	41.10
Moving	33.12	26.37	-	29.74
Resting	31.21	9.23	-	20.22
Others	13.46	4.4	-	8.93
Dry thorn	(n = 2715)	(n = 819)	(n = 5562)	(n = 9096)
Feeding	47.08	57.63	52.35	52.35
Moving	17.21	12.14	15.46	14.94
Resting	29.55	13.77	24.26	22.33
Others	6.16	16.45	7.92	10.18

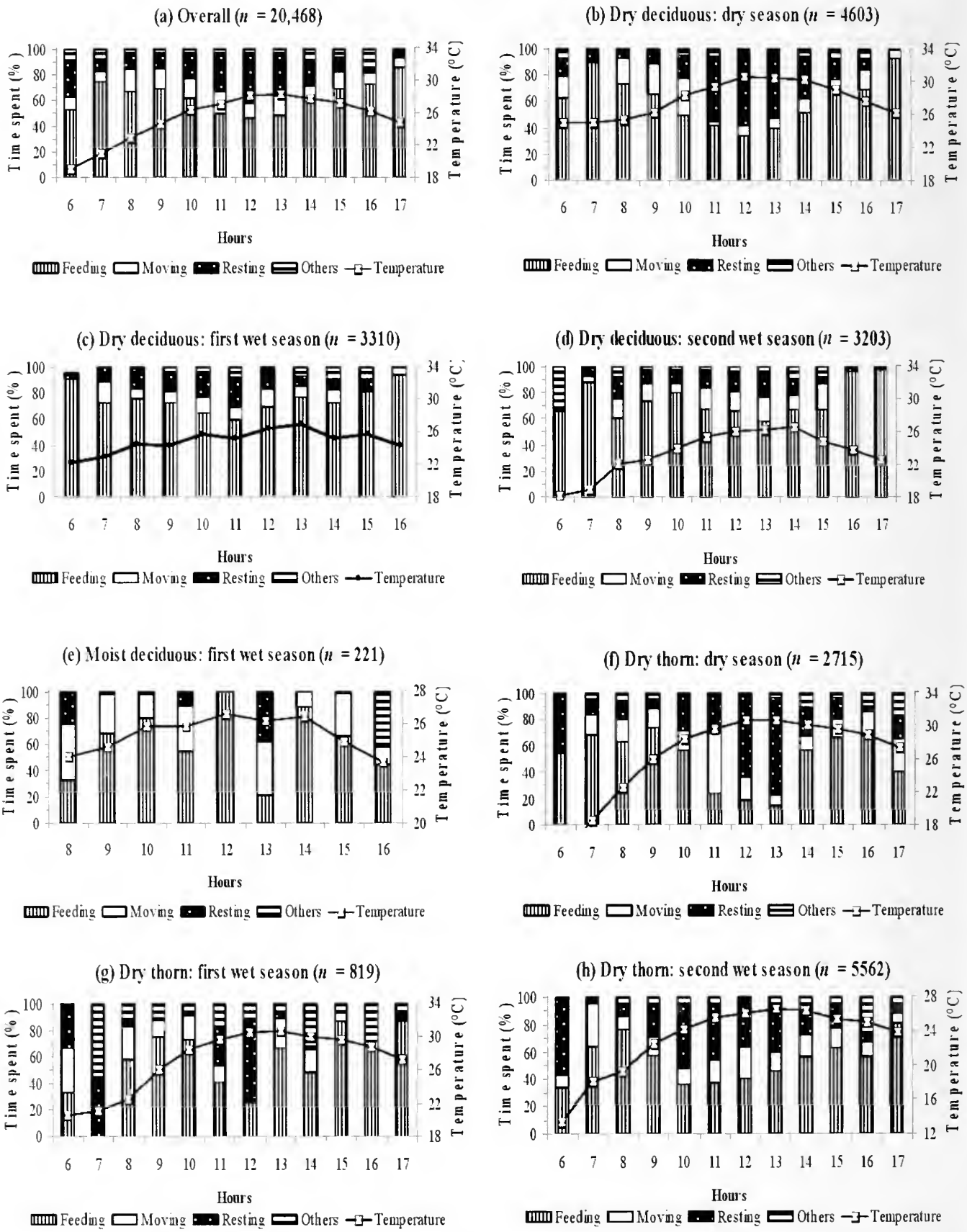


Fig. 1: Season-wise diurnal activity pattern of elephants in different habitats of Nilgiri Biosphere Reserve

second wet seasons, but there were significant variations in resting (M-W U = 4581, P = 0.01) and moving (M-W U = 5500, P = 0.01) between the wet seasons.

Grass biomass

In dry deciduous forest, mean grass biomass varied significantly across the three seasons (K-W-χ^2 = 32.1122, P = 0.0001) (Table 2). The biomass was significantly higher during the second wet season (921 gm/m²) as compared to the dry (573.9 gm/m², M-W U = 1838.5, P = 0.0001) and the first wet (618.1 gm/m², M-W U = 3033, P = 0.0014) seasons, and in the first wet season as compared to the dry season (M-W U=2039.5, P = 0.0002). Similarly, in thorn forest, grass biomass varied significantly across the three seasons (K-W-χ^2 = 102.46, P = 0.0001), and was significantly higher during the second wet season (524.1 gm/m²) than the dry (156.9 gm/m², M-W U = 781.5, P = 0.0001) and the first wet (405 gm/m², M-W U = 2263.5, P = 0.003) seasons. The grass biomass in the first wet season was also significantly more than in the dry season (M-W U=1088, P = 0.0001). Sampling was not carried out in moist deciduous forest due to manpower constraints as mentioned under methods. The observed variation in biomass between dry and wet seasons could marginally be due to variation in water content in grass samples.

The areas under cattle grazing had significantly lower grass biomass in the dry deciduous forest during the dry season (un-grazed = 725 gm/m² and grazed =188 gm/m², M-W U = 220, P = 0.0002) and in second wet season (ungrazed = 1019 gm/m² and grazed = 520 gm/m², M-W U = 388.5, P = 0.0016). However, the influence of grazing was statistically insignificant in dry deciduous during the first wet season (un-grazed = 677gm/m² and grazed = 600 gm/m², M-W U = 511, P = 0.10), and in all the seasons in dry thorn forest (dry season ungrazed = 190 gm/m² and grazed = 152 gm/m², M-W U = 318.5, P = 0.23; first wet: ungrazed = 420 gm/m² and grazed = 390 gm/m², M-W U = 426.5, P = 0.34; second wet season ungrazed = 528 gm/m² and grazed = 480 gm/m², M-W U = 238.5, P = 0.69).

Browse and grass ratio in the diet

Out of 10,743 feeding observations (*viz.*, 7,003 in dry deciduous, 153 in moist deciduous and 3,587 in dry thorn forest), grazing and browsing constituted 84.6% and 15.4%, respectively. Grass dominated the diet of elephants during all the seasons in dry deciduous and dry thorn forests, indicating the importance of grass in the diet of elephants in this region. Browsing was more during the dry season in dry deciduous (15.1%) and dry thorn (47.1%) forests than during the wet seasons (Table 2). The percentage of grazing and browsing varied significantly across seasons in dry deciduous (χ^2 = 148.64, df = 2, P = 0.00001) and dry thorn forests (χ^2 = 554.24, df = 2, P = 0.00001). Elephants fed significantly more on grass and less on browse in dry deciduous than in dry thorn forest in all the seasons (dry season - χ^2 = 459.43, df = 1, P = 0.00001; first wet season - χ^2 = 6.37, df = 1, P = 0.01 and second wet season - χ^2 = 65.71, df = 1, P = 0.00001), indicating the importance of grass in dry deciduous forest.

Species composition in the diet

Overall, 83 plant species eaten by elephants were recorded from 11,186 feeding scans. Feeding scan observations (n = 443) made on the habitual crop raiding bull were also included in this analysis to know the diversity of food plants eaten by elephants. Of the 83 plant species, 59 were browse species (trees, shrubs, herbs and bamboo), and the rest (24) were grass species (Appendix 1). Among the 24 grass species, six constituted more than 75% of the total diet (*Themeda cymbaria* 39.5%, *Heteropogon contortus* 13.4%, *Themeda triandra* 10.9%, *Bothriochloa* sp. 7.3%, *Aristida adscensionis* 2.4% and *Cymbopogon flexuosus* 2.3%). Among the 59 browse species, *Acacia intsia*, bamboo spp. and *Kydia calycina* were the most important, and contributed 5.4, 4.4 and 1.8%, respectively to the total diet.

Table 2: Grass biomass (gm/sq. m) and grass: browse ratio in the diet of elephants in dry deciduous and dry thorn forests of Nilgiri Biosphere Reserve (grass biomass not assessed in moist deciduous forest due to inadequate manpower)

Season	Dry deciduous		Moist deciduous	Dry thorn	
	Grass biomass/m² (n = 254)	Grass: browse ratio (n = 7003)	Grass: browse ratio (n = 153)	Grass biomass/m² (n = 251)	Grass: browse ratio (n = 3587)
Dry	573.9	85: 15	78: 22	156.9	53: 47
First Wet	618.1	92: 8	31: 69	405.0	89: 11
Second Wet	921.0	95: 5	-	524.1	88: 12
Annual	720.2	91: 9	54: 46	352.0	74: 26

In dry deciduous forest, 36 species of food plants were recorded from 7,003 feeding observations (Appendix 1). The number of grass species eaten (13) was less than browse species (23). The tall grass *T. cymbaria* alone contributed 62.8% of the diet and *T. triandra* 17.1%, other grass species formed <5%. Bamboo (4.4%) and *K. calycina* (2.9%) were the two major browse species (Table 3). Seasonal use of these food plants varied considerably, but the tall grass *T. cymbaria* was always the principal diet during all the seasons (Table 3). The proportion of the top four species (*T. cymbaria*, *T. triandra*, bamboo and *C. flexuosus*) and the rest of the browse and grass species (pooled separately as other browse and other grass spp.) utilised varied significantly among seasons ($\chi^2 = 1118.87$, df =10, $P = 0.01$).

Table 3: Major food species eaten (%) by elephants in different habitats in Nilgiri Biosphere Reserve

Food species	Season			Annual
	Dry	First wet	Second wet	
Dry deciduous	(n = 2510)	(n = 2236)	(n = 2257)	(n = 7003)
Bamboo spp.	6.9	3.1	3.1	4.4
Cymbopogon flexuosus	-	2.4	8.0	3.4
Themeda cymbaria	71.4	70.9	45.2	62.8
Themeda triandra	12.2	14.8	24.8	17.1
Other browse spp.	8.2	4.9	1.9	5.1
Other grass spp.	1.3	3.8	17.0	7.2
Moist deciduous	(n = 9)	(n = 289)	(n = 71)	(n = 369)
Bamboo spp.	-	34.9	25.4	32.20
Curcuma spp.	-	6.9	45.1	14.30
Helicteres isora	-	4.2	-	9.75
Cyrtococcum patens	-	12.8	-	11.60
C. flexuosus	-	4.8	7.0	5.14
T. cymbaria	-	8.0	1.4	6.50
Other browse spp.	22.2	17.3	21.1	11.55
Other grass spp.	77.8	11.1	-	8.96
Dry thorn	(n = 1430)	(n = 497)	(n = 1887)	(n = 3814)
Acacia intsia	27.3	10.1	8.8	15.9
Bothriochloa sp.	4.9	72.8	20.2	21.3
Heteropogon contortus	30.1	11.5	48.8	36.9
Other browse spp.	24.2	1.4	5.6	12.0
Other grass spp.	13.4	4.2	16.6	13.9

In moist deciduous forest, 22 species of food plants were recorded from 369 feeding observations. The diet of elephants was dominated by browse species both in terms of number of species (15) and bulk (67.8%) (Appendix 1). Bamboo (32.2%), *Curcuma* sp. (14.3%), *Helicteres isora* (9.75%) and *Dioscorea* sp. (2.16%) were the major browse plants of elephants in this habitat (Table 3). Short grass, *Cyrtococcum patens*, contributed a major part (11.6%) followed by *T. cymbaria* (6.5) and *C. flexuosus* (5.14%). Other grass and browse species contributed very little to the total diet. Seasonal use of these food plants varied significantly between the first and the second wet seasons ($\chi^2 = 83.57$, $df = 7$, $P = 0.01$).

In dry thorn forest, 56 species of food plants were recorded from 3,814 feeding observations (Appendix 1). Elephants fed on more number of browse species (41) over grass (15) in this habitat. However, in terms of bulk, browse constituted only 27.9% of the overall diet, while grass species contributed 72.1% (Table 3). Among the grass species, *H. contortus* (36.9%) and *Bothriochloa* sp. (21.3%) were important. Elephants ate the thorny shrub *A. intsia* more (15.9%) among the 41 browse species in this habitat. The percent composition of each species in the diet of elephants varied among the seasons ($\chi^2 = 1525.33$, $df = 16$, $P = 0.01$). Elephants ate more diverse food species during the dry season in dry deciduous (19 species) and dry thorn (42 species) forests than during the wet seasons (first wet: 17 and 9 spp. and second wet: 18 and 25 spp. respectively in dry deciduous and dry thorn forests). The number of species eaten was also greater in the dry thorn forest (56 spp.) than in the dry deciduous (36 spp.).

DISCUSSION

Overall, elephants showed bimodal feeding peaks, one in the morning and another in the evening, while at midday almost equal time was devoted for feeding and resting, which is similar to the pattern observed on African elephants (Wyatt and Eltringham 1974; Guy 1976; Kalemera 1987) and Asian elephants (McKay 1973; Vancuylenburg 1977; Easa 1989). Ambient temperature influences feeding activity significantly in dry deciduous and thorn forests more in the dry season than wet seasons. This is reflected in the bimodal feeding pattern and the significant negative correlation obtained between feeding and temperature during the dry season. Ambient temperature influences the body temperature of both the Asian and African elephants (Elder and Rodgers 1975; Weissenbock 2006). The most likely reason for the afternoon

inactivity is heat avoidance rather than sleep due to the poor thermoregulatory capacity of the large body mass (low surface-to-volume ratio) and the absence of sufficient sweat glands in their skin (Wyatt and Eltringham 1974; Hiley 1975).

The overall feeding time (60%) estimated in this study is comparable to 65% reported in Asian elephants in Parambikulam (Easa 1989), but low compared to 74% reported in Mudumalai (Sivaganesan and Johnsingh 1995), and Idukki (Vinod and Cheeran 1997) wildlife sanctuaries in India and >75% in Sri Lanka (McKay 1973; Vancuylenberg 1977). The variation in feeding time, in NBR between Sivaganesan and Johnsingh (1995) and the present study is likely due to differences in sampling area (habitat) and time of observation, as elephants spent more time feeding in dry and moist deciduous forests than in dry thorn forest (as recorded in this study). In most secondary forests, direct observation on elephants is difficult especially during midday resting, which mostly take place in dense undergrowth and thick canopied shady areas like riverine and stream beds. Inadequate observations during such midday resting hours and pooling of such data without standardization would result in bias towards feeding activity. Thus, the observed difference in feeding time estimated by Sivaganesan and Johnsingh (1995) and this study could be due to any or a combination of the above-mentioned reasons. The same reasons could also be attributed for the higher feeding time (>75%) estimated by McKay (1973), Vancuylenberg (1977), and Vinod and Cheeran 1997 (Idukki).

Elephants spent significantly less time feeding during the dry season compared to the first and second wet seasons in dry deciduous forest, and the first wet season in dry thorn forest. These may be attributed to higher ambient temperatures and poor shade availability as shown by studies on savannah elephants in Africa (Guy 1976; Barnes 1979) and the Asian Elephant (McKay 1973; Vancuylenberg 1977). Elephants in dry thorn forest spent significantly less time on feeding during the second wet season than the first wet season, even though climatic conditions were ideal in thorn forest during the second wet season with lower ambient temperatures than in the first wet and dry seasons. A possible reason could be the higher availability of grass (the principal food of elephants – discussed further on) during the second wet season than in the other seasons as shown by grass biomass results. With an increase in food abundance, elephants could reduce overall feeding time through higher intake rate as reported elsewhere in African elephants (Guy 1975). Conversely, the lower time spent on feeding in the dry thorn forest, despite less biomass of food in this habitat (than in the dry deciduous forest), could be a result of exposure to higher ambient temperature, coupled with poor shade availability and greater human disturbance. Barnes (1983) states that the time spent on feeding may depend not only on the quality of food, but also upon the cost (e.g., heat stress, disturbance) imposed in its acquisition. Thus, feeding time seems to vary between areas, influenced by factors such as food availability, ambient temperature and human disturbance.

Browse and grass ratio in the diet

Extensive variation in the proportion of grass and browse consumption by elephants in different areas has raised questions as to whether the Asian Elephant is primarily a grazer or browser. Given that Asian elephants inhabit a wide range of habitats from rainforest (a predominantly browse-dominated habitat), to savanna (a predominantly grass dominated habitat), there is bound to be a significant variation in the grass and browse ratio in the elephant diet. Browse dominates the diet of elephants in rainforests of Malaysia (Olivier 1978), northeastern India (Sukumar *et al.* 2003) and in Bihar, central India (Daniel *et al.* 1995), and also in relatively low rainfall degraded areas in the Eastern Ghats of southern India (Sukumar 1990; Rameshkumar 1994; Daniel *et al.* 2006, 2008). On the other hand, grass dominates the diet of elephants in grass-dominated habitats of Sri Lanka (McKay 1973), deciduous forests of Mudumalai Wildlife Sanctuary (Sivaganesan and Johnsingh 1995) and mixed forests (evergreen, semi-evergreen, moist and grasslands) of Idukki Wildlife Sanctuary (Vinod and Cheeran 1997). Similarly, African elephants also showed wide variations in grass and browse consumption (Buss 1961; Field 1971; Beekman and Prins 1989; Kalemera 1989; Viljoen 1989; White *et al.* 1993) according to the habitats they occupy. In this study in NRB, the diet of elephants was found dominated by grass (84.6%), consistent with the observations of Sivaganesan and Johnsingh (1995) for the same area.

Seasonal variations in grazing and browsing by elephants have been related to changes in the chemical composition of food plants (Field 1971; Olivier 1978; Sukumar 1989; Sivaganesan and Johnsingh 1995). Increased browsing during the dry season and grazing during the wet seasons have been related to higher level of crude protein. Since an elephant's daily requirement is 0.3 gm of digestible protein/kg of body weight (McCullagh 1969), a marginal increase in browse consumption would be sufficient to meet this requirement. Excessive protein intake is also undesirable, as nitrogen excretion requires more water, which may be in short supply (Sukumar 1990). Grass contains more carbohydrates (53%) than browse (49%) (Field 1971), and is also more accessible to all the age classes of elephants. Therefore, elephants need not selectively feed on protein-rich browse during the dry season, but a marginal increase in

browsing would perhaps be sufficient to compensate for the lower intake of protein from the consumption of low-protein grass during the dry season. This means that when browse and grass are equally available, elephants could predominantly feed on grass with a marginal increase in browse during the dry season to meet the optimum requirements as recorded in dry deciduous forest in this study.

In this study, an almost equal consumption of browse (47%) and grass (53%) by elephants in dry thorn forest during the dry season coincided with the significantly lower grass biomass. For example, from the second wet season to the dry season, the grass biomass dropped from 524 gm/m² to 157 gm/m². Elephants were seen scraping the short grass with their forefoot toenails in this season as grass height was too short (<10 cm) to be grasped by the trunk. Very low consumption of grass by elephants despite high crude protein during the first wet season in 'short grass browse dominated habitat' of Sathyamangalam Forest Division was also attributed to poor grass growth (Sukumar 1989). Therefore, the increase in browse consumption by elephants in dry thorn forest during the dry season could not be taken only as browse preference due to high protein content, but as an alternative to inadequate grass resources. In the dry deciduous forest, the browsing rate doubled during the dry season but its percentage was still much less than that of grass, supporting the earlier hypothesis. Similarly, the reason for the consumption of more diverse food plants during the dry season than in the wet season, and likewise, in the dry thorn than in the dry deciduous forests could be due to lower availability of grass. The larger number of food species consumption by elephants reported from the high rainfall browse dominated habitats of Asia (Olivier 1978; Chen *et al.* 2006; Himmelsbach *et al.* 2006; Roy *et al.* 2006; Campos-Arceiz *et al.* 2008) and Africa (White *et al.* 1993) further suggests the above reasoning that elephants in the absence of sufficient grass availability would go for more diverse food species. This could be the effect of secondary compounds from browse plants as reported (Clauss *et al.* 2003).

Although studies on stable carbon isotope ratios in the bone collagen of Asian elephants state that browse is more important than grass for elephants (Sukumar *et al.* 1987; Sukumar and Ramesh 1992, 1995), browse was not preferred by elephants over grass in the study area. Cerling *et al.* (1999), through isotopic analysis from modern and fossil proboscideans, showed that extinct elephants (those that survived from Pliocene or Miocene up to almost 1 million years ago) were predominantly grazers, and the modern elephants are predominantly browsers, but with grazing dominating the diet of elephants in some regions in Africa and Asia. This study (Cerling *et al.* 1999) for the modern Asian species used the findings from Sukumar and Ramesh (1992, 1995). Although the bone samples for the analysis by Sukumar and Ramesh (1992, 1995) were collected from the dead elephants in the Nilgiri-Eastern Ghats region, details such as where these elephants predominantly ranged and what proportion of the samples came from the elephants that ranged in the grass or browse dominated habitats are unknown. A more detailed stable carbon isotope study with sufficient samples from individuals with known ranging history would shed better light on these aspects of elephant ecology. However, Olivier (1978) argued that the trend in body size and dental features suggest that elephants are highly adapted to grass feeding and thus can cope up with an abrasive, nutritionally poor diet of high fiber and low protein. Because of seasonal variations in grass availability, he believed that they must be able to switch over alternatively to browsing. Such a trend indicates that elephants may be basically grazers, but their ability to survive in rain forests and deserts indicate that they are highly adapted, being also able to exploit browse in the absence or insufficient grass supply. Overall, our findings support Olivier (1978) and show that grass forms the principal diet of elephants in this part of Nilgiri Biosphere Reserve.

ACKNOWLEDGEMENTS

We thank US Fish and Wildlife Service for funding the study and the State Forest Departments of Tamil Nadu, Karnataka and Kerala, for permitting us to undertake the study in their states. We extend our sincere thanks to Mr. J.C. Daniel the Principal Investigator of the Project and former Director of Bombay Natural History Society, Mumbai, for his consistent support. We thank R.F.W. Barnes, visiting scholar Division of Biological Sciences, University of California and Dr. Guha Dharmarajan, Perdue University, Indiana, USA, for their valuable comments on the manuscript.

REFERENCES

Altmann, J. (1974): Observational study of behaviour: sampling methods. *Behaviour 49*: 227-267.

Barnes, R.F.W. (1979): Elephant ecology in Ruaha National Park, Tanzania. Ph.D. Thesis, University of Cambridge.

Barnes, R.F.W. (1983): Elephant behaviour in semi-arid environment. *Afr. J. Ecol. 21*: 185-196.

Baskaran, N., U. Anbarasan & R. Sukumar (2004): Impacts of human disturbances on the elephant habitats of Mudumalai Wildlife Sanctuary, South India. Technical Report to Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012, India.

Beekman, J.H. & H.H.T. Prins (1989): Feeding strategy of sedentary large herbivore in East Africa, with emphasis on the African

buffalo. *Syncerus caffer*. *Afr. J. Ecol. 27*: 129-147.

Buss, I.O. (1961): Some observation of food habits and behaviour of African elephant. *J. Wildl. Manage. 25(2)*: 131-148.

Campos-Arceiz, A., T.Z. Lin, W. Htun, S. Takatsuki & P. Leimgruber (2008): Working with mahouts to explore the diet of work elephants in Myanmar (Burma). *Ecol. Res. 23*: 1057-1064.

Cerling, T.E., J.M. Harris & M.G. Leakey (1999): Browsing and grazing in elephants: the isotope record of modern and fossil proboscideans. *Oecologia 120*: 364-374.

Champion, H.G. & S.K. Seth (1968): Revised survey of forest types in India. Manager of Publication, New Delhi. 404 pp.

Chen, J., X.B. Deng, L. Zhang & Z.L. Bai (2006): Diet composition and foraging ecology of Asian elephants in Shangyong, Xishuangbanna, China. *Acta Ecol Sin 26*: 309-316.

Clauss, M., R. Frey, B. Kiefer, M. Lechner-Doll, W. Loehlein, C. Polster, G.E. Rossner & W.J. Streich (2003): The maximum attainable body size of herbivorous mammals: morphophysiological constraints on foregut, and adaptations of hindgut fermenters. *Oecologia 136*: 14-27.

Daniel, J.C., A.A. Desai, N. Sivaganesan, H.S. Datye, S. Rameshkumar, N. Baskaran, M. Balasubramanian & S. Swaminathan (1995): Ecology of the Asian elephant. Final Report 1987-1994. Bombay Natural History Society, Bombay.

Daniel, J.C., R. Manakadan, S. Swaminathan, A. Desai & N. Mohan Raj (2006): An assessment of the population, distribution, habitat-use and problems of the Asian Elephant *Elephas maximus* in Koundinya Wildlife Sanctuary, Andhra Pradesh, India. Final Report. Bombay Natural History Society, Mumbai, and U.S. Fish and Wildlife Service, Washington, D.C.

Daniel, J.C., R. Manakadan, S. Swaminathan, A. Desai, N. Mohan Raj, R. Ramesh Babu & G. Balasubramanian (2008): The population, distribution, habitat and problems of the Asian Elephant *Elephas maximus* in Andhra Pradesh, India, including an assessment of the causes for their migration from the Hosur-Dharmapuri forests of Tamil Nadu into Andhra Pradesh. Final Report. Bombay Natural History Society, Mumbai, and U.S. Fish and Wildlife Service, Washington, D.C.

Easa, P.S. (1989): Certain aspects of ecology and ethology of the Asian elephant (*Elephas maxmimus* L.) in Parambikulam Wildlife Sanctuary, South India. Ph.D. Thesis, University of Kerala. Trivandrum.

Elder, W.H. & D.H. Rodgers (1975): Body temperature in the African elephant as related to the ambient temperature. *Mammalia 1(3)*: 395-399.

Field, C.R. (1971): Elephant ecology in the Queen Elizabeth National Park, Uganda. *E. Afr. Wildl. J. 9*: 99-123.

Guy, P.R. (1975): The daily food intake of the African elephant (*Loxodonta africana* Blumenbach) in Rhodesia. *Arnoldia Rhod. 7(26)*: 1-8.

Guy, P.R. (1976): Diurnal activity patterns of elephant in the Sengwa area, Rhodesia. *E. Afr. Wildl. J. 14*: 285-295.

Hiley, P.G. (1975): How the elephant keeps its cool. *Nat. Hist. 84(10)*: 34-41.

Himmelsbach, W., M.A. Gonzalez-Tagle, K. Fuldner, H.H. Hoefle & W. Htun (2006): Food plants of captive elephants in the Okkan Reserved Forest, Myanmar (Burma), Southeast Asia. *Ecotropica 12*: 15-26.

Kalemera, M.C. (1987): Dry season diurnal activity of elephants in Lake Manyara, National park, Tanzania. *Afr. J. Ecol. 25*: 255-264.

Kalemera, M.C. (1989): Observations on feeding preference of elephants in the *Acacia tortilis* woodlands of Lake Manyara, National park, Tanzania. *Afr. J. Ecol. 27*: 325-333.

McCullagh, K.G. (1969): The growth and nutrition of the African elephant. II. The chemical nature of the diet. *E. Afr. Wildl. J. 7*: 91-98.

McKay, G.M. (1973): Behavioural ecology of the Asiatic elephant in southern Ceylon. Smithsonian contribution to Zoology. 125: Pp. 1-113.

Norusis, M.J. (1990): SPSS/PC + Advanced statistics 4.0. SPSS Inc., Chicago, Illinois. 949 pp.

Olivier, R.C.D. (1978): On the ecology of Asian Elephant. Ph. D. Thesis, University of Cambridge.

Project Elephant (2007): Census in Project Elephant Reserves in India: http://envfor.nic.in/pe/ elephant2007.pdf. Accessed on March 12, 2009.

Ramesh Kumar, S. (1994): Ecology of Asian Elephants (*Elephas maximus*), their habitats and interactions with people in Hosur and Dharmapuri Forest Division, Tamil Nadu, south Indian. Ph.D. Thesis. Bharathidasan University, Tiruchirapally.

Roy, M., T. Bhattacharya, N. Baskaran & R. Sukumar (2006): Foraging ecology of the Asian elephant (*Elephas maximus*) in northern West Bengal, northeastern India. Pp. 153-162. *In*: *Proc. International Elephant Conservation and Research Symposium*, October 21-22, 2006, Copenhagen Zoo, Denmark.

Sivaganesan, N. & A.J.T. Johnsingh (1995): Food resources crucial to the wild elephants in Mudumalai Wildlife Sanctuary, Tamil Nadu, India. Pp. 405-423. *In*: Daniel, J.C. & H.S. Datye (Eds): A week with elephants. Proceedings of the International Seminar on the conservation of Asian Elephant. Mudumalai Wildlife Sanctuary, June 1993. Bombay Natural History Society, Oxford University Press, Bombay, India.

Sivaganesan, N. & M. C. Sathyanarayana (1995): Tree mortality caused by elephants in Mudumalai Wildlife Sanctuary, South India. Pp. 314-330. *In*: Daniel, J.C. & H.S. Datye (Eds): A week with elephants. Proceedings of the International Seminar on the conservation of Asian elephant. Mudumalai Wildlife Sanctuary, June 1993. Bombay Natural History Society, Oxford University Press, Bombay, India.

Sukumar, R. (1989): The Asian elephant: Ecology and management. Cambridge University Press, Cambridge. 251 pp.

Sukumar, R. (1990): Ecology of Asian elephant in south India. II. Feeding habitats and crop raiding patterns. *Journal of Trop. Ecol. 6*: 33-53.

Sukumar, R. (2003): The Living Elephants: Evolutionary Ecology, Behaviour and Conservation. Oxford University Press. New York. 478 pp.

Sukumar, R. & R. Ramesh (1992): Stable carbon isotope ratios in Asian elephant collagen: implications for dietary studies. *Oecologia 91*: 536-539.

Sukumar, R. & R. Ramesh (1995): Elephant foraging: Is browse or grass more important? Pp. 368-374. *In*: Daniel, J.C. & H.S. Datye (Eds): A Week with Elephants. Proceedings of the International Seminar on the conservation of Asian Elephant. Mudumalai Wildlife Sanctuary, June 1993. Bombay Natural History Society, Oxford University Press, Bombay, India.

Sukumar, R., S.K. Bhattacharya & V. Krishnamurthy (1987): Carbon isotope evidence for different feeding patterns in an Asian elephant population. *Curr. Sci. 56*: 11-14.

Sukumar, R., A. Venkataraman, N. Baskaran, G. Dharmarajan, M. Roy, H.S. Suresh & K. Narendran (2003): Study of elephants in Buxa Tiger Reserve and adjoining areas in northern West Bengal and preparation of conservation action plan. Final Report submitted to West Bengal Forest Department. Centre for Ecological Science, Indian Institute of Science, Bangalore, December 2003.

Vancuylenberg, B.W.B. (1977): Feeding behaviour of the Asiatic elephants in the South-east Sri Lanka in relation to conservation. *Biol. Conserv. 12*: 33-53.

Viljoen, P.J. (1989): Habitat selection and preferred food plants of a

desert-dwelling elephant population in the northern Namib desert, South West Africa/Namibia. *Afr. J. Ecol. 27*: 227-240.

VINOD, T.R. & J.V. CHEERAN (1997): Activity time budget of Asian elephants (*Elephas maximus* L.) in Idukki Wildlife Sanctuary, Kerala, South India. *Indian Forester 123*: 948-951.

WEISSENBOCK, N.M. (2006): How do elephants deal with various climate conditions? Previous results, recent data and new hypotheses. Pp. 217-224. *In*: Proceeding of International Elephant Conservation and Research symposium. October 21-22, 2006, Copenhagen Zoo, Denmark.

WHITE, L.J.T., E.G.C. TUTIN & M. FERNANDEZ (1993): Group composition and diet of elephants *Loxodonta africana cyclotis* Matschie 1900, in the Lope Reserve, Gabon. *Afr. J. Ecol. 31*: 181-199.

WYATT, J.R. & S.K. ELTRINGHAM (1974): The daily activity of elephants in Rwenzori National Park, Uganda. *E. Afr. Wildl. J. 12*: 273-289.

Appendix 1: Food plants (%) in diet of elephants in different habitats in Nilgiri Biosphere Reserve

S. No.	Plant species	DDF (n = 7003)	MDF (n = 369)	TF (n = 3814)	Overall (n = 11186)
	Browse species				
1	*Acacia chundra*			0.55	0.18
2	*Acacia ferruginea*			0.26	0.08
3	*Acacia intsia*	0.02	0.27	15.8	5.44
4	*Acacia leucophloea*			0.57	0.19
5	*Acacia suma*			0.05	0.01
6	*Achyranthes aspera*			0.15	0.05
7	*Aerva lanata*			0.02	0.001
8	*Albizia amara*			1.31	0.44
9	*Albizia lebbeck*		0.27		0.001
10	Bamboo spp.	4.44	32.2	1.75	4.44
11	*Bauhinia racemosa*	0.04		0.6	0.23
12	*Boerhavia diffusa*			0.02	0.001
13	*Capparis sepiaria*			0.02	0.001
14	*Catunaregam torulosa*			0.05	0.01
15	*Commiphora caudata*	0.02		0.02	0.02
16	*Curcuma* spp.		14.3		0.47
17	*Cynotis* sp.			0.05	0.01
18	*Dalbergia latifolia*			0.02	0.001
19	*Dalbergia sissoides*			0.02	0.001
20	*Desmodium triquetrum*	0.01			0.001
21	*Dichrostachys cinerea*			0.07	0.02
22	*Dioscorea* sp.		2.16		0.07
23	*Diospyros montana*			0.05	0.01
24	*Eriolaena quinquelocularis*	0.19		0.26	0.12
25	*Ficus benghalensis*			0.49	0.08
26	*Ficus* sp.	0.1		0.05	0.17
27	*Ficus virens*			0.02	0.01
28	*Furcraea foetida*			0.07	0.02
29	*Givotia rottleriformis*	0.05		0.05	0.08
30	*Gmelina arborea*	0.01			0.001
31	*Grewia glabra*			0.47	0.001
32	*Grewia hirsuta*	0.04		0.05	0.18
33	*Grewia orbiculata*			0.13	0.13
34	*Grewia tiliaefolia*	0.14	0.81		0.13
35	*Hardwickia binata*		1.62		0.05
36	*Helicteres isora*	0.01	9.75		0.33
37	*Ipomoea* sp.		1.08	0.68	0.26
38	*Kydia calycina*	2.87	0.54		1.81
39	*Lagerstroemia lanceolata*	0.02	0.27		0.02
40	*Laggera alata*		0.27		0.001

Appendix 1: Food plants (%) in diet of elephants in different habitats in Nilgiri Biosphere Reserve (*contd.*)

S. No.	Plant species	DDF (n = 7003)	MDF (n = 369)	TF (n = 3814)	Overall (n = 11206)
41	*Malvastrum coromandelianum*			0.02	0.001
42	*Mangifera indica*	0.02			0.01
43	*Mimosa pudica*		0.54		0.01
44	*Mimusops* sp.			0.15	0.05
45	*Olea dioica*		0.27		0.001
46	*Phyllanthus emblica*	0.08		0.02	0.06
47	*Pleiospermium alatum*			0.02	0.001
48	*Pongamia glabra*	0.02			0.01
49	*Pterocarpus marsupium*			0.02	0.001
50	*Randia dumetorum*	0.14		0.18	0.15
51	*Solanum* sp.	0.29			0.18
52	*Strychnos potatorum*			0.39	0.01
53	*Syzygium cuminii*	0.02			0.01
54	*Tamarindus indica*			0.78	0.26
55	*Tectona grandis*	0.65	1.89	0.49	0.64
56	*Terminalia tomentosa*	0.01			0.001
57	*Zizyphus mauritiana*			0.78	0.26
58	*Zizyphus oenoplia*			0.02	0.001
59	*Zizyphus xylopyrus*	0.05		0.55	0.22
	Unidentified browse spp.	0.25	1.35	0.55	0.39
	Grass species				
60	*Apluda mutica*	0.31	0.27	2.14	0.93
61	*Aristida adscensionis*			6.92	2.36
62	*Bothriochloa* sp.			21.3	7.27
63	*Chrysopogon* sp.			1.23	0.42
64	*Cymbopogon flexuosus*	3.35	5.14		2.27
65	*Cymbopogon* sp.			0.15	0.05
66	*Cyperus* sp.			0.05	0.01
67	*Cyrtococcum patens*		11.6		0.38
68	*Digitaria* sp.	1.55		0.68	1.2
69	*Eragrostiella bifaria*			0.1	0.03
70	*Eragrostis tenuifolia*	0.89			0.56
71	*Heteropogon contortus*	1.32		36.9	13.4
72	*Imperata cylindrica*		2.71		0.08
73	*Oplismenus compositus*	0.04		0.26	0.11
74	*Oryza granulata*	0.14			0.08
75	*Panicum* sp.			0.07	0.02
76	*Pennisetum hokanackeri*	0.01			0.001
77	*Pennisetum* sp.			0.1	0.03
78	*Phoenix pusilla*	0.01			0.001
79	*Setaria intermedia*	0.07	1.89		0.1
80	*Sporobolus* sp.	0.07		0.31	0.15
81	*Themeda cymbaria*	62.8	6.5		39.5
82	*Themeda triandra*	17.1	0.54	0.68	10.9
83	*Vetiveria lawsonii*			0.05	0.01
	Unidentified grass spp.	2.72	3.52	1.04	2.18

■ ■ ■

AN ANNOTATED AND ILLUSTRATED CHECKLIST OF THE OPISTHOBRANCH FAUNA OF GULF OF KUTCH, GUJARAT, INDIA WITH 21 NEW RECORDS FOR GUJARAT AND 13 NEW RECORDS FOR INDIA: PART 1

Deepak Apte[1,2], Vishal Bhave[1,3] and Dishant Parasharya[1,4]

[1]Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk, S.B. Singh Road, Mumbai 400 001, Maharashtra, India.
[2]Email: spiderconch@gmail.com
[3]Email: vishalbhave@gmail.com
[4]Email: dparasharya@gmail.com

The Opisthobranch fauna of Gujarat is among the least studied molluscs. Field surveys were undertaken along the Gulf of Kutch over a period of four months under the All India Co-ordinated Project on Taxonomy (AICOPTAX – Mollusca) funded by the Ministry of Environment and Forests, Government of India, and supported by the Gujarat State Forest Department and Marine National Park authorities. 33 species belonging to 19 families were recorded, of which 21 are new records to Gujarat and 13 are new records to Indian coast.

Key words: Opisthobranch, Gulf of Kutch, AICOPTAX, Doridiidae

INTRODUCTION

Opisthobranchs are among the least studied molluscs in India. The work done on opisthobranch fauna is sparse and patchy. The earliest work dates back to the 1880s by Alder and Hancock (1864), Kelaart (1858a,b; 1859a,b,c,d; 1883), and Bergh (1877). Studies on the opisthobranch fauna of Gulf of Kutch are limited to a few publications by Burn (1970), Narayanan (1970), Eliot (1909a,b), Gideon *et al.* (1957), Menon *et al.* (1970), Narayanan (1969, 1970, 1971a,b), Rudman (1980) and Deomurari (2006). The most comprehensive work on the opisthobranchs of the Gulf of Kutch was that by Narayanan (1969, 1970, 1971a,b).

Other notable works on Indian Opisthobranchia are by Eliot (1906a,b,c, 1909a,b, 1910a,b, 1916), Farran (1905), Hornell (1909a,b, 1949, 1951), O'Donoghue (1932), Rao (1936, 1952, 1961), Rao and Alagarswami (1960), Rao and Rao (1980), Rao *et al.* (1974), Satyamurthi (1952), Burn (1970), Valdés *et al.* (1999), and Fontana *et al.* (2001). Indo-Pacific opisthobranchs were studied by Gosliner and Willan (1991), Gosliner (1992, 1994, 1995), Gosliner and Behrens (1998), Gosliner and Johnson (1999), Jensen (1992), Rudman (1980, 1984, 1986, 1990), Yonow (1984a,b, 1986, 1988, 1989, 1990, 1992, 1994, 1996, 2000, 2001, 2008a,b), Yonow and Hayward (1991), Fahey and Gosliner (2003) and Apte (2009). Brunckhorst (1993) reviewed the Phyllidiidae in Indo-Pacific region, and Yonow (1996) reviewed 11 species from the Indian Ocean. More recently Dayrat (2010) reviewed basal Discodorids of the world.

The present study was carried out along the Gulf of Kutch, Gujarat, India. The Gulf of Kutch is a large inlet of the Arabian Sea, *c.* 60 km wide at its broadest and tapering north-eastwards for 170 km. It includes 735,000 ha under the Marine National Park and Marine Sanctuary which are situated along the southern side of the Gulf from Okha (22° 30' N; 69° 00' E) and eastward to the vicinity of Khijadia (22° 30' N; 70° 05' E). A vast area of intertidal mudflats, salt marshes and seasonally inundated coastal flats extend north-east along the Wagardhrai creek to about 23° 15' N and 70° 40' E. The National Park and Marine Sanctuary include 42 islands and a complex of fringing reefs backed by mudflats and sandflats, coastal salt marsh, and mangrove forest. Field collection was carried out from December 2008 to March 2009.

METHODOLOGY

Direct search during low tides was used to collect the specimens. Specimens were stored in 100% ethyl alcohol after studying the morphological characters. Digital images of live specimens of each species were taken to record true colours. Notes on egg cases were made wherever possible. Specimens were relaxed before preserving in $MgCl_2$.

RESULTS AND DISCUSSION

During the study a total of 33 species belonging to 19 families were recorded. Of these 33 species, 21 are new records to Gujarat and 13 are new records to the Indian coast. This clearly indicates that the opisthobranch fauna in India, particularly in Gujarat, is not well-studied. A comprehensive assessment is necessary to reveal the true diversity. Table 1 summarizes the findings of this study.

The Gulf of Kutch also hosts a very high density population of *Hypselodoris infucata*, *Peltodoris murrea*, *Atagema* cf. *rugosa*, and *Dendrodoris fumata*. We are presently in the process of determining the population structure of these species.

Table 1: Opisthobranch fauna of Gulf of Kutch

Sr. No	Species	Present Study	New record to India	New record to Gujarat
1.	*Hydatina zonata*	√	-	-
2.	*Bulla ampulla*	√	-	-
3.	*Haminoea ovalis*	√	√	√
4.	*Aplysia dactylomela*	√	-	-
5.	*Berthellina citrina*	√	-	-
6.	*Berthellina* cf. *citrina* (spotted form)	√	-	-
7.	*Berthella stellata*	√	√	√
8.	*Elysia tomentosa*	√	-	√
9.	*Elysia thompsoni*	√	√	√
10.	*Elysia obtusa*	√	√	√
11.	*Plocamopherus ceylonicus*	√	-	-
12.	*Carminodoris* cf. *grandiflora*	√	√	√
13.	*Gymnodoris alba*	√	-	√
14.	*Gymnodoris* sp.	√	√	√
15.	*Chromodoris bombayana*	√	-	√
16.	*Hypselodoris infucata*	√	-	-
17.	*Peltodoris murrea*	√	√	√
18.	*Tayuva lilacina*	√	-	√
19.	*Atagema* cf. *rugosa*	√	√	√
20.	*Atagema spongiosa*	√	-	√
21.	*Sclerodoris* cf. *tuberculata*	√	√	√
22.	*Jorunna funebris*	√	-	-
23.	*Dendrodoris fumata*	√	-	√
24.	*Doriopsilla* sp.	√	√	√
25.	*Doriopsilla* cf. *miniata*	√	-	-
26.	*Bornella stellifer*	√	-	-
27.	*Dermatobranchus fortunata*	√	√	√
28.	*Flabellina bicolor*	√	-	√
29.	*Phestilla lugubris*	√	-	√
30.	*Cuthona yamasui*	√	√	√
31.	*Phidiana militaris*	√	-	-
32.	*Pteraeolidia ianthina*	√	√	√
33.	*Sakuraeolis gujaratica*	√	-	-
		33	13	21

Family: Hydatinidae

***Hydatina zonata* (Lightfoot, 1786) (Fig. 1a)**

India: Widely distributed both on the east and west coast of India.

Wider Distribution: Indo-West Pacific region.

Size: 10-30 mm.

Description: This is a benthic species. Shell very light and semi-transparent. Body whorl in the centre bears one distinct pair of dark brown band. A single band present near the spire and at the base of body whorl.

Status: Uncommon.

Family: Bullinidae

***Bulla ampulla* Linnaeus, 1758 (Fig. 1b)**

India: Widely distributed both on the east and west coast of India.

Wider Distribution: Indo-West Pacific region.

Size: 8-20 mm.

Description: Seasonal congregation of this species is common. Mostly occurs on sand flats. Shells are solid with a large body whorl, white with profuse dark to light brown mottling.

Status: Common.

Family: Haminaeidae

***Haminoea ovalis* Pease, 1868 (Fig. 1c)**

India: Gulf of Kutch. This is the first record of this species for India.

Wider Distribution: Australia, Samoa, Japan, Guam.

Size: 12 mm.

Description: It resembles *H. cymbalum*. Shell is fragile and transparent. Animal is brilliantly coloured. Light green ground colour is profusely spotted with orange spots which are encircled by light green. Surface also bears deep blue spots on mantle and foot. Foot is short, and spotted orange and blue.

Status: Uncommon.

Family: Aplysiidae

***Aplysia dactylomela* Rang, 1828 (Fig. 1d)**

India: Widely distributed in India.

Wider Distribution: Red Sea, Africa, Hawaii, South Pacific, Australia, Japan, Sri Lanka, Caribbean.

Size: 100-180 mm.

Description: A large animal usually seen in large congregations in shallow waters from December to February. The shell is considerably reduced in these animals and is present inside the body. They show remarkable colour variations. In Lakshadweep it is dotted dull brown with black and white spots; mantle is bordered pink. Specimens from Gulf of Kutch are usually dull green with black spots. Pink lining of mantle flap is also absent. The animals release a purple dye when disturbed.

Status: Common.

Family: Pleurobranchidae

***Berthellina citrina* (Rüppell and Leuckart, 1828) (Fig. 1e)**

India: Gulf of Kutch, Lakshadweep.

Wider Distribution: South Africa to Arabian Sea, Red Sea, Australia, New Zealand, Hawaii, Seychelles, Japan, Norfolk Island (South Pacific), French Polynesia, Maldives.

Size: 20-40 mm.

Description: A small sea slug occurring on reef sand. Body colour deep orange with light orange foot; Rhinophores light orange.

Status: Common.

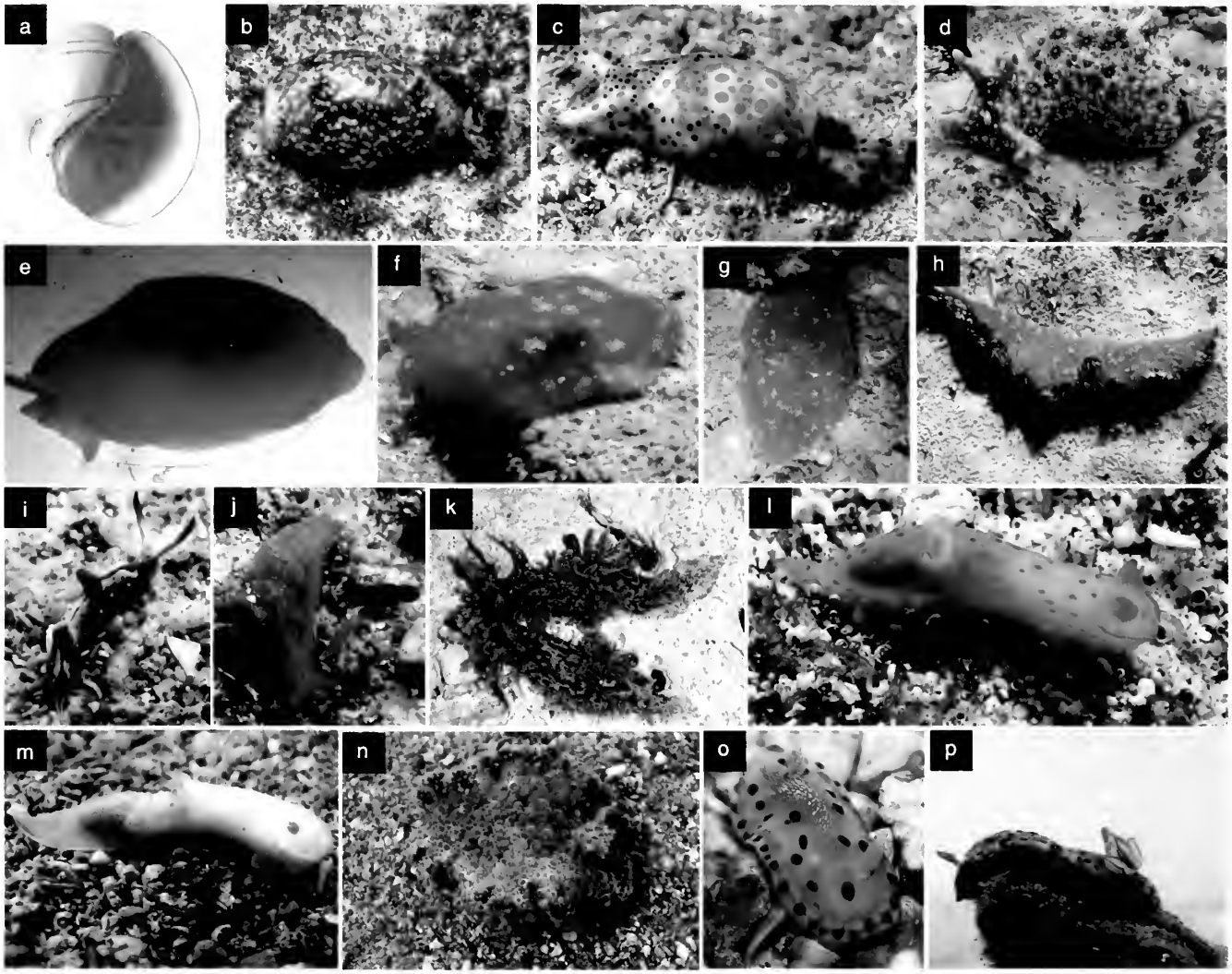


Fig. 1: a. *Hydatina zonata*, b. *Bulla ampulla*, c. *Haminoea ovalis*, d. *Aplysia dactylomela*, e. *Berthellina citrina*, f. *Berthellina* cf. *citrina*, g. *Berthella stellata*, h. *Elysia tomentosa*, i. *Elysia thompsoni*, j. *Elysia obtusa*, k. *Plocamopherus ceylonicus*, l. *Gymnodoris alba*, m. *Gymnodoris* sp., n. *Carminodoris* cf. *grandiflora*, o. *Chromodoris bombayana*, p. *Hypselodoris infucata*

***Berthellina* cf. *citrina* (Rüppell and Leuckart, 1828) (spotted form) (Fig. 1f)**

India: Gulf of Kutch.

Wider distribution: Unknown.

Description: A small sea slug occurring on reef sand or below the rocks. Body colour deep orange with light orange foot; Rhinophores light orange. This form is heavily spotted with white.

Status: Common.

***Berthella stellata* (Risso, 1826) (Fig. 1g)**

India: Gulf of Kutch.

Wider Distribution: Red Sea, Australia, Mexico, South Africa, Indo-west Pacific.

Size: 5-15 mm.

Description: A small slug, it prefers sandy substrate. Colour light yellow-orange; Rhinophores and oral tentacles transparent and light yellow. Some specimens have a star-shaped opaque white pattern on the dorsa.

Status: Rare.

Family: **Elysiidae**

***Elysia tomentosa* Jensen, 1997 (Fig. 1h)**

India: Gulf of Kutch, Lakshadweep.

Wider Distribution: South Africa, Red Sea, Indo-West Pacific.

Size: 18-40 mm.

Description: A large *Elysia* seen on coral sand. It is deep green yellow in colour. The parapodia are lined by black and pink bands. Rhinophores are reddish brown. They usually occur among *Caulerpa racemosa*.

Status: Abundant.

***Elysia thompsoni* Jensen, 1993 (Fig. 1i)**

India: Gulf of Kutch. It is the first record outside Western Australia

Wider Distribution: Western Australia.

Size: 20 mm (Single specimen).

Description: These small sea slugs are herbivorous. They feed by sucking sap from green algae *Caulerpa* sp. and *Codium* sp. The animal is usually translucent greyish white with violet parapodial margin. Tips of rhinophores are purple violet. Body and parapodia covered with numerous black spots.

Status: Rare.

***Elysia obtusa* Baba, 1938 (Fig. 1j)**

India: Gulf of Kutch.

Wider Distribution: Australia, Hong Kong, Japan, Korea, Hawaii.

Size: 5-12 mm.

Description: A small, herbivorous sea slug, it is translucent yellow with fine white spots. All specimens were identical, except that in the specimens found in Ratnagiri, broken white line on the parapodia is clearly seen, but in Gujarat specimens, the parapodial white line is not clearly visible.

Status: Uncommon.

Family: **Polyceridae**

***Plocamopherus ceylonicus* (Kelaart, 1858) (Fig. 1k)**

India: South Gujarat, Alibaug (Maharashtra), Gulf of Mannar (Tamil Nadu).

Wider Distribution: Australia, Singapore, Philippines, Indonesia, Marshall Island.

Size: 20-45 mm.

Description: These nocturnal slugs are found under rocks. The gills are surrounded by four papillae having pink rounded knobs that emit light when disturbed (pers. obs.). Foot and mantle bear bright orange yellow spots. Foot is extended to form tapering tail which is used to swim actively when disturbed (pers. obs.).

Status: Rare.

Family: **Gymnodorididae**

***Gymnodoris alba* (Bergh, 1877) (Fig. 1l)**

India: Gulf of Kutch, Lakshadweep.

Wider Distribution: Japan, China, Indonesia, Australia, Hawaii, Singapore, Philippines, Southern Africa.

Size: 20 mm.

Description: A small sea slug mostly found on sandy substrate. The light orange or cream coloured body profusely spotted with bright orange spots. Rhinophores are white or pale orange. Gills are white.

Status: Uncommon.

***Gymnodoris* sp. (Fig. 1m)**

India: Gulf of Kutch.

Wider Distribution: Australia, South Pacific.

Size: 28 mm.

Description: Uncommon, it is found on sandy substrate. Light cream coloured body is profusely spotted with light orange spots. Mantle bears fine papillae with yellow tips. Rhinophores and gills are pale yellow. Foot has an orange tip.

Status: Uncommon.

Family: **Dorididae**

***Carminodoris* cf. *grandiflora* (Pease, 1860) (Fig. 1n)**

India: Gulf of Kutch.

Wider Distribution: Not known.

Size: 60-75 mm.

Description: It mostly remains attached to the lower side of rocks. Its perfectly camouflaged body makes it impossible to locate it. Surface bears rounded tubercles which are smaller and densely packed at the peripheral margins of the mantle. Brown tubercles are surrounded by a white ring at the base. Ground colour is light brown and heavily mottled. Gill leaves are feathery, light brown.

Status: Uncommon.

Family: **Chromodorididae**

***Chromodoris bombayana* (Winkworth, 1946) (Fig. 1o)**

India: Mumbai, Ratnagiri.

Wider Distribution: Known only from India.

Size: 4-16 mm.

Description: It is a tiny sea slug from rocky reefs. Base colour of the body is white with highly decorated surface. Margin is deep orange lined by a row of deep purple spots. Dorsal surface is profusely spotted with silver spots. Rhinophores and gills have silver spots. Foot is short and white in colour.

Status: Uncommon.

***Hypselodoris infucata* (Rüppell and Leuckart, 1828) (Fig. 1p)**

India: Gulf of Kutch, Lakshadweep.

Wider Distribution: Indo-West Pacific: India, Red Sea, Indonesia, Vietnam, New Caledonia, Israel, South Africa, Philippines.

Size: 2-45 mm.

Description: Colour is light purple grey and profusely spotted with black and yellow spots. Rhinophores are red and finely ribbed. Gills are white with red margin. Mating pairs are commonly seen from November to April.

Status: Abundant.

Family: **Discodoridiidae**

***Peltodoris murrea* (Abraham, 1877) (Fig. 2a)**

India: Gulf of Kutch.

Wider Distribution: Maldives, Mauritius, Reunion, to New Caledonia and Japan.

Size: 10-45 mm.

Description: A small discodorid usually seen in shallow pools and under rocks. It prefers reef substrate with large silt contents. Colour is white with dark orange or black spots. Rhinophores are yellow.

Status: Abundant.

***Tayuva lilacina* (Gould, 1852) (Fig. 2b)**

India: Malvan (Maharashtra), Gulf of Kutch, Gulf of Mannar (Tamil Nadu), Waltair (Andhra Pradesh).

Wider Distribution: Indian Ocean, Australia, Philippines, Red Sea, Japan, South Africa, Thailand, Hawaii, New Caledonia.

Size: 30-150 mm.

Description: A large sea slug, usually seen in shallow pools and under rocks. It prefers rocky substrate. Brown mottling on the foot, gills highly frilled. This species is usually confused with *Sebadoris fragalis* (earlier *D. fragalis*). The mantle of *T. lilacina* does not break off while that of *D. fragilis* breaks off if disturbed. DNA sequencing will help solve the mystery of these species. We have collected samples from Ratnagiri (Maharashtra) where mantle of the individuals does break off as described while as specimens from Gulf of Kutch does not autotomize the mantle.

Status: Common.

***Atagema* cf. *rugosa* Pruvot-Fol, 1951 (Fig. 2c)**

India: Gulf of Kutch.

Wider Distribution: Australia.

Size: 12-25 mm.

Description: A small discodorid usually seen in shallow pools and under rocks. It prefers muddy reefs. Mantle is white and tuberculate.

Status: Common.

***Atagema spongiosa* (Kelaart, 1858) (Fig. 2d)**

India: Gulf of Kutch, Waltair.

Wider Distribution: Indo-West Pacific: Australia, South Korea, Philippines, Christmas Island, Singapore, Red Sea.

Size: 90-130 mm.

Description: It has sponge-like external appearance. Mantle is deeply pitted and brown in colour with few green and pale red patches. Foot and underside is dark purplish.

Status: Common.

Family: **Platydoridiidae**

***Sclerodoris* cf. *tuberculata* Eliot, 1904 (Fig. 2e)**

India: Gulf of Kutch.

Size: 15-70 mm.

Description: It is a small *Sclerodoris*. Rhinophores are deep red. Gill leaves are feathery and red. It is always found under rocks with red coloured encrusting sponge. Ventral surface orange.

Status: Common.

Family: **Kentrodoridiidae**

***Jorunna funebris* (Kelaart, 1858) (Fig. 2f)**

India: Gulf of Kutch, Andaman and Nicobar, Gulf of Mannar, Lakshadweep.

Wider Distribution: Indo-West Pacific: Red Sea, Oman, Maldives, Australia to Japan, Papua New Guinea, Hong Kong, Singapore.

Size: 90 mm.

Description: A common slug in Indian waters. The surface of this sea slug has a rough texture, a character typical of the genus. Black rings present on the white body are rough to touch. Rhinophores are black and lamellate with a white base. Gills are black. Some areas of the Gulf of Kutch have very high density populations of this species. The size is also very large compared to other areas.

Status: Abundant.

Family: **Dendrodoridiidae**

***Dendrodoris fumata* (Rüppell and Leuckart, 1831) (Fig. 2g)**

India: Gulf of Kutch, Ratnagiri.

Wider Distribution: Red Sea, Western Australia, Korea, New Caledonia, Seychelles, Reunion, Singapore, Japan.

Size: 10-60 mm.

Description: It is found mostly in shallow pools and under rocks on muddy reef. This species resembles some forms of *D. nigra* except that it has 5-6 bushy and branching gills which expand to larger than the body width. Rhinophores have white tips. Species shows colour variation from light brown to red.

Status: Common.

Remarks: We have *D. nigra* but from Lakshadweep and Andaman Islands. Based on our work, we believe that *D. fumata* and *D. nigra* have distinct site separation; *fumata* prefer muddy reefs while *nigra* prefer high quality reef. Species identified by Narayanan (1968) from Gujarat as *D. nigra* in fact are most likely *D. fumata* as this is the most abundant species in this locality. We have not found a single specimen of *nigra* in the last 10 years from this locality. *D. fumata* is seen all along Maharashtra and Gujarat coast, western coast India, which have muddy reefs. Also for *D. nigra*, juveniles

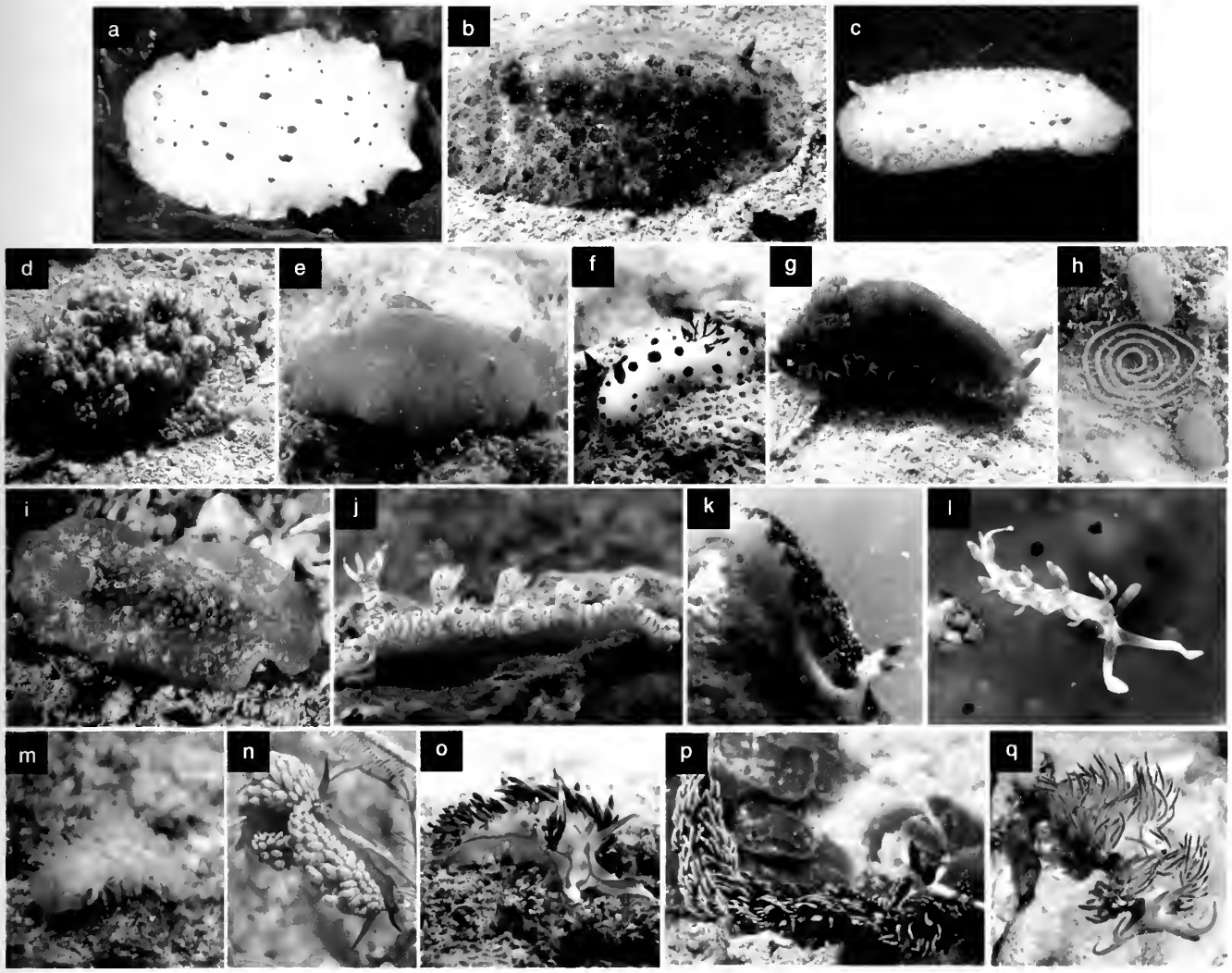


Fig. 2: a. *Peltodoris murrea*, b. *Tayuva lilacina*, c. *Atagema* cf. *rugosa*, d. *Atagema spongiosa*, e. *Sclerodoris* cf. *tuberculata*, f. *Jorunna funebris*, g. *Dendrodoris fumata*, h. *Doriopsilla* sp., i. *Doriopsilla* cf. *miniata*, j. *Bornella stellifer*, k. *Dermatobranchus fortunata*, l. *Flabellina bicolor*, m. *Phestilla lugubris*; n. *Cuthona yamasui*, o. *Phidiana militaris*, p. *Pteraeolidia ianthina*, q. *Sakuraeolis gujaratica*

have red band on foot margin while as *D. fumata* juveniles are light orange and lack red band.

***Doriopsilla* sp. (Fig. 2h)**

India: Gujarat.

Wider Distribution: Unknown.

Size: 10-20 mm.

Description: It is a small sea slug found on muddy substrate. The entire animal including rhinophores and gills are yellow. Surface bears numerous outgrowths. Egg case is also yellow.

Status: Common.

***Doriopsilla* cf. *miniata* (Alder and Hancock, 1864) (Fig. 2i)**

India: Gulf of Kutch.

Wider Distribution: South Africa and Gulf of Aden.

Size: 30-40 mm.

Description: It is a large *Doriopsilla*. Rhinophores and gills are light yellow orange. In some specimen gills are deep orange red. Body is mottled with network of white lines. Colour of the egg case matches the specimen, i.e., the dark orange form lays dark orange egg case, while the light yellow form lays light yellow egg case. It differs from *miniata* in that the white lines, instead of meandering all over the dorsum, are concentrated on the tubercles.

Status: Rare.

Family: **Bornellidae**

***Bornella stellifer* (Adams and Reeve, 1848) (Fig. 2j)**

India: Gulf of Kutch (Gujarat), Ratnagiri and Revdanda (Maharashtra), Gulf of Mannar.

Wider Distribution: Australia, Singapore, Malaysia, Indonesia, Taiwan, American Samoa, South Africa.

Size: 30 mm (Single specimen).

Description: A small sea slug found on rocky reefs. Oral tentacles paired and finger-like. Gills placed at the base of each cerata. Rhinophores present on long stalks and surrounded by long papillae. It feeds on the hydroids. Colour, deep reddish brown with white patches. Tips of cerata and papillae with apical red band.

Status: Uncommon.

Family: **Arminidae**

***Dermatobranchus fortunata* (Bergh, 1888) (Fig. 2k)**

India: Gulf of Kutch.

Wider Distribution: Australia, Philippines.

Size: 10-25 mm.

Description: This small sea slug is found under rocks on muddy reefs. When disturbed, animal secretes large quantity of slime. Rhinophores are bulbous at the tip and have orange and black apical bands. Oral flap has orange border. Egg mass is yellow, spiral conical ribbon-like.

Status: Seasonally common.

Family: **Flabellinidae**

***Flabellina bicolor* (Kelaart, 1858) (Fig. 2l)**

India: Gulf of Kutch, Lakshadweep. This is the first record of this species from Gujarat.

Wider Distribution: Widely distributed in Indo-Pacific, Papua New Guinea, Japan, Hong Kong, Maldives, South Africa to Hawaii, Red Sea.

Size: 10-20 mm.

Description: A small sea slug usually seen under rocks or among dead coral branches. It has a long and narrow body with numerous cerata which are in pairs, and have a distinct orange coloured band near the tip. However, specimens from Gulf of Kutch are always with yellow coloured bands. Besides cerata, the head also bears orange banded oral and propodial tentacles. Rhinophores are bulbous and brown in colour.

Status: Uncommon in the Gulf of Kutch, common in Lakshadweep.

Family: **Tergipedidae**

***Phestilla lugubris* (Bergh, 1870) (Fig. 2m)**

India: Gulf of Kutch, Lakshadweep. This is the first record of this species from Gujarat.

Wider Distribution: Tanzania, Red Sea, Indonesia, Australia, Hawaii, Japan, Vietnam, Hong Kong.

Size: 40-45 mm.

Description: These sea slugs are closely associated with *Porites* sp. They feed on the polyps of this species (pers. obs.). Body colour is light brown. Body surface bears numerous cerata. Each cera is bulbous in nature with distinct white bands and ringed nodes.

Status: Uncommon in the Gulf of Kutch. Common in Lakshadweep.

***Cuthona yamasui* Hamatani, 1993 (Fig. 2n)**

India: Gulf of Kutch.

Wider Distribution: Tropical Indo-West Pacific.

Size: 30-35 mm.

Description: This species seems to show colour variation, particularly of head, rhinophores and oral tentacles appear to range in colour from translucent orange to dark blue-black. Body colour is somewhat translucent light orange-brown. There is a prominent white band between the rhinophores. The tips of the oral tentacles and rhinophores are whitish. Cerata are elongated. The tips of the cerata are black followed by a yellow and turquoise blue band. Rest of the cerata is greyish-white in appearance. It is found feeding on the stinging hydroid *Aglaophenia* sp. (pers. obs.).

Status: Uncommon.

Family: **Facelinidae**

***Phidiana militaris* (Alder and Hancock, 1864) (Fig. 2o)**

India: South Gujarat, Ratnagiri (Maharashtra).

Wider Distribution: Malaysia, Papua New Guinea.

Size: 20 mm.

Description: A beautiful nocturnal sea slug, it is closely associated with *Goniopora* corals. Cerata are transparent and digestive gland is bright violet and orange. Oral tentacles and rhinophores bear distinct orange lines. They are seasonally common and seen in small groups among *Goniopora* polyps.

Status: Seasonally common.

***Pteraeolidia ianthina* (Angas, 1864) (Fig. 2p)**

India: Gulf of Kutch.

Wider Distribution: Australia, Singapore, China, Vanuatu, Fiji, Japan, Hawaii, Madagascar, Seychelles, Maldives.

Size: 50 mm.

Description: It is a large aeolid. Body covered with numerous cerata. Tentacles have distinct purple coloured bands. It occurs on coral sand. No data available about this species in India.

Status: Very rare.

***Sakuraeolis gujaratica* Rudman, 1978 (Fig. 2q)**

India: Endemic to the Gulf of Kutch. This is the second record of this species from its type locality after it was described in 1971.

Size: 20 mm.

Description: Body is elongated. The oral tentacles are long and slender. Five sets of cerata are distinct on the body. The body is pale orange. Tips of rhinophores and cerata deep orange. Digestive gland inside cerata is deep violet, oral tentacles are orange.

Status: Rare.

ACKNOWLEDGEMENTS

This paper is a result of field work conducted during the "All India Co-ordinated Project on Taxonomy – Mollusca" funded by the Ministry of Environment and Forests, Government of India.

We are grateful to the Department of Environment and Forests, Government of Gujarat, Mr. Pradeep Khanna, IFS, PCCF (Wildlife), for providing necessary permits to visit the marine National Park and Sanctuary areas. We are thankful to Mr. D.S. Narve, IFS Conservator of Forests, Marine National Park, Mr. P.H. Sata DCF, Mr. Radadia ACF, Mr. B.H. Dave RFO Sikka and Mr. Dipak Pandya RFO, Dwarka for their help in field work. Mr. Vinod Gajjar, Mr. Vishwas Shinde, Mr. Sudhir Sapre, and Ms. Swapna Prabhu also assisted during the field work.

Dr. Bill Rudman, Dr. T. Gosliner and Dr. N. Yonow helped to validate some species.

REFERENCES

Alder, J. & A. Hancock (1864): Notice on the collection of Nudibranchiate mollusca made in India by Walter Eliot Esq. with descriptions of several new genera and species. *Trans. Zool. Soc. Lond, 5*: 117-147.

Apte, D.A. (2009): Opisthobranch fauna of Lakshadweep Islands, India with 52 new records to Lakshadweep and 40 new records to India. *J. Bombay Nat. Hist. Soc. 106(2)*: 162-175.

Bergh, L.S.R. (1877): Malacologische Untersuchungen. *In*: Semper, C.G. (Ed.): *Reisen im Archipel der Philippinen, Wissenschaftliche Resultate.* Band 2, Heft 12: 495-546, pls. 58-61.

Brunckhorst, D.J. (1993): The systematics and phylogeny of phyllidiid nudibranchs (Doridoidea). *Records of the Australian Museum, supplement 16*: 1-107, pls. 1-9.

Burn, R. (1970): *Phyllidia (Phyllidiella) zeylanica* Kelaart a rare nudibranch from the Indian subcontinent. *Memoirs of the National Museum of Victoria 31*: 37-40.

Burn, R.F. & K.R. Narayanan (1970): Taxonomic notes on *Eolis militaris* Alder & Hancock, 1864 (Opisthobranchia, Eolidacea). *Journal of the Malacological Society of Australia 2(1)*: 83-86.

Dayrat, B. (2010): A monographic revision of basal Discodorid sea slugs (Mollusca: Gastropoda: Nudibranchia: Doridina). *Proc. Calif. Acad. Sci. 61 (supplement 1)*: 1-403.

Deomurari, A. (2006): *Berthellina citrina* from the Gulf of Kutch, India. [Message in] Sea Slug Forum. Australian Museum, Sydney. Available from http://www.seaslugforum.net/find/17187, July 29, 2006.

Eliot, C.N.E. (1906a): On the nudibranchs of southern India and Ceylon, with special reference to the drawings by Kelaart and the collections belonging to Alder and Hancock preserved in the Hancock Museum at Newcastle-on-Tyne. *Proc. Zool. Soc. London*. pp. 636-691, pls. 42-47.

Eliot, C.N.E. (1906b): On the nudibranchs of southern India and Ceylon, with special reference to the drawings by Kelaart and the collections belonging to Alder and Hancock preserved in the Hancock Museum at Newcastle-on-Tyne. No. 2. *Proc. Zool. Soc. London*. Pp. 999-1008.

Eliot, C.N.E. (1906c): Nudibranchiata, with some remarks on the families and genera and description of a new genus, Doridomorpha. Pp. 540-573, pl. 32. *In*: Stanley Gardiner, J. (Ed.): The fauna and geography of the Maldive and Laccadive Archipelagoes, being the account of the work carried on and of the collections made by an expedition during the years 1899 and 1900, vol. 2.

Eliot, C.N.E. (1909a): Report on the nudibranchs collected by Mr. James Hornell at Okhamandal in Kattiawar in 1905-6. *In*: Report to the government of Baroda on the marine zoology of Okhamandal, 1: 137-145.

Eliot, C.N.E. (1909b): Notes on a collection of nudibranchs from Ceylon. *Spolia Zeylanica, Colombo 6(23)*: 79-95.

Eliot, C.N.E. (1910a): Nudibranchs collected by Mr. Stanley Gardiner from the Indian Ocean in H.M.S. Sealark. *In*: Reports of the Percy Sladen Trust Expedition to the Indian Ocean in 1905, under the leadership of Mr. J. Stanley Gardiner, M.A. *Transactions of the Linnaean Society, Zoology, series 2, 13(2)*: 411-439, pl. 25.

Eliot, C.N.E. (1910b): Notes on nudibranchs from the Indian museum. *Records of the Indian Museum 5(4)*: 247- 252, pl. 19.

Eliot, C.N.E. (1916): Mollusca Nudibranchiata. In: Fauna of the Chilka Lake. *Memoirs of the Indian Museum 5*: 375-380.

Farran, G.P. (1905): Report on the Opisthobranchiate Mollusca collected by Prof. Herdman. *In*: W.A. Herdman's report on the pearl oyster fisheries of the Gulf of Mannar. *3 Suppl. Report 21*: 329-364. The Ray Society, London.

Fahey, S.J. & T. Gosliner (2003): Mistaken identities: On the Discodorididae genera *Hoplodoris* Bergh, 1880 and *Carminodoris* Bergh, 1889 (Opisthobranchia, Nudibranchia). *Proc. Calif. Acad. Sci. 54(10)*: 169-208, 31 fig.

Fontana, A., Maria Letizia Ciavatta, Lisette D'Souza, Ernesto Mollo, Chandra G. Naik, P.S. Parameswaran, Solimabi Wahidulla & Guido Cimino (2001): Selected chemo-ecological studies of marine opisthobranchs from Indian coasts. *Journal of the Indian Institute of Science 81(4)*: 403-415.

Gideon, P.W., P.K.B. Menon, S.R.V. Rao & K.V. Jose (1957): On the marine fauna of the Gulf of Kutch: A preliminary survey. *J. Bombay Nat. Hist. Soc. 54(3)*: 690-706.

Gosliner, T.M. (1992): Biodiversity of Tropical Opisthobranch Gastropod Faunas. *Proceedings of the Seventh International Coral Reef Symposium, Guam, 1992, Vol. 2*: 702-709.

Gosliner, T.M. (1994): New species of *Chromodoris* and *Noumea* (Nudibranchia: Chromodorididae) from the western Indian Ocean and southern Africa. *Proc. Calif. Acad. Sci. 48(12)*: 239-252, 8 figs.

Gosliner, T.M. (1995): The genus *Thuridilla* (Opisthobranchia: Elysiidae) from the tropical Indo-Pacific, with a revision of the phylogeny and systematics of the Elysiidae. *Proc. Calif. Acad. Sci. 49(1)*: 1-54.

Gosliner, T.M. & D.W. Behrens (1998): Five new species of *Chromodoris* (Mollusca: Nudibranchia: Chromodorididae) from the tropical Indo-Pacific Ocean. *Proc. Calif. Acad. Sci. 50(5)*: 139-165.

Gosliner, T.M. & R.F. Johnson (1999): Phylogeny of *Hypselodoris* (Nudibranchia: Chromodorididae) with a review of the monophyletic clade of Indo-Pacific species, including descriptions of twelve new species. *Zool. Jour. of the Linnean Soc 125*: 1-114.

GOSLINER, T. & R. WILLAN (1991): Review of the Flabellinidae (Nudibranchia: Aeolidacea) from the tropical Indo-Pacific, with the descriptions of five new species. *Veliger 34(2)*: 97-133.

HORNELL, J. (1909a): Report to the Government of Baroda on the marine zoology of Okhamandal in Kattiawar, pt 1, Williams and Norgate, London.

HORNELL, J. (1909b): A note on the presence of symbiotic algae in the integuments of nudibranchs of the genus *Melibe*. *In*: Report to the government of Baroda on the marine zoology of Okhamandal, 1, pp. 145-148.

HORNELL, J. (1949): The study of Indian molluscs (part II). *J. Bombay Nat. Hist. Soc. 48(3)*: 543-569 [Opisthobranchia: 547-553].

HORNELL, J. (1951): Indian molluscs. Bombay Natural History Society, pp. 1-96, 1 pl. (Nudibranchia pp. 41-42).

JENSEN, K.R. (1992): Anatomy of some Indo-Pacific Elysiidae (Opisthobranchia: Sacoglossa (=Ascoglossa), with a discussion of the generic division and phylogeny. *Journal of Molluscan Studies 58(3)*: 257-296.

KELAART, E.F. (1858a): Descriptions of new and little known species of Ceylon nudibranchiate molluscs and zoophytes. *Journal of the Ceylon Branch of the Royal Asiatic Society 3(1)*: 84-139, 2 pls.

KELAART, E.F. (1858b): Description of a new Ceylonese nudibranch. *Ann. Mag. Nat. Hist.*, series 3, 1(4): 257- 258, pl. 10 B.

KELAART, E.F. (1859a): Descriptions of new and little-known species of Ceylonese nudibranchiate molluscs. *Ann. Mag. Nat. Hist. series 3, 3*: 291-304.

KELAART, E.F. (1859b): Descriptions of new and little-known species of Ceylonese nudibranchiate molluscs. *Ann. Mag. Nat. Hist. series 3, 3*: 488-496.

KELAART, E.F. (1859c): On some additional species of nudibranchiate molluscs from Ceylon. *Ann. Mag. Nat.Hist. series 3, 4*: 267-270.

KELAART, E.F. (1859d): Description of new and little-known species of Ceylonese nudibranchiate molluscs, and zoophytes, 64 pp. "Trincomalie 1st November 1857".

KELAART, E.F. (1883): New and little known species of Ceylon nudibranchiate molluscs, and zoophytes. *Journal of the Ceylon Branch of the Royal Asiatic Society, 1856-61 3(9)*: 76-125.

MENON, P.K.B., A.K. DATTA GUPTA & D. DAS GUPTA (1970): On the marine fauna of the Gulf of Kutch. *J. Bombay Nat. Hist. Soc. 58(2)*: 475-494, pls. 1-10.

NARAYANAN, K.R. (1968): On three opisthobranchs from the south-west coast of India. *J. Mar. Biol. Ass. India 10(2)*: 377-380; figs. 1-2.

NARAYANAN, K.R. (1969): On the opisthobranchiate fauna of the Gulf of Kutch. Proceedings of the Symposium on Mollusca held at Cochin from January 12 to 16, 1968, Symposium Series 3, pt. 1, pp. 189-213; figs. 1-20. *Marine Biological Association of India*, Mandapam Camp, India.

NARAYANAN, K.R. (1970): On a species of the genus *Berthellina* (Opisthobranchia: Notaspidea) of the Gulf of Kutch. *Journal of the Marine Biological Association of India 12*: 210-213.

NARAYANAN, K.R. (1971a): On two doridacean nudibranchs (Mollusca: Gastropoda), from the Gulf of Kutch, new to the Indian coast. *J. Bombay Nat. Hist. Soc. 68(1)*: 280-281.

NARAYANAN, K.R. (1971b): On a species of the genus *Berthellina* (Opisthobranchia: Notaspidea) of the Gulf of Kutch. *J. Mar. Biol. Ass. India 12(1-2)*: 210-212; tbl. 1.

O'DONOGHUE, C.H. (1932): Notes on Nudibranchata from southern India. *Proceedings of the Malacological Society of London 20*: 141-166.

RAO, K.V. (1936): Morphology of the *Kalinga ornata* (Alder and Hancock). *Rec. Ind. Mus. 38*: 41-79.

RAO, K.V. (1952): *Cuthona adayarensis*, A new Nudibranch (Mollusca: Gastropoda) from Madras. *J. Zool. Soc. India, Calcutta 3*: 229-238.

RAO, K.V. (1961): On the two Opisthobranchiate molluscs, *Placobranchus ocellatus* Hasselt and *Discodoris boholiensis* Bergh from Indian waters not hitherto been recorded. *J. Mar. Biol. Ass. India 3 (1&2)*: 253-259.

RAO, K.V. & K. ALAGARSWAMI (1960): An account and the structure of early development of a new species of nudibranchiate gastropod, *Eolidina (Eolidina) mannarensis*. *J. Mar. Biol. Ass. India 2(1)*: 6-16.

RAO, N.V. & K.V. SURYA RAO (1980): On a rare nudibranch, *Thordisa crosslandi* Eliot (Mollusca: Dorididae) from the west coast of India. *Bulletin Zoological Survey of India 2(2-3)*: 219, pl. IV.

RAO, K. V., P. SIVADAS & L. K. KUMARY (1974): On three rare doridiform nudibranch molluscs from Kavaratti Lagoon, Laccadive Islands. *Journal of the Marine Biological Association of India 16(1)*: 113-125.

RUDMAN, W.B. (1980): Aeolid opisthobranch molluscs (Glaucidae) from the Indian Ocean and the south-west Pacific. *Zoological Journal of the Linnean Society 68*: 139-172.

RUDMAN, W.B. (1984): The Chrormodorididae (Opisthobranchia: Mollusca) of the Indo-West Pacific: a review of the genera. *Zoological Journal of the Linnean Society 81*: 115-273.

RUDMAN, W.B. (1986): The Chromodorididae (Opisthobranchia: Mollusca) of the Indo-West Pacific: the genus *Glossodoris* Ehrenberg (H. & A. Adams). *Zoological Journal of the Linnean Society 86*: 101-184.

RUDMAN, W.B. (1990): The Chromodorididae (Opisthobranchia: Mollusca) of the Indo-West Pacific: further species of *Glossodoris, Thorunna* and the *Chromodoris aureomarginata* colour group. *Zoological Journal of the Linnean Society 100*: 263-326.

SATYAMURTHI, S.T. (1952): The mollusca of Krusadai Island. 1. Amphineura and Gastropoda. *Bull. Mad. Govt. Mus. (Nat. Hist.) 1(2)*: 216-251.

VALDÉS, A., E. MOLLO & J.A. ORTEA (1999): Two new species of *Chromodoris* (Mollusca, Nudibranchia, Chromodorodidae) from southern India, with a re-description of *Chromodoris trimarginata* (Winckworth, 1946). *Proceedings of the California Academy of Sciences 51(13)*: 461-472.

YONOW, N. (1984a): Doridacean nudibranchs from Sri Lanka, with descriptions of four new species. *The Veliger 26(3)*: 214-222.

YONOW, N. (1984b): Opisthobranchia. Pp. 304, pls. 34-37. *In*: Sharabati, D. (Ed.): Red Sea Shells. KPI Ltd., London.

YONOW, N. (1986): Red Sea Phyllidiidae (Mollusca, Nudibranchia) with descriptions of new species. *Journal of Natural History 20(6)*: 1401-1428.

YONOW, N. (1988): Red Sea Opisthobranchia. 1. The family Phyllidiidae (Mollusca, Nudibranchia). *Fauna of Saudi Arabia 9*: 138-151.

YONOW, N. (1989): Red Sea Opisthobranchia. 2. The family Chromodorididae (Mollusca, Nudibranchia). *Fauna of Saudi Arabia 10*: 290-309.

YONOW, N. (1990): Red Sea Opisthobranchia. 3. The orders Sacoglossa, Cephalaspidea, and Nudibranchia: Doridacea (Mollusca, Opisthobranchia). *Fauna of Saudi Arabia 11*: 286-299.

YONOW, N. (1992): Observations on the diet of *Philinopsis cyanea* (Martens) (Cephalaspidea, Aglajidae). *J. Conch., London 34(4)*: 199-204.

YONOW, N. (1994): Opisthobranchs from the Maldive Islands, including descriptions of seven new species (Mollusca: Gastropoda). *Revue française d'aquariologie herpetology 20(4)*: 97-130.

YONOW, N. (1996): Systematic revision of the family Phyllidiidae in the Indian Ocean Province: Part 1 (Opisthobranchia: Nudibranchia: Doridoidea). *J. Conch., London 35(6)*: 483-516.

YONOW, N. (2000): Red Sea Opisthobranchia 4: The Orders Cephalaspidea, Anaspidea, Notaspidea, and Nudibranchia: Dendronotacea and Aeolidacea. *Fauna of Saudi Arabia 18*: 87-131.

YONOW, N. (2001): Results of the Rumphius Biohistorical Expedition to Ambon (1990). Part 11. Doridacea of the families Chromodorididae and Hexabranchidae (Mollusca, Gastropoda, Opisthobranchia, Nudibranchia), including additional Molukkan material. *Zool. Verh. Leiden 75(1-15)*: 1-50.

YONOW, N. (2008a): Sea Slugs of the Red Sea. Pensoft Publishers, Sofia, Bulgaria. 304 pp.

YONOW, N. (2008b): Opisthobranchs of the Gulf of Eilat and the Red Sea: an account of similarities and differences. Pp. 177-196. *In*: Por, F. (Ed.): Aqaba – Eilat, The Improbable Gulf. Environment, Biodiversity and Preservation. The Hebrew University Magnes Press, Jerusalem.

YONOW, N. & P.J. HAYWARD (1991): Opisthobranches de l'Ile Maurice, avec la description de deux éspèces nouvelles (Mollusca: Opisthobranchia). *Revue française d'aquariologie herpetology 18(1)*: 1-30.

■ ■ ■

FISH DIVERSITY, PRODUCTION POTENTIAL AND COMMERCIAL FISHERIES OF RAMSAGAR RESERVOIR, DATIA, MADHYA PRADESH, INDIA

R.K. Garg[1], R.J. Rao[2] and D.N. Saksena[3]

[1]Centre of Excellence in Biotechnology, M.P. Council of Science and Technology (MPCST), Vigyan Bhawan, Nehru Nagar, Bhopal 462 003, Madhya Pradesh, India. Email: rkgargmpcst@gmail.com
[2]Conservation Biology Unit, School of Studies in Zoology, Jiwaji University, Gwalior 474 011, Madhya Pradesh, India. Email: soszool@rediffmail.com
[4]Aquatic Biology Laboratory, School of Studies in Zoology, Jiwaji University, Gwalior 474 011, Madhya Pradesh, India. Email: dnsaksena@gmail.com

This contribution focuses on the fish diversity, production dynamics and commercial fisheries of Ramsagar reservoir. Ramsagar is a small (140 ha) man-made reservoir in Datia district, Madhya Pradesh, India, constructed over Nichroli nallah in the Sindh river basin. A total of 42 species of fishes belonging to 28 genera, 15 families and 6 orders were recorded. Order Cypriniformes with 21 species showed maximum species diversity; minimum species diversity was shown by orders Beloniformes, Osteoglossiformes and Synbranchiformes with one species each. Out of 42 species, 15 species were identified as commercially important. According to their economic importance these fishes are categorized into three groups. They are major carps (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*), local major (*Wallago attu*, *Heteropneustes fossilis*), and local minor (*Puntius conchonius*, *P. sarana*, *P. sophore*, *P. ticto*, *Xenentodon cancila*, *Notopterus notopterus*, *Mastacembelus armatus*, *Channa marulius*, *C. striata* and *C. punctatus*). The fish production data of the last five years of the reservoir revealed that maximum fish yield (45.62 kg/ha/yr) was recorded in 2000-01, which is lower than the average fish yield of Indian reservoirs. Fish yield rate upto 100, 75, 50 kg/ha/year in respect of small, medium and large Indian reservoirs.

Keywords: Fish diversity, commercially important fishes, fish yield, Ramsagar reservoir

INTRODUCTION

India is one of the mega biodiversity hotspots contributing to the world's biological resources. Central India, including the three states: Madhya Pradesh, Chattisgarh and Rajasthan, has diverse water resources such as streams, rivers, reservoirs, sub-terrain aquatic systems, traditional lakes and domestic ponds that harbour a wide variety of freshwater fishes (Sarkar and Lakra 2007). Fisheries resources occupy a prominent place in the economy of any country. The main benefits that can be derived from fishery development and its associated growth can be categorized as (a) nutritional and food supply (b) income (c) employment (d) infrastructure and (e) rescue and defence services.

Out of the total fish production of *c.* 5.66 million tonnes during 1999-2000, about 3.84 million tonnes came from marine sources and the rest are from inland waters. The Inland fish diversity of India is vast and varied, and one of the richest in the world (Tamang *et al.* 2007). Inland aquaculture contributes to 70% of total global fish production (Simoes *et al.* 2008). It includes the great river systems and extensive network of irrigation canals, man-made reservoirs, lakes, ponds, tanks, etc. The capture, culture and culture-cum capture fisheries have different settings and require different inputs, infrastructure and developmental strategy (Verma 1969).

Development of inland fisheries mainly depends on the intensity of stocking cultivable waters with quick growing fishes, namely major carps and exotic varieties. This in turn depends on the production of large quantities of cultivable fish seed, including fish fry and fingerlings in state fish farms and nurseries. In the context of a chronically protein deficient diet of majority of the people in India, especially in Madhya Pradesh, the production of protein food, like fish need special attention. Therefore, fisheries and its development should form an important aspect of planning, so as to provide cheap protein food. Besides providing direct employment, the industry is also an important income generator as it supports canneries, processing establishments, gear and equipment manufacturers, boat yards, refrigeration and ice-making plants, and transport services in addition to those working in State Fisheries Department, Fisheries Corporation, and other government fisheries based institutions. In view of the above, a study of fish diversity, production potential and yield of fish has been undertaken in the present communication.

MATERIAL AND METHODS

Study site: Ramsagar is a small man-made reservoir with a spread of *c.* 140 ha constructed on Nichroli nallah, a tributary of Sindh river. The reservoir is located *c.* 80 km south of Gwalior and 8 km north-west of Datia city, Madhya Pradesh (Fig. 1). Geographically, it lies between 25° 40.48' N and 78° 23.88' E at an altitude of 229 m above msl. The Reservoir is used for different purposes, like drinking water supply,

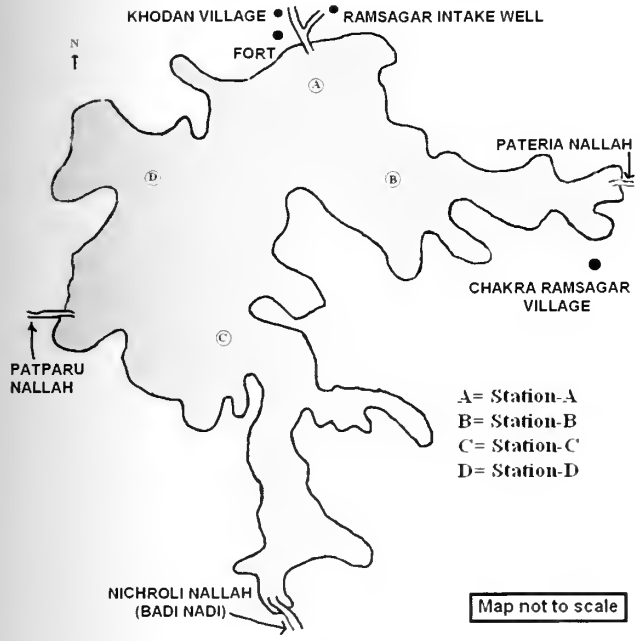


Fig. 1: Text figure of Ramsagar reservoir showing sampling stations

irrigation, fisheries, etc. It is totally rain fed through various drains that bring water from the surrounding hilly catchment areas, except the side having 'pucka (concrete)' and 'Kachcha (earthen)' embankments.

Methods: The fish specimens were collected twice every season using dragnets, gill nets and cast net (Ghagaria Jaal) with the help of local fishermen. Smaller specimens were preserved in 8% formalin, while large specimens were dissected for visceral preservation and later preserved in formalin. The specimens were identified to species level using keys provided by Srivastava (1980), Talwar and Jhingran (1991) and Jayaram (1999).

Fishing activity in the reservoir is directly under the control of Assistant Director, M.P. Government Fisheries Department, Datia, whose office is located near Lala Ka Tal in Datia city. The data on fish production of the reservoir were collected from this office.

Table 1: Fish species richness in Ramsagar Reservoir

S. No.	Families	Genera	Species	% Contribution of families
1.	Cyprinidae	11	21	50.00
2.	Bagridae	02	04	9.52
3.	Channidae	01	03	7.14
4.	Siluridae	02	02	4.76
5.	Schilbeidae	02	02	4.76
6.	Sisoridae	01	01	2.38
7.	Clariidae	01	01	2.38
8.	Heteropneustidae	01	01	2.38
9.	Belonidae	01	01	2.38
10.	Mastacembelidae	01	01	2.38
11.	Chandidae	01	01	2.38
12.	Nandidae	01	01	2.38
13.	Gobiidae	01	01	2.38
14.	Balitoridae	01	01	2.38
15.	Notopteridae	01	01	2.38
Total		**28**	**42**	

RESULTS AND DISCUSSION

The ichthyofauna of a reservoir represents the faunal diversity of the parent river system. Studies conducted so far indicate that large reservoirs harbour around 60 species of fishes, of which at least 40 contribute to commercial fisheries. The fast growing Indo-Gangetic carps, popularly known as Indian major carps, occupy a prominent place among commercially important fishes. More recently, a number of exotic species have also contributed substantially to commercial fisheries. A database on fisheries resources of the reservoir ecosystem seems to be an essential prerequisite for a meaningful management of the aquatic resources.

Fish Diversity: The fish species obtained during the survey under the present study were found to belonged to 42 species under 28 genera, 15 families and 6 orders (see Appendix 1). The maximum numbers of fish species (21) belong to Family Cyprinidae (50%). Families Notopteridae, Balitoridae, Sisoridae, Clariidae, Heteropneustidae, Belonidae, Mastacembelidae, Chandidae, Nandidae, and Gobiidae are represented by only one species (2.38%); families Siluridae and Schilbeidae are represented by two species (4.76%), Family Channidae is represented by three species (7.14%), and Family Bagridae is represented by four species (9.52%) (Table 1). Order-wise, maximum fish species (52.38%) is represented by Cypriniformes (Fig. 2). Dubey and Verma (1965), while studying the fish fauna of Madhya Pradesh, reported 104 species, of which 50% belong to Family Cyprinidae. Bhat (2003) studied the diversity and composition of freshwater fishes in river systems of Western Ghats and recorded 92 species, with Cyprinidae being the dominant group. Agarwal and Saksena (1977) studied the fish fauna of Madhya Pradesh and reported 48 species, of which 39.58% belong to Family Cyprinidae. Dubey *et al.* (1980) recorded 70 fish species, including exotic species from Chambal division, of which Family Cyprinidae contributed 45.71%. Rao *et al.* (1988) studied Gandhisagar reservoir and reported 41 species, of which Family Cyprinidae contributed 53.65%. Saxena and Shrivastava (1989) studied fishes of Kunwari river, north Madhya Pradesh, and recorded 46 species with 47.82% of

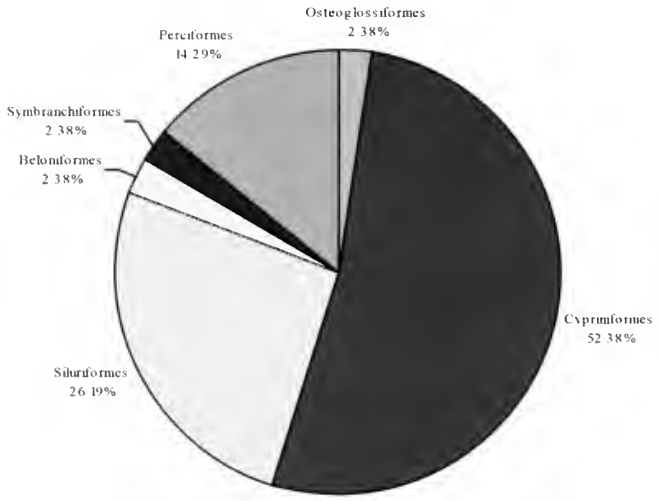


Fig. 2: Percentage contribution of different orders of fish species in the Ramsagar reservoir

Family Cyprinidae. If a comparison of fish fauna of Ramsagar reservoir is made with other reservoirs and water bodies, it becomes quite apparent that, the Ramsagar reservoir has rich fish diversity with maximum contribution of Family Cyprinidae. Saksena and Verma (1993) have reported 3 species of genus *Tor* and 7 species of genus *Puntius* from Madhya Pradesh. In the present study, only *Tor tor* has been reported. Shukla *et al.* (2003) have described 39 species of fishes with family Cyprinidae contributing more than 51%. Sarkar *et al.* (2007) studied Samaspur Bird Sanctuary, Uttar Pradesh, and recorded 46 fish species belonging to 7 orders, 19 families and 33 genera. Saksena (2007) has revised the list of fishes from north Madhya Pradesh and reported a total of 73 species, including 7 species of exotic fishes.

Fish Production Potential: In the developed world, fisheries of inland lakes and reservoirs largely cater to recreational needs, whereas in a highly populous developing country like India, these resources can play a vital role in augmenting food production for human consumption and mitigating protein deficiency. The national fish production rate of Indian reservoirs is estimated as 20.13 kg/ha/yr (Sugunan 1997; Ahirrao and Mane 2000) with a modest increase in fish yield rate up to 100, 75, and 50 kg/ha/yr with respect to small, medium and large Indian reservoirs (Sugunan 1997). The present low level of fish production in Indian reservoirs can be attributed to inadequate management as many of them have high propensities of production from a limno-chemical point of view (Khedkar 2005). In many of the reservoirs, the high rate of primary and secondary productivity is not being channelized to fish production (Khanna and Bhutiani 2005). Insufficient understanding of the reservoir ecosystem often comes in the way for adopting effective management measures (Paik and Chakraborty 2003). The productivity from the reservoirs can be increased through a number of approaches like better management measures, higher value for fish catch through improvement in processing and marketing and through more equitable distribution of benefits (Sultan *et al.* 2005). Fish yield of 74.80 kg/ha/yr has been recorded in Markonahalli reservoir, Karnataka (Ramakrishnaih *et al.* 1998) whereas, Jhingran and Sugunan (1990) have recorded fish productivity as 100 kg/ha/yr in Gulariya reservoir. Khan *et al.* (1990) observed fish productivity of 139.60 kg/ha/yr in Bachhara reservoir. Murugesan and Manoharan (2000) recorded fish productivity of 224.80 kg/ha/yr in privately managed Palar-Poranthian reservoir. A fish productivity of 133.50 kg/ha/yr was found in Naktara reservoir, Madhya Pradesh (Dwivedi *et al.* 2000). The fish productivity in Ramsagar reservoir was recorded for five years and it is observed that maximum fish productivity (45.62 kg/ha/yr) occurred in 2000-2001, while minimum fish productivity (8.96 kg/ha/yr) was seen in 2002-2003. If we compare fish productivity of Ramsagar reservoir with other reservoirs, we notice that, productivity of Ramsagar reservoir is very low. This could be primarily due to escape of fishes from sluice gates at the time of discharge of water for irrigation and drinking supply to Datia city, disturbing the balance of fish production in the reservoir. Diminished natural breeding ultimately reduces the fish production in Ramsagar reservoir. The Reservoir is primarily meant for irrigation, flood control and drinking purposes. Fisheries have been recognized as a secondary activity. Hence, fish production management practices are constrained and have limited scope for adoption of modern practices. The inflow

Table 2: Royalty charges of Fisheries Department and fish price in Datia and Gwalior market

S. No.	Species	Fisheries Department charges (royalty) /kg	Market rates of Fish/kg
1.	**Major Carps**: *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*	14.00 Rs/kg	60-65 Rs/kg
2.	**Local Major**: *Wallago attu*, *Heteropneustes fossilis*	10.00 Rs/kg	50-60 Rs/kg
3.	**Local Minor**: *Puntius conchonius*, *P. sarana*, *P. sophore*, *P. ticto*, *Xenentodon cancila*, *Notopterus notopterus*, *Mastacembalus armatus*, *Channa marulius*, *C. striata*, *C. punctatus*	8.00 Rs/kg	20-25 Rs/Kg

Table 3: Year-wise fish production of Ramsagar Reservoir

S. No.	Year	Seed of fish species	Total fish seed released in the reservoir	Fish yield/ ha	Total fishing yield from the reservoir	Royalty collected from fishermen by Fisheries Department
1.	2000-01	(a) *Catla catla* (b) *Labeo rohita* (c) *Cirrhinus mrigala*	2, 80, 000.00*	45.62 kg/ha/yr	6.3925 metric tons (6, 392.50 kg)	Rs. 69, 293.00
2.	2001-02	(a) *Catla catla* (b) *Labeo rohita* (c) *Cirrhinus mrigala*	2, 35, 000.00*	23.64 kg/ha/yr	3.313 metric tons (3, 313.00 kg)	Rs. 35, 556.00
3.	2002-03	(a) *Catla catla* (b) *Labeo rohita* (c) *Cirrhinus mrigala*	2, 35, 000.00*	8.96 kg/ha/yr	1.256 metric tons (1, 256.00 kg)	Rs. 11, 210.00
4.	2003-04	(a) *Catla catla* (b) *Labeo rohita* (c) *Cirrhinus mrigala*	1, 55, 000.00*	23.97 kg/ha/yr	3.359 metric tons (3, 359.00 kg.)	Rs. 30, 634.00
5.	2004-05	(a) *Catla catla* (b) *Labeo rohita* (c) *Cirrhinus mrigala*	2, 80, 000.00*	27.10 kg/ha/yr	3.798 metric tones (3, 798.00 kg)	Rs. 37, 504.00

*Fish seed (fingerlings) 100-105 mm in size

and outflow of water and highly fluctuating water levels are main reasons for low fish productivity of Ramsagar reservoir affecting the same adversely.

Commercial Fisheries of Ramsagar Reservoir: Out of 42 fish species, 15 species were identified as commercially important fetching good market price. According to their economic importance these fishes are categorized into three groups (Table 2): major carps (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*), local major (*Wallago attu*, *Heteropneustes fossilis*), local minor (*Puntius conchonius*, *P. sarana*, *P. sophore*, *P. ticto*, *Xenentodon cancila*, *Notopterus notopterus*, *Mastacembelus armatus*, *Channa marulius*, *C. striata*, and *C. punctatus*). The fish caught from the reservoir are marketed locally in Datia fish market and are seldom transported to other places. The fish marketing surveys conducted in Datia and Gwalior city revealed that there was one wholesale fish market each in Datia and Gwalior, and five retail markets in Datia and Badoni town and six in Gwalior city. All fishes sold are fresh. There was no major fish drying process at the reservoir, however, a small quantity of dried fish are dispatched to Gorakhpur. The data collected for the last five years on fisheries resources of Ramsagar reservoir show that maximum fish were caught from February to April and these were procured by the Fishermen Co-operative Societies. The payments to the society are made on weekly basis. The Co-operative Societies dispatch the fishes by Jeep from Ramsagar reservoir to wholesale markets at Datia and Ladheri in Gwalior city. The fishes are sold at the rate of Rs. 50-70/kg during different months in different markets. It is alarming that there is much lower fish production rate in Ramsagar as compared to other Indian reservoirs (Sugunan 1997; Khedkar 2005). Kharat *et al.* (2003) have suggested various strategies for conservation of fish including halting of siltation, promoting controlled harvest, imposing checks on exotic species, introduction of carp fingerlings, controlling water pollution and construction of fish ladders on dams.

It has been observed that illegal fishing practices also reduce the annual yield of fish. The vast area of the Ramsagar reservoir invites poachers for illegal fishing. The reservoir should be suitably protected against unauthorized and illegal fishing to safe guard the stock. Because of non-availability of patrolling crafts, the security staff is quite handicapped in performing their duties. It was proposed to strengthen the staff and also to provide them with mechanized boats for patrolling the reservoir, so that the fishing wealth of the Ramsagar reservoir is suitably protected, especially during the breeding season. The Fisheries Department of the Government of Madhya Pradesh has started implementing some measures for stock replenishment of major carps by introducing fingerlings, for the last few years (Table 3). This would yield good results in years to come.

ACKNOWLEDGEMENTS

The authors thankfully acknowledge the University Grants Commission, New Delhi, for financial assistance (SAP-II, No. F-03.07.2002). We are also thankful to Mr. P.K. Bali, Assistant Director (Fisheries), Datia, Madhya Pradesh, for providing valuable information on fishes of the reservoir, then Head School of Studies in Zoology, Jiwaji University, Gwalior and the Coordinator, SAP-DRS Phase-I (UGC) for providing necessary laboratory facilities.

REFERENCES

AGARWAL, S.S. & D.N. SAKSENA (1977): Checklist of fishes from Gwalior, Madhya Pradesh. *J. Jiwaji Univ. 5(2)*: 164-169.

AHIRRAO, S.D. & A.S. MANE (2000): The diversity of ichthyofauna and fisheries from freshwaters of Parbhani district, Maharastra State. *J. Aqua. Biol. 15(1&2)*: 40-43.

BHAT, A. (2003): Diversity and composition of freshwater fishes in river systems of Central Western Ghats, India. *Environ. Biol. Fish. 68*: 25-38.

DUBEY, G.P. & M.N. VERMA (1965): A preliminary study of the fish fauna of Madhya Pradesh. *J. Vikram Univ. 8(4)*: 1-8.

DUBEY, P.K., L.P. MAHESHWARI & A.K. JAIN (1980): Ichthyo-Geographical Survey of Chambal Division Madhya Pradesh. *J. Jiwaji Univ. 8(2)*: 113-122.

DWIVEDI, R.K., M.A. KHAN, H.P. SINGH, D.N. SINGH & R.K. TYAGI (2000): Production dynamics and fisheries development in Naktara reservoir, Madhya Pradesh, India. *J. Inland Fish. Soc. India 32(2)*: 81-86.

JAYARAM, K.C. (1999): The fresh water Fishes of Indian region. Narendra Publishing House Delhi, India. 551 pp.

JHINGRAN, A.G. & V.V. SUGUNAN (1990): General guidelines and planning criteria for reservoir fisheries management. Pp. 1-8. *In*: Jhingran, A.G. & U.K. Unnithan (Eds): Proceeding National Workshop on Reservoir Fisheries. January 3-4, 1990. Special Publication. 3 Asian Fisheries Society, Indian Branch, Mangalore, India.

KHAN, M.A., R.K. DWIVEDI, S.N. MEHROTRA, K.P. SRIVASTAVA & P. KATIAH (1990): Stocking as a management tool in optimizing fish yield from a small reservoir (Bachhra) in Ganga basin. Pp. 71-76. *In*: Jhingran, A.G. & V.K. Unnithan (Eds.): Proceeding National Workshop on Reservoir Fisheries. January, 3-7, 1990. Asian Fisheries Society, Indian Brach, Mangalore.

KHANNA, D.R. & R. BHUTIANI (2005): Fish ecology of a lake at Haridwar District with special reference to its economics. *Aquaculture 6(1)*: 17-24.

KHARAT, S., N. DAHANUKAR, R. RAUT & M. MAHABALESHWARKAR (2003): Long-term changes in freshwater fish species composition in North Western Ghats, Pune District. *Curr. Sci. 84(6)*: 816-820.

KHEDKAR, G.D. (2005): Studies on fish diversity in relation to the bird habitat from Nathsagar bird sanctuary area, Nathsagar reservoir, Paithan, District Aurangabad, Maharastra. *J. Aqua. Biol. 20(2)*: 231-238.

MURUGESAN, V.K. & S. MANOHARAN (2000): Management of Reservoir Fisheries through private Entrepreneurs-Case studies. *J. Inland Fish. Soc. India 32(2)*: 68-75.

PAIK, T.K. & S.K. CHAKRABORTY (2003): Ichthyofauna of east Singhbhum District, Jharkhand, India. *J. Aqua. Biol. 18(2)*: 55-60.

RAMAKRISHNAIH, M.K., D.S. RAO, P.K. SUKUMARAN & M. KARTHIKEYAN (1998): Ecology of Fisheries of Markonahalli reservoir (Karnataka). Central Inland Capture Fisheries Research Institute, Barrackpore. *Bulletin 78*: 41.

RAO, K.S., K.N. KARTHA, S. SHRIVASTAVA, S.S. PANDYA & U. CHOUBEY (1988): Studies on the commercial fisheries and its fluctuations in Gandhi Sagar Reservoir. Pp. 55-65. *In*: Kulshrestha, S.K. (Ed.) Proceeding National Symposium Past, Present & Future of Bhopal Lake.

SAKSENA, D.N. (2007): Fish diversity of Northern Madhya Pradesh (Gwalior and Chambal Division). Pp. 50-57. *In*: Lakra, W.S. & U.K. Sarkar (Eds): Freshwater Fish Diversity of Central India. National Bureau of Fish Genetic Resources (ICAR), Lucknow, India.

SAKSENA, D.N. & M.N. VERMA (1993): Eco-distribution des barbeaux des gerres *Tor* et *Puntius* (Cyprinidae) au Madhya Pradesh. *Inde. Cahiers d. Ethologie 13(2)*: 235-238.

SAXENA, R. & P. SHRIVASTAVA (1989): A checklist of fish fauna of Kunwari River, North Madhya Pradesh. *J. Inland Fish. Soc. India 21(1)*: 41-45.

SARKAR, U.K. & W.S. LAKRA (2007): An overview of the Diversity and Conservation Status of Freshwater Fishes of Central India. Pp. 7-18. *In*: Lakra, W.S. & U.K. Sarkar (Eds): Proceeding of the workshop on "Conservation Assessment of Freshwater Fish Diversity (CAFF) for Central India" organized by National Bureau of Fish Genetic Resources (NBFGR), Lucknow (U.P.) dated on November 25, 2006 at CIAF, Bhopal, M.P.

SARKAR, U.K., D. KAPOOR, S.K. PAUL, A.K. PATHAK, V.K. BASHEER, P.K. DEEPAK, S.M. SHRIVASTAVA & L.K. TYAGI (2007): Fish diversity in the water bodies of Samaspur Bird Sanctuary, Uttar Pradesh: towards developing a freshwater aquatic Sanctuary. *J. Bombay Nat. Hist. Soc. 104(1)*: 51-54.

SHUKLA, A.N., A. PANDEY & S. SHRIVASTAVA (2003): Observations on Fish biodiversity variation in Gambhir dam, Ujjain (M.P.), India. *Aqua. 4(1)*: 15-21.

SIMOES, F.D.S., A.B. MOREIRA, M.C. BISINOTI, S.M.S GIMENEZ & M.J.S. YABE (2008): Water quality index as a simple indicator of aquaculture effects on aquatic bodies. *Ecolog. Ind. 8(5)*: 476-484.

SRIVASTAVA, G. (1980): Fishes of U.P. and Bihar, Vishwavidyalaya Prakashan, Varanasi, India.

SUGUNAN, V.V. (1997): Reservoir fisheries of India. *FAO Fish. Tech. paper*: 345.

SULTAN, S., M. CHAUHAN & V.I. SHARMA (2005): Commercial fisheries in Pahunj reservoir under different fishing regimes. *Journal of Inland Fisheries Society of India 37(2)*: 48-53.

TALWAR, P.K. & A.G. JHINGRAN (1991): Inland Fishes of India and Adjacent Countries. Vol. 1&2. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi, India.

TAMANG, L., S. CHAUDHRY & D. CHOUDHURY (2007): Ichthyo-faunal contribution to the state and comparison of habitat contiguity on taxonomic diversity in Senkhi stream, Arunachal Pradesh, India. *J. Bombay Nat. Hist. Soc. 104(2)*: 170-177.

VERMA, M.N. (1969): Hydrobiological study of a tropical impoundment, Tekanpur reservoir, Gwalior, India, with special reference to the breeding of Indian carps. *Hydrobiologia 34(3-4)*: 358-368.

Appendix 1: Systematic list of fish species recorded in the Ramsagar Reservoir

Order: Osteoglossiformes
Family: Notopteridae
Genus: *Notopterus* Lacépéde
1. *Notopterus notopterus* (Pallas)

Order: Cypriniformes
Family: Cyprinidae
Subfamily: Danioninae
Genus: *Salmostoma* Swainson
2. *Salmostoma bacaila* (Hamilton-Buchanan)
3. *Salmostoma clupeoides* (Bloch)

Genus: *Barilius* Hamilton-Buchanan
4. *Barilius barila* (Hamilton-Buchanan)
5. *Barilius bendelisis* (Hamilton-Buchanan)
6. *Barilius bola* (Hamilton-Buchanan)

Genus: *Rasbora* Bleeker
7. *Rasbora daniconius* (Hamilton-Buchanan)

Genus: *Danio* Hamilton-Buchanan
8. *Danio devario* (Hamilton-Buchanan)

Subfamily: Cyprininae
Genus: *Tor* Gray
9. *Tor tor* (Hamilton-Buchanan)

Genus: *Puntius* Hamilton-Buchanan
10. *Puntius conchonius* (Hamilton-Buchanan)
11. *Puntius sarana* (Hamilton-Buchanan)
12. *Puntius sophore* (Hamilton-Buchanan)
13. *Puntius ticto* (Hamilton-Buchanan)

Genus: *Osteobrama* Heckel
14. *Osteobrama cotio cotio* (Hamilton-Buchanan)

Genus: *Catla* Vallenciennes
15. *Catla catla* (Hamilton-Buchanan)

Genus: *Cirrhinus* Oken
16. *Cirrhinus mrigala* (Hamilton-Buchanan)
17. *Cirrhinus reba* (Hamilton-Buchanan)

Genus: *Labeo* Cuvier
18. *Labeo bata* (Hamilton-Buchanan)
19. *Labeo calbasu* (Hamilton-Buchanan)
20. *Labeo gonius* (Hamilton-Buchanan)
21. *Labeo rohita* (Hamilton-Buchanan)

Subfamily: Garrinae
Genus: *Garra* Hamilton-Buchanan
22. *Garra gotyla gotyla* (Gray)

Family: Balitoridae
Subfamily: Nemacheilinae
Genus: *Acanthocobitis* Peters
23. *Acanthocobitis botia* (Hamilton-Buchanan)

Order: Siluriformes
Family: Bagridae
Subfamily: Bagrinae
Genus: *Mystus* Scopoli
24. *Mystus bleekeri* (Day)
25. *Mystus tengara* (Hamilton-Buchanan)

Genus: *Sperata* Holly
26. *Sperata aor* (Hamilton-Buchanan)
27. *Sperata seenghala* (Sykes)

Family: Siluridae
Genus: *Ompok* Lacépéde
28. *Ompok bimaculatus* (Bloch)

Genus: *Wallago* Bleeker
29. *Wallago attu* (Bloch & Schneider)

Family: Schilbeidae
Subfamily: Schilbeinae
Genus: *Eutropiichthys* Bleeker
30. *Eutropiichthys vacha* (Hamilton-Buchanan)

Genus: *Silonia* Swainson
31. *Silonia silondia* (Hamilton-Buchanan)

Family: Sisoridae
Genus: *Bagarius* Bleeker
32. *Bagarius bagarius* (Hamilton-Buchanan)

Family: Clariidae
Genus: *Clarias* Scopoli
33. *Clarias batrachus* (Linnaeus)

Family: Heteropneustidae
Genus: *Heteropneustes* Muller
34. *Heteropneustes fossilis* (Bloch)

Order: Beloniformes
Family: Belonidae
Genus: *Xenentodon* Regan
35. *Xenentodon cancila* (Hamilton-Buchanan)

Order: Synbranchiformes
Family: Mastacembelidae
Subfamily: Mastacembelinae
Genus: *Mastacembelus* Scopoli
36. *Mastacembelus armatus* (Lacépéde)

Order: Perciformes
Family: Chandidae (Ambassidae)
Genus: *Chanda* Hamilton-Buchanan
37. *Chanda nama* (Hamilton-Buchanan)

Family: Nandidae
Subfamily: Nandinae
Genus: *Nandus* Vallenciennes
38. *Nandus nandus* (Hamilton-Buchanan)

Family: Gobiidae
Subfamily: Gobiinae
Genus: *Glossogobius* Gill
39. Glossogobius giuris (Hamilton-Buchanan)

Family: Channidae
Genus: *Channa* Scopoli
40. *Channa marulius* (Hamilton-Buchanan)
41. *Channa striata* (Bloch)
42. *Channa punctatus* (Bloch)

- No exotic fish was caught from Ramsagar reservoir.

■ ■ ■

DEMOGRAPHY OF CAPTIVE ASIAN ELEPHANTS *ELEPHAS MAXIMUS* LINNAEUS IN THREE MANAGEMENT SYSTEMS IN TAMIL NADU, INDIA

V. Vanitha[1,2], K. Thiyagesan[1,3] and N. Baskaran[4]

[1]Department of Zoology, A.V.C. College, Mannampandal 609 305, Mayiladuthurai, Tamil Nadu, India.
[2]Current Address: D.G.G. Arts College (Women), Mayiladuthurai 609 001, Tamil Nadu, India. Email: vanithabaskar@rediffmail.com
[3]Email: kthiyagesan1@rediffmail.com
[4]Asian Nature Conservation Foundation, Innovation Centre, Indian Institute of Science, Bengaluru 560 012, Karnataka, India. Email: nagarajan.baskaran@gmail.com

Captive Asian elephants *Elephas maximus* are managed in three systems in Tamil Nadu namely, private, Hindu temples and forest department. We studied the population size and structure, natality and mortality during 2003-05 in the three systems to assess their long-term viability. The population in the three systems totalled 133 individuals in 2005 with adult class constituting over 75% of the population. Sex ratio of the population was biased towards females in private establishments (male to female 1:10) and temples (1:21), but male biased in the forest department (1:0.5) with adult males constituting 50% of the total population. There was no breeding in private and temple populations. In the forest department population, fecundity has dropped (0.065/adult female/year) over the past 10 years (1996-2005) compared to an earlier (1969-1989) estimate (0.155/adult female/year). Mean mortality estimated together for the three systems is higher (3.9%) than reported earlier (1.9%). Given the aging population trends and with no breeding and fewer chances of additions from the forest department due to ban on elephant sale, captive populations in private establishments and temples may not survive in the long run. Sustainability appears rather remote for population of the forest department system with a male bias, increase in mortality and a decrease in fecundity.

Key words: Asian elephant, *Elephas maximus*, captive elephants, population, natality, mortality

INTRODUCTION

The Asian Elephant *Elephas maximus* Linnaeus, listed as an 'endangered' species by the IUCN (International Union for Conservation of Nature Red List 2008), presently exists as fragmented population in southern and south-eastern Asia. Currently, wild Asian elephants are estimated to be 36,000-52,000 individuals distributed across 13 Asian countries (Sukumar and Santiapillai 2006). The Asian elephant is considered an integral part of the culture and mythology of India, and elsewhere in Asia; the people of Indus Valley civilization first captured it probably about 4,000 years ago (Carrington 1959). There were about 19,500 captive Asian elephants in 1997 with Myanmar holding the largest captive population (6,000-7,000) followed by Thailand (3,800-4,000) and India (2,800-4,000) (Lair 1997). The IUCN Asian Elephant Specialist Group estimates the captive Asian elephant numbers within the range countries at 16,365 and less than 2,000 in non-range countries, including about 1,000 in North America and Australia, and 296 in Europe (Hedges 2006).

In India, captive elephants are distributed across almost all states (including numerous non-range states), as this animal is an integral part of the country's cultural and religious landscape. According to Project Elephant (MoEF 2004), about 3,400-3,600 captive elephants are distributed across 23 states and union territories, including the Andaman and Nicobar Islands. A majority of these are found in the north-eastern (55%) and southern (25%) states. In Tamil Nadu, southern India, elephants are managed in captivity by the State Forest Department, religious institutions and individual owners for various purposes. The Government of Tamil Nadu has categorized these elephants into three captive systems: forest department captive elephants (managed at timber camps and zoos), temple elephants (managed at Hindu temples), and private elephants (managed by trusts, charities, mosques and individual owners).

Several studies have been made in the past on captive elephant management in Tamil Nadu, but these have been sporadic, isolated, short term, and/or have not been comprehensive (Sukumar *et al.* 1988; Gokula 1993; Krishnamurthy 1995; Krishnamurthy and Wemmer 1995; Sukumar *et al.* 1997). Additionally, little long-term quantitative data are available on their numbers; a comparative analysis of different captive management systems and their influence on elephants' natural behaviour has not been attempted. Further, most of the data available on captive elephants in India pertain to timber camp elephants managed by the state forest department and hardly any information exists on those managed by private owners and Hindu temples, which constitute over 50% of the captive population in southern India (Lair 1997).

Lair (1997) in his global comprehensive review on captive Asian elephants states that India, the birthplace of

elephant captivity, has very little published data on captive elephant numbers. Further, he concludes that captive elephant numbers estimated in India are clearly an underestimation, and highlights the need for a detailed survey to fulfil the basic information. A recent report by Project Elephant (MoEF 2004) puts the maximum number of captive elephants in India at 3,600, and recommends a detailed survey and assessment for their welfare. In addition, the available data on the population and demographic status of captive elephants in India are scarce. The data on the number of individuals alone are inadequate to predict future trends of any population. The age structure, age specific fecundity, and mortality, age at first conception, and last calving, and mean-calving interval are important parameters to understand population dynamics and predict future trends (Laws and Parker 1968; Corfield 1973; Caughley 1977; Laws 1981; Lindeque 1991; Stearns 1992), are lacking for most of the captive populations. In this paper, we present the data on population demography of captive Asian elephants in Tamil Nadu, India, collected between 2003 and 2005, as part of a long-term comparative study on the status and management of captive Asian elephants in Tamil Nadu.

METHODS

Data on population size and structure, natality and mortality were collected from: (1) the Tamil Nadu forest department – captive elephants managed at the timber elephant camps at Mudumalai and Anamalai wildlife sanctuaries, and Arignar Anna Zoological Park (AAZP), Chennai, (2) Hindu temples, and (3) private owners in Tamil Nadu.

Population Size and Structure

A comprehensive list of captive elephants maintained under the three different management regimes, with special emphasis on temple and private collections (as data on these two systems was lacking), was first prepared. The list was compiled by examining governmental records and from enquiries with veterinarians and elephant researchers. This was later found to comprise of *c.* 90% of the temple and *c.* 80% of the private elephants in the State. The presence and information on the remaining elephants were obtained during intensive surveys carried out through enquiries with temple authorities, *mahouts* (elephant keepers) and private owners. Altogether, data was collected on 34 facilities in the private system, 41 in temple systems, and 3 (namely, the elephant camps at Anamalai and Mudumalai, and the Arignar Anna Zoological Park, i.e., two camps and one zoo) in the forest department system. During the survey, data was collected on the age and sex of all the elephants through enquiries with the *mahouts* and by verifying with studbooks/registers (where available). Age was estimated by the shoulder height method (Sukumar *et al.* 1988) if proper age records were not available. Data were additionally collected from temple and private elephants at the one month long annual rejuvenation camps conducted jointly by the Tamil Nadu Hindu Religious and Endowment Charity (HR & CE) and Tamil Nadu Forest Department at Mudumalai Wildlife Sanctuary during 2003-2005.

Natality and Mortality

Data on natality and mortality of elephants in the three systems of captive management was collected from register of records and through monitoring during the study period. Natality generally refers to the addition of newborn individuals into the population, but in this study, it also includes the addition of individuals through purchase/transfer/confiscation/rescues, as these additions add to the captive population size. Fecundity was calculated by dividing the total number of calves that were born during the study period by the total number of sexually mature female elephant-years following Sukumar *et al.* (1997). Elephant-years refer to the summation of all individual elephants multiplied by their number of year(s) representation/ survival in a given system for a particular period. For example, out of 25 different elephants managed in a given system over a two-year period, 20 of them represented for 2 years and the remaining five only for a one-year period, which translates to 45 elephant-years (i.e. 20*2 + 5*1 = 45). Age-specific mortality was computed by dividing the total number of individuals that died within a given age class by the total number of elephant-years lived in that age class (Sukumar *et al.* 1997) during 2003-2005 in the three systems. Data available on the number of elephants managed and that died as per the Forest Department records for the period 1996-2002 was also used to have a larger sample size in the mortality rate analysis.

Data analysis

The elephants were categorized broadly into four major age classes: calf (<1-year old; 90-120 cm height), juvenile (1-5 years; 121-180 cm), subadult (5-15 years; 181-210 cm for female and 181-240 for male), and adult (15 years and above; >210 cm for female and >240 cm for male) based on shoulder height (Sukumar *et al.* 1988). The trend in population size of elephants in the forest department system from 1996 to 2005 was tested using linear regression. Year-wise differences in the age-sex composition of elephants during the study period (2003-05) within each system and among the three systems were analyzed using likelihood-ratio chi-squared statistics (G^2) (Agresti 1996).

RESULTS

Population Size

The total population size of captive elephants in the three management systems in Tamil Nadu was *c.* 132-135 elephants between 2003 and 2005 (Table 1). The total number of elephants at the end of the year was the same in 2003 and 2004 (135 elephants), but dropped to 133 in 2005. Within a given system, the number of elephants at the beginning and at the end of each year of the study varied due to addition of individuals (births, capture, transfer from other systems and purchase) and reduction due to mortality, sale and transfers. Although the overall number of individuals was almost the same, there was little turnover within the three-year period.

The districts of Madurai (n = 9) and Tiruchirapalli (n = 8) had more private elephants, and Thanjavur (n = 7) and Madurai (n = 6) had the most number of temple elephants. All the elephants in the private and temple systems were purchased either from the forest department (mostly before 1982 when the ban on capture of elephants for sale came into force) or recently from other state private systems, except for one from birth in the private facility. The source of origin (captive born and wild-caught) for many of these elephants was not available due to improper maintenance of register records. Among the 53 elephants managed between 2003 and 2005 in the forest department, 24 were captured from the wild, 16 were captive born, 9 were wild 'orphans', and 1 was confiscated from a private owner in 2003. The origin of the remaining three (including one transferred back in 2004 from a temple due to difficulty in handling) could not be ascertained due to absence of records. Long-term data from 1996 to 2005 on the population size of captive elephants managed by the forest department (Fig. 1) indicate a significantly declining trend (linear regression of population against time $R^2 = 0.6679$, $P < 0.01$, n = 10) over the past ten years.

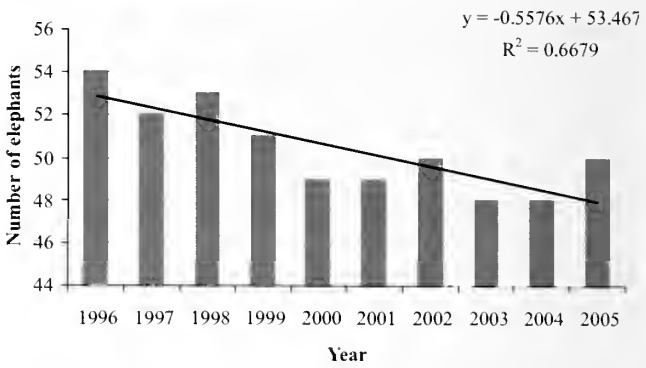


Fig. 1: Number of captive elephants with the Tamil Nadu Forest Department between 1996 and 2005

Population Structure

Age structure data revealed an aging population trend with the adult class forming more than two-thirds of the total population size in all the captive systems (Table 2). Among the three captive systems, the proportion of adult class was the highest in the private system (87%) followed by the forest department system (75%). The subadult class was the highest in the temple (30%) followed by forest department system (16%). Juveniles and calves were mostly found in the forest department system (Table 2).

The age-sex composition of elephants did not vary during the three-year study period (2003-05) within each system (private: G^2 = 5.68, df = 10, P = 0.84; temple: G^2 = 6.41, df = 6, P = 0.42 and forest department: G^2 = 6.96, df = 14, P = 0.94), but it was statistically different among the systems within each year (2003: G^2 = 63.17, df = 12, P = 0.0000; 2004: G^2 = 67.06, df = 10, P = 0.0000 and 2005: G^2 = 64.51, df = 12, P = 0.0000). The age-sex composition data reveal that the captive elephant populations were female-biased (male: female ratio = 1: 2.4) across the three systems (Table 2). However, while females formed the major proportion (>90%) of the population with adult class having a significant share in private and temple systems, males (66%) outnumbered females (34%) across all the age classes in the forest department system.

Natality

Natality was the highest in the forest department system (n = 12) compared to private (n = 4) and temple (n = 2) systems

Table 1: Population size of elephants managed in the three captive systems in Tamil Nadu during 2003-2005

Management system	Population size					
	2003		2004		2005	
	Initial	Final	Initial	Final	Initial	Final
Private	40	43	43	44	44	42
Temple	42	44	44	43	43	41
Forest Department	50	48	48	48	48	50
Total	132	135	135	135	135	133

Initial and final refer to population size in the beginning (January) and end (December) of the year.

(Fig. 2). There were 4 births from the 14 sexually mature females in the age class of 15-60 years in forest department. This works out to 39 sexually mature female-elephant years over the last three years. Only one birth was observed in the private system (with 93 sexually mature female-elephant years) and none in the temples (with 81 sexually mature female-elephant years) during the study period. All the new additions to the temples were by purchase from other states. There was one transfer from a temple to the forest department. The only female in the private system that gave birth to a calf was purchased from a timber camp on the Andaman Islands - the gestation period indicating that the cow had conceived in the timber camp (which has bulls). There were no other records of captive birth in private and temple systems during the study period, and purchase was the only mode of addition in these systems. Three elephants were added to the private system and two to the temple management through purchases from other states, mostly from the north-eastern states of Assam and Arunachal Pradesh. The forest department system, which mostly manages its captive elephants in semi-natural condition at the timber camps of Anamalai and Mudumalai, had the highest addition by capture ($n = 7$), mostly 'orphans' from the wild. The birth of 4 calves during 2003-05 among the 39 sexually mature female-elephant years in the forest department works out to a fecundity rate of 0.10 calf/adult female/year. Long-term data (1996-2005) from the forest department showed that the fecundity rate had declined considerably (0.065 calf/adult female/year; Vanitha 2007) compared to an earlier estimate of 0.155 calf/adult female/year; Sukumar *et al.* 1997) for the period between 1969 and 1989.

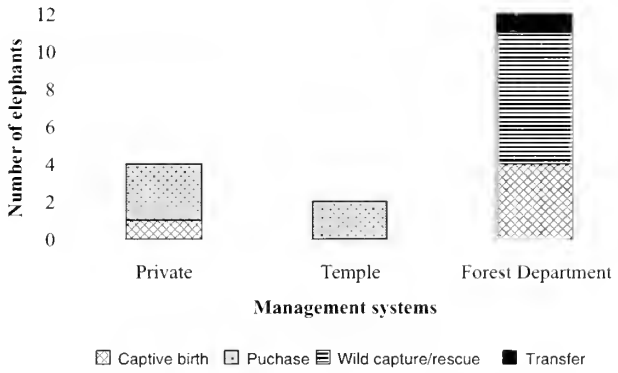


Fig. 2: Recruitment of elephants in the three management systems in Tamil Nadu between 2003 and 2005

Mortality

Totally, there were 149 individual elephants (44 in private, 43 in temples and 62 in forest department) during 2003-05. This works out to 419 elephant-years over the three-year period. Sixteen elephants died during 2003-05: 2 elephants each in the private and temple systems (all in

Table 2: Age structure, age-sex composition and sex ratio of the elephants managed in the three captive systems in Tamil Nadu during 2003-2005

Management Systems	Major age class	Mean age-sex composition (2003-2005)					
		Age structure (%)	Male (%)	SD*	Female (%)	SD*	Sex ratio M:F
Private	Adult	86.8	4.4	1.4	82.4	3.1	1: 20.9
	Subadult	8.8	0.9	1.6	7.9	2.7	1: 3
	Juvenile	3.5	3.5	1.4	0.0	-	1.3: 0
	Calf	0.9	0.9	-	0.0	-	0.3: 0
	Total	100	9.6	1.3	90.4	1.3	1: 9.5
Temple	Adult	68.0	4.7	0.2	63.3	2.3	1: 13.5
	Subadult	29.7	0.0	-	29.7	2.7	0: 12.7
	Juvenile	2.3	0.0	-	2.3	3.9	0: 1
	Calf	0.0	0.0	-	0.0	-	-
	Total	100	4.7	0.2	95.3	0.2	1: 20.7
Forest Department	Adult	75.4	50.0	2.1	25.3	2.2	1: 0.54
	Subadult	16.4	9.6	2.1	6.9	1.3	1: 0.7
	Juvenile	5.5	4.1	2.1	1.4	1.2	1: 0.3
	Calf	2.7	2.0	2.0	0.7	1.2	1: 0.3
	Total	100	65.8	1.1	34.2	1.1	1: 0.5

* SD = Standard Deviation: Calculated based on variation in % composition of each age-sex class during 2003-05.

2005) and 12 elephants in forest department system (4 each in 2003, 2004 and 2005), which works out to a mean annual mortality of 3.8% for the three systems. Of the 16 deaths, adult mortality accounted for 9 individuals (3%), followed by 4 for calves (4.4%), 2 for subadults (2.6%) and 1 juvenile (7.7%). Overall, males experienced a higher proportion of mortality (5.7%; 9/158 elephants) than female (2.8%; 7/246 elephants) segments. The mortality rate was much higher in the forest department system (7.6%) than private (1.5%) and temple (1.5%) management systems. Five (42%) out of 12 cases of deaths occurring in the forest department were of calves (4) and juveniles (1) indicating a higher mortality of younger elephants. There have been reports of increase in mortality (three cases during the past 3-4 years) among younger age classes due to *Herpes* virus in the forest department system, especially at the timber camps (Forest Department Register Records 1996-2005). A few elephants in the timber camps were suspected for tuberculosis (Forest Department records), a widespread disease among the global captive populations. A year-wise analysis of mortality across the three systems indicated that 50% of the 16 mortalities occurred during 2005 and the rest were spread equally during 2003 (25%) and 2004 (25%). Age-specific mortality, worked out incorporating additional data from the forest department for the period 1996-2002, showed a mean mortality rate of 3.9% based on 784 elephant-years (Table 3).

DISCUSSION

The population size of captive elephants in Tamil Nadu varied between 132 and 135 during the study period (2003-2005), which falls within the figures of the Project Elephant Report (MoEF 2004) between 127 and 145. The population size remained more or less the same in all the three captive systems, at 42-44 for private, 41-44 for temple and 48-50 for forest department. However, available long-term data over a 10-year period (1996-2005) from the forest department system revealed a significantly declining trend. The reasons for the decline (in spite of gradual increase in the number of orphaned calves rescued from the wild) over the ten-year period (1995-2005) compared to an earlier ten-year period (1985-1995) could be due to a reproductive decline (as shown by fecundity data) and increase in mortality. The absence of long-term data from temple and private systems did not permit the study to predict trends in these populations; but this is demographically not important, as there is no breeding in these systems.

Adults were the predominant age class in all the three systems of management comprising 87, 68 and 75% of the population in private, temple and forest department systems respectively. Private and temple captive populations consisted mostly of older animals due to absence of breeding and lack of recruitment of young elephants (especially from the state forest department due to the ban on elephant sale in recent years) and also due to the long lifespan of elephants. With no breeding, the elephant populations in the private and temple systems were female-biased (90%), as most of the facilities in these systems prefer to manage females due to the difficulty in maintaining bulls in captivity especially during *musth* (Krishnamurthy 1998; Sukumar 2003). In the forest department system, where breeding occurs, the overall sex ratio is skewed towards males with half the population being adult males. The system with low proportion of females in adult (25%, mostly above 40 years old) and subadult (7%) classes, does not promise self-sustainability in future. The reason for the aged population, and with male biased sex ratio

Table 3: Age-specific mortality of captive elephants managed in Tamil Nadu (pooled data from forest department records from 1996 to 2005, and of the private and temple elephants from 2003 to 2005)

Age class	Female		Male		Overall	
	Mortality rate (%)	*n**	Mortality rate (%)	*n**	Mortality rate (%)	*n**
0-1	28.6	7	33.3	9	31.3	16
1-2	0	4	12.5	8	8.3	12
2-5	15.4	13	4.3	23	8.3	36
5-10	4.4	45	10.0	30	6.7	75
10-20	1.8	57	1.2	86	1.4	143
20-40	3.4	119	3.4	118	3.4	237
40-60	1.8	164	1.3	79	1.6	243
60-80	14.3	21	0	1	13.6	22
Total	3.95	430	3.95	354	3.95	784

**n* refers to the number of individuals at risk (of death), expressed as the number of elephant-years over the age-class interval.

in the forest department system, could be due to selective disposal of young females in the past to Hindu temples, which mostly replenished their stock from the forest department system (Sukumar *et al.* 1997; Krishnamurthy 1998; Vanitha 2007). There is a female-biased population in the temple system and a female-biased elephant disposal (sale/gift) in the forest department system. Twenty of the 28 elephants sold between 1959 and 2004 to Hindu temples by the forest department were females and the majority were <10 years old (Vanitha 2007). The two peaks in disposal, first during 1971-72 (6 elephants) and second during 1995-96 (7 elephants), with the majority being females (8 elephants, <10 years old), resulted in the loss of prime reproductive age class (30-35 years) and younger adult class (15-20 years) that would have started breeding from 1995 and 2005 respectively in the forest department system. A remarkable decline in calving rate from 2.8 calves/year between 1971 and 1995 (69 calvings in 25 years) to just 0.9 calves/year between 1996 and 2005 (9 calvings in 10 years) (Vanitha 2007) also supports the hypothesis that the loss of prime reproductive age class is due to selective disposal of young female elephants in the past (1959-1996). Therefore, the fecundity dropped considerably from 0.155 (estimated for the period 1969-1989; Sukumar *et al.* 1997) to 0.065 during 1996-2005 (Vanitha 2007).

Being a polygynous species, elephant populations are naturally female biased. The elephants at the timber camps of the forest department are the only breeders in captivity in Tamil Nadu. With larger number of calves of the camp elephants sired by bulls from the wild, a female-biased population would not have been a problem for a sustainable growth rate in the captive population. Nevertheless, the prevalence of male-biased population in the forest department system and the non-breeding female-biased populations in the other two systems are not conducive for self-sustainability in the future.

The higher mortality observed in the forest department system (7.6%) compared to private (1.5%) and temple (1.5%) systems could be attributed, to some extent, to the higher mortality of calves and juveniles than the other age classes as reported earlier for captive (Sukumar *et al.* 1997; Mar 2001) and wild (Sukumar 2003) populations. The absence or poor representation of such age classes in the private and temple systems may be the reason for lower mortality rate in these two systems. Nevertheless, excluding juveniles and calves, the mortality rate still work out to 5% (7 deaths out of 141 elephant years between 2003 and 2005) in the forest department system. Similarly, a higher age-specific mortality has been reported in all the age classes of the forest department elephants over the past 10 years from 1996 to 2005 (Vanitha 2007) compared to the earlier report for the same population using a larger database from 1925 to 1989 (Sukumar *et al.* 1997). The higher mortality is alarming and threatens the long-term survival of the forest department captive elephants. The rise in calf mortality (31.3%) in the recent 10 years compared to the earlier report (19%) could possibly be due to more arrivals of 'orphans' from the wild in the recent years and their higher susceptibility to mortality. Exclusion of orphans reduced the recorded levels of calf mortality to 14.3%, which is less than 19% reported by Sukumar *et al.* (1997). The mean mortality estimated for the three captive systems together based on 784 elephant-years was 3.9%, including orphans and 3.5% excluding orphans. This is higher than that (1.9% estimated from detailed age-class mortality figures) reported earlier for the captive population (based on 5,560 elephant-years, Sukumar *et al.* 1997) and for the wild population (3%, Daniel *et al.* 1987) in southern India. Even though, the present estimate of mortality is from a smaller sample size (<50 elephant-years) in age class categories such as 0-1, 1-2, 2-5 and 60-80 years, the remaining age classes where the sample size is reasonable (>50 elephant-years) also experienced mortality higher than reported earlier (Sukumar *et al.* 1997). Therefore, the present mortality rate should be a cause for concern. Diseases such as herpes and tuberculosis (Forest Department records and personal communication from Forest Department veterinarians) could also be contributing to the increased mortality besides higher susceptibility of the aging population.

The Asian Elephant in spite of its long history of captivity has not been bred sustainably in captivity (Kurt and Mar 2003). There are hardly any records of captive elephant births or breeding in Indian temples (Krishnamurthy 1998) – temples consider reproduction in the temple premises to be inauspicious. Private owners do not encourage breeding as maintenance of pregnant/ lactating cows is expensive (Krishnamurthy 1998). However, there are a number of cases of privately owned elephants breeding in captivity in the north-eastern states of Assam and Arunachal Pradesh (Bist *et al.* 2002; Sarma 2004), since they are managed in close quarters to forested areas, wherein cows have contact with wild bulls. However, there has been a declining interest among these owners to manage elephants due to loss of demand in forestry operations owing to the ban on logging (Bist *et al.* 2002). Thus, the future scope of captive breeding among private systems in the north-eastern states could virtually stop. The intensively managed captive populations of Asian elephants in the western zoos (Wiese 2000; Brown *et al.* 2006) and the extensively managed large population in Myanmar (Leimgruber *et al.* 2008) are also in a reproductive decline. Thus, it is only the extensively managed captive elephant

populations of forest department in the timber camps of India and the Pinnewala Elephant Orphanage in Sri Lanka, where the captive elephant populations breed at a sustainable level (Sukumar *et al.* 1997; Kurt and Mar 2003), that remain the last hope against the extinction of the species in captivity.

To ameliorate the negative trends in population structure and sex ratio and to retain the long history of forest department timber camp elephants, inputs from the wild, especially females of young adult and subadult classes, should be given priority. Capturing and transferring of problem elephants, especially herds ranging in isolated habitats with no sign of breeding and or long-term survival, to forest department timber camps could be considered as a solution for restructuring the captive population, which will also reduce human-elephant conflict in the natural habitats. The captive populations in the private and temple systems may not survive in the long run given that the (i) aged population structures and susceptibility to higher mortality, (ii) absence of breeding, and (iii) lesser chances of additions from the state forest department due to the ban on the sale of elephants. To improve this situation, the private and temple systems need to consider common elephant housing that would bring in opportunities for captive breeding apart from socialization with conspecifics.

ACKNOWLEDGEMENTS

We thank the Tamil Nadu Forest Department, Hindu Religious and Charitable Endowment Board, Government of Tamil Nadu and private elephant owners of Tamil Nadu for permitting this study. We acknowledge the critical comments and inputs by Leimgruber P., Conservation Ecology Centre, National Zoological Park, Smithsonian Institution, Washington, DC, USA, and Dharmarajan, G., Purdue University, Indiana, USA, that shaped this manuscript significantly.

REFERENCES

Agresti, A. (1996): An Introduction to Categorical Data Analysis. Wiley-Interscience, New York.

Bist, S.S., J.V. Cheeran, S. Choudhury, P. Barua & M.K. Misra (2002): The domesticated Asian elephants in India. Pp.129-148. *In*: Giant in our hands. Proc. International workshop on the domesticated Asian elephants, Bangkok, Thailand, February 2001.

Brown, J.L., E. Freeman & C. Duce (2006): Update on the reproductive status of female Asian and African elephants in the SSP population of North America. Pp. 48-57. *In*: Proc. of International Elephant Conservation and Research Symposium. Copenhagen, Denmark October 2006.

Carrington, R. (1959): Elephants: A short account of their natural history, evolution and influence on mankind. Basic Books, Inc., New York.

Caughley, G. (1977): Analysis of vertebrate populations. John Wiley & Sons, London.

Corfield, T.F. (1973): Elephant mortality in the Tsavo National Park, Kenya. *J. East Afri. Wildl. 11*: 339-368.

Daniel, J.C., A.A. Desai, N. Sivaganesan & S. Rameskumar (1987): The study of some endangered species of Wildlife and their habitats. Technical Report, Bombay Natural History Society, Bombay, India.

Gokula, V. (1993): A comparative study on the status and management of temple elephants with Forest camp and Zoo elephants. M. Phil. thesis, A.V.C. College, Mayiladuthurai, India.

Hedges, S. (2006): Asian elephants in captivity: Status needs and values; in Elephant Range States Meeting. January 24-26, 2006, Kuala Lumpur, Malaysia, IUCN/SSC Report.

IUCN Red List (2008): The IUCN Red List of Threatened Species. http://www.iucnredlist.org/details/7140: Date of Access October 16, 2008.

Krishnamurthy, V. (1995): Reproductive pattern in captive elephants in the Tamil Nadu Forest Department: India. Pp. 450-455. *In*: Daniel, J.C. & H.S. Datye (Eds): A Week with Elephants. Proc. International Seminar. BNHS and Oxford University Press, Bombay, India.

Krishnamurthy, V. (1998): Captive elephant management in India under different systems: Present trends. *Zoo's Print 13(3)*: 1-4.

Krishnamurthy, V. & C. Wemmer (1995): Timber elephant management in Madras Presidency of India (1844-1947). Pp. 456-472. *In*: Daniel J.C. & H.S. Datye (Eds): A Week with Elephants. Proc. International Seminar. BNHS and Oxford University Press, Bombay, India.

Kurt, F. & K. Mar (2003): Guidelines for the management of captive Asian elephants and the possible role of the IUCN/SSC Asian Elephant Specialist Group. *Gajah 22*: 30-42.

Lair, R.C. (1997): Gone Astray — The care and management of the Asian elephant in domesticity. Food and Agriculture Organization (FAO), Regional Office for Asia and the Pacific (RAP), Thailand: RAP Publication.

Laws, R.M. (1981): Experiences in the study of large mammals. Pp. 1-18. *In*: Fowler, C.W. & T.D. Smith (Eds): Dynamics of large mammal populations. Wiley & Sons, New York.

Laws, R.M. & I.S.C. Parker (1968): Recent studies on Elephant populations in East Africa. Symposium of the Zoological Society of London *21*: 319-359.

Leimgruber, P., B. Senior, Uga, Myint Aung, M.A. Songer, T. Mulle, C. Wemmer & J.D. Ballou (2008): Modeling population viability of captive elephants in Myanmar (Burma): implications for wild population. *Anim. Conserv. 11(3)*: 198-205.

Lindeque, M. (1991): Age structure of the elephant population in the Etosha National Park, Namibia. *J. Madoqua. 18*: 27-32.

Mar, K.U. (2001): The studbook of timber elephants of Myanmar with special reference to survivorship analysis. Pp. 195-211. *In*: Giant in our hands. Proc. International workshop on the domesticated Asian elephants. Bangkok, Thailand, February 2001.

MoEF (2004): Project Elephant Report. Ministry of Environment and Forests, Government of India, New Delhi.

Sarma, K.K. (2004): The traditional keeping of elephants in captivity by three ethnic tribes of Assam: A uniquely subaltern culture. *In*: Jayewardene, Jayantha (Ed.): Endangered Elephants: Past, Present and Future. Biodiversity and Elephant Conservation Trust.

Stearns, S.C. (1992): The evolution of life histories. OUP, Oxford.

Sukumar, R. (2003): The living elephants: Evolutionary Ecology, Behaviour and Conservation. Oxford University Press, New York.

Sukumar, R., N.V. Joshi & V. Krishnamurthy (1988): Growth in the Asian elephants. Proc. Indian Acad. Science. *Anim. Sci. 97(6)*: 561-571.

Sukumar, R., V. Krishnamurthy, C. Wemmer & M. Rodden (1997):

Demography of Captive Asian Elephants (*Elephas maximus*) in Southern India. *Zoo. Biol. 16*: 263-272.

SUKUMAR, R. & C. SANTIAPILLAI (2006): Planning for Asian elephant conservation. *Gajah. 25*: 9-20.

VANITHA, V. (2007): Studies on the status and management of captive Asian elephants (*Elephas maximus*) at Tamil Nadu in Southern India, Ph.D. thesis, Bharathidasan University, Tiruchirapalli, India.

WIESE, R.J. (2000): Asian elephants are not self-sustaining in North America. *Zoo. Biol. 19*: 299-309.

■ ■ ■

GERMINATION RATE OF MESQUITE *PROSOPIS JULIFLORA* SEEDS PASSED THROUGH GUT OF THE INDIAN WILD ASS *EQUUS HEMIONUS KHUR* IN SALT DESERT OF INDIA

Bitapi C. Sinha[1,3], S.P. Goyal[1,4] and P.R. Krausman[2]

[1]Wildlife Institute of India, P.O. Box 18, Chandrabani, Dehradun 248 001, Uttarakhand, India.
[2]Wildlife Biology, Boone and Crockett Program in Wildlife Conservation, University of Montana, Missoula, Montana 59812, USA. Email: paul.krausman@umontana.edu
[3]Email: bcs@wii.gov.in
[4]Email: goyalsp@wii.gov.in

Understanding the importance of seeds passed through the gut of ungulates and subsequent germination has been a major focus in habitat restoration programmes. Mesquite *Prosopis juliflora* is a dominant shrub species in the habitat of the Indian Wild Ass *Equus hemionus khur* in the Salt Desert, India. Information on germination rates of mesquite in this ecosystem is important for its control. However, germination may be related to salinity, soil pH, and ruminant digestibility. We collected seeds from mesquite pods and fecal matter of Indian Wild Ass to determine rates of germination when treated with 98% H_2SO_4 for different durations, pH, and NaCl concentrations. Seeds scarified in concentrated sulphuric acid before germination for 5 to 30 minutes had a coefficient of germination (CRG) ranging from 27 to 44. There was an inverse relationship between CRG and NaCl concentrations. Higher germination of scarified seeds occurred when pH = 3 (CRG = 15-32) more than other pH values (CRG range = 0-14). Unscarified seeds had lower rates of germination (CRG < 15.6) at different pH media than scarified seeds. Seeds that passed through the gut without a pericarp had higher germination rates than seeds that passed through the gut with a pericarp or the ones that were collected from pods.

Key words: Indian Wild Ass, *Prosopis juliflora*, seed germination

INTRODUCTION

Concern about deforestation, desertification, and fuel wood shortages in the 1970s and 1980s promoted research resulting in translocation of mesquite (*Prosopis juliflora*) and other hardy tree species to new environments across the world (Mwangi and Swallow 2005). Although some exotic plant introductions were accidental, many were intentional for wildlife and habitat improvement, ornamental purposes, wood or fibre production, or other crop uses (Harrod 2001). Mesquite was introduced to meet fuel wood requirements of local people in arid and semi-arid areas, e.g., large areas around the Little Rann of Kutch (LRK) in Western India were open grasslands, where it was introduced by the ruler of Radhanpur during 1899-1900. Since 1953, regular plantations of mesquite is undertaken on the fringes of LRK to control soil salinization and for fuel wood; it has now spread throughout India (Patel 1977).

Mesquite pods are rich in protein (12-13%) and sugar, and are good forage for livestock. However, horses and cattle can develop digestive complications and even die from heavy consumption of mesquite pods (Dahl 1982). Besides livestock, the endangered Indian Wild Ass (locally: *khur*; *Equus hemionus khur*) also consumes mesquite pods during critical periods (May-June) when food reserves are scarce. The dry pericarp of mesquite contains phytotoxins that inhibits seed germination (Warrag 1994); this difficulty is bypassed by using animals as agents for seed dissemination, as in seeds of *Acacia* spp. (Lamprey 1967). The spread of mesquite in and around LRK is a major threat for the long term maintenance of the habitat of the *khur* (Goyal *et al.* 1999; Sinha and Goyal 1999). Our objectives were to determine seed germination viability of mesquite in relation to salinity, pH, and ruminant digestibility.

METHODS

We collected mesquite seeds from dried pods (n = 900) and *khur* faecal matter (n = 1,800) from the LRK and stored them at room temperature before germination trials. We separated seeds in the faecal matter into groups with and without a pericarp so that we could evaluate the effect of the digestion process in the gut on seed germination associated with the pericarp.

We scarified seeds collected from the faecal matter and the pods in 98% H_2SO_4 for 5, 10, 15, 20, 25 and 30 minutes, and then washed them thoroughly under tap water before germination. Seeds were germinated in NaCl solutions with concentrations of 0.0, 2.0, 4.0, 6.0, 8.0, and 10.0 gm litre^{-1} at pH 7.0 and pH media of 1, 3, 5, 9 and 11. We prepared pH media by adding NaOH for pH 9 and 11, and concentrated H_2SO_4 for pH 1, 3, 5. We placed 2 replicates of healthy seeds on moistened Whatman No.1 filter paper with distilled water in 8.5 cm diameter plastic petri dishes and allowed them to

germinate at room temperature (29 °C to 31 °C) for 15 days. We considered seeds to have germinated when the radicle protruded from the seed.

We calculated the rate of seed germination as coefficients of germination (CRG) described by Maguire (1962):

$$CRG = \sum_{I=1}^{n} (gn - g(n-1)/n),$$

where, gn is the accumulated germination on a given day, g(n-1) is the germination percentage on the previous day, n is the number of days incubated, and I is individual data from 1

Larger the CRG, greater the aggregate rate of germination. Statistical analysis was conducted using SPSS Version 8.0 software (SPSS Inc. 1998).

RESULTS

The propagation of mesquite is exclusively by seeds. Manual extraction of seeds is difficult and time consuming, due to the indehiscent spongy wall of the seed pod (Warrag 1994). Mesquite seeds are covered with a hard coat that inhibits germination. Seedling establishment in the arid and semi-arid regions largely depends on the climatic and edaphic conditions. The optimum time required for scarifying mesquite seeds in 98% H_2SO_4 to give maximum germination in 15 days was 15 to 30 min. Scarified seeds germinated in distilled water showed a higher rate of germination in all categories: seeds passed from the gut of the animal without pericarp (CRG = 30.00-44.43), seeds passed through gut with pericarp (CRG = 31.10-35.27), and seeds extracted from mesquite pods (CRG = 27.38-41.57) compared to seeds that were unscarified and germinated at different pH and salinity levels (Table 1). The CRG values did not differ significantly across categories (i.e., seeds passed through the guts without pericarp, seeds passed through the gut with pericarp, and from pods and treatments: seeds scarified in 98% H_2SO_4 for different times ranging from 5 to 30 min) (Table 2).

Rate of germination of scarified seeds in 98% H_2SO_4 for 20 minutes showed an inverse relationship with NaCl concentrations (Fig. 1). Two-way ANOVA indicates that the rate of seed germination did not differ significantly among seeds passed through the gut with and without a pericarp, however, values differed significantly ($P < 0.001$) across NaCl concentrations (Table 3). Seed germination tolerated NaCl concentration up to 6.0 gm litre^{-1}; the mean CRG value (34.3) did not differ significantly from the mean value (34.8) for the seeds germinated in distilled water at this concentration of NaCl.

Scarified and untreated seeds germinated more at pH 3 and 11 with no germination at pH 1, except in seeds passed through the gut without a pericarp (Table 1). Low germination was recorded at pH 5 and 9. Seeds scarified in H_2SO_4 for 5 to 30 minutes showed a coefficient CRG between 30 and 44 (Table 1), whereas the highest CRG (44) was in seeds that passed through the gut without a pericarp.

Table 1: Coefficient rate of germination (CRG) of mesquite seeds, Salt Desert, India

Treatments	CRG of mesquite seeds		
	Passed through gut		Pods
	Without pericarp	With pericarp	
Scarified in 98% H_2SO_4 Time (min)			
5	34.71	34.81	31.94
10	29.99	31.02	27.38
15	32.21	34.57	34.71
20	33.45	35.27	33.33
25	43.43	33.59	39.06
30	44.43	31.10	41.57
Scarificed seeds for 20 minutes germinated in different pH solutions			
1	2.13	0.00	0.00
3	15.82	32.32	31.49
5	3.62	14.17	4.63
9	6.60	6.71	4.02
11	30.54	32.90	32.40
Untreated seed germinated at different pH solutions			
1	0.00	0.00	0.00
3	13.48	7.83	6.63
5	0.47	0.00	0.41
9	0.41	2.60	0.95
11	15.57	0.95	4.88

Table 2: Two way ANOVA of coefficient rate of germination of mesquite seeds from the Salt Desert, India, between treatment with sulphuric acid for different time periods and categories

Source of variation	SS	Df	MS	F	P-value
Between seed treatments[1]	192.22	5	38.44	2.76	0.08
Between seed categories[2]	26.76	2	13.38	0.96	0.41
Error	138.99	10	13.89	-	-
Total	357.98	17	-	-	-

[1]Seeds scarified in 98% concentration of sulphuric acid for 5, 10, 15, 20, 25 and 30 minutes.
[2]Seeds passed through the guts with pericarp and without pericarp and from pods.

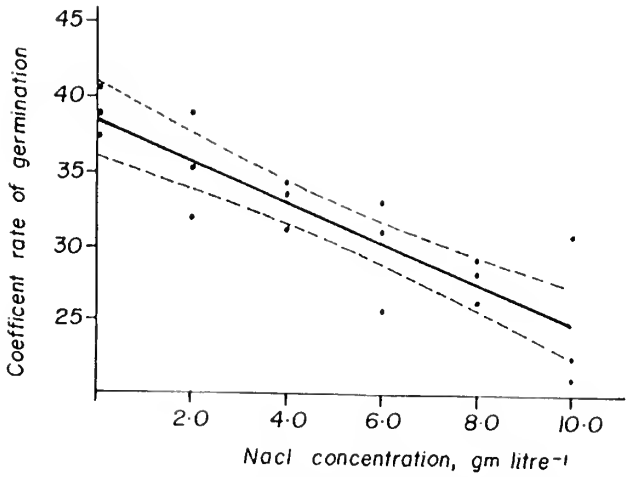


Fig. 1: Coefficient rate of germination of mesquite seeds in relation to NaCl concentrations, in Salt Desert, India. (-) Linear regression; (....) 95% confidence interval

Table 3: Two way ANOVA for coefficient rate of germination between mesquite seed types and NaCl concentrations, Salt Desert, India

Source of variation	SS	Df	MS	F	P-value
Between seed treatments[1]	396.58	5	79.31	9.68	0.001
Between seed categories[2]	44.38	2	22.19	2.71	0.11
Error	81.864	10	8.18	-	-
Total	522.824	17	-	-	-

[1]Different NaCl concentrations.
[2]Seeds passed through the guts with pericarp and without pericarp and from pods.

DISCUSSION

Seeds with hard coats that were scarified in 98% H_2SO_4 germinated more than the unscarified seeds in other studies (Everitt 1983; Kissock and Hafferkamp 1983). Seed germination was significantly reduced by NaCl in Blackbrush *Acacia angustifolia*, Guajillo *A. berlandieri*, Guaycan *Porlieria angustifolia* (Everitt 1983), and in Kadad *Dichrostachys cinerea* (Hashim 1990). Seeds of Kadad germinated between pH 3 and 11, but no germination was recorded for seeds at pH 1 and 13 (Hashim 1990). There was also significant reduction in seed germination at pH 2 and pH 12 in blackbrush, guajillo, and guaycan (Everitt 1983). Mesquite seeds can tolerate salinity up to 6.0gm/litre.

Pods of various mesquite species are consumed by domestic and wild herbivores. In the Rajasthan desert, India, the pods of mesquite *P. cineraria* are consumed by the Indian Gazelle *Gazella gazella* and Indian Antelope *Antilope cervicapra* (Goyal *et al.* 1988). Untreated seeds with and without a pericarp collected from the faeces of *khur* indicated higher CRG (7.8-15.6) at pH 3 and 11 than seeds collected from pods (4.9-6.6) as the seed coat is softened by the intestinal chemicals in the gut of the animal. Lamprey (1967) reported an increase in germination of Acacia *Acacia tortillas* seeds that passed through wild ungulates. Janzen (1981) reported that digestive fluids of large mammals in general are not adequate to scarify the seeds though there is an increase in seed germination rate over unscarified seeds. Contrary to this, reduction in germination has been observed in seeds of kadad and honey mesquite *Prosopis* spp. passed through goat gut (Hashim 1990), and Coyote *Canis latrans* digestive systems (Meinzer *et al.* 1975).

The dry pericarp of mesquite seeds contain water soluble phytotoxin that could inhibit seed germination (Warrag 1994). This might be an extension of the vivipary – avoidance process and a safeguard against potential intraspecific competition (Warrag 1994). As a result, seeds dispersed by animals in faecal matter are likely to germinate. The LRK has varying degrees of soil salinity and pH (Sinha and Goyal 1999) and CRG of scarified seeds decreases with the increase in NaCl concentrations. This increased germination rate of mesquite seeds would dominate the landscape and lead to a decrease in the overall availability of grasslands. A reduction in grasslands due to exotic mesquite would have long term conservation consequences for faunal communities in the ecosystem. Additional studies would help the management of protected areas for *khur* by developing nursery techniques for the successful establishment of mesquite grown in the saline desert outside the sanctuary for meeting the fuel wood requirements of local people.

ACKNOWLEDGEMENTS

We are grateful to the Director and Dean of the Wildlife Institute of India (WII) for his continuous encouragement and the Gujarat Forest Department for their kind support during this study. The study was funded by WII.

REFERENCES

Dahl, B.E. (1982): Mesquite as a rangeland plant. *In*: Proceedings of the symposium. Pub. College of Agricultural Sciences, Texas Tech University, Lubbock, Texas, USA.

Everitt, J.H. (1983): Seed germination characteristics of three woody plant species from the south Texas. *Journal of Range Management 36*: 411-414.

Goyal, S.P., H.C. Bohra, P.K. Ghosh & I. Prakash (1988): Role of *Prosopis cineraria* in the diet of two Indian desert antelopes. *Journal of Arid Environments 14*: 285-290.

Goyal, S.P., B. Sinha, N. Shah & H.S. Panwar (1999): Sardar Sarovar

Project-A Conservation Threat to the Indian wild ass *Equus hemionus khur*. *Biological Conservation 88*: 277-284.

HARROD, R.J. (2001): The effect of invasive and noxious plants on land management in eastern Oregon and Washington. *Northwest Science 75*: 85-90.

HASHIM, I.M. (1990): Germination of Kadad (*Dichrostachys cinerea*) seed following pod digestion by goats and various chemical treatments. *Forest Ecology and Management 38*:105-110.

JANZEN, D.H. (1981): Differential seed survival and passage rate in cows, horses, surrogate pliestocene dispersal agents. *Oikos 38*: 150-156.

KISSOCK, D.C. & M.R. HAFFERKAMP (1983): Presowing seed treatment and temperature effect on germination of *Engelmannia pinnatifida* and *Indigofera miniata* var *leptosepala*. *Journal of Range Management 36*: 94-96.

LAMPREY, H.F. (1967): Notes on the dispersal and germination of some tree seeds through the agency of mammals and birds. *East African Wildlife Journal 12*: 81-85.

MAGUIRE, J.D. (1962): Speed of germination – aid in selection and evaluation of seedling emergence and vigor. *Crop Science 2*: 126-129.

MEINZER, W.P., D.N. UCKERT & J.T. FLINDERS (1975): Food niche of coyotes in the rolling plains of Texas. *Journal of Range Management 28*: 35-38.

MWANGI, E. & B. SWALLOW (2005): Invasion of *Prosopis juliflora* and local livelihoods: Case study from the lake Baringo area of Kenya. ICRAF Working paper - no. 3. Nairobi: World Agroforestry Centre.

PATEL, G.D. (1977): Gujarat State Gazetteers: Surendranagar district. Govt. Publication Dept. Ahmedabad, India.

SINHA, B. & S.P. GOYAL (1999): An exotic mesquite (*Prosopis juliflora*) a threat for conserving habitat of endangered flagship species (Indian Wild Ass *Equus hemionus khur*) of salt desert ecosystem in western India. VI International Rangeland Congress, Townsveille, Australia.

SPSS INC. (1998): SPSS Base 8.0 for Windows User's Guide. SPSS Inc., Chicago, IL., USA.

WARRAG, M.O.A. (1994): Autotoxicity of mesquite *Prosopis juliflora* pericarps on seed germination and seedling growth. *Journal of Arid Environments 27*: 79-84.

■ ■ ■

LIFE HISTORY OF *ATTACUS ATLAS* L. (LEPIDOPTERA: SATURNIIDAE) ON *LITSEA MONOPETALA* JUSS. IN NORTH-EAST INDIA

B.N. Sarkar[1,3], B.C. Chutia[2], J. Ghose[1,4] and A. Barah[1,5]

[1]Central Muga Eri Research & Training Institute, Central Silk Board, Lahdoigarh 785 700, Jorhat, Assam, India.
[2]Department of Zoology, Nowgong College, Nagaon 782 001, Assam, India. Email: bhuban08@yahoo.co.in; bhuban78@gmail.com
[3]Email: bnsarkarcsb@yahoo.com
[4]Email: jghosecsb@yahoo.co.in
[5]Email: anukul_barah@rediffmail.com

Attacus atlas L., the source of 'Fagara Silk', is a wild silk moth of north-east India. The detailed life history, bionomics and rearing performance of *A. atlas* in relation to a newly reported food plant *Litsaea monopetala* Juss, which is the major food plant of Muga silkworm *Antheraea assamensis* Helfer, has been described in the present study. Life cycle of *Attacus atlas* silkworm has five larval instars. Each larval instar exhibits distinguishing colour variation and tubercular arrangement. The first instar larva measured 1.12 ±0.28 cm, 0.19 ±0.07 cm and 0.017 ±0.02 gm in length, breadth, and weight, respectively, while the fifth instar larva measured 12.06 ±0.82 cm, 2.08 ±0.11 cm and 37.08 ±1.22 gm in length, breadth and weight. Wing span of 19.1-25.5 cm in male, and 20.9-27.4 cm in female moths was recorded. The embryonic period and total larval duration were 10.8 ±0.82 days and 41 ±2.94 days, respectively, while pupal period of 20.4 ±1.14 days in male, and 21.6 ±1.14 days in female was recorded. The cocoon weight, shell weight and shell ratio were measured as 12.98 ±0.89 gm, 1.698 ±0.10 gm and 13.06% in male and 15.65 ±0.66 gm, 1.790 ±0.08 gm and 11.45% in female. Silk filament of *Attacus* cocoon is not reelable, but can be spun. The percentage of degumming loss, yarn yield and spinning waste were recorded to be 15.72, 30.41 and 53.87% respectively.

Key words: *Attacus atlas*, *Litsea monopetala*, life history

INTRODUCTION

Attacus atlas L. is a wild silk moth of north-east India and popularly known as 'Atlas moth' or 'Deo-muga' or 'Kotkari muga' in Assamese. It is widely distributed in South Eastern Asia, and abundantly found in India and the Indian Ocean Archipelago (Lampe 1984; Peigler 1989). The genus *Attacus* comprises of 15 known species (Peigler 1989) all over the world. Out of these, only one species, namely *Attacus atlas* is known to occur in India (Arora and Gupta 1979); the silk produced by *A. atlas* is called 'Fagara silk'. It is the largest silkmoth in the world. Fairly good numbers of records are available about the host plant diversity and distribution of *A. atlas* (Jolly *et al.* 1979; Chowdhury 1981; Lampe 1984; Peigler 1989; Thangavelu 1991; Bhattacharya *et al.* 2004; Singh and Suryanarayan 2005; Singh and Chakravorty 2006; Sahu and Bindroo 2007). The larvae of *Attacus* are highly polyphagous, feeding on a wide range of food plants. Arora and Gupta (1979) reported about 19 species of food plants from India alone. Chutia *et al.* (2009) recently reported three more species of host plants of *Attacus* from Nagaland, India. Saikia and Handique (2000) reported *Meyna laxiflora* (Kutkura) as the most preferred host plant of the *Attacus* silkworm and carried out detailed study on the biology and its commercial characteristics. *Attacus atlas* was hitherto not recorded feeding on *Litsea monopetala* Juss (locally known as *Soalu*); therefore its life history and rearing performance on this food plant is not known. Hence, a detailed study was conducted on the life history of *A. atlas* on *L. monopetala* Juss at Central Muga Eri Research & Training Institute, Central Silk Board, Lahdoigarh, Assam, to evaluate the commercial aspects of this lesser known silk moth.

MATERIAL AND METHODS

Initially, two late instar larvae of *Attacus atlas* were collected from *Litsea monopetala* in its natural habitat. The collected larvae were maintained on the food plant until pupation at Central Muga Eri Research & Training Institute. After pupation the cocoons were brought to the grainage house for seed production. After 22 days, the pupae metamorphosed into female moths. In absence of a male, a female moth was tied in the open at night for natural coupling with wild males successfully. The gravid female laid eggs up to 4 days. The eggs were incubated at room temperature. After 10 days of incubation period, the newly hatched larvae were released on the selected bushes of *L. monopetala*. Rearing was conducted under strict vigilance inside nylon net cover till the larvae matured. On maturity, the larvae were put in dry leaf for cocoon-making. 26 cocoons were harvested after 7-8 days of spinning. Of which, 16 cocoons were assigned for seed production and 10 cocoons were used for preliminary spinning trial. The cocoons were boiled in one litre of 10% sodium carbonate solution for 30 minutes for degumming.

The degummed cocoons were washed thoroughly in plain water to remove traces of alkali and then squeezed and dried to form a lump. Spinning was done in a CSTRI motorized spinning machine. The entire process was conducted during May-July 2008, and the data pertaining to morphometric parameters, cocoon and yarn characteristics, physiological and production parameters were recorded simultaneously. In the immediate next generation, from August-October 2008, the above data was recorded again to confirm.

All data were recorded and five replications were conducted for each treatment. The mean values and standard deviations were calculated from computed values.

RESULTS AND DISCUSSION

Morphometric parameters

Egg: The eggs are oval, slightly flattened dorso-ventrally, pinkish grey with a brownish strip and polygonal punctuations. The eggs measure 0.26 ±0.009 cm and 0.24 ±0.007 cm in length and breadth, respectively, and weigh 0.0078 gm. The embryonic period is 10.8 ±0.84 days.

1st Instar: Head is smooth and black. Body is pinkish grey with brownish stripes. Black irregular markings can be seen on the inter-segmental region. Tubercles are whitish with black setae. The larvae measure 1.12 ±0.28 cm and 0.19 ±0.07 cm in length and breadth, respectively, and weigh 0.017 ±0.02 gm. The first instar larval duration is 4.8 ±0.84 days.

2nd Instar: The larva is dull white with black irregular markings and whitish tubercles. Deep orange elongated markings appear on anterior and posterior lateral region of the body. Prothoracic hood is soft, transparent and whitish in colour. The larvae measure 1.96 ±0.40 cm and 0.72 ±0.29 cm in length and breadth, respectively, and weigh 0.323 ±0.10 gm. This stage lasts for 4.6 ±0.55 days.

3rd Instar: The body is icy white to greenish with or without white fleshy tubercles. The length, breadth and weight of the larvae are 3.82 ±1.14 cm, 1.2 ±0.22 cm and 3.612 ±0.98 gm, respectively. The instar duration is 6.6 ±0.55 days.

4th Instar: The larva is greenish, and the whole body is covered with lime-like powder. The length, breadth and weight of the larvae are 6.38 ±0.69 cm, 1.8 ±0.28 cm and 1.8 ±0.28 gm, respectively. This instar lasts for 10.4 ±0.55 days.

5th Instar: The larval body is greenish, but covered with a lime-like sticky powder. The dorsal tubercles are whitish, whereas lateral tubercles are blue with black tips. The thoracic legs are conical and carry sharp distal claws. Each abdominal segment from 6th to 9th bears a pair of abdominal legs, which are fleshy and flat at the end. Terminal end looks like a disc with a series of inwardly curved hooks arranged in a semi-circle. While dorsal tubercles project backward, the lateral tubercles project forward. Hampson (1892) first reported the characteristic tubercular arrangement in *Attacus atlas* L. The larva is about 12.06 ±0.82 cm, 2.08 ±0.11 cm, 37.08 ±1.22 gm in length, breadth and weight, and instar duration is 14.2 ±0.84 days.

Pupa: The pupa is dark brown in colour. It is 3.44 ±0.48 cm in length, 1.96 ±0.28 cm in breadth and 11.29 ±0.79 gm in weight in case of male, while it is 5.12 ±0.31 cm, 2.56 ±0.15 cm, 13.86 ±0.65 gm in length, breadth and weight in female.

Moth: The ground colour of the moth is red orange to tomato red. The basal area of the forewing has brown edges with red and pale black lines and middle area is red brown. A large transparent hyaline spot is present at the end of the cell with black edge. Apical area has yellow to pink shade. A yellow brown marginal band with a highly wavy black line is present in both the fore and hind wings. The wing span of the male and female moths is 19.1-25.5 cm and 20.9-27.4 cm, respectively.

The forewing and hind wing length of a male is about 9.5-11.9 cm and 7.6-8.1 cm, respectively. The hyaline area of forewing and hind wing is about 119 to 144 sq. mm and 135 to 176 sq. mm, respectively. The orange brown antenna is about 2.1 to 2.2 cm in length and 0.9 to 1.1 cm in breadth.

The forewing and hind wing length of a female is about 10.5-13.5 cm and 9.8-10.3 cm, respectively. Forewing and hind wing hyaline area is about 375-493 sq. mm and 368-475 sq. mm, respectively. The orange brown antenna is 1.9-2.0 cm in length and 0.3-0.4 cm in breadth.

Cocoon and yarn characteristics

Cocoon: Cocoon characters like shell weight, shell ratio, and yarn characteristics like yarn colour, degumming loss and yarn yield percentage are of commercial importance as they reflect on silk quality. *Attacus atlas* cocoons are coarse and deep grey in colour with a prominent peduncle. The length, breadth and weight of cocoons are 8.2 ±1.02 cm, 2.8 ±0.22 cm and 12.98 ±0.89 gm in males, and 9.24 ±1.18 cm, 3.46 ±0.32 cm and 15.65 ±0.66 gm in females, respectively. The shell weight and shell ratio of cocoons are 1.698 ±0.10 gm and 13.06 ±0.53% in male, and 1.790 ±0.08 gm and 11.45 ±0.65% in female.

Silk yarn: 'Fagara silk' produced by *A. atlas* is grayish in colour. Degumming loss of *Attacus* cocoons is recorded to be 15.72% in sodium carbonate degumming (5 gm/l). From 100 gm of cocoon shell, 30.41 gm of hand spun yarn and 53.87 gm spinning waste were produced in the trial study. Preliminary studies register 30.41% spun silk recovery of

coarser count. Although yarn yield or, silk recovery percentage in *Attacus atlas* cocoons is less, there is possibility to enhance yarn yield by adopting improved softening device(s) to make it more economic and useful.

Physiological parameters

Metamorphosis: *A. atlas* is holometabolous in nature. It undergoes complete metamorphosis and passes through four stages, namely egg, larva, pupa (cocoon) and adult (moth) during its life cycle.

Moultinism: The larva moults five times. When moulting, anterior part of the body remains suspended, prothoracic hood becomes stretched and protruding head is bent ventrally inward.

Voltinism: *A. atlas* is bi-voltine in habit in the climatic condition of north-eastern region of India. It completes two life cycles, one during May-June and other during August-September.

Diapause period: *A. atlas* is in pupal diapause from November to April during extreme cold weather.

Production parameters

Oviposition: Average oviposition per female in *Attacus atlas* silkworm was recorded to be 197.6 ±9.79.

ERR: Effective Rate of Rearing (EER) of *Attacus atlas*, i.e., the survival rate, was calculated to be 42.2 ±6.30%, which was calculated as number of cocoons harvested/ number of worms reared x 100.

Cocoon yield: 26.4 ±3.85 number of cocoons were harvested from one batch, i.e., eggs laid by a single female moth.

REFERENCES

Arora, G.S. & I.J. Gupta (1979): Taxonomic studies of some of the Indian non-mulberry silk moths (Lepidoptera: Saturniidae). *Memoirs Zoological Survey, India 16*: 1-63.

Bhattacharya, A., B.K. Singh & P.K. Das (2004): Biodiversity of wild silk moths in Assam (North-East India). *Annals of Forestry 12(2)*: 208-216.

Chowdhury, S.N. (1981): Muga Silk Industry *In*: Muga Silk Industry. Directorate of Sericulture (Ed.), Govt. of Assam, Guwahati, Assam. Pp. 1-177.

Chutia, B.C., L.N. Kakati & K.C. Singh (2009): Biodiversity of wild silk moths in Nagaland. *J. Bombay Nat. Hist. Soc. 106(1)*: 112-117.

Jolly, M.S., S.K. Sen, T.N. Sonwalkar & G.K. Prashad (1979): Non-Mulberry Sericulture. *In*: Manual of Sericulture. Published by Food and Agriculture Organization of United Nation and reprint by Central Silk Board (1987) Rome, FAO. *4(29)*: 1-119.

Lampe, R.E.J. (1984): Die Saturniiden der Cameron-und Genting-Highlands in West Malaysia (Lepidoptera: Saturniidae). *Neue Entomologische Nachrichten 11*: 16. 8 col. pls.

Peigler, R.S. (1989): A revision of the Indo-Australian genus *Attacus*. Lepidoptera Research Foundation, Inc. Beverly Hills, California, U.S.A. Pp. 1-169.

Sahu, A.K. & B.B. Bindroo (2007): Wild silk moth Biodiversity in the North-Eastern Region of India: Need for Conservation. *Indian Silk* (June): 16-19.

Saikia, B. & R. Handique (2000): Biology of a wild silk moth, *Attacus atlas* L. *International Journal of Wild Silk Moths and Silk 5*: 345-347.

Singh, K.C. & R. Chakravorty (2006): Seri-biodiversity of North-Eastern India – an update. Pp. 8-19. *In*: Handique, J.P. & M.C. Kalita (Eds): Biodiversity Conservation and Future Concern. Gauhati University, Guwahati.

Singh, K.C. & N. Suryanarayana (2005): Wild silk moth wealth of India. Pp. 419-421. *In*: Dandin, S.B., R.K. Misra, V.P. Gupta & Y.S. Reddy (Eds): Advances in Tropical Sericulture. Central Sericultural Research & Training Institute, Mysore.

Thangavelu, K. (1991): Wild sericigenous insect of India – a need for conservation. *J. Wild Silk moths 91*: 71-77.

■ ■ ■

NEW DESCRIPTIONS

RECORD OF THE GENUS *SCHIZOPRYMNUS* FOERSTER (HYMENOPTERA: BRACONIDAE) FROM INDIA, WITH DESCRIPTIONS OF TWO NEW SPECIES

ZUBAIR AHMAD[1,2] AND ZAHEER AHMED[1]

[1]Section of Entomology, Department of Zoology, Aligarh Muslim University, Aligarh 202 002, Uttar Pradesh, India.
[2]Email: dzubair@gmail.com

The genus *Schizoprymnus* Foerster of the subfamily Brachistinae (Hymenoptera: Braconidae) is recorded for the first time from India. Two new species, namely *Schizoprymnus indicus* sp. nov. and *Schizoprymnus transiens* sp. nov., are described and illustrated. The diagnostic characters of these two species have been provided.

Key words: Hymenoptera, Braconidae, Brachistinae, *Schizoprymnus*, new record, new species, India

INTRODUCTION

The genus *Schizoprymnus* Foerster belongs to the subfamily Brachistinae. It is mainly characterized by presence of anterior three metasomal tergites immovably fused to form a metasomal carapace and absence of two transverse sutures on the carapace. However, some species of *Schizoprymnus* have the carapace with the first suture almost entirely and the second one at least laterally developed (Papp 1984, 1991, 1993; Belokobylskij 1994, 1998). The members of this genus are endoparasitoids of larval Coleoptera (Shaw and Huddleston 1991).

The Indo-Australian species of *Schizoprymnus* were revised by Papp (1984, 1991, 1993). Currently, it is represented by 35 species from the Indo-Australian region (Papp 1993). In the present work, the genus is recorded for the first time from India and two species are described as new. Sharkey and Wharton (1997) have been followed for terminologies

The following abbreviations are used in the text: OOL – ocello-ocular line (distance from the outer edge of a lateral ocellus to the compound eye); POL – post-ocellar line (distance between the inner edges of the two lateral ocelli); AOL – anterior-ocellar line (distance between the inner edges of anterior and lateral ocellus); OD – diameter of an ocellus; ZDAMU- Zoology Department, Aligarh Muslim University.

Schizoprymnus indicus sp. nov.

(Figs 1-4)

Female: Body length, 1.9 mm; forewing length, 1.5 mm.

Head: Dorsally 1.7x as wide as long; OOL:POL:AOL:OD = 4:5:10:2; eyes in dorsal view 2x as long as temple; temple punctuate, rounded behind eyes; face punctuate 2.8x as wide as high medially; malar space about 2.5x basal width of mandible; antennae 23 segmented, shorter than the body length.

Mesosoma: Length of mesosoma 1.4x its height; mesoscutum smooth; notauli deep and crenulate, posteriorly merging with a few large foveae; scutellum smooth and polished; mesopleuron smooth medially, punctuate to foveolate posteriorly; propodeum reticulate rugose; fore wing 1.15x as long as body length; pterostigma 2.6x as long as wide, issuing vein r slightly distally from its middle; radial cell rather short, proximal section of metacarp 0.3x as long as pterostigma; distal section of metacarp as long as proximal section; length of hind femur 3.5x as long as broad, hind tibia about as long as tarsi; tibial spur about 0.3x as long as basitarsus.

Metasoma: Carapace reticulate rugose, 1.8x as long as wide in dorsal view; suture between first and second tergites distinct while absent between second and third tergites; apical rim of carapace semicircularly excised with a pair of denticles; ovipositor sheaths in lateral view distinctly shorter than carapace.

Colour: Black; mandible, tegulae, legs light yellowish brown; antennae, ovipositor sheaths and wing venation blackish brown.

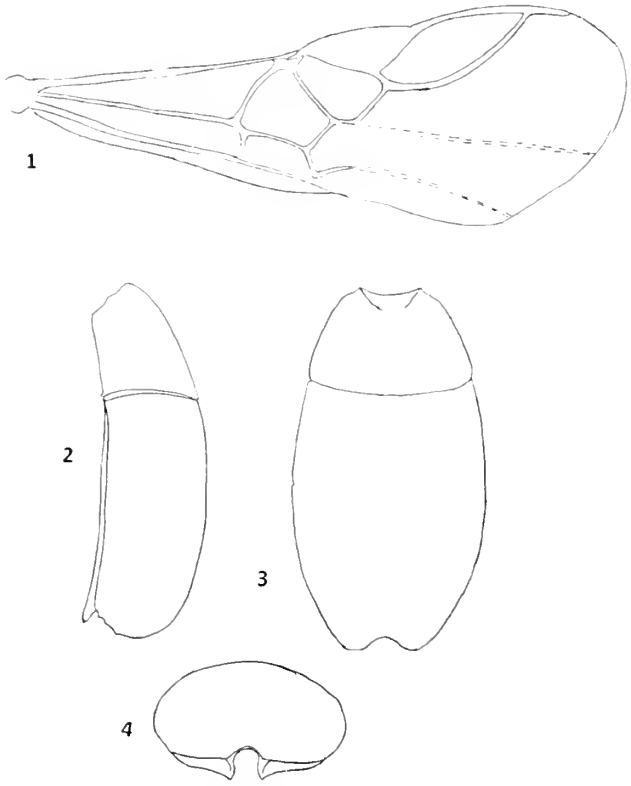
Male: Similar to female, except body size and genital organs.

Holotype: ♀, INDIA: Jammu and Kashmir, Rajouri, 1.iv.2000, Coll. Zaheer Ahmed (ZDAMU); **Paratypes**: 1♀, 1♂, data same as holotype (ZDAMU)

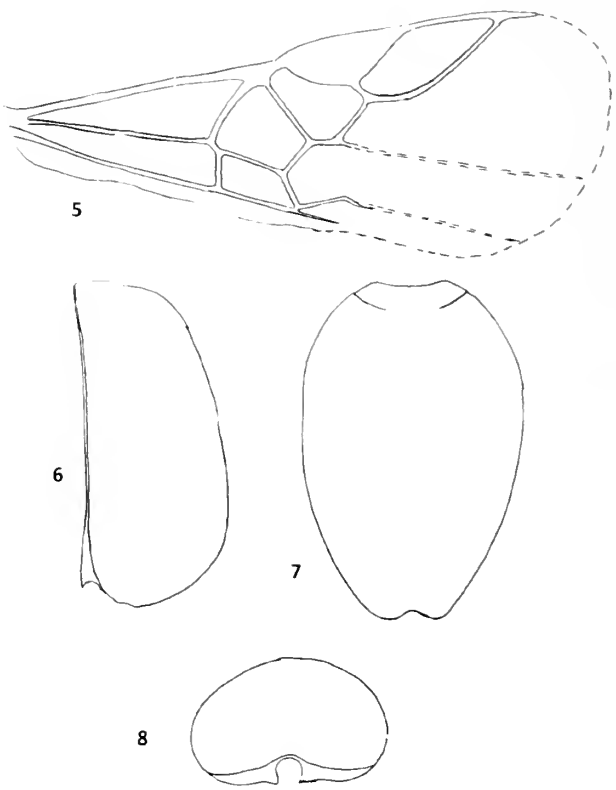
Host: Unknown.

Distribution: INDIA: Jammu and Kashmir.

Remarks: *Schizoprymnus indicus* sp. nov. closely resembles *Schizoprymnus tortilis* Papp, but differs in having: antennae 23 segmented (antennae 17-19 segmented in *tortilis*); carapace 1.8x as long as wide (carapace about as long as wide



Figs 1-4: *Schizoprymnus indicus* sp. nov.
1. Forewing; 2. Metasoma, lateral view;
3. Metasoma, dorsal view; 4. Metasoma, view from behind



Figs 5-8: *Schizoprymnus transiens* sp. nov.
5. Forewing; 6. Metasoma, lateral view; 7. Metasoma, dorsal view
8. Metasoma, view from behind

in *tortilis*), distal section of metacarp 0.3x as long as proximal section (distal section of metacarp 0.5x as long as proximal section in *tortilis*).

Etymology: The new species is named after its type locality.

Schizoprymnus transiens sp. nov.

(Figs 5-8)

Female: Body length, 2.1 mm; forewing length, 1.6 mm.

Head: Transverse, 2.0x as wide as long dorsally; OOL:POL:AOL:OD = 5:8:9:3; eyes in dorsal view about as long as temple; temple rounded behind eyes; vertex smooth except few indistinct punctures; face finely punctuate, 3.2x as wide as high medially; clypeus finely punctuate, 2.1x as wide as high; malar space about 1.2x basal width of mandible; antennae broken beyond 21 segments.

Mesosoma: Stout, 1.6x as long as high laterally; middle lobe of mesoscutum indistinctly punctuate, lateral lobe smooth; notauli deep and crenulate, posteriorly merging with few large foveae; scutellum smooth medially punctuate to foveolate elsewhere; propodeum reticulate rugose, notched antero-medially; forewing 0.8x as long as body length; pterostigma 2.3x as long as wide, issuing vein r from its middle; radial cell rather short, proximal section of metacarp as long as pterostigma; distal section of metacarp 0.3x as long as proximal section; length of hind femur 3.5x as long as broad; hind tibia 1.1x as long as tarsi; hind tibial spur about 0.28x as long as basitarsus.

Metasoma: Carapace longitudinally rugose, 1.4x as long as wide in dorsal view; suture between first second and third tergites distinct only laterally; apical rim of carapace semicircularly excised with a pair of dentacles; ovipositor sheaths in lateral view distinctly shorter than carapace.

Colour: Black; mandible, tegulae, legs clypeus antennae up to fifth segments honey yellow; antennae beyond fifth segments, ovipositor sheaths and wing venation blackish brown.

Male: Unknown.

Holotype: ♀, INDIA: Uttar Pradesh, Bulandshahr, 1.iv.2000, Coll. Zubair Ahmad (ZDAMU). **Paratype**: 1♀, same data as holotype (ZDAMU).

Host: Unknown.

Distribution: INDIA: Uttar Pradesh.

Remarks: *Schizoprymnus transiens* sp. nov. also resembles *Schizoprymnus tortilis* Papp, but differs in having: mesosoma stout (mesosoma moderate in *tortilis*); carapace

1.4x as long as wide (carapace about as long as wide in *tortilis*), ovipositor sheaths in lateral view distinctly shorter than carapace (ovipositor sheaths in lateral view as long as carapace in *tortilis*); ocelli large (ocelli small in *tortilis*).

Etymology: The new species is named after its intermediate form between *S. indicus* sp. nov. and *S. tortilis* Papp.

ACKNOWLEDGEMENTS

We thank Dr. M. Hayat and Dr. Shujauddin for reviewing the manuscript and offering useful suggestions. The authors are also thankful to the Chairman, Department of Zoology for laboratory facilities.

REFERENCES

Belokobylskij, S.A. (1994): To the knowledge of the braconid fauna of the Russian Far East (Hymenoptera, Braconidae): new species of the subfamily Brachistinae. *Russian Entomol. J. 3*: 81-108.

Belokobylskij, S.A. (1998): Subfam. Brachistinae (Calyptinae). Pp. 440-489. *In*: Lehr, P.A. (Ed.): Opredelitel' nasekomykh Dal'nego Vostoka Rossii. Setchatokryloobraznye, skorpionnitzy, pereponchatokrylye [Keys to Insects of the Russian Far East. Neuropteroidea, Mecoptera, Hymenoptera]. Vol. 4, Dal'nauka, Vladivostok. (In Russian.).

Papp, J. (1984): First survey of the Triaspidini species of the Indo-Australian region (Hymenoptera: Braconidae: Calyptinae) I. The genus *Triaspis* Haliday. *Acta Zool. Hung. 30(1-2)*: 137-158.

Papp, J. (1991): First survey of the Triaspidini species of the Indo-Australian Region (Hymenoptera, Braconidae, Calyptinae). II. The genus *Schizoprymnus* Foerster. I. *Acta Zool. Hung. 37*: 75-99.

Papp, J. (1993): First survey of the Triaspidini species of the Indo-Australian region (Hymenoptera: Braconidae: Calyptinae) III. The genus *Schizoprymnus* Foerster. *Acta Zool. Hung. 39(1-2)*: 129-173.

Sharkey, M.J. & R.A. Wharton (1997): Morphology and Terminology. Pp. 19-37. *In*: Wharton, R.A., P.M. Marsh & M.J. Sharkey (Eds): Manual of the New World Genera of the Family Braconidae (Hymenoptera). The International Society of Hymnenopterists: Washington D.C.

Shaw, M.R. & T. Huddleston (1991): Classification and biology of braconid wasps (Hymenoptera: Braconidae). *Handbook for the identification of British Insects 7:* 3-126.

■ ■ ■

MISCELLANEOUS NOTES

1. A NOTE ON DISTRIBUTION RANGE OF HANUMAN LANGUR *SEMNOPITHECUS ENTELLUS* (DUFRESNE) AND RHESUS MACAQUE *MACACA MULATTA* (ZIMMERMANN) IN RAJASTHAN

SATISH KUMAR SHARMA[1]

[1]Sajjangarh Wildlife Sanctuary, Udaipur 313 001, Rajasthan, India. Email: sksharma56@gmail.com

Many workers namely, Agoramoorthy (1992), Bhargava (1984), Bhati and Srivastava (1988), Chhangani (2002), Mathur (1994), Mathur and Manohar (1986, 1987, 1993, 1994), Manohar and Mathur (1992), Mohnot (1984), Roonwal (1984), Roonwal *et al.* (1984), Sharma (1995, 1999, 2001a,b, 2002, 2004, 2007), Sharma *et al.* (2000), Sharma *et al.* (2006), Sivsubramanian (1986), Tehsin (2006) and Wada (1984) have studied various aspects of two primate species of Rajasthan, namely Hanuman Langur *Semnopithecus entellus* (Dufresne) and Rhesus Macaque *Macaca mulatta* (Zimmermann). The extent of distribution range of both the primates in Rajasthan is an important aspect of primate biology, which is neglected. Sporadic information about the distribution range of *S. entellus* in Rajasthan is available in Bhati and Srivastava (1988), Mohnot (1984), and Roonwal (1984), but nothing is known about the distribution range of *M. mulatta* in the State.

To fill this gap and to learn the exact distribution range of both these primates in the wild in Rajasthan, I screened my field notes from 1980 to 2007. During this period, I had travelled the entire state widely. All the habitats were visited frequently. Many forest areas, cities, towns, temples and markets were studied to record the presence of primates. Findings of this study are presented in Table 1.

It is evident from Table 1 that *S. entellus* has a greater distribution range than *M. mulatta* in Rajasthan (Fig. 1). *S. entellus* is present in Aravallis, and east and west of Aravallis up to Jodhpur district. Wild population of *S. entellus* is present in 28 districts, namely Kota, Baran, Bundi, Jhalawar, Karauli, Sawai Madhopur, Dholpur, Bharatpur, Alwar, Dausa, Jaipur, Jhunjhunu, Sikar (eastern part), Nagaur (eastern part), Ajmer, Bhilwara, Tonk, Chittorgarh, Banswara, Dungarpur, Udaipur, Rajsamand, Pali, Sirohi, Jalore (northern part), Barmer (eastern part), Churu (eastern part) and Jodhpur (eastern part). Wild population of *S. entellus* is absent in the extreme western and northern part of the state. This species is absent in wild in Ganganagar and Hanumangarh districts but sometimes solitary animals (probably released /introduced) are seen inside Ganganagar and Hanumangarh city area.

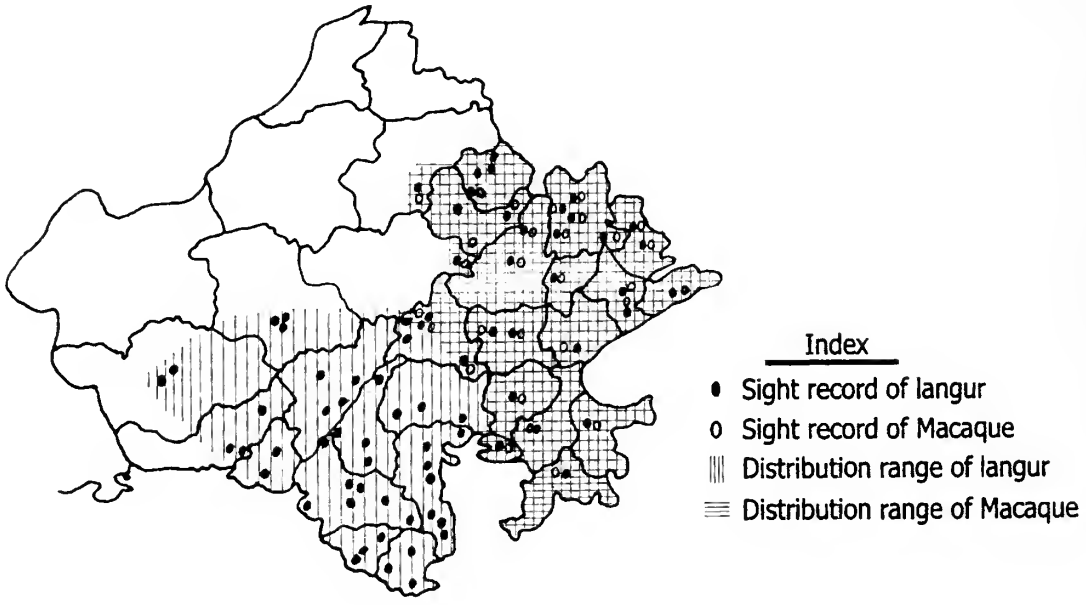


Fig. 1: Text figure of distribution range of Hanuman Langur and Rhesus Macaque in Rajasthan

Table 1: Distribution of *S. entellus* and *M. mulatta* in Rajasthan

District	Locality of occurrence of primates	
	Semnopithecus entellus	*Macaca mulatta*
Udaipur	Phulwari WLS, Sajjangarh WLS, Kumbhalgarh WLS, Jaisamand WLS, Baghdarrah, Jawar, Dhariyawad and whole of Udaipur district	Absent in wild
Rajsamand	Rajsamand, Kankroli, Nathdwara and entire district	Absent in wild
Dungarpur	Dungarpur city, Waid, Aaspur, and entire district	Absent in wild
Banswara	Banswara, Ghatol, Garhi and entire district	Absent in wild
Pali	Pali, Sadri, Ranakpur and entire district	Absent in wild
Bhilwara	Bhilwara, Gangapur, Sahada, Mandal, Mandalgarh and entire district	Absent in wild
Chittorgarh	Chittorgarh, Sitamata, Menal, Chhoti Sadri, Badi Sadri, Nimbaheda, Pratapgarh, Arnod and entire district except Rawatbhata	Rawatbhata
Jalore	Jalore city, Jaswantpura, Sunda Mata	Absent in wild
Sirohi	Mt. Abu, Abu Road, Sirohi, Pindwara and entire district	Absent in wild
Jodhpur	Mandor, Arnaji, Jodhpur	Absent in wild
Jaisalmer	Big troops absent. Sometimes individuals (probably released /introduced) are seen in city (Dr. A.K. Chhangani pers. comm.)	Absent in wild
Barmer	Barmer, Kawas	Absent in wild
Ganganagar and Hanumangarh	Absent, sometimes individuals (probably released / introduced) are seen in city (Dr. Pratap Singh pers. comm.)	Absent in wild
Ajmer	Todgarh - Raoli WLS, Pushkar, Beawar and entire district	Species present at Majewala, Pushkar and Pisangan. It is absent in southern part of Ajmer district
Sawai Madhopur	Entire district	Ranthambhore NP, Sawai Madhopur city and entire district
Nagaur	Maroth	Maroth
Karauli	Karauli, Hindon and entire district	Karauli, Hindon and entire district
Kota	Kota city and entire district	Kota city and entire district
Bharatpur	KNP, Bharatpur city, Deeg and entire district	KNP, Bharatpur city, Deeg and entire district
Bundi	Bundi city and entire district	Bundi city and entire district
Alwar	Sariska Tiger Project, Thanagaji, Alwar city, Vijai Mandir, Tatarpur, Bansur, Jindoli and entire district	Sariska Tiger Project, Thanagaji, Alwar city, Vijai Mandir, Tatarpur, Bansur, Jindoli and entire district
Jhunjhunu	Lohargal, Jhunjhunu and other urban areas	Lohargal (Teh. Nawalgarh)
Jaipur	Jaipur city, Amber, Nahargarh WLS, Shahpur, Jamwa Ramgarh WLS, Malpura and entire district	Jaipur city, Amber, Nahargarh WLS, Shahpur, Jamwa Ramgarh WLS, Malpura and entire district
Sikar	Sikar city, Baleshwar temple and other urban area	Patan, Khachariyawas, Khatu Shyam, Baleshwar and Ganeshwar temple near Neem-ka-Thana
Churu	Salasar	Salasar
Dholpur	Dholpur and entire district	Dholpur and entire district
Dausa	Bandikui, Dausa, Mandawar and entire district	Bandikui, Dausa, Mandawar and entire district
Baran	Baran town, Shahab\shanganj, Sitamata and entire district	Baran town, Shahabad, Kishanganj, Sitamata and entire district
Jhalawar	Jhalawar, Jhalarapatan and entire district	Jhalawar, Jhalarapatan and entire district
Tonk	Tonk town, Niwai, Deoli, Uniyara and entire district	Tonk town, Niwai, Deoli, Uniyara and entire district

The Jodhpur population of *S. entellus* represents the extreme western geographical limit of the species beyond which the Hanuman Langur is not found in the Thar desert (Mohnot 1984; Roonwal 1984). Rhesus Macaque has a more restricted distribution range in Rajasthan than Langur. The Macaque is present in the wild in 18 districts of north-eastern and south-eastern part of the state, namely Jhunjhunu, Sikar (eastern part), Nagaur (eastern part), Churu (eastern part), Jaipur, Dausa, Alwar, Bharatpur, Dholpur, Karauli, Sawai Madhopur, Kota, Bundi, Baran, Jhalawar, Chittorgarh (eastern part), Tonk and Ajmer. Langur and Macaque are sympatric in distribution in 18 districts in northern and central Aravallis, as well as in the eastern plains and Hadoti zone of south-eastern Rajasthan. Wild population of macaque is absent in southern Aravallis and major part of the Thar desert. As far as desert areas are concerned, macaque is present in four desert districts, namely Churu, Jhunjhunu, Sikar (eastern part) and Nagaur (eastern part) and lives sympatrically with the Langur. *S. entellus* is allopatric in distribution in 10 districts, namely Bhilwara, Banswara, Dungarpur, Udaipur, Rajsamand, Sirohi (all southern Aravalli districts); Pali, Jalore, Barmer and Jodhpur (all Thar desert districts). It is evident from Table 1 that macaque is absent from deeper zones of the Thar desert and southern hilly forest tracts of the state. This species does not extend beyond the eastern fringe of the Thar desert.

Sometimes single individuals or group of twos, threes and even more of langurs and macaques are seen in distant cities and towns out of their known distribution range. Where they come from is not known. After residing for a few days or months they disappear (Bhargava 1984). Sometimes these nomadic primates create panic in urban areas and people demand their removal. In such a situation, the free ranging primates are captured either by municipal authorities or officials of the Forest Department, and they are released in remote areas.

The presence of the Indira Gandhi Canal in the Thar desert has increased the availability of water and greenery in the western part of the State. New plantations in the canal area are providing potential habitat for the primates. Many bird species earlier not seen in the region are now observed here (Sharma 2001). In the near future, primates are also likely to appear in newer areas of the Thar desert.

ACKNOWLEDGEMENTS

I gratefully acknowledge late Dr. I. Prakash, Prof. S.S. Katewa, Dr. Chhaya Bhatnagar, Prof. S.M. Mohnot, Dr. Anil Chhangani, and Dr. Pratap Singh for discussions and guidance. I sincerely thank the Forest Department of Rajasthan for their kind cooperation and logistic support during the present study.

REFERENCES

AGORAMOORTHY, G. (1992): Reproductive biology of the Hanuman Langur *Presbytis entellus* in Jodhpur, western India. *J. Bombay Nat. Hist. Soc. 89(1)*: 84-93.

BHARGAVA, R.N. (1984): Primates in the Indian Desert (The Hanuman Langur, *Presbytis entellus*, and the Rhesus macaque, *Macaca mulatta*). Pp. 41-45. *In*: Roonwal, M.L., S.M. Mohnot & N.S. Rathore (Eds): Current Primate Researches. Department of Zoology, University of Jodhpur, Jodhpur (India).

BHATI, U.S. & A. SRIVASTAVA (1988): Habitat sharing by Hanuman Langurs and Indian Flying Fox. *J. Bombay Nat. Hist. Soc. 85(3)*: 608-609.

CHHANGANI, A.K. (2002): Group composition and sex ratio in Hanuman Langurs (*Semnopithacus entellus*) in Aravalli Hills of Rajasthan India. *Zoos' Print Journal 17(8)*: 848-852.

MANOHAR, R.R. & R. MATHUR (1992): Interspecific play behaviour between Hanuman Langur *Presbytis entellus* and Rhesus Macaque *Macaca mulatta*. *J. Bombay Nat. Hist. Soc. 89(1)*: 114-115.

MATHUR, R. (1994): Parturition in feral Rhesus Macaque *Macaca mulatta*: A case report. *J. Bombay Nat. Hist. Soc. 91(1)*: 132-133.

MATHUR, R. & B.R. MANOHAR (1986): A note on the interaction of Common Langur (*Presbytis entellus*) and Wolf (*Canis lupus*). *J. Bombay Nat. Hist. Soc. 83(3)*: 653.

MATHUR, R. & B.R. MANOHAR (1987): Group number and composition of Hanuman Langur (*Presbytis entellus*) in Jaipur, India. *J. Bombay Nat. Hist. Soc. 84(1)*: 193-199.

MATHUR, R. & B.R. MANOHAR (1993): Home range of Hanuman Langur (*Presbytis entellus*) in four habitats in Jaipur, India. *J. Bombay Nat. Hist. Soc. 90(3)*: 494-495.

MATHUR, R. & B.R. MANOHAR (1994): Number and size of groups of *Presbytis entellus* in four different habitats in and around Jaipur, Rajasthan. *J. Bombay Nat. Hist. Soc. 91(2)*: 275-281.

MOHNOT, S.M. (1984): Research potential of Jodhpur Langurs (*Presbytis entellus*). Pp. 47-55. *In*: Roonwal, M.L., S.M. Mohnot & N.S. Rathore (Eds): Current Primate Researches. Department of Zoology, University of Jodhpur, Jodhpur (India).

ROONWAL, M.L. (1984): Tail form and carriage in Asian and other primates, and their behavioral and evolutionary significance. Pp. 93-151. *In*: Roonwal, M.L., S.M. Mohnot & N.S. Rathore (Eds): Current Primate Researches. Department of Zoology, University of Jodhpur, Jodhpur (India).

ROONWAL, M.L., S.M. MOHNOT & N.S. RATHORE (1984): Current primate researches. Department of Zoology, University of Jodhpur, Jodhpur (India).

SHARMA, S.K. (1995): Destruction of *Cuscuta reflexsa* Roxb. by the Rhesus Macaque *Macaca mulatta* (Zimmerman) *J. Bombay Nat. Hist. Soc. 92(2)*: 290.

SHARMA, S.K. (1999): Mammalian fauna of Rajasthan. *Bionature 19(1)*: 7-13.

SHARMA, S.K. (2001a): Food habits of Hanuman Langur (*Semnopitheus entellus*) during dry season at Mount Abu Wildlife Sanctuary. *Zoos' Print Journal 16(12)*: 669.

SHARMA, S.K. (2001b): Impact of Indira Gandhi Canal on the desert avifauna of Rajasthan. Pp. 1-459. (A study report submitted to Govt. of India, Ministry of Environment & Forests, New Delhi.)

SHARMA, S.K. (2002): High tension electric poles used as night roost by troops of Hanuman Langur *Presbytis entellus* at Nahargarh Wildlife Sanctuary, Jaipur. *J. Bombay Nat. Hist. Soc. 99(1)*: 103.

SHARMA, S.K. (2004): Electric pylons used as night roost by troops of Rhesus Macaque *Macacca mulatta* at Sariska Tiger Reserve, Alwar district, Rajasthan. *J. Bombay Nat. Hist. Soc. 101(3)*: 439.

SHARMA, S.K. (2007): Study of biodiversity and ethnobiology of Phulwari Wildlife Sanctuary, Udaipur (Rajasthan). Ph.D. Thesis. MLS University Udaipur (Rajasthan).

SHARMA, S., S.K. SHARMA & S. SHARMA (2000): Notes of mammalian fauna of Rajasthan. *Zoos' Print Journal 18(4)*: 1085-1088.

SHARMA, V., K. JANI, C. BHATNAGAR & S.K. SHARMA (2006): Biodiversity of mammals in Sajjangarh Wildlife Sanctuary, Udaipur. Wildlife Division Udaipur: An attempt to study the habitat preference of some. *Bull. Bio. Sci. 4(1)*: 39-44.

SIVSUBRAMANIAN, C. (1986): A note on the Rhesus Macaque *Macaca mulatta* feeding on *Calotes*. *J. Bombay Nat. Hist. Soc. 83 (Supp.)*: 197.

TEHSIN, R.H. (2006): Effect of Neem *Azadirachta indica* leaves on wounded Common Langur (*Semnopithecus entellus*) (Dufrense). *J. Bombay Nat. Hist. Soc. 103(1)*: 95.

WADA, K. (1984): Rhesus Monkey distribution in the lower Himalayas and secondary forest succession. *J. Bombay Nat. Hist. Soc. 81(2)*: 355-363.

2. SIGHT RECORD OF THE INDIAN WOLF *CANIS LUPUS PALLIPES* IN THE RIVER GANDAK FLOODPLAINS

SUSHANT DEY[1,3], VIVEKSHEEL SAGAR[2], SUBHASIS DEY[1,4] AND SUNIL K. CHOUDHARY[1,5]

[1]Vikramshila Biodiversity Research & Education Center, Department of Botany, T.M. Bhagalpur University, Bhagalpur 812 007, Bihar, India.
[2]Freshwater & Wetlands Programme, World Wide Fund for Nature-India, 172-B, Lodi Estate, New Delhi 110 003, India.
Email: viveksheelsagar@yahoo.com
[3]Email: ranadey_vbrec@yahoo.com
[4]Email: subhasisvbrec2@yahoo.com
[5]Email: sunil_vikramshila@yahoo.co.in

The Indian Wolf *Canis lupus pallipes* is categorized as Endangered by the IUCN (an assessment by the Canid Specialist Group of IUCN) and is a Schedule I animal in the Wildlife (Protection) Act 1972 of India. It had once one of the largest natural range of any land mammal (Sheldon 1992). The Indian Wolf is widely distributed over peninsular India (Jhala 2003). Before division, Bihar was amongst the range states of the Indian wolf distribution. Presence of Indian Wolf has been recorded in Chhotanagpur plateau region of south Bihar, presently Jharkhand, since the British times, where it had gained the notoriety of being a child-lifter and even a man-eater (Pocock 1939; Shahi 1982). There are no records of the Indian Wolf being present in the geographic region north of the Ganges river in Bihar. Another subspecies of the wolf found in the Indian subcontinent, *Canis lupus chanco* commonly called the Tibetan wolf, has a trans-Himalayan distribution up to east Nepal and the range extends into Tibet, China, Manchuria and Mongolia (Jhala 2003). There is no record of its presence in the Terai region of India and Nepal.

The Gandak is a mountain-fed river known as the Krishna-Gandaki in its upper reaches. It rises in the high region of Tibet and Nepal, where it drains a large region, before emerging on the plains of the West Champaran district of northern Bihar. It enters India at Valmikinagar (27° 26' 192" N; 83° 54' 429" E) in West Champaran from where it traverses *c.* 331 km before meeting the Ganges at Hazipur near Patna (25° 39' 935" N; 85° 10' 643" E). The Gandak river is braided throughout its course between the point where it emerges in the plains to its confluence with the Ganga. A barrage is constructed across Gandak river at the Indo-Nepal border at Valmikinagar to divert the water for irrigation and power generation. The water discharge below the barrage is very low during the summer and winter months making the river extremely shallow downstream of the barrage. From the point of entry, it flows along the Valmikinagar Tiger Reserve in Bihar on the left bank, and Nepal on the right bank, then after entry into Gorakhpur district in Uttar Pradesh along the Soahagi Barwa Wildlife Sanctuary on the right bank in Uttar Pradesh and again enters West Champaran district in Bihar. Extensive farming is done on the floodplains along both the banks where sugarcane cultivation is dominant. Cultivated fields are spread between with large patches and extensive tracts of grasslands dominated by Poaceae species. These grasslands provide ideal habitat for different species of ungulates, namely Nilgai *Boselaphus tragocamelus*, Indian Wild Boar *Sus Scrofa*, the Hog Deer *Axis porcinus*, and the Indian Hare *Lepus nigricollis*. This indicates that the wolf has in fact a wide variety of prey available in this area. This feature is predominant till *c.* 220 km downstream, after which extensive cucurbit cultivation is practiced till the confluence point in the floodplains and on every available mid-channel island. The Indian Wolf prefers to live in scrublands,

grasslands and semi-arid pastoral/ agricultural landscape (Jhala 2003). They do not prefer heavy forest cover. They are not present in the Valmikinagar Tiger Reserve (pers. comm. with S. Sinha of Wildlife Trust of India, 2010).

We conducted a survey of river Gandak (in India, *c.* 331 km) from the Indo-Nepal border at Valmikinagar (just after barrage) in West Champaran district in the north, to its confluence with river Ganga at Hazipur in Vaishali district in the south from January 6-23, 2010. The main objective of the river Gandak survey was to record aquatic mega fauna mainly the Gharials *Gavialis gangeticus* and the dolphins *Platanista gangetica gangetica* present in the river. The survey was conducted everyday from 10:00 to 16:00 hrs. Hence, there was ample time (after the completion of the primary survey) to interact with villagers and for surveying the surrounding grasslands for wildlife. The information regarding the presence of different species of wildlife present in the grasslands was gathered opportunistically from local villagers encountered on the riverside, and from the direct and indirect sightings (of pellets, pugmarks, hoof prints) by the survey team members. Local villagers were asked open-ended questions regarding different species without suggesting the profile of the animals. They were later shown field guides and species identification pamphlets and were asked to identify animals they had recently encountered or seen in the vicinity. The field guide was in English and villagers (mostly illiterate) could not read them so their information was based on their experience, hence, unbiased. GPS coordinates of the animals, detected by direct as well as indirect sightings, were recorded and marked in the Occupancy Survey datasheet.

On the morning of the January 20, 2010, at around 08:00 hours, a pair of Indian wolf was seen running in the middle of a patch of wheat cultivation about 15 m from the camp site (26° 06' 945" N; 84° 56' 469" E) at a place called Singhgahi Dhaala, 264 km downstream from the starting point of the survey. This area was semi-isolated and was characterized by patch wheat farming within grassland tract. The nearest human settlement was *c.* 2 km and metal road about 3.5 km away from the camp site. One large male was seen leading followed by a smaller female about 10 m behind. They ran across the camp site in a relaxed manner, where 10 members of the survey crew and an equal number of villagers were talking, without arousing much curiosity from the villagers or from the wolves. They ran into the grassland thicket and emerged about 100 m north of the campsite, the male scent-marked on the trunk of a Jamun tree and again went inside the grassland thicket. The pair of wolf was circling a herd of Nilgai cows with calves. The survey team had pitched their tents on the elevated river bank at the edge of the river. The wolves were about 30 m from the river waterline. About 30 Nilgais, comprising bulls, cows and calves were seen grazing in the wheat fields, scattered in a radius of 150 m from the campsite and totally impervious to our presence. Two Indian Hares were also seen running across a tractor track in between the grasslands. Previous night, a group of five jackals had sneaked into the campsite in search of morsels and started howling and making a ruckus, and had to be shooed away. About 50 m from the camp site at the waterline of the river, hoof prints of a small sounder of Wild Boar were also seen. Other than Ratwal (91 km downstream, 26° 58' 603" N; 84° 10' 611" E) and Sakmahi Tola (180 km downstream, 26° 29' 424" N; 84° 32' 845" E) along the Gandak river, Singhgahi Dhaala was the third place where villagers were able to describe the Hog Deer and confirm its presence in the grassland of the area.

Public attitude is very tolerant to predators in India (Boitani 1992; Promberger and Schroder 1993; Thiel 1993). During interactions with local villagers, we could come to know that they never harm 'Nilgais' despite the fact that they are destructive to their standing crops. Villagers believe that the 'Nilgais' symbolically represent the Goddess Laxmi (the goddess of wealth and prosperity in Hindu religion) and if they are harmed, their fields will turn barren as a curse. This statement was confirmation of their attitude with an incident observed at Ratwal earlier, when at night a herd of Nilgais raided wheat cultivation, villagers keeping the night vigil started burning big bales of dried grass. Taking cue from the first fire, the neighbouring villagers did the same and so did others. There was no shouting, no beating of drums, no chasing, no bursting of crackers, just burning of the bales of grass. When asked about the incident, the villagers said "Like us, they (Nilgais) also need to survive, so why harm them".

Unregulated exploitation of grassland is the main threat to the wolves as it will have a negative conservation impact. Indian wolf and its prey need grassland for survival. All along the river Gandak, grassland is exploited for local consumption as well as for economic gain and is totally unmonitored and unregulated. The only regulation in place is natural inaccessibility of the place. Bales of grass are transported by bullock carts, tractors and also by large motorized boats for local consumption. The shallow depth of the River Gandak prevents motorized boat from reaching upstream hence preventing large-scale exploitation of the grasslands. The first motorized boat encountered loading grass was at 257 km downstream from the start. This feature has probably prevented the grassland from being totally destroyed.

Discussion

The sighting of Indian Wolf in the wet-grassland habitat of river Gandak floodplains might have two explanations:

1. This new sight record of Indian Wolf in the river Gandak floodplains might be the extension of the known eastern distribution range of Indian Wolf from the Chhotanagpur plateau in Jharkhand to include the region north of the river Ganges. The presence of a variety of ungulates, cover, and access to large source of water represents an ideal habitat suitable for the survival of the Indian Wolf (Jhala 2003). To this, adds the fact that people here seem not to have forgotten the art of coexistence with predators as in other parts of India (Jhala and Sharma 1997).
2. The Indian Wolf *Canis lupus pallipes* and the Tibetan Wolf *Canis lupus chanco* are considered subspecies of the Gray Wolf *Canis lupus*. Recent DNA studies have shown that there is another wolf that is very genetically different from these two subspecies, so much so that researchers are calling it a new species *Canis himalayensis* with population less than 350 and assessed as critically endangered. It reportedly ranges from north-west Jammu through Himachal to eastern Nepal. Our sighting north of the Ganga, south of Nepal could be that of the Himalayan Wolf. There is no way to substantiate it. At the best, we can only say that the wolf sighted by us in the river Gandak floodplains might be either *Canis lupus pallipes* or *Canis pallipes himalayensis*. Moreover, the encounter with the Indian Wolf in Singhgahi Dhaala reveals three unique facts for the area, namely
   i) That the immediate behavioural response of the villagers and the wolf show us that this is a common feature in the region, and hence, the wolf is well-established in that area and not new colonization.
   ii) The close and casual approach of the wolves to a sizeable human congregation (20 individuals) in close proximity in broad daylight and no reports of persecution of human beings by the wolves, reveal that there is very little or no man-animal conflict in the area.
   iii) Strong religious sentiments and beliefs of the local community may have helped conserve the wildlife in general and the prey base of the Indian wolf in particular which needs immediate and thorough investigation.

ACKNOWLEDGEMENTS

This work was done during the river Gandak Gharial Survey 2010. The authors are thankful to Dr. P. Gautam of WWF-India, Mr. Vivek Menon of Wildlife Trust of India, and Mr. Samir Whitaker of Gharial Conservation Alliance for organizing fund for this survey. We are also grateful to Mr. B.A. Khan, Chief Wildlife Warden, Bihar, and Mr. J.P. Gupta, Director- Valmiki Tiger Reserve, for their help during the survey.

REFERENCES

Boitani, L. (1992): Wolf management in intensively used areas of Italy. Pp. 158-171. *In*: Harrington, F.H. & P.L. Paquet (Eds): Wolves of the World. Noyes Publications, Park Ridge, New Jersey. 474 pp.

Jhala, Y.V. (2003): Status, Ecology and conservation of Indian Wolf *Canis lupus pallipes* Sykes. *J. Bombay Nat. Hist. Soc. 100(2&3)*: 293-307.

Jhala, Y.V. & D.K. Sharma (1997): Child lifting by wolves in eastern Uttar Pradesh. *India J. Wildl. Res. 2(2)*: 94-101.

Pocock, R. (1939): Fauna of British India. Mammalia Vol. 1, London: 446 pp.

Promberger, C. & W. Schroder (1993): Wolves in Europe: Status and perspectives. Munich Wildl. Soc., Ettal, Germany.

Shahi, S.P. (1982): Status of the grey wolf (*Canis lupus pallipes*) in India: A preliminary survey. *J. Bombay Nat. Hist. Soc. 79(3)*: 493-502.

Sheldon, J.W. (1992): Wild dogs: The natural history of non-domestic Canidae. Academic Press, Inc., New York. 248 pp.

Thiel, R.P. (1993): The Timber Wolf in Wisconsin. University of Wisconsin Press, Madison.

3. WILDLIFE MORTALITY FROM VEHICULAR TRAFFIC IN SRIHARIKOTA ISLAND, SOUTHERN INDIA

S. Sivakumar[1,2] and Ranjit Manakadan[1,3]

[1]Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk, S.B. Singh Road, Mumbai 400 001, Maharashtra, India.
[2]Email: sivaprema3sep@yahoo.com
[3]Email: ransan5@rediffmail.com

Introduction

Increasing road networks severely affect wild fauna and flora, as is well-documented in many studies around the world (e.g., Mader 1984; Fahrig *et al.* 1995; Reed *et al.* 1996; Gibbs 1998). There have been a few studies on the impacts of vehicular traffic on wildlife in India (Gokula 1997; Vijayakumar *et al.* 2001; Chhangani 2004). This note discusses the wildlife casualties due to vehicular traffic in

Sriharikota Island from observations carried out from January 2002 to December 2003.

Study area

Sriharikota is a spindle-shaped island (181 sq. km) situated in Nellore and Tiruvallur districts of Andhra Pradesh and Tamil Nadu respectively. The island is bordered to the east by the Bay of Bengal and to the north, south and west by the Pulicat Lake. The Island comprises of low ridges of sand, marine and aeolian in origin, rising 4.5-6.0 m above msl and sloping from west to east. The water table is at a depth of *c.* 2-5 m. Sriharikota has one of the last remaining, largest, and best-preserved tracts of Tropical Dry Evergreen Forest in India. Beside the natural forest, the island has plantations of eucalyptus, casuarina and cashew. The Island is a high security area and under the control of the Indian Space Research Organisation (ISRO) being its satellite launching establishment. There is a network of roads in the forest areas, mostly in the central part of the Island, some of which are subject to regular vehicular traffic during office hours, and less frequently at night during certain periods.

Table 1: Records of the road kills of three faunal groups during 2002-2003

	Total no. of Kills
Mammals	
Indian Gerbille *Tatera indica*	24
Three-striped Palm Squirrel *Funambulus palmarum*	13
Golden Jackal *Canis aureus*	3
Slender Loris *Loris lydekkerianus*	3
Small Indian Civet *Viverricula indica*	1
Black-naped Hare *Lepus nigricollis*	1
Common Mongoose *Herpestes edwardsi*	1
Birds	
Greater Coucal *Centropus sinensis*	5
Indian Little Nightjar *Caprimulgus asiaticus*	3
Common Tailorbird *Orthotomus sutorius*	3
Spotted Owlet *Athene brama*	1
Brown Shrike *Lanius cristatus*	1
Spotted Dove *Streptopelia chinensis*	1
Oriental Magpie-Robin *Copsychus saularis*	1
Indian Jungle Crow *Corvus [macrorhynchos] culminatus*	1
Red-vented Bulbul *Pycnonotus cafer*	1
Red-wattled Lapwing *Vanellus indicus*	1
Reptiles	
Saw-scaled Viper *Echis carinata*	26
Green Whip Snake *Ahaetulla nasuta*	19
Variegated Kukri Snake *Oligodon taeniolata*	12
Russell's Viper *Daboia russelii*	11
Common Indian Bronzeback *Dendrelaphis tristis*	9
Buff-striped Keelback *Amphiesma stolata*	6
Common Cat Snake *Boiga trigonata*	6
Spectacled Cobra *Naja naja*	3
Olivaceous Keelback *Atretium schistosum*	2
Common Rat Snake *Ptyas mucosus*	1
Red Sand Boa *Eryx johnii*	1
Checkered Keelback *Xenochrophis piscator*	1
Common Indian Krait *Bungarus caeruleus*	1
Common Garden Lizard *Calotes versicolor*	28
Indian Chameleon *Chamaeleo zeylanicus*	5
Indian Pond Terrapin *Melanochelys trijuga*	4
Common Indian Monitor *Varanus bengalensis*	4

Methods

Data on road-kills was based on incidental records obtained during field trips from January 2002 to December 2003 during a 3-year project on the faunal diversity of the Island. The data collected on road kills pertained to the species killed, its numbers and the habitat characteristics around the site. Most of the field visits were from 07:00-12:00 hrs and to a lesser degree from 15:30-18:30 hrs and 19:30-22:30 hrs. The data discussed is based on 571 field trips carried out during a year.

Discussion

The Three-striped Palm Squirrel *Funambulus palmarum* and Indian Gerbil *Tatera indica* constituted the majority (80.4%) of the road kills among the seven species of mammals recorded in road kills. Both the species are also among the most abundant mammals of the Island (Manakadan *et al.* 2004a). Three records of the road kills of Slender Loris *Loris lydekkerianus*, a Schedule I species under the Wildlife Protection Act (1972) were obtained. The Slender Loris is an arboreal species and is known to move from one forest patch to another by moving on land in open areas, but this makes them highly vulnerable to predators (Singh *et al.* 1999), and as seen in Sriharikota also road kills.

Ten species of birds were recorded in road kills. The Greater Coucal *Centropus sinensis* constituted 28% of the road kills, followed by Indian Little Nightjar *Caprimulgus asiaticus* (17%) and Common Tailorbird *Orthotomus sutorius* (17%). The Greater Coucal is more prone to road kills as it is a weak flier and frequents roads to feed on the road kills of amphibians and reptiles. The Indian Little Nightjar tends to rest on roads at night, and thus gets killed after being dazed by the light of approaching speeding vehicles.

Fifty percent of the 34 recorded reptilian species of the Island was recorded in road kills. Snakes were the most affected group, species (76.5%) and abundance (70.5%) wise. Males of the Common Garden Lizard *Calotes versicolor* tend to get killed more as they engage in courtship/territorial display on roads. Kills of frog species, especially after they

emerged from the water bodies along road on attaining adulthood were common, but is not discussed in this paper.

Overall, more kills occurred during July, comprising mostly of snakes. The kills of snakes occurred after the first showers after the long spell of the dry season. Snakes are more active during this period due to various reasons (Whitaker 1978). Other than accidental kills, we recorded intentional killing of snakes and also birds, such as Grey Junglefowl *Gallus sonneratti* and Greater Coucal *Centropus sinensis* by drivers. Snakes are killed due to the hatred for snakes, while the two bird species are collected for food or killed for fun.

The forest and wildlife of Sriharikota are well protected due to the Island's high security status. However, the wildlife does face problems (Manakadan *et al.* 2004b), one of which is the threat of road kills. Measures are needed to reduce the incidences of road kills through awareness programmes, check on speed limits of vehicles, creation of speed breakers, culverts and installing sign boards at road kill prone areas. Decrease in the extent of the road network (where possible) could also be explored. All these recommendations have been communicated to the authorities of the spaceport in our report.

ACKNOWLEDGEMENTS

We thank the Indian Space Research Organisation for financial support and the authorities in the SDSC-SHAR, Sriharikota, for support and co-operation. We thank J. Patrick David for perusal and comments on the draft.

REFERENCES

Chhangani, A.K. (2004): Mortality of wild animals in road accidents in Kumbhalgarh Wildlife Sanctuary, Rajasthan, India. *J. Bombay Nat. Hist. Soc. 101(1)*: 151-154.

Fahrig, L., J.H. Pedlar, S.E. Pope, P.D. Taylor & J.F. Wegner (1995): Effect of road traffic on amphibian density. *Biol. Conserv. 73*: 177-182.

Gibbs, J.P. (1998): Amphibian movements in response to forest edges, roads, and streambeds in southern New England. *J. Wildl. Manage. 62(2)*: 584-589.

Gokula, V. (1997): Impact of vehicular traffic on snakes in Mudumalai Wildlife Sanctuary. *Cobra 27*: 26.

Mader, H.J. (1984): Animal habitat isolation by roads and agricultural fields. *Biol. Conserv. 29*: 81-96.

Manakadan, R., S. Sivakumar & A.R. Rahmani (2004a): An ecological account of the faunal diversity of Sriharikota Island and its environs. Final Report: Part 1 – Birds and Mammals. Bombay Natural History Society, Mumbai.

Manakadan, R., S. Sivakumar & A.R. Rahmani (2004b): An ecological account of faunal diversity of Sriharikota Island and its environs. Final Report: Part V- Conservation Issues. Bombay Natural History Society, Mumbai.

Reed, A.R., J.J. Barnard & J.W. Baker (1996): Contribution of roads to forest fragmentation in the Rocky Mountains. *Conserv. Biol. 10(4)*: 1098-1106.

Singh, M., D.G. Lindburg, A. Udhayan, M.A. Kumar & H.N. Kumara (1999): Status survey of Slender Loris *Loris tardigradus lydekkerianus* in Dindigul, Tamil Nadu, India. *Oryx 33(1)*: 31-37.

Vijayakumar, S.P., K. Vasudevan & N.M. Ishwar (2001): Herpetofaunal mortality on roads in the Anamalai hills, southern Western Ghats. *Hamadryad 26(2)*: 253-260.

Whitaker, R. (1978): Common Indian Snakes. Macmillan India Limited, Madras.

4. FACTORS CAUSING NEST LOSSES IN THE PAINTED STORK *MYCTERIA LEUCOCEPHALA*: A REVIEW OF SOME INDIAN STUDIES

Abdul Jamil Urfi[1]

[1]Department of Environmental Biology, University of Delhi, New Delhi 110 007, India. Email: ajurfi@rediffmail.com

Losses at egg and nestling stages significantly impact fitness in birds and so their assessment becomes critical in developing conservation strategies for endangered species. The near threatened Painted Stork *Mycteria leucocephala* with a stronghold in India is a flagship of wetlands and heronries (BirdLife International 2001). Although recent researches have explored several aspects of its biology, including sexual size dimorphism (Urfi and Kalam 2006), foraging behaviour (Kalam and Urfi 2008), resource partitioning (Istiaq *et al.* 2010), nesting (Urfi *et al.* 2007; Meganathan and Urfi 2009) and habitat ecology (Sundar 2006), a broad based overview of the various biotic and abiotic factors responsible for nest losses in this species is warranted. The present study aims to address this shortcoming.

Biotic factors

Predation on Eggs and Nestlings

Nest predation is the single most important ecological factor influencing reproductive success in birds. Ensuring safety from ground predators, chiefly mammals, has been a strong selective force in the evolution of coloniality in birds (Brown and Brown 2001). Most Painted Stork colonies are either located on islands or on large trees on land and so the impacts of direct predation by land animals is minimized. However, mammalian predators can sometimes reach island colonies by swimming when the water is shallow or a bridge

is formed due to a sudden drop in water level. Pande (2006) records an instance at Bhadalwadi Tank of stray dogs, Common Mongoose *Herpestes edwardsi*, Jackal *Canis aureus* and Wolf *Canis lupus* being able to gain access to Painted Stork nests when the water level surrounding the colony dropped unexpectedly. Although, cases of mammalian predators reaching nesting colonies located on islands in the sea by swimming are probably rare, at Man Marodi island in the Gulf of Kutch, where Painted Stork build nests on *Salvadora*, quite close to ground level, jackals have been reported to prey upon nestlings (Urfi 2003). Reportedly, they arrive on the island by swimming at low tide, from nearby mainland areas. At Ranganthittu Bird Sanctuary, troops of Bonnet Macaque *Macaca radiata* were recorded to swim across the river to the bird colonies on islets and plunder the eggs in the nests (Neginhal 1982). Village heronries such as Kokre Bellur (Neginhal 1977; Nagulu and Rao 1983) or heronries on large trees in city parks, such as gardens in Bhavnagar (Parasharya and Naik 1990) are good examples of safety from ground predators being ensured due to location of nests at a height. The only way in which ground predators can have access to nestlings is when they accidentally fall off from their nests. While the predators in village heronries are mostly feral dogs (Subramanya and Manu 1996) in island colonies they may be the Mugger Crocodile (*Crocodylus palustris*), as in the case of Ranganthittu (Neginhal 1982).

Since most observations on nest losses are based on observations made during the day, the impact of night time predation remains largely unaccounted for. However, some scattered reports confirm its occurrence. For instance, Common Indian Monitor *Varanus bengalensis* climbing on trees and devouring the eggs of Painted Stork in evenings at the Delhi Zoo is one recorded case (Meganathan and Urfi 2009). At Bharatpur, most kills of fledgling Painted Stork by *Aquila* were recorded on moonlit nights (Naoroji 1990).

The main predation pressure is of course exerted by raptors against which there is often no protection. Several points are of interest here. Firstly, in north India at least the period when nests have fledglings is the same time when the influx of migratory raptors begins (Naoroji 1990). Secondly, recent studies at Delhi Zoo and Sultanpur (Urfi *et al.* 2007; Meganathan and Urfi 2009) have hinted of a broad correlation between the body sizes of predator and prey. For instance, while Crow *Corvus splendens* attack small nestlings (<15 days old), Black Kite *Milvus migrans* showed a preference for older nestlings (> 15 days). Thirdly, there are differences in predator species at colonies located in urban areas and those in the country, as would be expected. While at Delhi Zoo, which is located in a large city, omnivorous, birds like crows and kites account for most of the egg and nestling losses, at natural areas like Sultanpur and Keoladeo, those raptors which are partial to undisturbed areas in the country such as Greater Spotted Eagle *Aquila clanga*, Steppe Eagle *Aquila nipalensis*, Imperial Eagle *Aquila heliaca* and Pallas's Fishing Eagle *Haliaeetus leucoryphus* are the main predatory agents (Naoroji 1990; Urfi *et al.* 2007). This therefore leads to the question, since at urban sites predation pressure is lower, compared to colonies in the countryside, could this be an additional inducement for the formation of colonies in urban premises, besides conditions of safety and availability of suitable nesting substrates?

Detailed observations on the mode of attack by *Aquila* spp. are known largely through the observations of Naoroji (1990) at Bharatpur. For instance, only nestlings were taken and adults were seldom attacked. The hunting method of raptors was opportunistic and cases of their trying to bully adults, mostly unsuccessfully, to leave nests were also recorded. Kleptoparasitism among the raptors and often involving crows (*Corvus splendens* and *C.* [*macrohynchos*] *culminatus*) was common. An examination of nestlings attacked revealed that a number of individuals had sustained head and neck injuries, suggesting that most attacks were directed towards the head. Earlier, Lowther (1949) recorded a breast portion of Painted Stork eaten and rest discarded. Interestingly, while at the Keoladeo, nests in isolated patches were observed to be preyed upon as frequently as nests in groups, spatial variations in predation rates were observed at Delhi Zoo (Meganathan and Urfi 2009).

Infertile Eggs

Eggs lying in nests, generally untouched by predators and hence assumed to be infertile, have been recorded at Delhi Zoo and Sultanpur (Desai *et al.* 1977; Urfi *et al.* 2007; Meganathan and Urfi 2009).

Starvation

Starvation is often attributed to be a major cause of nestling loss in birds, especially in the first two weeks post hatching. At the Delhi Zoo the figure of yearly starvation deaths was estimated at around 38% (Desai *et al.* 1977). Although the deceased nestlings were not examined to study body condition and to verify the cause of death, the study noted that competition between the siblings, in which older nestlings monopolized all the food regurgitated by the parents on the nest floor, resulted in the younger siblings losing condition and eventually dying. In some years, notably 1966, 1967 and 1971, the number of nestling deaths, assumed to have been caused due to starvation, was recorded to be 44%,

50% and 55% respectively. Compared to 1968-1970 when such mortalities were below 33%, this is a high number and could be due to shortage of food. However, the authors do not mention if these years were also years of bad monsoon, when food production in the natural wetlands, which is rain dependent, would be expected to be low.

Abiotic factors

Weather

Although the Painted Stork exhibits a wing spread behaviour at nest, typical of genus *Mycteria* (Hancock *et al.* 1992), to shield nestlings from the sun and also regurgitate water to bring down nest temperatures on hot days, no cases of nestling mortalities due to over heating are on record. However, fluctuations in environmental temperatures leading to nestling mortalities in White Stork *Ciconia ciconia* have been reported (Jovani and Tella 2004). It would be expected that for warm tropical environments like India, hypothermia related mortalities would be rare. However, in Delhi, where environmental temperatures in December and January can drop to *c.* 7°C in the night (WWIS 2010) some nestling mortalities can be expected. Indeed, bodies of juveniles and adults (n<5) were observed on days immediately succeeding very cold days during 1988-1992 at the Delhi Zoo (Urfi unpubl. obs). However, since the corpses observed to be strewn on branches of trees close to the nests, were not recovered for a post mortem examination, it could not be ascertained if these deaths were indeed due to hypothermia. Dead nestlings and adults were also observed during the study in 2005-06 (Meganathan and Urfi 2009).

Human factors

Though storks and other heronry birds build colonies in urban premises, they are quite sensitive to human disturbance (Urfi 1990; Datta and Pal 1993; Gadhvi 2002).While many cases of nest losses due to human factors are on record some interesting ones are enumerated below. In Udupuria, nestlings and juveniles were attacked by (honey) bees when a hive on one of the nesting trees was accidentally disturbed by villagers. Twelve nestlings and 23 subadults were found dead, up to 200 m from the colony (Nair 2006). At Bhavnagar, many subadults making their initial flights were recorded to get entangled in the kite strings and get killed. Unfortunately, the timing of kite flying festival in the city coincides with the time when the young are big enough to make the first local flights (Parasharya and Naik 1990). In addition to these, disturbance leading to nest abandonment, either due to the presence of large number of people near the colony or bursting firecrackers (Vashishtha 2001) and putting up scare crows are also on record. At Ranganthittu, if the tourist boats go very near the breeding birds they get frightened and fly away leaving their nests unprotected. The crows anticipating this situation follow the boats and pillage the eggs and even take away the nestlings from the unguarded nests (Neginhal 1982).

ACKNOWLEDGEMENT

I thank the University of Delhi for providing funds under its scheme – 'Strengthen R & D Doctoral Research Programme by providing funds to university faculty' which enabled me to complete this paper.

REFERENCES

BirdLife International (2001): Threatened birds of Asia: The BirdLife International Red Data Book. BirdLife International: Cambridge, U.K.

Brown, C.R. & M.B. Brown (2001): Avian coloniality, progress and problems. *In*: Nolan, Jr., V. & C.F. Thompson (Eds): Current Ornithology. Kluwer Academic/Plenum Publishers: New York.

Datta, T. & B.C. Pal (1993): The effect of human interference on the nesting of the Openbill Stork (*Anastomus oscitans*) at the Raiganj Wildlife Sanctuary, India. *Biological Conservation 64*: 149-154.

Desai, J.H., G.H. Menon & R.V. Shah (1977): Studies on the Reproductive pattern of the Painted Stork, *Ibis leucocephalus* Pennant. *Pavo 15*: 1-32.

Gandhvi, I. (2002): Painted Storks abandon nesting colony at Bhavnagar, Gujarat. *Newsletter for Birdwatchers 42*: 12.

Hancock, J.A., J.A. Kushlan & M.P. Kahl (1992): Storks, Ibises and Spoonbills of the World. Academic Press, New York. Pp. 385.

Ishtiaq, F., S. Javed, M.C. Coulter & A.R. Rahmani (2010): Resource partitioning in three sympatric species of storks in Keoladeo National park, India. *Waterbirds 33*: 41-49.

Jovani, R. & J.L. Tella (2004): Age-related environmental sensitivity and weather mediated nestling mortality in White Storks (*Ciconia ciconia*). *Ecography 27*: 611-618.

Lowther, E.H.N. (1949): A Bird Photographer in India. Oxford University Press, London. Pp. xii, 150.

Kalam, A. & A.J. Urfi (2008): Foraging behaviour and prey size of the Painted Stork (*Mycteria leucocephala*). *J. Zoology. 274*: 198-204.

Meganathan, T. & A.J. Urfi (2009): Inter-colony variations in nesting ecology of Painted Stork (*Mycteria leucocephala*) in the Delhi Zoo (North India) *Waterbirds 32*: 352-356.

Nagulu, V. & J.V.R. Rao (1983): Survey of South Indian Pelicanries. *J. Bombay Nat. Hist. Soc. 80*: 141-143.

Nair, A.K. (2006): Udpuria - A Stork Paradise. *Hornbill 2*: 32-33.

Naoroji, R. (1990): Predation by *Aquila* Eagle on nestling storks and herons in Keoladeo Ghana National Park, Bharatpur. *J. Bombay Nat. Hist. Soc. 87*: 37-46.

Neginhal, S.G. (1977): Discovery of a pelicanry in Karnataka. *J. Bombay Nat. Hist. Soc. 74*: 169-170.

Neginhal, S.G. (1982): The birds of Ranganathittu. *J. Bombay Nat. Hist. Soc. 79*: 581-593.

Pande, S. (2006): Bhadalwadi Tank, A refuge for Painted Storks. *Hornbill 2*: 11-15.

PARASHARYA, B.M. & R.M. NAIK (1990): Ciconiiform birds breeding in Bhavnagar city, Gujarat. A study of their nesting and a plea for conservation. Pp. 429-445. *In*: Daniel, J.C. & J.S. Serrao (Eds): Conservation in Developing Countries. Problems and Prospects. Bombay Natural History Society. Oxford University Press, Delhi.

SUNDAR, K.S.G. (2006): Flock size, density and habitat selection of four large waterbirds species in an agricultural landscape in Uttar Pradesh, India: implications for management. *Waterbirds 29*: 365-374.

SUBRAMANYA, S. & K. MANU (1996): Saving the Spot-billed Pelican. A successful experiment. *Hornbill 2*: 2-6.

URFI, A.J. (1990): Mysterious disappearance of Painted Stork from Delhi Zoo heronries and abrupt termination of their breeding. *Newsletter for Birdwatchers. 30*: 3-5.

URFI, A.J. (2003): Record of a nesting colony of Painted Stork *Mycteria leucocephala* at Man-Marodi Island in the Gulf of Kutch. *J. Bombay Nat. Hist. Soc. 100*: 109-110.

URFI, A.J. & A. KALAM (2006): Sexual size dimorphism and mating pattern in the Painted Stork (*Mycteria leucocephala*) *Waterbirds 29*: 489-496.

URFI, A.J., T. MEGANATHAN & A. KALAM (2007): Nesting ecology of the Painted Stork (*Mycteria leucocephala*) at Sultanpur National Park, Haryana, India. *Forktail 23*: 150-153.

VASHISHTHA, S.C. (2001): Painted Storks abandon colony after bursting of crackers at Pandad, Gujarat. *Newsletter for Birdwatchers 41*: 13

WWIS (WORLD WEATHER INFORMATION SERVICE) (2010): India, Weather information for New Delhi. http://www.worldweather.org/066/c00224.htm. accessed on March 5, 2010.

5. PARTIAL ALBINISM IN BLACK IBIS *PSEUDIBIS PAPILLOSA*

RAJESH C. SENMA[1,2] AND CHIRAG A. ACHARYA[1,3]

[1]Department of Zoology, M.N. College, Visnagar 384 315, Gujarat, India.
[2]Email: rcsibis@gmail.com
[3]Email: drchirag_acharya@yahoo.com

Albinism is the absence of the pigment melanin in organisms. Albinism in birds has been classified into four groups (Pettingill 1956). Total albinism is complete absence of melanin; incomplete albinism is lack of pigment either in the plumage, eyes or unfeathered parts, but never all three. In Imperfect albinism melanin is reduced either in the plumage, eyes, or unfeathered parts. Partial albinism is total absence of melanin from only a few feathers; the pigment-free areas may be symmetrical or asymmetrical.

On August 18, 2009, at 11:00 hrs, during our 3-year study at Kharodo between Miyasana and Nandali village, situated in Mehsana district, north Gujarat (23° 55' N; 72° 38' E), 5 km far from Kheralu, we observed asymmetrical partial albinism in a Black Ibis *Pseudibis papillosa* feeding in a small flock. This is the first record of asymmetrical partial albinism in Black Ibis from this area (Fig. 1).

Albinism in birds has been reported in the past: Great-tail Grackle (Phillips 1954), House Wren and Carolina Wren (Ross 1963), Carolina Wren (Seneca 1985), Hooded Crow (Slagsvold *et al.* 1987), Black Drongo (Prasad 2000), and Red-vented Bulbul (Patel 2009).

Total albinism is caused due to complete lack of tyrosinase activity in the organism. Mechanisms leading to partial loss of tyrosinase activity in birds has not been elucidated, but presumably involve mutations or other known mechanisms of gene inactivation.

Fig. 1: Asymmetrical partial albinism observed in a small flock of Black Ibis

The observation that some families of birds are more prone to albinism than others is interesting, but the biological causes underlying these observations remain unclear. Hopefully, continued documentation of aberrant plumages in all families of birds will eventually lead to generation of testable hypotheses to explain these fascinating and striking plumage patterns.

ACKNOWLEDGEMENTS

Financial support from UGC, New Delhi, through a RGNJRF scheme for SC/ST candidates is gratefully acknowledged. We are thankful to Prin. Dr. M.I. Patel for his valuable suggestions. We also thank Prof. R.M. Gohel, Paras Desai and Chirag Patel for their help in field.

REFERENCES

PATEL, P. (2009): Albinism in birds. *Vihang*: *Pool among bird watchers* (Gujarati) *3*: 56-57.

PETTINGILL, S. JR. (1956): A laboratory and field manual of Ornithology. 3rd Ed. Burgess Publ. Co., Minneapolis.

PHILLIPS, A.P. (1954): The cause of partial albinism in a Great-tailed Grackle. *Wilson Bull. 66*: 66.

PRASAD, G. (2000): The Black Drongo's (*Dicrurus macrocercus* (Bechstein)) white crown. *Zoos' Print Journal 15(10)*: 349.

ROSS, C.C. (1963): Albinism among North American birds. *Cassinia 47*: 2-21.

SENECA, J.J. (1985): A record of extreme leucism in the Carolina Wren. *Wilson Bull. 97*: 222.

SLAGSVOLD, T., G. ROFSTAD & J. SANDVIK (2009): Partial albinism and natural selection in the hooded crow *Corvus corone* cornix. *Journal of Zoolgy 24(1)*: 157-166.

6. FIRST RECORD: SELECTION OF AN ELECTRIC POLE AS A ROOSTING SITE BY BLACK IBIS IN NORTH GUJARAT REGION

RAJESH C. SENMA[1,2] AND CHIRAG A. ACHARYA[1,3]

[1]Department of Biology, M.N. College, Visanagar 384 315, Gujarat, India.
[2]Email: rcsibis@gmail.com
[3]Email: drchirag_acharya@yahoo.com

We observed 72 Indian Black Ibis *Pseudibis papillosa* on a giant electric pole on the roadside, and 42 on another electric pole off the road at Vasaniya Mahadev (23° 19' N; 72° 38' E, 89 m above msl), Gujarat, when we were returning from Gandhinagar on December 25, 2009, at 18:05 hrs. We stopped our car and waited for sunset, after sunset we could hear the Indian Black Ibis call. We waited for two hours to confirm if this was a roosting site of the Indian Black Ibis. We also asked the local people who confirmed that Indian Black Ibis gathered to roost on electric poles. On earlier occasions (three to four times) we have noted similar behaviour on the outskirts of Visnagar (23°42' N; 71°34' E, 127 m above msl), Gujarat; where five to seven Black Ibis were observed roosting on an electric pole (Eds: photographic evidence provided). This, however, is the first record of a flock of Black Ibis roosting on electric poles.

During a three-year period we had observed Indian Black Ibis usually roosting on tall trees like Nilgiri *Eucalyptus globulus*, Neem *Azadirachta indica*, Mango *Mangifera indica*, Polyalthia *Polyalthia longifolia* and species of *Ficus*. Several authors (Chavda 1988; Vyas 1992; Chavda 1997; Soni 2008) have noted that Black Ibis use tall trees like *Cocos nucifera*, *Borassus flabellifer*, *Roystonea regia*, *Millingtonia hortensis*, *Polyalthia cerasoides*, *Ficus amplissima*, *Tamarindus indica*, *Sterculia foetida*, *Ficus religiosa*, *Prosopis cineraria*, *Albizia lebbeck* for roosting. They are part of a single or multi species communal roost. Usually the birds select the largest trees in the vicinity, probably because such trees are safer than the shorter trees. But selection of a giant electric pole for roosting might be an adaptive response of the birds to its abnormal height.

ACKNOWLEDGEMENTS

We thank UGC (Rajiv Gandhi National Fellowship Scheme for SC/ST students) for providing financial assistance. We are also grateful to Dr. M.I. Patel, Principal, M.N.College, Visnagar for providing facilities.

REFERENCES

CHAVDA, P.B. (1988): Behavioural and Ecological study of Indian Black Ibis *Pseudibis papillosa* at Junagadh. M. Phil. dissertation, Saurashtra University, Rajkot.

CHAVDA, P.B. (1997): Studies on some ecological aspects of the Indian Black Ibis *Pseudibis papillosa* (Temminck), at Junagadh and its surrounding area. Ph.D. Thesis, Saurashtra University, Rajkot.

SONI, K.C. (2008): Study on population, foraging, roosting and breeding activities of the Black Ibis / Red napped Ibis (*Pseudibis papillosa*) inhabiting the arid zone of Rajasthan. Ph.D. Thesis, Maharshi Dayanand Saraswati University, Ajmer.

VYAS, S. (1992): Ecological and Behavioral Study of the Indian Black Ibis. Ph.D. Thesis, Saurashtra University, Rajkot.

7. OCCURRENCE OF THE GREAT INDIAN BUSTARD *ARDEOTIS NIGRICEPS* IN BIKANER REGION OF THE THAR DESERT

PARTAP SINGH[1,4], D.R. SAHARAN[1], JITENDAR SOLANKI[2] AND S.P. MEHRA[3]

[1]5-C-137, JNV Colony, Bikaner 334 003, Rajasthan, India.
[2]Vinayaka Guest House, Old Ginani, Bikaner 334 001, Rajasthan, India. Email: vinayakguesthouse@gmail.com
[3]Kesar Bhawan, 16/747, P. No. 90, B/d Saraswati Hosp., Ganeshnagar, Pahada, Udaipur 313 001, Rajasthan, India.
Email: spmehra@yahoo.com
[4]Email: partapsk@yahoo.com

Great Indian Bustard (hereafter, GIB) *Ardeotis nigriceps* is an endangered bird species of India (Islam and Rahmani 2002) and is the state bird of Rajasthan. According to an estimate of Rahmani and Manakadan (1990) the total number

of GIBs in India is between 1,500-2,000, and that too if the species does not migrate from Rajasthan to Andhra Pradesh (two states with maximum number of GIBs). This number seems to be exaggerated as other species of genus *Ardeotis* are known for migrating long distances (Ziembicki and Woinarski in press) and species *nigriceps* might also be travelling long distances. Dharamkumarsinhji's survey conducted on behalf of WWF (World Wildlife Fund Project 453, 1970-78), estimated total population of *A. nigriceps* throughout its range in India as no more than 1,260 in 1969 and 745 in 1978 (Roberts 1991). The species can no longer be seen in Haryana, Punjab (Grimmett *et al.* 1998) and Uttar Pradesh (Allen 1918). Soon many more states may join this list of its former range of distribution. Ali and Ripley (1983) opined that not only is the distribution constricting, but also the number is dwindling due to human pressure.

We recently observed a single male *Ardeotis nigriceps* in the grasslands of Nokh Daiya, a small village about 30 km from Bikaner City. We were monitoring the wildlife census parties of Bikaner, and while moving from Nokh Daiya to Gajner Blackbuck Sanctuary we spotted GIB in the uninhabited outskirts of the villages *"Rohi"*. This is the first authentic record of occurrence of GIB near Bikaner in the last 20 years. Earlier records of its distribution indicate that the species was quite abundant in Bikaner region. Hume (1890) reported a collection of more than 100 bustard eggs from Bikaner region. Survey of BNHS in early 1980s reported the occurrence of this bustard species near Gajner, though they could not sight it (Rahmani and Manakadan 1990). Sighting of this endemic bird is welcome news for naturalists of the region. One pair of GIBs has also been reported to occur in the Tal Chhapar Blackbuck Sanctuary (Punia pers. comm.). The pair was first sighted in July and stayed in the Sanctuary for about two and half months.

The biggest threat to avian diversity of Gajner, Nokh Daiya, and its vicinity are the Plaster of Paris (POP) factories. About 150 factories in the area use wood to heat up the furnaces to prepare POP. One factory consumes one truck load of wood in five to six days, a huge pressure on the native flora. The factory owners claim to import the wood from Gujarat but the declining tree numbers in the region seem to tell another story. Some factories also use cow dung cakes (cow dung mixed with hay) instead of wood. The other big threat to the native birds is the construction of big water reservoirs, which will store IG canal water and after filtration this will be supplied for human use. The large grasslands on the outskirts of Gajner Sanctuary can provide ideal refuge to this endangered species of India. If anthropogenic interferences are reduced, there is no reason this species should not roost and breed here.

REFERENCES

Ali, S. & S.D. Ripley (1983): Compact Handbook of Birds of India and Pakistan. Oxford University Press, Delhi. 1-737 + 104 Plates.

Allen, G.O. (1918): The great Indian Bustard in Mirzapur district, U.P. *J. Bombay Nat. Hist. Soc. 26(1-2)*: 673.

Grimmett, R., C. Inskipp & T. Inskipp (1998): Birds of the Indian Subcontinent. Oxford University Press, Delhi. Pp. 1-888.

Hume, A.O. (1890): The Nests and Eggs of Indian Birds. 3 Vols., 2nd Edn. R.H. Porter, London.

Islam, M.Z. & A.R. Rahmani (2002): Threatened Birds of India. *Buceros* Vol. 7 (1 -2). Compiled from Threatened Birds of Asia. Birdlife International Red Data Book (2001). Cambridge, U. K.: Birdlife International.

Rahmani, A.R. & R. Manakadan (1990): The past and present distribution of the great Indian Bustard *Ardeotis nigriceps* (Vigors) in India. *J. Bombay Nat. Hist. Soc. 87(2)*: 175-191.

Roberts, T.J. (1991): The Birds of Pakistan. Vol. I. Oxford University Press, Karachi. Pp. 1-598.

Ziembicki, M. & J. Woinarski (in press): Monitoring continental movement patterns of the Australian Bustard through community-based surveys and remote sensing. Pacific Conservation Biology.

8. ADDITION TO THE AVIFAUNA OF THE INDIAN SUBCONTINENT – "WHITE-FACED" PLOVER *CHARADRIUS DEALBATUS* FROM ANDAMAN AND NICOBAR ISLANDS, INDIA

Nikhil Bhopale[1]

[1]Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk, S.B. Singh Road, Mumbai 400 001, Maharashtra, India. Email: nikhilbhopale23@gmail.com

The "White-faced" Plover *Charadrius dealbatus* breeds in the south coast of China, including Hainan. It winters locally along the coast from southern Vietnam, through the Gulf of Thailand and south along the west coast of the Malay Peninsula to Singapore, and the east coast of Sumatra, Indonesia (Kennerley *et al.* 2008).

During a BNHS camp in the Andaman and Nicobar Islands, I spotted a wader, which at first glance looked like the

Kentish Plover *Charadrius alexandrinus*, on the sand bar of Smith and Ross Islands (13°18' 15" N; 93° 04' 21" E) in North Andamans on March 18, 2010. I was not sure about its identification so I clicked a few photographs. On further observations through a 10 x 5 binocular, the face looked much whiter compared to that of a Kentish Plover, and the legs were orangish with longer tarsus, more white on wings (in flight). Literature survey (Grimmett *et al.* 1999; Kazmierczak 2000; Rasmussen and Anderton 2005) could not help in identification.

After coming back I searched www.orientalbirdimages.org, unsuccessfully, for different races of Kentish Plover. I refined my web-search, and looked for the term "White-faced" Plover (after its characteristics) without knowing of the existence of such a bird. My search ended at a published paper on a bird called "White-faced" Plover by Peter Kennerley. The bird spotted at Andaman and Nicobar Islands matched the descriptions and photographs of the "White-faced" Plover *Charadrius dealbatus* in Kennerley *et al.* (2008). After confirming the identification I visited the BNHS collection where I found six specimens of '*dealbatus*', but all from south-east Asia. Therefore, this is the first record of *Charadrius dealbatus* for the Indian subcontinent.

ACKNOWLEDGEMENTS

I thank Mr. Peter Kennerley for confirming the identification of the bird. I thank Mr. Vithoba Hegde, Senior Field Assistant, BNHS, for showing the specimens in the BNHS Collection.

REFERENCES

Kazmierczak, K. (2000): A Field Guide to the Birds of India, Sri Lanka, Pakistan, Nepal, Bhutan, Bangladesh and the Maldives, Om Book Service. Pp. 114.

Grimmett, R., C. Inskipp & T. Inskipp (1999): Pocket Guide to the Birds of the Indian Subcontinent. Oxford University Press. Pp. 126.

Rasmussen, P.C. & J.C. Anderton (2005): Birds of South Asia – The Ripley Guide. Vol. 2. Smithsonian Institution & Lynx Edicions. Pp. 116.

Kennerley, P., D. Bakewell & P. Round (2008): Rediscovery of a long-lost *Charadrius* plover from South-East Asia. *Forktail 24*: 63-79.

9. FIRST RECORD OF THE HUME'S LEAF-WARBLER *PHYLLOSCOPUS HUMEI* FROM KACHCHH, GUJARAT, INDIA

Nikhil Bhopale[1]

[1]Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk, S.B. Singh Road, Mumbai 400 001, Maharashtra, India.
Email: nikhilbhopale23@gmail.com

Hume's Leaf-warbler *Phylloscopus humei* breeds from Central Asia to West Mongolia. It winters in gardens, orchards, and dry-deciduous forests in the Indian subcontinent from *c.* 1,400 m downwards to the plains of northern Pakistan and peninsular India south to Belgaum, Hyderabad and Anantagiri, east to lower hills of Sikkim; Nepal, Bhutan and Bangladesh (Ali and Ripley 1987; Grimmett *et al.* 1999; Kazmierczak 2000; Rasmussen and Anderton 2005).

In Gujarat, specimens of the Hume's Leaf-warbler were collected from Bodeli and Dabka, Baroda district, and from Mheskatri, Surat Dangs (Ali 1955). The species is not listed in THE BIRDS OF KUTCH (Ali 1945). Jugal Tiwari (pers. comm.), a former scientist of the BNHS, who has been birding in the Kachchh area since the 1990s has had no sighting of the species in the area.

During a BNHS birding camp in Kachchh, I spotted a Leaf-warbler at around 4-5 m height in the canopy of a tree on December 24, 2009, at 17:00 hrs in the Chadwa Private Reserve (23° 09' N; 69° 28' E) near Pragsar lake, 15 km south-west of Bhuj. On further observations through 10 x 5 binoculars, I noted it to have two white wing-bars and, a dark bill and legs, suggestive of Hume's Leaf-warbler. We observed the bird for 15 minutes, it gave a short *tze-weet* call, further confirming its identity, and record of occurrence in Kachchh. The similar Yellow-browed Leaf-warbler *Phylloscopus inornatus* has yellowish wing-bars and ear-coverts, pale lower mandible, paler legs and has a different call (Kazmierczak 2000).

ACKNOWLEDGEMENTS

I would like to thank Mr. Jugal Tiwari for providing valuable information on the species. I am grateful to Dr. Ranjit Manakadan for his expert comments on the note.

REFERENCES

Ali, S. (1945): The Birds of Kutch, Oxford University Press, 175 pp.

Ali, S. (1955): The Birds of Gujarat, Part II. *J. Bombay Nat. Hist. Soc. 52(4)*: 759.

Ali, S. & S.D. Ripley (1987): Handbook of the Birds of India

and Pakistan, Compact Edition, Oxford University Press. Pp. 549.

GRIMMETT, R., C. INSKIPP & T. INSKIPP (1999): Pocket Guide to the Birds of the Indian Subcontinent. Oxford University Press. Pp. 294.

KAZMIERCZAK, K. (2000): A Field Guide to the Birds of India, Sri Lanka, Pakistan, Nepal, Bhutan, Bangladesh and the Maldives. Om Book Service. Pp. 258.

RASMUSSEN, P.C. & J.C. ANDERTON (2005): Birds of South Asia – The Ripley Guide. Vol. 2. Smithsonian Institution & Lynx Edicions. Pp. 308.

10. AN OBSERVATIONAL NOTE ON GANGETIC LATIA *CROSSOCHEILUS LATIUS LATIUS* IN KHOH RIVER, UTTARAKHAND, INDIA

VIDYADHAR ATKORE[1]

[1]Wildlife Institute of India, P.O.Box.18, Chandrabani, Dehradun 248 001, Uttarakhand, India.
Current Address: Ashoka Trust for Research in Ecology and Environment (ATREE), Jakkur Post, Srirampura, Bengaluru 560 064, Karnataka, India. Email: vidyadhar.atkore@gmail.com

The taxonomic description of many freshwater fishes has been illustrated earlier by taxonomists in the country. The information on general behaviour, including their migration, reproduction, feeding habits of many freshwater fishes are poorly known.

During my M.Sc. dissertation study from November 2004 to April 2005 on the conservation status of freshwater fishes in the tributaries of River Ramganga in Uttarakhand, I made an interesting observation on *Crossocheilus latius* in the Khoh river (Atkore 2005). It is a specialized hill stream fish widely distributed in the Ganges, Brahmaputra, Mahanadi rivers and upper catchment of Krishna river basin in the Western Ghats (Talwar and Jhingran 1991). The species can grow up to 16.5 cm and prefers boulders, gravel bottom and swift flowing section of the channel unit.

It was originally described as *Cyprinus latius* in 1822 by Hamilton Buchanan in his 'GANGETIC FISHES FROM THE TISTA' from the base of Darjeeling Himalayas. He classified this fish as *Cyprinus garra* due to certain similar morphological features and habits that the fish has in common with some species of *Garra* (Mukerji 1934).

On March 12, 2004, I was surveying fish in the Khoh river along with my field assistant Bahadur. The shrubby vegetation along the bank and big boulders made it difficult for the fish to move upstream. A deep pool had formed at the bottom of the boulders, but some species, especially Snow Trout *Schizothorax richardsonii*, were jumping over boulders to move upstream. One species caught my attention, it was *Crossocheilus latius*. Three individuals of this species were attached to a boulder and slowly moving upstream. Unlike the other species, these were crawling and not jumping over the boulders. While doing so, they lost contact with water for sometime. I observed their movement for ten minutes 16:20 hrs to 16:30 hrs from a close distance. The height of the boulder above the water column was 2.2 m and the width was 0.6 m. The boulder was moist due to intermittent water contact. The lower part of the boulder had algal growth. It seems that this species showed local migratory movement. I did not find any feeding marks by this species on the exposed boulders in this observation. Buchanan (1822) believed that *Crossocheilus latius* was an ancestor of *Garra*. Hora (1921) confirmed that *Crossocheilus* species resemble *Garra* in its structure of air-bladder and the skeleton of the mouthparts.

Available literature on the ecology of species was limited. However, Hora and Mukerji (1936) noted that *Garra gotyla* and *Crossocheilus latius* may compete for food (algae) in the same habitat but they did not provide any data to support their observation. Previous study showed that, *Garra gotyla* was relatively dominant (13.55%) than *Crossocheilus latius latius* (0.44%) in Khoh river (Atkore 2005). Again, with this data it may be difficult to conclude that these two species compete with each other for the same food resource. However, this needs further close observation on feeding behaviour or data on gut content of both these species from the same habitat in order to prove this.

ACKNOWLEDGEMENTS

This observation was a part of Masters Dissertation from Wildlife Institute of India, Dehradun, supported by Ministry of Environment and Forests, Government of India. I sincerely thank Patrick David, Chandrima Home and anonymous referees for their valuable comments. I also thank my field assistants including Bahadur, without whom this work could not have been accomplished.

REFERENCES

ATKORE, V.M. (2005): The conservation status of freshwater fishes in the tributaries of Ramganga with special reference to Golden Mahseer (*Tor putitora*) Uttarakhand, India. A master's thesis copy submitted to Saurashtra University, Rajkot, Gujarat. 76 pp.

HORA, S.L. (1921): Indian Cyprinoids Fishes of the genus *Garra* with notes on related species from other countries. *Rec. Ind. Mus. 22*: 633-687.

HORA, S.L. & D.D. MUKERJI (1936): Fish of the Eastern Doons, United Province. *Rec. Indian Mus. 38*: 133-145.

MUKERJI, D.D. (1934): Report on Burmese fishes collected by Lt. Col. R.W. Burton from the tributary streams of the Mali Hka River of the Myitkyina district (Upper Burma). *J. Bombay Nat. Hist. Soc. 37(1)*: 38-80.

TALWAR, P.K. & A.G. JHINGRAN (1991): Inland Fishes of Indian and adjacent countries. Pvt. Ltd. 1 & 11, New Delhi. 1158 pp.

11. A NEW RECORD OF LARVAL HOST PLANT OF TAWNY COSTER *ACRAEA VIOLAE* (FABRICIUS)

RUDRA PRASAD DAS[1,3], ARJAN BASU ROY[2,4], RADHANATH POLLEY[2] AND GOUTAM SAHA[1,5]

[1]Entomology & Wildlife Biology Research Unit, Department of Zoology, University of Calcutta, 35 Ballygunge Circular Road, Kolkata 700 019, West Bengal, India.
[2]Nature Mates-Nature Club, 4/10A Bijoygarh, Kolkata 700 032, West Bengal, India.
[3]Email: rudraprasaddas@hotmail.com
[4]Email: naturemates@gmail.com
[5]Email: gkszoo@rediffmail.com

Tawny Coster *Acraea violae* (Fabricius) belonging to Family Nymphalidae can be easily identified by its slow fluttering flight (Wynter-Blyth 1957) and is fairly common at lower Bengal plains (Kehimkar 2008). On September 07, 2009, on a sunny morning, while walking through an abandoned rail track near a small village – Belun, Burdwan district (location: 23° 41.568' N; 88° 04.459' E); altitude: 12 m above msl) West Bengal, India, dozens of Tawny Coster larvae of different instars were spotted creeping on the railway tracks. After close observation they were found feeding on a small herb called 'Spade Flower' or 'Pink Ladies Slipper' *Hybanthus enneaspermus* (L.) F. Muell (=*Ionidium suffruticosum* Ging) of Family Violaceae (Paria 2005). The herb grows up to a height of 60 cm and has pink-purple spade-shaped solitary flowers. The plant is well-distributed throughout India. Common Hindi and Bengali names of this plant are '*Ratanpurush*' and '*Nunbora*' respectively. The known larval host plants of Tawny Coster are *Passiflora foetida*, *P. edulis*, *P. subpeltata*, *Adenia hondala* (Family Passifloraceae), and *Aposora lindleyana* (Family Euphorbiaceae) (Kunte 2000; Robinson *et al.* 2001; Kehimkar 2008), which are mostly climbers. But record of *Hybanthus enneaspermus* (L.) F. Muell as larval host plant for this butterfly has not been documented earlier. It indicates the diversification of known larval host plant for Tawny Coster.

Fig 1: Caterpillar of *Acraea violae* (Fabricius) feeding on the leaves of *Hybanthus enneaspermus* (L.) F. Muell

This new source of food for the larva will help to strengthen the chance of survival of this species in the wild. It may also lead to a record of range extension of this butterfly, where these plants are found in abundance.

ACKNOWLEDGEMENT

We thank Mr. Tamoy Ghosh (President, iREBEL) for his support during our visit to Belun village.

REFERENCES

KEHIMKAR, I. (2008): The Book of Indian Butterflies. Bombay Natural History Society, Mumbai. 497 pp.

KUNTE, K. (2000): Butterflies of Peninsular India (India: A Lifescape Fascicle 1). Universities Press (Hyderabad) and Indian Academy of Sciences (Bangalore). 254 pp.

PARIA, N.D. (2005): Medicinal Plant Resources of South West Bengal. Directorate of Forests, Government of West Bengal, Kolkata. 198 pp.

ROBINSON, G.S., P.R. ACKERY, I.J. KITCHING, G.W. BECCALONI & L.M. HERNANDEZ (2001): Hostplants of the Moth and Butterfly Caterpillars of the Oriental Region. Natural History Museum, London. 722 pp.

WYNTER-BLYTH, M.A. (1957): Butterflies of the Indian Region. Bombay Natural History Society, Mumbai. 523 pp.

12. A CHECKLIST OF ANTS OF THIRUNELLI IN WAYANAD, KERALA

K.A. Karmaly[1,3], S. Sumesh[1,4], T.P. Rabeesh[1,5] and Lambert Kishore[2]

[1]Department of Zoology, St. Xavier's College for Women Aluva, Kerala 683 101, India.
[2]Department of Zoology, Malabar Christian College, Calicut, Kerala 673 100, India. Email: lambert3698@rediffmail.com
[3]Email ID: dr.karmaly@gmail.com
[4]Email ID: sumeshsdas@gmail.com
[5]Email ID: rabeeshtp@gmail.com

Introduction

Wayanad is in the north-east of Kerala, India. Study sites are located at Thirunelli (11°27'-15°58' N; 75°47'-70°27' E) in Wayanad region, southern part of Western Ghats. Biogeographically, Wayanad region of Western Ghats is a transitional zone between the moist-deciduous and dry-deciduous forests, harbouring many restricted habitats, endemic species, as well as disjunctive populations of species that are found in moist deciduous, evergreen and dry-deciduous forests (WWF 2001).

Thirunelli forests spread over an area of 20.55 sq. km and occur at an elevation of *c*. 900 m and above. The distance from the mean sea level and forest cover creates a salubrious climate in the region. Generally the year is divided into four seasons; cold (10 °C), and hot (35 °C) weather, South-West and North-East monsoon. The average rainfall is 2,200 mm per year. Climate of Wayanad are characteristic of the Western Ghats and the flora and fauna are showing very rich biodiversity.

The present study attempts to record the ant fauna in deciduous and shola forests at Thirunelli in Wayanad. The ants collected from different parts of Thirunelli were identified using taxonomic keys.

Methodology

The collection of ants is made by random sampling methods with sweep net, brush method and all out search method. The collected specimens were processed, preserved in 70% ethanol and prepared in the laboratory for systematic studies. The specimens were mounted on a rectangular card of 20 mm x 10 mm and pinned with Asta insect pins of 38 mm x 0.53 mm of No.3. Observations were made using High-performance, Modular Stereozoom microscope with a 40x magnification. Ants were identified using identification key by Bolton (Bolton 1994) and Fauna of British India (Bingham 1903).

Observation and Result

Considering the study of distribution of ants in Thirunelli-Wayanad area, 39 ants were found (Table 1) belonging to six subfamiles (Bolton 1994).

In Dolichoderinae, five species were found: *Tapinoma melanocephalum melanocephalum* (Fabricius). *Tapinoma indicum indicum* (Forel), which are common in these areas and present in the litter floor of all forest vegetation of Thirunelli-Wayanad region, *Technomyrmex albipes albipes* (Smith) was commonly found in all vegetation, and *Technomyrmex bicolor bicolor* Emery and *Technomyrmex elatior* Forel were rare.

Subfamilies Aenictinae and Dorylinae with three species was the least dominant: in Aenictinae, *Aenictus ambiguus* Shuck, *Aenictus westwoodi* Forel, were mostly found in western India and in Dorylinae, *Dorylus orientalis* Westwood, common in southern India.

Thirteen species of ant belong to Subfamily Formicinae, the dominant family in Thirunelli. *Anoplolepis gracilipes* (Smith), found throughout the region, *Oecophylla smaragdina* (Fabricius), *Camponotus angusticollis angusticollis* (Jerdon), *Camponotus compressus* (Fabricius), *Camponotus parius* Emery, *Camponotus sericeus sericeus* (Fabricius) were common in this area, *Camponotus misturus fornaronis* Forel and *Camponotus radiatus* Forel were rare in this region, *Polyrhachis illaudata illudata* Walker and *Polyrhachis punctillata punctillata* Roger are the first report from Wayanad region, and *Polyrhachis convexa* Roger is the first report from the Indian subcontinent; Roger (1863 a) reported this species from Sri Lanka. *Lepisiota opaca opaca* a less dominant group was also found from this region.

Subfamily Myrmicinae showed 14 ant species. *Myrmicaria brunnea* Saunders, *Solenopsis geminata* (Fabricius) were common in the study area. The other non-endemic species – *Cardiocondyla parvinoda* Forel, *Cardiocondyla wroughtoni* Forel, *Crematogaster ebenina* Forel, *Monomorium wroughtoni* Forel, *Pheidole spathifera* Forel, *Pheidologeton affinis affinis* (Jerdon), *Tetramorium smithi* (Mayr), and *Tetramorium wroughtoni* (Forel); *Leptothorax rothneyi* Forel, *Myrmicaria* Saunders sp., *Strumigenys smythiesi* Forel, and *Carebara wroughtonii* (Forel) – were the rare species found from this area.

Five species of subfamily Ponerinae were collected, *Cryptopone* sp. is the first report for Wayanad region. *Diacamma rugosum sculptum* (Jerdon), *Diacamma scalpratum* (Smith), *Leptogenys ocellifera* (Roger), and *Odontomachus haematodes* (Linnaeus) were commonly encountered in the study area.

Table 1: Checklist of Ants of Thirunelli in Wayanad

Genus	species	Synonym	Habitat
Subfamily: Dolichoderinae			
Tapinoma	*melanocephalum melanocephalum* (Fab., 1793)	*Tapinoma australe* Santschi, 1928 *Tapinoma australis* Santschi, F. 1928 *Tapinoma familaris* Smith, F. 1860 *Tapinoma nana* Jerdon, 1851 *Tapinoma pellucida* Smith, F. 1857	Moist grass
Distribution in Kerala: Alappuzha (Muthukulam), Kannur (Aralam farm), Thrissur (Peechi KFRI, Kottapuram), Kottayam, Wayanad (Muthenga, Thirunelli), Malappuram (Calicut University Campus, Mampad College Campus), Ernakulam (Bolghaty, Tripunithura, Edappally), Calicut (Madappally, Devagiri), Idukki (Marayoor, Mathikettan Shola), Kasaragod (KAU Campus Padannakad).			
Tapinoma	*indicum indicum* (Forel, 1895)	-	Moist grass
Distribution in Kerala: Thiruvananthapuram (Neyyar), Palakkad (Parambikulam), Alappuzha (Muthukulam), Idukki (Meenuli, Thekkady), Wayanad (Muthenga, Thirunelli), Kannur (Aralam farm), Malappuram (Calicut University Campus).			
Technomyrmex	*albipes albipes* (Smith, 1861)	*Technomyrmex albitarse* (Mots., 1863) *Technomyrmex nigrum* (Mayr, 1862) *Technomyrmex rufescens* Santschi 1928 *Technomyrmex vitiensis* Mann, 1921	Moist grass
Distribution in Kerala: Wayanad (Muthenga, Thirunelli), Kollam (Thenmala), Alappuzha (Muthukulam), Ernakulam (Aluva), Thrissur (Chimmnoy Wildlife Sanctuary).			
Technomyrmex	*bicolor bicolor* Emery, 1893	-	Moist grass
Distribution in Kerala: Alappuzha (Muthukulam), Ernakulam (Aluva), Calicut (Anakampoyil, Madappally), Malappuram (Calicut University Campus), Wayanad (Muthenga, Thirunelli).			
Technomyrmex	*elatior* Forel, 1902	-	Moist grass
Distribution in Kerala: Wayanad (Thirunelli).			
Subfamily: Aenictinae			
Aenictus	*ambiguus* Shuck, 1840	-	Subterranean
Distribution in Kerala: Wayanad (Thirunelli), Kottayam (Pala).			
Aenictus	*westwoodi* Forel, 1901	-	Subterranean
Distribution in Kerala: Wayanad (Thirunelli).			
Subfamily: Dorylinae			
Dorylus	*orientalis* Westwood, 1835	*Dorylus curtisii* (Shuckard, 1840) *Dorylus longicornis* Shuckard, 1840 *Dorylus obertheri* (Emery, 1881)	Subterranean
Distribution in Kerala: Wayanad (Thirunelli, Muthenga), Idukki (Kuttikanam), Palakkad (Nelliyampathy).			
Subfamily: Formicinae			
Anoplolepis	*gracilipes* (Smith, 1857)	*Anoplolepis longipes* (Jerdon, 1851) *Anoplolepis trifaciata* (Smith, 1858)	Everywhere
Distribution in Kerala: Thiruvananthapuram (Vithura, Peppara), Kollam (Thenmala), Pathanamthitta, Kottayam, Thrissur (Chimmnoy Wildlife Sanctuary), Ernakulam, Calicut, Idukki (Thekkady), Kannur (Aralam), Malappuram (Calicut University Campus), Kasaragod (Cherkala), Palakad, Wayanad (Muthenga, Thirunelli).			
Camponotus	*angusticollis angusticollis* (Jerdon, 1851)	*Camponotus ardens* (Smith, 1858) *Camponotus impetuosa* (Smith, 1858) *Camponotus prismaticus* Mayr, 1862	Leaves/Soil
Distribution in Kerala: Ernakulam, Thrissur (Chimmnoy Wildlife Sanctuary), Palakkad (Silent Valley, Aalathur), Malappuram (Calicut University Campus, Kohinoor, Manjeri, Nilambur), Calicut (Anakampoyil), Wayanad (Thirunelli).			

Table 1: Checklist of Ants of Thirunelli in Wayanad (*contd.*)

Genus	species	Synonym	Habitat
Camponotus	*compressus* (Fabricius, 1787)	*Camponotus callida* (Smith, 1858) *Camponotus indefessa* (Sykes, 1835) *Camponotus quadrilaterus* Roger, J. 1863	Leaves
Distribution in Kerala: Thiruvananthapuram (Peppara, Neyyar, Karyavattom, CTCRI Campus), Kollam, Thrissur (Chimmnoy Wildlife Sanctuary), Palakkad (Parambikulam), Alappuzha (Muthukulam), Idukki (Meenuli, Thekkady), Wayanad (Muthenga, Thirunelli), Kannur (Aralam farm), Malappuram (Calicut University Campus).			
Camponotus	*misturus fornaronis* Forel 1892	-	Everywhere
Distribution in Kerala: Idukki (Thekkady), Ernakulam (Kochi, Edappally, Aluva), Malapuram (Calicut University Campus, Madappally, Kohinoor), Calicut (Mampad), Wayanad (Thirunelli, Muthenga), Thrissur (Vellanikara).			
Camponotus	*parius* Emery, 1889	-	Everywhere
Distribution in Kerala: Thiruvananthapuram (Vithura, Peppara), Kollam (Thenmala), Idukki, Kottayam, Ernakulam (Kalamassery, Aluva), Thrissur (Manalikkad, Chimmnoy Wildlife Sanctuary), Palakkad (Kottekkad), Malapuram, Calicut, Kannur, Kasaragod (Cherkala), Malabar, Wayanad (Thirunelli).			
Camponotus	*sericeus sericeus* (Fabricius, 1798)	*Camponotus aurulent* (Latreille, 1802) *Camponotus obtusa* (Smith, 1858) *Camponotus pyrrhocephala* (Mots., 1863)	Grassy field
Distribution in Kerala: Thiruvananthapuram (Vithura, CTCRI Campus, Peppara), Kollam (Thenmala), Kottayam (Bharanaganam), Idukki, Allepey, Ernakulam (Aluva), Thrissur (Vellanikara, Kodungallor), Palakkad, Malapuram (Kohinoor, Calicut University Campus), Calicut (Anakampoil), Kannur, Kasaragod (Cherkala), Wayanad (Muthenga, Thirunelli).			
Camponotus	*radiatus* Forel, 1892	-	Leaves
Distribution in Kerala: Malappuram (Kohinoor), Wayanad (Thirunelli).			
Lepisiota	*opaca opaca* (Forel, 1892)	-	Leaves
Distribution in Kerala: Ernakulam (Aluva), Malappuram (Kohinoor, Calicut University Campus), Wayanad (Muthenga, Thirunelli).			
Oecophylla	*smaragdina* (Fabricius, 1775)	*Oecophylla macra* (Guérin, 1831) *Oecophylla virescens* (Fabricius, 1775 *Oecophylla viridis* (Kirby, 1819) *Oecophylla* zonata (Guérin, 1838)	Trees
Distribution in Kerala: Wayanad (Thirunelli), throughout Kerala.			
Polyrhachis	*convexa* Roger, 1863	-	Leaves
Distribution in Kerala: Wayanad (Muthenga, Thirunelli).			
Polyrhachis	*illaudata illudata* Walker, 1859	*Polyrhachis duodentata* Donisthorpe, 1942 *Polyrhachis mayri* Roger, 1863 *Polyrhachis latispinosa* Donisthorpe, 1942	Leaves
Distribution in Kerala: Wayanad (Muthenga, Thirunelli, Vythiri).			
Polyrhachis	*punctillata punctillata* Roger, 1863	-	Leaves
Distribution in Kerala: Wayanad (Muthenga, Thirunelli), Thiruvananthapuram (Vithura), Thrissur (Chimmnoy Wildlife Sanctuary).			
	Subfamily: Myrmicinae		
Cardiocondyla	*parvinoda* Forel, 1902	-	Soil
Distribution in Kerala: Wayanad (Thirunelli).			
Cardiocondyla	*wroughtonii* (Forel, 1890)	*Cardiocondyla bimaculata* Wheeler, 1929 *Cardiocondyla emeryi chlorotica* Menozzi, 1930 *Cardiocondyla hawaiensis* Forel, 1899 *Cardiocondyla longispina* Karavaiev, 1935 *Cardiocondyla quadraticeps* Forel, 1912	Soil
Distribution in Kerala: Wayanad (Thirunelli), Palakkad (Silent Valley National Park).			
Crematogaster	*ebenina* Forel, 1902	-	Trees
Distribution in Kerala: Wayanad (Thirunelli).			

Table 1: Checklist of Ants of Thirunelli in Wayanad (*contd.*)

Genus	species	Synonym	Habitat
Leptothorax	*rothneyi* Forel, 1902	-	Trees
Distribution in Kerala: Wayanad (Thirunelli), Palakad (Nelliyampathy).			
Monomorium	*wroughtoni* Forel, 1902	-	Soil
Distribution in Kerala: Wayanad (Thirunelli).			
Myrmicaria	*brunnea* Saunders, 1842		Soil
Distribution in Kerala: Wayanad (Thirunelli), throughout Kerala.			
Myrmicaria Saunders, 1842 sp.		-	Soil
Distribution in Kerala: Wayanad (Thirunelli).			
Pheidole	*spathifera* Forel, 1902	-	Soil
Distribution in Kerala: Wayanad (Thirunelli), Calicut (Madappally).			
Pheidologeton	*affinis affinis* (Jerdon, 1851)	*Pheidologeton australis* Forel, 1915 *Pheidologeton bellicosa* (Smith, 1858) *Pheidologeton calida* (Smith, 1863) *Pheidologeton laboriosa* (Smith, 1861) *Pheidologeton mjobergi* Forel, 1918	Soil
Distribution in Kerala: Wayanad (Thirunelli), Malappuram (Mampad).			
Solenopsis	*geminata* (Fabricius, 1804)	*Solenopsis bahiaensis* Santschi, 1925 *Solenopsis cephalotes* Smith, 1859 *Solenopsis clypeata* (Smith, 1858) *Solenopsis coloradensis* (Buckley, 1867) *Solenopsis diabola* Wheeler, 1908 *Solenopsis drewseni* (Mayr, 1861) *Solenopsis eduardi* Forel, 1912 *Solenopsis galapageia* Wheeler, 1919 *Solenopsis geminata medusa* Mann, 1916 *Solenopsis glaber* (Smith, 1862) *Solenopsis innota* Santschi, 1915 *Solenopsis laboriosus* (Smith, 1860) *Solenopsis laevissima* (Smith, 1860b) *Solenopsis lincecumii* (Buckley, 1867) *Solenopsis mandibularis* Westwood, 1840 *Solenopsis mellea* (Smith, 1859) *Solenopsis nigra* Forel, 1908 *Solenopsis paleata* Lund, 1831 *Solenopsis perversa* Santschi, 1925 *Solenopsis polita* (Smith, 1862) *Solenopsis rufa* (Jerdon, 1851) *Solenopsis saxicola* (Buckley, 1867)	Soil
Distribution in Kerala: Thrissur (KAU Campus), Calicut (Madappaly, Devagiri), Wayanad (Thirunelli), Kollam (Thenmala).			
Carebara	*wroughtonii* (Forel, 1902)	-	Soil
Distribution in Kerala: Wayanad (Thirunelli).			
Strumigenys	*smythiesii* Forel, 1902	-	Soil
Distribution in Kerala: Wayanad (Thirunelli).			
Tetramorium	*wroughtoni* Forel, 1902	-	Under Stones
Distribution in Kerala: Calicut (Mampad), Wayanad (Thirunelli).			
Tetramorium	*smithi* Mayr, 1879	*Tetramorium kanariense* Forel, 1902 *Tetramorium laevinode,* Forel, 1902	Under Stones
Distribution in Kerala: Wayanad (Thirunelli), Calicut (Devagiri).			
	Subfamily: Ponerinae		
Cryptopone Emery, 1893 sp.		-	Soil
Distribution in Kerala: Wayanad (Thirunelli).			

Table 1: Checklist of Ants of Thirunelli in Wayanad (*contd.*)

Genus	species	Synonym	Habitat
Diacamma	*rugosum sculptum* (Jerdon, 1851)	-	Soil
Distribution in Kerala: Kollam (Thenmala), Thrissur (Chimmnoy Wildlife Sanctuary, KAU Campus), Wayanad (Thirunelli).			
Diacamma	*scalpratum* (Smith, 1858)	*Diacamma compressum* Mayr, 1879	Soil
Distribution in Kerala: Kollam (Thenmala), Calicut (Mampad), Wayanad (Thirunelli).			
Leptogenys	*ocellifera* (Roger, 1861)	-	Soil
Distribution in Kerala: Kollam (Thenmala), Wayanad (Thirunelli), Malappuram (Madappally).			
Odontomachus	*haematodes* (Linnaeus, 1758)	*Odontomachus hirsutiusculus* Smith, 1858 *Odontomachus maxillosa* (De Geer, 1773) *Odontomachus pallipes* Crawley, 1916	Soil
Distribution in Kerala: Kollam (Thenmala), Malappuram (Madappally), Calicut (Mampad), Wayanad (Thirunelli).			

ACKNOWLEDGEMENTS

We are grateful to the Department of Science and Technology, Goverment of India for financial assistance. We are grateful to Dr. T.C. Narendran, Emeritus Professor, Department of Zoology, University of Calicut, Kerala, for critically examining this manuscript and also express our thanks to the Principal Sr. T.F. Pauly, St. Xavier's College for Women, Aluva, for extending her support.

REFERENCES

Bingham, C.T. (1903): Ants and Cuckoo Wasps. The Fauna of British India, including Ceylon and Burma: Hymenoptera 2. 506 pp. London.

Bolton, B. (1994): Identification Guide to the Ant Genera of the World. Harvard University Press, Cambridge, London. Pp. 222.

Roger, J. (1863a): Die neu aufgeführten Gattungen und Arten meines Formiciden-Verzeichnisses nebst Ergänzung einiger früher gegebenen Beschreibungen, *Berl. Entomol. Z.* 7: 131-214.

Roger, J. (1863b): Verzeichniss der Formiciden-Gattungen und Arten, *Berl. Entomol. Z. 7(B)* Beilage: 1- 65.

WWF (2001): Wild World. WWF full report, South Western Ghats montane rain forests (IMO151). http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0151_full.html.

13. FIRST REPORT ON THE OCCURRENCE OF AN ECONOMICALLY IMPORTANT SPIRAL NEMATODE *HELICOTYLENCHUS MULTICINCTUS* COBB. FROM GOA

I.K. Pai[1] and H.S. Gaur[2]

[1]Department of Zoology, Goa University, Goa 403 206, India. Email: ikpai@unigoa.ac.in
[2]Division of Nematology, Indian Agricultural Research Institute, New Delhi 110 012, India. Email: hsg_nema@iari.res.in

Nematodes constitute the largest and diverse group of metazoans on earth. Four of every five metazoans are nematodes. Of the estimated 5,00,000 species of nematodes, only *c.* 25,000 are known till date (Walia and Bajaj 2003). They may feed on bacteria, algae, fungi and may also be parasitic on plants and animals.

Among nematodes, spiral nematode *Helicotylenchus multicinctus* Cobb. is a well-known plant parasitic nematode causing severe damage to banana plantation. There are reports on the role of *H. multicinctus* on banana by Baghel and Edwards (1977) and Rajendran *et al.* (1979). Goa produces a large quantity of bananas; however, *H. multicinctus* has not been recorded so far.

Soil samples were collected at a depth of 15-30 cm from a banana plantation in Canacona, Goa. Nematodes were extracted using Cobb's decanting and sieving technique (Cobb 1904, 1913). Based on the studies of morphological characters, the nematode was identified as *Helicotylenchus multicinctus*.

ACKNOWLEDGEMENT

We sincerely thank Indian National Science Academy (INSA), New Delhi, for providing Visiting Fellowship to one of the authors (IKP).

REFERENCES

BAGHEL, P.P.S. & J.C. EDWARDS (1977): *Helicotylenchus multicinctus* on Banana. *The Allahabad Farmer 48*: 285-289

COBB, N.A. (1904): Free living and freshwater New Zealand nematodes. *Proc. Cambridge Phil. Soc. 12*: 363-374.

COBB, N.A. (1913): New nematode genera found inhabiting freshwater and non-brackish soils. *J. Wash. Acad. Sci. 3*: 434-444.

RAJENDRAN, G., T.G. NAGANATHAN & V. SHIVAGAMI (1979): Studies on banana nematodes. *Indian J. Nematol. 9*: 54.

WALIA, R.K. & H.K. BAJAJ (2003): Textbook on Introductory Plant Nematology. ICAR, New Delhi.

14. *SCOLOPENDRA HARDWICKEI* (NEWPORT, 1844) FEEDING ON *OLIGODON TAENIOLATUS* (JERDON, 1853) IN THE SCRUB JUNGLES OF PONDICHERRY, SOUTHERN INDIA

UTPAL SMART[1], PRAKASH PATEL[2,3] AND PRADEEP PATTANAYAK[2]

[1]Amphibian and Reptile Diversity Research Centre, Department of Biology, University of Texas at Arlington, TX 76019-049.
Email: utpalsmart@gmail.com
[2]Project Ecolake, Sri Aurobindo Ashram, Pondicherry 605 002, Pondicherry, India.
[3]Email: prakashpatel48@gmail.com

Apart from feeding on three different species of bats (Molinari *et al.* 2005), centipedes of the genus *Scolopendra* (Chilopoda: Scolopendromorpha) have also been reported to prey upon reptiles by Lawrence in 1953, Butler in 1970 and in 1975 by Easterla (Carpenter and Gillingham 1984). These include frogs, toads, small lizards, and serpents (Molinari *et al.* 2005).

Individuals of three North American snake species, namely Central Texas Whipsnake *Masticophis taeniatus girandi* (Stejneger and Barbour 1917), Texas Brown Snake *Storeria dekayi texana* (Trapido 1944), and Lined Snake *Tropidoclonion lineatum* have been recorded as the prey of the Giant Desert Centipede *Scolopendra heros* (Girard 1853), when kept in the same vivarium as the centipede. All the snakes were killed by incisions to the ventral neck and fed upon by the centipede on successive nights (Cates pers. comm.). Easterla (1975) describes a scolopendrid feeding on the Long-nose Snake (*Rhinocheilus* sp.) (Forti *et al.* 2007). All of the above records refer to North, Central and South American species of *Scolopendra*, some of which are known for their large sizes.

India harbours 95 species of Scolopendrids, *Scolopendra hardwickei* (Newport 1844) being the largest (Khanna 2009). There have been observations of Indian Scolopendrids feeding on toads and frogs (Daniels pers. comm.), and a gecko in the wild (Whitaker pers. comm.). This paper reports the first record of predation on *Oligodon taeniolatus* (Serpentes: Colubridae) by *S. hardwickei*, and one of the few published accounts of a Scolopendrid feeding on an Indian snake (for another record see Mirza and Ahmed 2009) under natural conditions, in a private reforestation site of the Sri Aurobindo Ashram near Pondicherry.

Oligodon taeniolatus is a Kukri snake which is active by day and night, and may be seen predating on amphibian and reptile eggs. It is an opisthoglyphous (rear-fanged) snake and possesses a functional venom gland and is known to feed on lizards in captivity (Whitaker and Captain 2004)

The observation was made by one of the authors (Pattanayak) on the dark night of July 06, 2009, around 21:00 hrs. The observer's attention was first drawn to the scene of predation by the sound of pebbles rubbing against one another. Upon investigation the source of the sound was identified as a struggling *Oligodon taeniolatus*, *c.* 36 cm long, trying to escape under a layer of pebbles while a large centipede, *c.* 25 cm long, fiercely held on to the area immediately behind the snake's cloacae.

The maxillipeds (the first 4 to 5 pairs) of the centipede had clearly pierced the Kukri's flesh; blood was oozing from the gaping lesion along with some viscera of the yet living reptile. The mandibles of the centipede were thrust into this wound and the arthropod seemed to be actively ingesting the snake's fluids.

Despite fiercely trying, the snake was unable to free itself from the clutches of the centipede, which then began to move up the length of the snake. While doing so it curved its appendages around the snake.

Forty-five minutes after the struggle began the centipede had moved its entire body upon the snake's dorsal surface and inflicted yet another deep wound near the throat. The snake seemed to be giving in but still put up some resistance as the predator and prey coiled into contorted postures.

Unfortunately, the centipede abandoned its prey when the observer got too close; the arthropod vanished swiftly into the immediate undergrowth while the snake crawled on limply. A closer inspection of the wounds revealed a protruding bone, demonstrating the depth and extent of the laceration the scolopendrid had inflicted on it. The snake was left alone and, judging by its conditions, probably died in the

hours that followed. The bite of a scolopendrid is painful to adult humans, and can be fatal to infants (Khanna 2009).

With the exception of the Long-nose Snake (Easterla 1975) the centipede was always longer than its prey and may have outweighed it as well (Carpenter and Gillingham 1984). In this case, though the centipede seemed heavier, the snake was clearly longer, but this did not seem to increase the odds of its survival; strangely enough, all through its ordeal, the snake made no attempts to bite back at the centipede.

Do scolopendrids regularly feed on snakes or was this a display of opportunistic behaviour, and hence a rare event? And to what limit does this fierce centipede go to get a meal, e.g., does it feed on other larger/venomous snake species as well? These are a few questions which when answered could lead to a whole new understanding of little known trophic links, e.g., arthropods preying on vertebrates, the complexity and significance of which probably has not been evaluated enough.

ACKNOWLEDGEMENTS

We would like to thank Jerry Cates, EntomoBiotics Inc. (Texas, U.S.A.) and Romulus Whitaker (Chengalpattu, India) for their prompt and informative correspondence. We are furthermore grateful to Dr. Vinod Khanna of the Z.S.I. (Dehradun, India) for his help with identification of the centipede. Dr. R.J. Ranjit Daniels, Director, Care Earth Trust (Chennai, India) is also cordially thanked not only for sharing information but also for reviewing the manuscript.

REFERENCES

Butler, W.H. (1970): A record of an invertebrate preying on vertebrate. *West. Aust. Nat. 11*: 146.

Carpenter, C.C. & J.C. Gillingham (1984): Giant Centipede (*Scolopendra alternans*) attacks Marine Toad (*Bufo marinus*), *Carib. J. Sci. 20(1-2)*: 71.

Easterla, D.A. (1975): Giant desert centipede preys upon snake. *Southwest. Nat. 20*: 411.

Forti, L.R., H.Z. Fischer & L.C. Encarnação (2007): Treefrog *Dendropsophus elegans* (Wied Neuwied, 1824) (Anura: Hylidae) as a meal to *Otostigmus tibialis* Brölemann, (Chilopoda: Scolopendridae) in the Tropical Rainforest in southeastern Brazil. *Braz. J. Biol. 67(3)*. São Carlos.

Khanna, V. (2009): Identifying Myriapods. http://www.authorstream.com/ Presentation/ Vinodkhanna-91275-soil-fauna-human-welfare-identifyingmyriapoda-trainings-etc-entertainment-ppt-powerpoint/

Lawrence, R.F. (1953): The biology of the cryptic fauna of forests. Cape Town, South Africa. 406 pp.

Mirza, Z.A. & J.J. Ahmed (2009): Note on predation of *Calliophis melanurus* Shaw, 1802 (Serpents: Elapidae) by *Scolopendra* sp. *Hamadryad 34(1)*: 166.

Molinari, J., E.E. Gutierrez, Antonio, A. de Ascenscensao, J.M. Nassar, A. Arends & R.J. Marquez (2005): Predation by Giant Centipedes, *Scolopendra gigantea*, on Three Species of Bats in a Venezuelan Cave. *Caribbean Journal of Science 41(2)*: 340-346.

Whitaker, R. & A. Captain (2004): Snakes of India, the Field Guide. Draco Books, Chengalpattu, Tamil Nadu. Pp. 140-144.

15. ARCHITECTURE OF ABUTTING SURFACES OF THE SHELLS OF ACORN BARNACLES

A.A. Karande[1] and M. Udhayakumar[2]

[1]303, A, Victory House, Chhotani Road – 2, Mahim, Mumbai 400 016, Maharashtra, India.
[2]Naval Materials Research Laboratory, Shil-Badlapur Road, Ambernath 421 506, Maharashtra, India.

Introduction

In recent years, several reports on the structure and architecture of the shells of acorn barnacles (Cirripedia, Crustacea) have been published (Karande and Palekar 1963; Klepal and Barnes 1975; Murdock and Currey 1978; Otway and Anderson 1985; Bourget 1997). By and large these reports deal with the adhesive and compressive strengths of various species settled on a variety of natural marine substrates and on man-made structures (Costlow 1956).

In the macrostructure study of barnacles, some of the shell structures considered are radial margins of parietes, alar margins of parietes, parietal canals, radial canals in basal plate, parietal sheath and interlamellar primary and secondary septae (Bourget 1997). All these structures which contribute to the strength of the shells are in the forms of ridges, teeth or lamellar ribs, and are sculptured more or less elaborately in different cirripede species. In the present study, abutting sculpturings of ten Indian species and eleven species endemic to the American coast were examined.

In this study, individual adult barnacles of various dimensions were used. The local barnacles examined were *Euraphia withersi* (Pilsbry), *Chthamalus malayensis* (Pilsbry), *Chirona amaryllis* (Broch), *Balanus amphitrite* (Darwin), *B. variegatus* (Darwin), *B. kodakovi* (Tarasov and Zevina), *Megabalanus tintinnabulum* (Linnaeus), *Tetraclita purpurascens* (Wood) and *Tetraclitella karandei* (Ross).

It also became possible to examine macrostructures of acorn barnacles sent to us by Dr. Arnold Ross of the American Museum of Natural History, San Diego. These species collected along the US coast were *Chthamalus dalli* (Pilsbury), *Chthamalus fissus* (Darwin), *Balanus* (*Semibalanus*) *cariosus* (Pallas), *B. crenatus* (Bruguiere), *B. glandula* (Darwin), *B. balanus* (Linnaeus), *B. rostratus* (Hock), *Tetraclita squamosa rubescens* (Darwin),

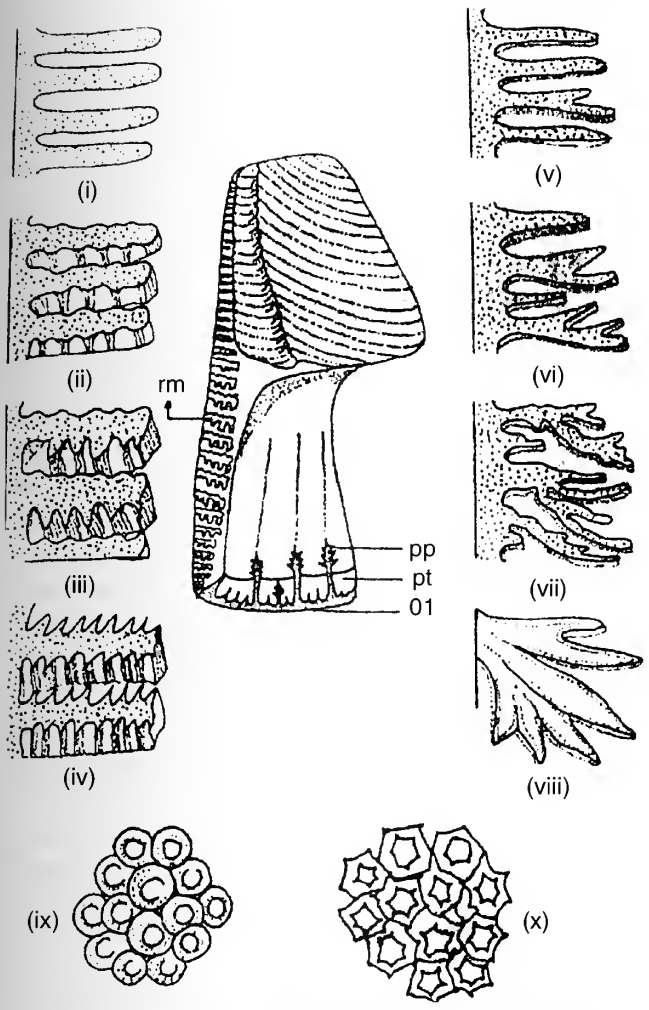


Fig. 1: Acorn barnacle parietal plate (semidiagrammatic); types of sculpturings on radial margin (rm); stripe (i to iv); lamellar (v to viii); dish-shape (ix to x); pp, pt, o1 (see Fig. 2)

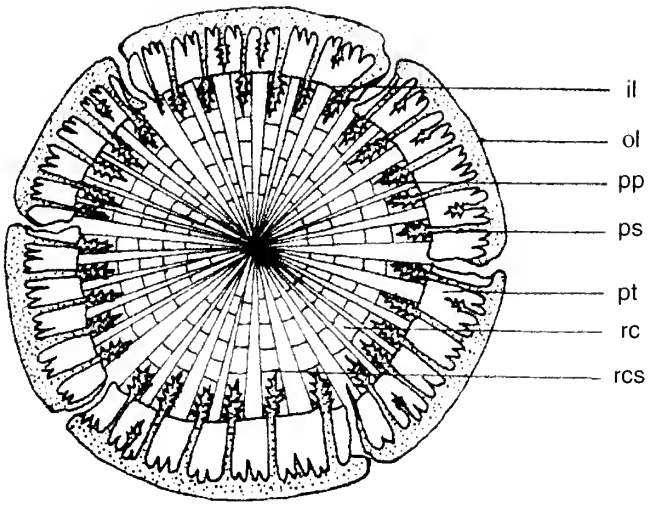


Fig. 2: Acorn barnacle shell (semidiagrammatic); a cross section of shell at the junction of the parietal plates and the basal plate; il: inner lamina; ol: outer lamina; pp: pinnate process; ps: parietal septum; pt: parietal tube; rc: radial canal; rcs: radial septum

T. rubescens elegans (Darwin), *T. stalactifera* (Lamark) and *Megabalanus tintinnabulum californicus* (Pilsbry).

All tropical species, except *Balanus kondakovi*, are collected at Mumbai. Of the US species, *B. crenatus*, *B. rostratus* and *T. stalactifera* are collected at Friday Harbour, Alaska and Puetro Refugio respectively. The rest of the species are collected from the Californian coast.

The nomenclature used for description of various shell components is the same as given by Bourget (1997). The semi-diagramatic illustrations of the shell components are given in Figs 1 and 2.

Radial margin of parietes: The radial margin which abuts against margin of an adjoining plate is variously sculptured in different species. In its simplest form as is seen in *E. withersi*, it shows parallely placed stripes that provide anchoring surface for the parietal plates (Fig. 1i). In *Chirona amaryllis* each of such stripes is moderately built and has a series of smooth teeth (Fig 1ii). In the three tropical balanids, namely, *Balanus amplitrite*, *B. variegatus* and *B. kondakovi*, each of the simple stripes becomes pectinated (Fig. 1iii). A pectinated surface is also noted in a recently collected balanid from Karwar coast, which is identified as *B. reticulates*. In *M. tintinnabulum* each stripe shows bipinnate pattern. Here each tooth is a sharp and pointed structure unlike rounded ones observed in balanids (Fig. 1iv).

In species like *B. glandula*, *B. crenatus* and *B. balanus*, all from the American coast, the sculpturing begins to lose its well-defined pectinated pattern observed in tropical balanids. The pectinated stripes assume lamellar forms which in turn branch and rebranch into ribbon-like or a water-spill like processes (Fig. 1v, vi, vii). An elaborately developed lamellar anchoring surface is thus observed in *B. rostratus* where pectinated pattern is completely lost (Fig. 1viii). It is, however, amply clear that this pattern has its origin in the basic stripe like geometric design.

In *C. malayensis*, an orderly arrangement of anchoring design is completely lost though there is some evidence of serially arranged stripes on the radial margin. The surface has irregularly placed short, round pits which interface with the elevations present on the adjoining plates. Here, generally the surface can be described as rough and devoid of any definite pattern (Fig. 1ix). In the temperate species *Chthamalus fissus* and *Ch. dalli*, unlike *Ch. malayensis*, an organized pattern of stripes is retained. These stripes, however, are not well demarcated from one another.

In tetraclitellan *Tetraclitella karandei* an anchoring pattern is distinctive. Here the abutting surface is not a solid plate. The surface is traversed by randomly placed holes, which in reality are the openings of the parietal canals. These

openings have flanged-like margins (Fig. 1x), which anchor on corresponding depressions on adjoining parietal plates.

In *T. purpurascens*, an anchoring surface is restricted to a very narrow area along the length of radial margin. Here the sculpturing is in the form of one row of deep pits. However, in both the Californian species, namely *Tetraclita squamosa rubescens* and *Tetraclita stalactifera*, the anchoring surfaces, unlike that of *Tetraclita purpurascens*, are elaborately lamellar as is also seen in some balanids. In *Tetraclita squamosa rubescens* particularly, the lamellar processes are heavily built.

Table 1 gives types of sculptural patterns of radial margins of parietes of the tropical and the temperate barnacle species.

Parietal canals: In *E. withersi*, *Chirona amaryllis* and in two chthamalids, the parietes are solid plates. In all the balanid species examined here, the plates are traversed by a single row of canals (Fig. 2). In *T. squamosa rubescens*, *T. stalactifera*, *T. purpurascens* and *T. karandei* parietes have several rows of canals. It is notable that *B. (semi) cariosus* of the family Archaebalanide shows several canals. These canals, however, are differently organized and are not homologous with those of balanids (Prof. William Newman pers. comm.).

Basal plate radial canals: The radial canals (Fig. 2rc) are present in all solid base species of chironid, balanid and megabalanid. These canals are, however, absent in temperate species, namely *B. balanus* and *B. crenatus*.

Interlamellar septae: The interlamellar septae emerging from the outer laminae of parietes (Fig. 2ol) terminate into wedge-shaped pinnate processes (Fig. 2pp). These help to strengthen the joints between the parietes and the base of a shell. Two types of wedge-shaped pinnate processes are reorganized. The more heavily built septal processes rest in the hollows of the radial canals located around the periphery of the basal plate. It is noted that in temperate balanids in *B. balanus* and *B. rostratus*, the secondary septal processes, unlike in tropical balanids, emerge from the inner walls of the parietes.

The sculpturings of radial margins of the parietes of the shell in acorn barnacles can be broadly divided into three patterns. The first pattern shows a series of simple stripes placed parallely to one another along the length of the margin. Each of these stripes may further assume a pectinated form. In the second pattern, the stripe may branch and rebranch to create an elaborate lamellar network. In a further modification, a lamellar form assumes moderately built sheet-like surface. The third pattern of sculpturing is notably different from the first two patterns. Here the abutting surface shows several interfacing shallow pits and domes, a stripe-like geometric pattern being totally absent.

A pattern of stripes, simple or pectinated, seems to be a basic form of abutting surface. A majority of the tropical

Table 1: Acorn barnacles; sculpturing patterns of radial margins of shell pariete of tropical and temperate species

Cirripede species	Radial margin sculpturing (see Fig. 1)									
	Stripe				Lamellar				Flanged-dish	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
Tropical										
Euraphia withersi	+									
Chthamalus malayensis									+	
Chirona amaryllis		+								
Balanus amphitrite			+							
Balanus variegatus			+							
Magabalanus tintinnabulum				+						
Tetraclita purpurascens										+
Tetraclita sp.	+									
Tetraclitella karandei										+
Temperate										
Chthamalus dalli	+									
Chthamalus fissus	+									
Balanus (semibalanus) cariosus							+			
Balanus balanus						+				
Balanus crenatus					+					
Balanus glandula					+					
Balanus rostratus							+			
Megabalanus tintinnabulum californicus				+						
Tetraclita squamosa rubescens							+			
Tetraclita rubescens elegans							+			
Tetraclita stalactifera								+		

barnacles, including *E. withersi* as well as balanids show this simple striped pattern. In balanids, particularly, a simple stripe may assume pectinated form and in megabalanid it may become multi-pectinated.

In tropical balanids like *B. amphitrite*, *B. kondakovi* and *B. variegates* the abutting surfaces show a series of pectinated stripes, whereas in temperate balanids, it shows an elaborately sculptured lamellar pattern. In tropical chthamalid *C. malayensis*, the parietes show pits and domes on the abutting surfaces. The temperate chthamalids on the other hand show simple stripes. Differing sculptural patterns are also observed amongst tetraclitilid species. The two tropical species, namely *Tetraclita purpurascens* and *Tetraclitella karandei* show pits and dome type of sculpturing whereas one *Tetraclita* sp., possibly an Indo-Pacific species, collected at Port Blair, (Andaman) shows simple stripped pattern. Each of the three temperate tetraclitilids, namely, *Tetraclita squamosa rubescens*, *T. rubescens elegence* and *T. stalactifera* shows lamellar pattern of sculpturing. Thus, amongst the members of each of three genera, namely balanids, chthamalids and tetraclitilids, separated from each other geographically, distinct variations in abutting surfaces are observed.

One observation that stands out boldly is that, as a rule, none of the tropical species examined show a lamellar pattern of abutting surface (Fig. 1 v to viii). On the other hand, among the American species, belonging to the three widely separated genera, the most prevalent sculpturing pattern is the lamellar one. Even *B. (semi) cariosus*, an archaebalanid, displays a lamellar pattern.

The differences in sculpturings observed even amongst the members of a single genus, as well as between the tropical and the temperate species, do not seem to have resulted because of varying ecological conditions. What little orderliness in abutting surfaces complexity is observed, suggests that this surface is not an unstable or a transient character. It is, therefore, unlikely to be influenced by varying ecological conditions. A total absence of a lamellar pattern in tropical barnacles, after all, cannot be due to any ecological factor. Furthermore, varying ecological conditions can prevail even within a restricted geographical area, and this situation can lead to alteration of surfaces even among individual members of a single species, as is evident in the opercular valves of *Chthamalus malayensis* (Karande and Palekar 1963). However, no such differences in the abutting surfaces of parietes of individuals of different sizes inhabiting varying environments are noticeable.

The tropical acorn barnacles: *Euraphia*, *Megabalanus* and *Balanus* show, in that order, an increasing elaboration of stripe pattern of the sculpturing (Table 1, Fig. 1). The temperate species of *Chthamalaus*, *Megabalanus* and *Balanus* also show an increasing complexity of this surface. It would, therefore, be worthwhile to investigate, using a larger representative species, if there exists any relation between this shell character and the cirripede phylogeny as suggested by Prof. William Newman (pers. comm.). The present authors found themselves ill-equipped to examine the likelihood of such relation. Hence this note.

ACKNOWLEDGEMENTS

We thank Dr. Arnold Ross for gift of variety of temperate barnacles in adequate numbers which motivated us to carry out this work. Thanks are also due to Prof. William Newman for his observations recorded in this paper.

REFERENCES

Bourget, E. (1997): Shell structure in sessile barnacles. *Nat. Can. 104(4)*: 281-323.

Costlow, J.D. (1956): Shell development in Balanus improvisus Darwin. *J. Morphol. 99*: 359-400.

Karande, A.A. & V.C. Palekar (1963): On a Shore barnacle *Chthamalus malayensis* Pilsbry from Bombay, (India). *Annals and Mag. of Nat. Hist. 13(4)*: 231-234.

Klepal, W. & H. Barnes (1975): The structure of wall plate in *Chthamalus depressus* (Poli). *J. Exp. Mar. Biol. Ecol. 20*: 265-285.

Murdock, G.R. & J.D. Currey (1978): Strength and design of shells of the two ecologically distinct barnacles, *Balanus balanus* and *Semibalanus (Balanus) balanoides* (Cirripedia). *Biol. Bull. Mar. Biol. Lab., Woods Hole. 155*: 169-192.

Otway, N.M. & D.T. Anderson (1985): Variability of shell growth and morphology of the wall plate junctions of the intertidal barnacle *Tesseropora rosea* (Cirripedia: Tetraclitidae). *Mar. Biol. 85*: 171-183.

16. *ANDRACHNE TELEPHIOIDES* L. (PHYLLANTHACEAE) – AN ADDITION TO THE FLORA OF PENINSULAR INDIA

M.M. Sardesai[1] and S.Y. Chavan[2]

[1]Department of Botany, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad 431 004, Maharashtra, India.
Email: sardesaimm@rediffmail.com
[2]Email: alysicarpus@gmail.com

Introduction

Andrachne telephioides L. is distributed in India, Pakistan, Afghanistan, and westwards along Mediterranean areas to Spain. In India, this sole representative of the

genus *Andrachne* L. is so far known from Jammu & Kashmir, Punjab, Haryana, Uttar Pradesh, Rajasthan and Madhya Pradesh (Balakrishnan and Chakrabarty 2007). However, the occurrence of an undetermined species of the genus is recorded for Maharashtra (Naik 1998; Almeida 2003).

The present investigation reveals the occurrence of *A. telephioides* in Maharashtra as well as Andhra Pradesh, being additions to the flora of these States. Hence, a short account of the species is presented here.

Andrachne telephiodes L., Sp. Pl.1014. 1753; Hook.f., Fl. Brit. India 5: 284. 1887; N.P. Balakr. & Chakrab., Fam. Euphorb. India 338. 2007. *A. naikii* M.R. Almeida, Fl. Maharashtra IVB: 287. 2003, nom. illeg.

Lectotype: "Habitat in Italia, Graecia, Media" (Radcliffe-Smith in Meikle, Fl. Cyprus 2: 1488. 1985): Herb. Linn. No. 1155.1 (Linn).

Glaucous, erect or diffuse monoecious herb; branches 7-15 cm long. Leaves oblong-obovate, 3-5 x 1-3 mm, obtuse at apex, entire, cuneate at base, penninerved, membranous, glabrous; petioles 1.0-2.5 mm long; stipules subpeltate, 1.5-2.0 mm long, irregularly incised. Inflorescence axillary, solitary or males often 2-3 together. Male flowers: pedicels 0.8-1.0 mm long; sepals 5-6, imbricate, connate at base, obovate, *c.* 1.5 x 0.5 mm; petals 5 or 6, linear-oblong, deeply notched at apex., *c.* 0.5 x 0.2 mm; disc glands 5 or 6, 0.15-0.18 mm long, 5-lobed; stamens 5 or 6, 0.4-0.6 mm long; filaments free or partially connate; anthers 4-lobed, *c.* 0.15 x 0.2 mm, elliptic-oblong; pistillode present. Female flowers: pedicels *c.* 2 mm long; sepals larger than in male flowers; petals minute; disc glands as in male; ovary 3-loculed; style short, bifid to base. Capsules depressed globose, 2-3 mm in diam., glabrous, consisting of three, 2-valved cocci; endocarp thinly woody. Seeds 2 per locule, triquetrous, with a convex, punctulate back, curved, rugose, sculptured, estrophiolate.

Flowering and Fruiting: December-February.

Habitat: Occasional, in open grounds, harvested fields and dry mud.

Distribution: Pakistan, Afghanistan, westwards along Mediterranean areas to Spain, INDIA: New record to Andhra Pradesh, Nijamabad district, Mirzapur, 7.iii.1981, Madhukar 6348 (BMAU). Maharashtra, Parbhani district, Parbhani town, 23.i.1981, Madhukar 6169 (BAMU).

ACKNOWLEDGEMENTS

We are thankful to the authorities of Botanical Survey of India, Western Circle, Pune, for confirming the identity. We thank Dr. V.N. Naik for valuable guidance in preparation of manuscript and Head, Department of Botany, Dr. B.A.M. University, Aurangabad, for providing herbarium facilities and constant encouragement. We thank the Linnaean Society of London for providing the image of the type specimen.

REFERENCES

ALMEIDA, M.R. (2003): Flora of Maharashtra (Family Euphorbiaceae) – IVB. Blatter Herbarium, St. Xavier's College, Mumbai. Pp. 279-355.

BALAKRISHNAN, N.P. & T. CHAKRABARTY (2007): The Family Euphorbiaceae in India. Bishen Singh Mahendra Pal Singh, Dehradun. 500 pp.

NAIK, V.N. (1998): Flora of Marathwada (Family Euphorbiaceae) – II. Amrut Prakashan, Aurangabad. Pp. 771-806.

■ ■ ■

Printed by Bro. Leo at St. Francis Industrial Training Institute, Borivli, Mumbai 400 103 and published on December 03, 2010 by Dr. Ashok Kothari for Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk, Shaheed Bhagat Singh Road, Mumbai 400 001, Maharashtra, India.

INSTRUCTIONS TO AUTHORS

The *Journal* welcomes concise reports of original research in natural history, taxonomy and other aspects of zoology and botany of general interest.

SUBMISSION OF MANUSCRIPT

Hard copies of manuscripts (including illustrations) **in duplicate**, typewritten **in double space** on one side of the paper and a copy of the MS on a floppy diskette or CD using MS Word, should be submitted to the Editor, *Journal of the Bombay Natural History Society*, Hornbill House, Shaheed Bhagat Singh Road, Mumbai 400 023. Submission of a manuscript to the *Journal* implies that it has not been submitted for publication elsewhere.

Please do not send manuscripts by e-mail unless requested to do so. We do not download unsolicited material.

PREPARATION OF MANUSCRIPT

Main Papers and New Descriptions

Manuscripts of papers for the Main section and New Descriptions should be as concise as possible. Pages should be numbered consecutively, and the matter on Page 1 should be arranged in the following order: Title of the paper; Name(s) of Author(s), Department(s) and Institution(s); Footnote containing address of Author for correspondence with e-mail id, followed by the List of Abbreviations used in text. A short running title derived from the original title may also be given for main papers. Page 2 should contain the Abstract. The text may be arranged in the following order: Introduction; Material and Methods or Methodology; Results; Discussion; Acknowledgements; References. Abstract, Key Words, Tables and Captions for Figures should be typed separately.

Title: The title should be such as to be useful for indexing and information retrieval.

Abstract: The abstract, not exceeding 200 words, should indicate the scope and significant content of the paper, highlighting the principal findings and conclusions.

Introduction: The introductory part should bear no heading, should be brief and state precisely the objective of the study in relation to the present status of knowledge in the field. Review of literature should be restricted to the essential references.

Material and Methods or Methodology: The nomenclature, sources of materials and the procedures should be clearly stated. New methods should be described in detail, but if the methods are well known, a mere reference to them will do; any modifications made in the methods should be stated.

Results: Only data relevant to the objectives of the study and main conclusions emerging from the study should be included. The data should be arranged in a unified and coherent sequence for clarity and readability. The same data should not be presented in both tables and figures, and such data as can be easily and briefly stated in the text should not be depicted diagrammatically. Only such tables and figures as are necessary should be given.

Tests of statistical significance should be identified and references used should be cited. Statements about the statistical significance of the results must be borne out by the level of significance, preferably provided in the tables and legends. The use of the word "significant" should be restricted to "statistically significant".

Discussion: The discussion should provide an interpretation of the results of the study, without repeating information already presented under Results. It should relate the new findings to the known and include logical deductions. Where necessary, the Results and Discussion can be combined.

Illustrations: The number of illustrations should be kept to the minimum and numbered consecutively in Arabic numerals. Simple linear plots or linear double reciprocal plots that can be easily described in the text should be avoided. Extension of graphs beyond the last experimental point is permissible only while extrapolating data.

Line drawings should be either laser prints of computer generated illustrations or manually prepared in Indian ink on tracing paper, drawn to approximately twice the printed size. The drawings are usually reduced to the page width or column size, and **care should be taken that the size of letters, numerals, dots and symbols is relatively uniform and sufficiently large to permit this reduction.**

Photographs: Photographs for reproduction must be clear, with good contrast. Prints should be at least 9x12 cm and on glossy, glazed paper.

Tables: Each table should have an explanatory title and should be numbered in Arabic numerals. Units (metric) of measurement should be abbreviated and placed below the headings. Negative results should be indicated as Nil (0) and absence of a datum by a dash.

Acknowledgements: Acknowledgements should be brief and relevant.

References: Responsibility for the accuracy of references rests with the author(s). Abstracts of papers presented at scientific meetings may be cited. References to literature should be alphabetically arranged under author's name, with the abridged titles of journals or periodicals in italics and titles of books or papers in Roman type, thus:

Aluri, Raju J.S. & C. Subha Reddi (1995): Ecology of the pollination in two cat-mint species. *J. Bombay Nat. Hist. Soc. 91(1)*: 63-66.

Prater, S.H. (1971): The Book of Indian Animals. 3rd Edn. Bombay Natural History Society, Mumbai. pp. 35-48.

Species names should carry the Author's name and subspecies (trinomials) should only be used where identification has been authentically established by comparison of specimens actually collected.

For the standardised common and scientific names of the birds of the Indian subcontinent refer to *Buceros* Vol. 6, No. 1 (2001).

Miscellaneous Notes: The section accommodates incidental observations on flora and fauna of the Asian region, and need not follow strictly the above section headings. No abstract is required, but key words may be included and references must be cited as in the rest of the *Journal*.

Reprints: 25 reprints will be supplied free of charge to the authors of Main Papers and New Descriptions. Authors of Miscellaneous Notes will be sent one free copy each of the *Journal*.

The Editors reserve the right, other things being equal, to publish a member's contribution before that of a non-member. The Editors also reserve the right to publish invited papers on priority.

Registered with the Registrar of Newspapers under RN 5685/57 ISSN 0006-6982

CONTENTS

NEW DESCRIPTIONS

Printed by Bro. Leo at St. Francis Industrial Training Institute, Borivli, Mumbai 400 103 and published by Dr. Ashok Kothari for Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk, Shaheed Bhagat Singh Road, Mumbai 400 001.
website: www.bnhs.org; Email: bnhs@bom4.vsnl.net.in

JOURNAL
OF THE
BOMBAY NATURAL HISTORY SOCIETY

AUGUST 2010 VOL. 107 (2)

BNHS INDIA CONSERVING NATURE SINCE 1883

JOURNAL OF THE BOMBAY NATURAL HISTORY SOCIETY

Hornbill House, Shaheed Bhagat Singh Marg, Mumbai 400 001.

VOLUME 107(2): AUGUST 2010

CONTENTS

NEW DESCRIPTIONS

MISCELLANEOUS NOTES

Cover Photograph: Indian Giant Squirrel
Ratufa indica
By N.A. Naseer

ACKNOWLEDGEMENT

We are grateful to the Ministry of Science and Technology,
Govt of India,
for enhanced financial support for the publication of the Journal.

Editorial

Are we reaching the Eremozoic Era?

Professor E.O. Wilson is one of the most famous conservation biologists and naturalists of the world. His basic work is on the ecology of ants but he has become strong proponent of biodiversity conservation. He is famous for coining the word 'sociobiology'. He is author and editor of several books, one of them is BIODIVERSITY that was first published in 1988 and has been reprinted many times. It makes fascinating, although sad, reading about the status of biodiversity in the world.

Wilson has come up with the phrase Eremozoic Era – the Age of Loneliness in his book THE CREATION (2006). His worry is that unless we stop the biodiversity loss that is happening at a frightening speed, we may be headed to an age where humans will survive the climate change and all other disturbances, and may even flourish in megacities, but it will be a lonely age in a biodiversity-depauperate world.

In the 5.4 billion years of Earth's life, there have been five major cataclysmic extinctions. Each of these extinctions resulted in more than 70-80% species going extinct. All these extinctions were the results of geological and other natural factors. It is calculated that almost 95 to 99% of the species that ever lived on this Earth are extinct. It is not a very reassuring statistic unless we look at it through the evolutionary perspective. Each natural extinction, whether it was due to basalt eruption or asteroid/comet hitting the Earth, resulted in mass extinction of the existing taxa and evolution of new taxa or groups. For example, the geological event that ended the Permian Era, 251 million years ago, and started the Triassic Era resulted in the extinction of nearly 96% of all marine species and 70% of all land species. After the Permian Era ended, new life forms evolved during the Triassic Era. We have to remember that these mass extinction took thousands of years if not millions, giving enough time for the Earth to settle down and evolutionary processes to take place, resulting in new taxa. Even the last mass extinction 65 million years ago which ended the Dinosaur Era, resulted in the Age of Mammals of what we see today.

The type of extinction that we are seeing today is totally unnatural and very fast. Owing to man-induced reasons, species are dying at a much faster rate, some say 100 to 1,000 times faster than the natural evolutionary process. For example, during the last 500 years, we have exterminated 450 bird species, and at present nearly 12% of the 10,000 bird species of the world are in danger of extinction. Mammals and amphibians are in a much worse condition. During the past 500 years, at least 80 mammal species have gone extinct out of the total of about 5,570 species known to science. The average extinction rate for mammals is less than two extinctions every million years, far lower than the current extinction rate for mammals.

Human encroachment, deforestation and habitat loss, climate change, spread of new diseases, poaching for meat, over-fishing and illegal wildlife trade are making survival difficult for most wild species. Hunting for bushmeat in Africa has emptied many forests. Closer home, we have vast tract of forests with very little wildlife. We have our own empty and silent forests. Tiger crises is always in the news, but how many people know that less than 10 individuals are left of the peninsular Wild Buffalo (including only one known breeding female) and less than 200 Hangul or Kashmir Stags are left. The Kondana Rat *Millardia kondana* is reported only from a small Sinhagadh plateau (less than 1 sq. km) near Pune, Maharashtra. Out of the 1,225 bird species recorded in India, about 155 are under threat of extinction: 14 are Critically Endangered, 16 are Endangered, 58 are Vulnerable, and the rest Near Threatened. There has been 97 to 99% decline in the *Gyps* vulture population since the spread of the killer-drug diclofenac from early 1990s. The Great Indian Bustard *Ardeotis nigriceps* is slipping away as its last remaining habitat is taken over by man. Soon its booming display call will become silent. We now have empty skies and silent dunes.

Thanks to the unrestricted use of chemical pesticides, insect populations have crashed, cascading the decline of so-called common birds. The chirpy call of the House Sparrow is no more heard in most houses as it cannot find soft-bodied insects for its chicks in cities and even in intensive agriculture areas. There has been 50-80% decline in the bee population in the world, so much so that in some parts of China, workers are employed in orchards to manually pollinate flowers.

Due to land hunger, thriving 'living' forests are being replaced by monoculture plantations, pastures or agriculture fields. For example, from 1990 to 2005, more than 70 million hectares of original forests was cleared, much of it in South America, for pastures. Deforestation, sometimes encouraged by governments, has reached alarming situation in much of South-east Asia, mainly for oil palm plantations.

Invasive species are a major threat to numerous taxa on islands, particularly to birds. Introduced cats, rats, mongoose, dogs have exterminated more bird species during the last 500 years than all other factors combined. Many small remote oceanic islands where sea birds used to breed are empty, thanks to invasive species.

In our housing societies where planting trees has become a fashion, mainly exotic fast-growing trees are planted which do not attract native birds and insects. We may have some greenery, but no bird sings in it.

Nearly 50 years ago, Rachel Carson wrote the famous book SILENT SPRING that brought into focus the horrors of pesticides to the general public. It resulted in official ban of the DDT in most countries and restriction on many pesticides. As far as biodiversity is concerned, since Rachel's book, we are sliding down to reach the Eremozoic Era – the Age of Silence.

Unless we reverse the extinction crises, soon the forest of the Kashmir Vale will not hear the loud bugle call of the Hangul, the forest of central India will not hear the spine-chilling roar of the tiger, and the dunes of the Thar desert will not hear the far-carrying booming call of the Great Indian Bustard. Even our neighbouring Magpie Robin will not delight us with its melodious song. Will we be happy in this silent world?

Asad R. Rahmani

■ ■ ■

ENSURING THE FUTURE OF THE TIGER AND OTHER LARGE MAMMALS IN THE SOUTHERN PORTION OF THE NILGIRI BIOSPHERE RESERVE, SOUTHERN INDIA

A.J.T. Johnsingh[1,2], R. Raghunath[1,3], Rajeev Pillay[1,4] and M.D. Madhusudan[1,5]

[1]Nature Conservation Foundation, 3076/5, 4th Cross, Gokulam Park, Mysore 570 002, Karnataka, India.
[2]Email: ajt.johnsingh@gmail.com
[3]Email: raghu@conservation.in
[4]Email: rajeev@conservation.in
[5]Email: mdm@conservation.in

The Nilgiri Biosphere Reserve, at the tri-junction of Tamil Nadu, Kerala and Karnataka, constitutes arguably one of the finest conservation landscapes in the global range of the tiger. We surveyed the southern part of this region, as well as the adjoining areas, to assess the status of large mammals both within and outside protected areas. Our field assessments suggest that large mammals are almost exclusively confined to protected areas with the few remaining populations outside under severe threat from habitat degradation and poaching. However, large stretches of contiguous forests still remain. We suggest the extension of the recently notified Mudumalai Tiger Reserve in Tamil Nadu such that connectivity is retained and strengthened with Biligiri Rangaswamy Temple Wildlife Sanctuary of Karnataka to the north-east and with Silent Valley National Park of Kerala to the south. We also provide suggestions on strengthening conservation in this landscape. The involvement of local communities in the establishment of the Siruvani Conservation Reserve in Kerala and Tamil Nadu, and Nilambur Conservation Reserve in Kerala, will bolster the conservation of large mammals in this landscape. With the suggested extension, Mudumalai Tiger Reserve has the potential of becoming arguably the finest habitat for tigers across Asia, given the variations in altitude, topography and climate which produce a diversity of vegetation types and consequently, provide the tiger with an assortment of prey ranging from Nilgiri Tahr in the high altitude montane grasslands to Blackbuck in the low-lying dry deciduous and thorn scrub forests.

Key words: connectivity, corridor, Mudumalai Tiger Reserve, Nilambur Conservation Reserve, protected area, Siruvani Conservation Reserve, wildlife

INTRODUCTION

Tigers *Panthera tigris* are in decline throughout their range and the global population of around 3,500 individuals (Karanth 2001), of which 50% survive in India (Jhala *et al.* 2008), is severely threatened by anthropogenic pressures. Consequently, despite international conservation efforts the range of the tiger has declined by 40% in the last decade (Dinerstein *et al.* 2007; Sanderson *et al.* 2006). India has made a commendable effort towards tiger conservation by establishing as many as 39 tiger reserves and notifying several more for establishment in the near future. However, the mere demarcation of protected areas as tiger reserves has not succeeded in maintaining populations of this endangered felid in these reserves, as evident from the disappearance of tigers from Sariska Tiger Reserve in Rajasthan in 2004 and from Panna Tiger Reserve in Madhya Pradesh in 2009. Again, the low density tiger populations in as many as 16 reserves and the ineffectiveness of management due to insurgency in reserves such as Palamau in Jharkhand, Simlipal in Orissa, Nagarjunasagar in Andhra Pradesh, Indravati in Chattisgarh, Valmiki in Bihar, Dampa in Mizoram and Namdapha in Arunachal Pradesh (Jhala *et al.* 2008) are major concerns for the future of the Tiger in India. It is therefore vital to strengthen tiger conservation in parts of India where law and order issues do not pose a problem, such that the continued survival of tiger can be ensured in at least some parts of its range. In this paper, we focus on the southern portion of the Nilgiri Biosphere Reserve, where we assess the status of the tiger and other large mammals. We recommend the extension of Mudumalai Tiger Reserve, which was notified in 2007, as well as the creation of Siruvani and Nilambur Conservation Reserves. We underline the conservation measures that need urgent implementation, such that the southern part of the Nilgiri Biosphere Reserve reaches its full potential in maintaining populations of the tiger, as well as an assemblage of sympatric predators and prey species.

STUDY AREA

One of the finest conservation landscapes in possibly the entire range of the tiger lies in the Nilgiri Hills and adjoining areas of southern India (Fig. 1). The intact tiger habitat here is nearly 8,000 sq. km, part of which falls under the Nilgiri Biosphere Reserve. Major protected areas in this region are Pushpagiri, Brahmagiri, Talacauvery, Biligiri Rangaswamy Temple, Cauvery, Sathyamangalam, Aralam and Wayanad Wildlife Sanctuaries, Bandipur, Nagarahole and Mudumalai

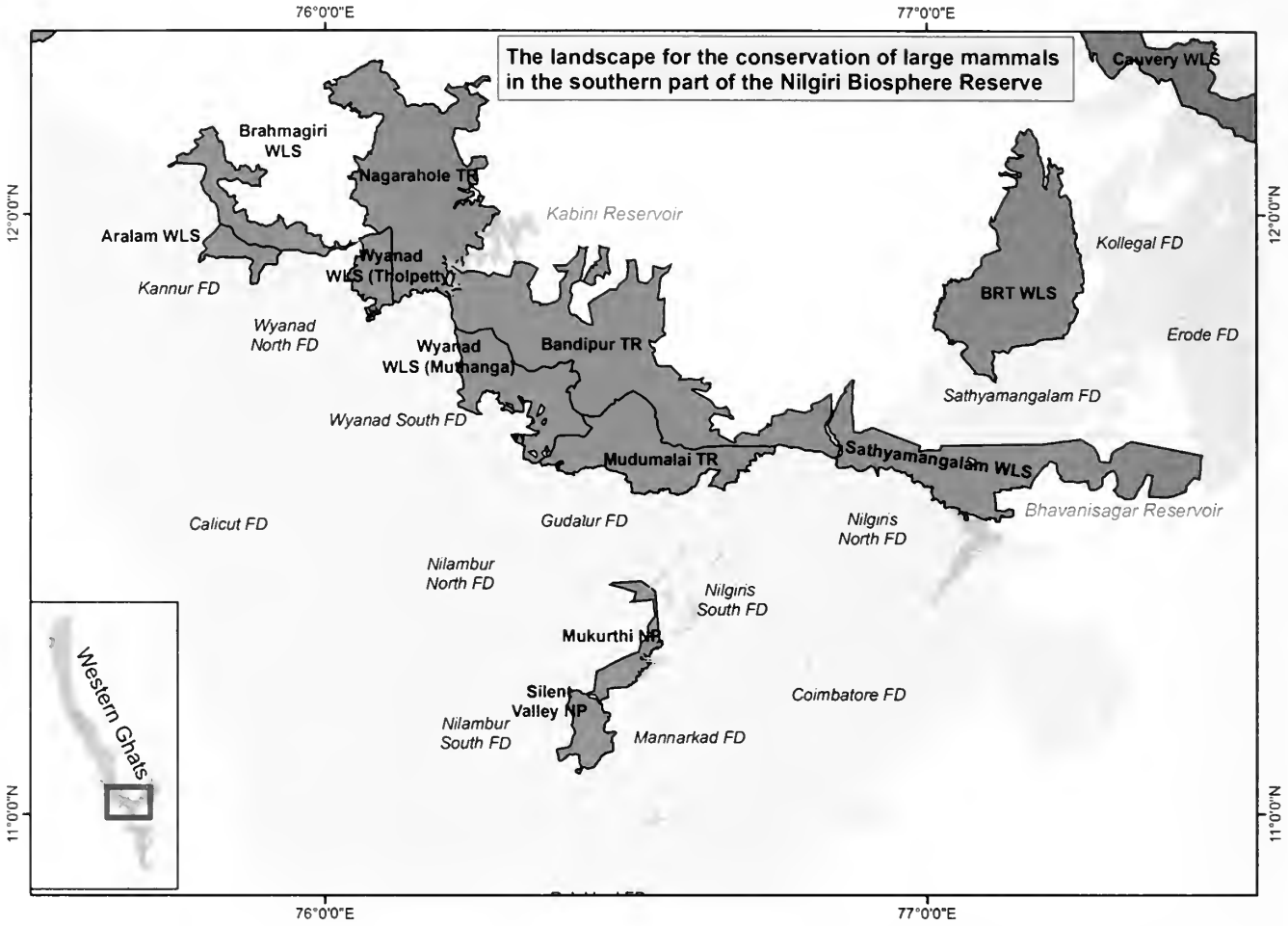


Fig. 1: The landscape for the conservation of large mammals in the southern part of the Nilgiri Biosphere Reserve

Tiger Reserves, and Silent Valley and Mukurthi National Parks. These protected areas are surrounded by reserve forests in the Forest Divisions of Palakkad, Mannarkad, Coimbatore, Nilgiris South, Nilambur South and North, Kozhikode (Thamarassery Range), Wayanad South, Hosur, Dharmapuri and Kollegal. Apart from the Tiger, other charismatic large mammals occurring in this tract are the Leopard *Panthera pardus*, Dhole *Cuon alpinus*, Striped Hyena *Hyaena hyaena*, Sloth Bear *Melursus ursinus*, Asian Elephant *Elephas maximus*, Gaur *Bos gaurus*, Nilgiri Tahr *Nilgiritragus hylocrius*, Sambar *Rusa unicolor*, Blackbuck *Antilope cervicapra*, Four-horned Antelope or Chowsingha *Tetracerus quadricornis*, Lion-tailed Macaque *Macaca silenus* and Nilgiri Langur *Trachypithecus johnii*. In the past, the forests between Biligiri Rangaswamy Temple Wildlife Sanctuary and Mudumalai Tiger Reserve possibly harboured the Cheetah *Acinonyx jubatus*, Wolf *Canis lupus*, Nilgai *Boselaphus tragocamelus* and Chinkara *Gazella bennettii* (Nicholson 1887; Pythian-Adams 1951).

METHODS

We carried out field surveys between November 2007 and July 2009 aimed at understanding habitat quality and documenting habitat use by large mammals in the southern part of the Nilgiri Biosphere Reserve and adjoining areas. We recorded the geographic locations of sightings and signs of large mammals we encountered. We also compiled a description of the dominant vegetation cover and land use along survey routes. The survey data was mapped in a Geographical Information System (GIS) along with remotely-sensed data. A forest cover layer was prepared for the area to examine connectivity and a description was compiled on the location and contiguity of natural habitat across the landscape. On the basis of large mammal occurrence, vegetation-land cover maps, discussions with local communities and Forest Department personnel and our own observations, passages of least resistance for the movement of large mammals were identified.

With regard to the extension of Mudumalai Tiger Reserve, we surveyed Mukurthi National Park, Gudalur and Bitharkadu ranges in Gudalur Forest Division, Singara, Sigur and Nilgiris Eastern Slope ranges in Nilgiris North Forest Division, Bhavanisagar, Sathyamangalam, T.N. Palayam,

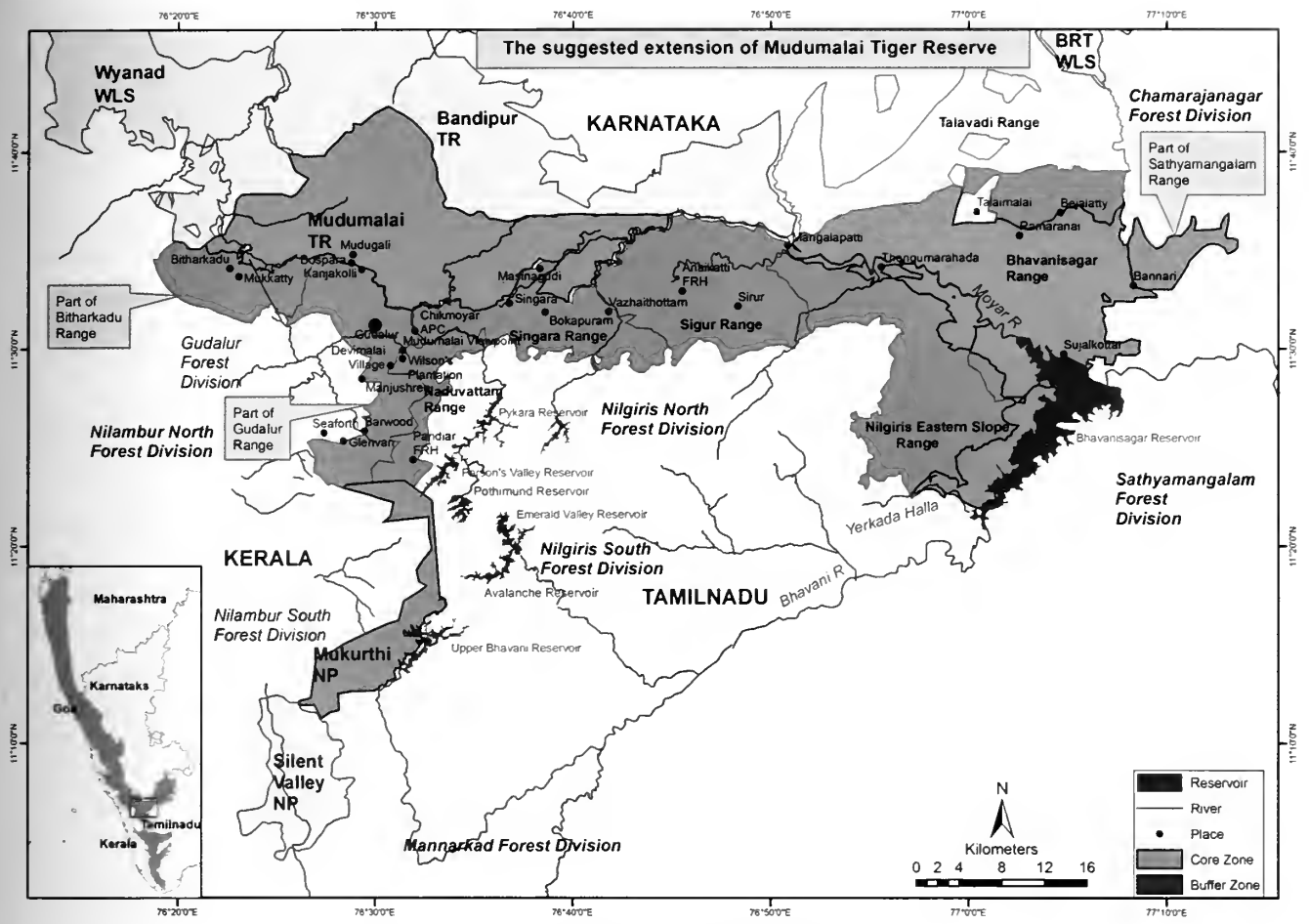


Fig. 2: The suggested extension of Mudumalai Tiger Reserve

Hasanur and Talavadi ranges in Sathyamangalam Forest Division in Tamil Nadu, and Biligiri Rangaswamy Temple Wildlife Sanctuary in Karnataka. The total survey effort was 1,400 km by vehicle and 145 km on foot.

With regard to the establishment of Nilambur and Siruvani Conservation Reserves, we surveyed areas to the east and south of Mukurthi and Silent Valley National Parks comprising Palakkad, Mannarkad, Coimbatore, Nilgiris South, Nilambur South and Nilambur North Forest Divisions, Thamarassey range in Kozhikode Forest Division and Meppady range in Wayanad South Forest Division. The total survey effort here was 840 km by vehicle and 24 km on foot.

RESULTS

Mudumalai Tiger Reserve and adjacent areas

The sighting of a Tiger and the presence of its feral buffalo kill near Thengumarahada village together with several sightings of Blackbuck, Chital *Axis axis* and Gaur in the recently established Sathyamangalam Wildlife Sanctuary indicate the richness of large mammal fauna in this area. Sathyamangalam Wildlife Sanctuary is connected with Mudumalai Wildlife Sanctuary to the east and Biligiri Rangaswamy Temple Wildlife Sanctuary to the north. The flat topography (mean altitude 200 m above msl), and dry deciduous and thorn scrub habitat of Sathyamangalam Wildlife Sanctuary makes it a fairly suitable habitat for Blackbuck. However, proliferation of *Opuntia dillenii* and *Prosopis juliflora*, both exotics from the new world, is gradually beginning to make the habitat too dense for Blackbuck and Chital which are species of open grassland habitats. This area is also well-connected to the montane grassland and *shola* habitats of Mukurthi National Park (average altitude 2,400 m above msl) through Sigur range, Mudumalai Wildlife Sanctuary, and Singara and Naduvattam ranges (Fig. 2). Therefore, these forests on the eastern side of the Western Ghats form a contiguous stretch from Mukurthi National Park to Biligiri Rangaswamy Temple Wildlife Sanctuary. On the west, the connectivity of Mukurthi National Park with Silent Valley National Park is intact.

We obtained direct sightings as well as indirect evidences for the Tiger, Leopard, Dhole, Elephant, Gaur, Wild Pig *Sus scrofa* and Sambar throughout the stretch from Mukurthi National Park to Sathyamangalam Wildlife Sanctuary. In the lower reaches of the eastern slopes, we observed species such as Chital, Chowsingha, Blackbuck, feral buffalo, Southern Plains Grey Langur *Semnopithecus dussumieri* and Bonnet Macaque *Macaca radiata*. This diversity of mammals highlights the unique nature of the habitat with its wide altitudinal range and diverse vegetation types where tigers possibly prey on an assortment of ungulates ranging from the Blackbuck, Chital, Wild Pig, Sambar, Gaur and feral buffalo in the lower elevations to the Nilgiri Tahr in the high altitudes.

However, we identified a number of threats to conservation in this area which include heavy traffic along the Dimbum – Sathyamangalam road and the depletion of the fish resources of the Moyar river, which harbours a population of around 100 mugger or freshwater crocodiles *Crocodylus palustris*, due to the pressure exerted by the Special Task Force camp. There are proposals to build a rail link between Sathyamangalam in Tamil Nadu and Chamarajanagar in Karnataka and a highway between Sathyamangalam and Sirur connecting Ooty/Gudalur, while resorts are proliferating in the Masinagudi area adjoining Mudumalai Tiger Reserve. The proliferation of *Lantana camara* and the lack of regeneration of palatable species for wild ungulates is a serious concern. Nearly 1,600 people live in 30 tiny enclaves in Mudumalai and Nelakottai ranges, and have not been relocated despite their willingness to do so. The growing firewood needs of Gudalur township poses a threat to the Mukurthi-Mudumalai corridor. Burgeoning tourism in the area could be inimical to conservation and there has been a delay in the extension of the Mukurthi National Park (78.46 sq. km) by another 33 sq. km.

Siruvani Hills and adjacent areas

We obtained direct sightings and indirect evidences of the Golden Jackal *Canis aureus*, Elephant, Gaur, Wild Pig, Sambar, Nilgiri Tahr, Nilgiri Langur, Southern Plains Grey Langur, Bonnet Macaque and Indian Giant Squirrel *Ratufa indica*. The moist deciduous forests here afford connectivity to Walayar and Agali ranges in Palakkad and Mannarkad Forest Divisions respectively (Fig. 3). We obtained several indirect signs of Elephant, Gaur and Sambar on a survey of the upper reaches of Agali range to assess connectivity between Siruvani Hills and Silent Valley National Park. We also sighted a tusker, a gaur bull, three Sambar and a Nilgiri Langur in Agali range. However, poaching is reportedly rampant here with many villagers and tribals possessing illegal firearms. We surveyed Attappady range in Mannarkad Forest Division where the valley is completely under human occupation while the southern hilly areas are forested. No signs of herbivores like Chital and Sambar were found during a drive of 60 km within Karamadai range in Coimbatore Forest Division and up to Pillur reservoir in Mettupalayam range which supplies water to about 50% of the population in Coimbatore city, the other half obtaining water from the Siruvani reservoir. Even though the habitat appears suitable, rampant hunting in the past when the reservoir was under construction and possible poaching at present may be the reason for the near absence of large mammals around the reservoir. Several tribal settlements were observed within Karamadai range each with a sizeable population of dogs. The possibility of tribals using dogs for poaching cannot be ruled out.

We observed a tusker at mid-day on the infrequently used Parali-Coonoor road, which suggests that less disturbed roads may serve as conduits for large mammals. The drive (about 50 km) from Karamadai range to Manjoor in Kundha range, Nilgiris South Forest Division yielded only one indirect evidence each of Sloth Bear, Elephant, Gaur and Sambar indicating that large mammal use of this hilly area is sporadic possibly as a result of speeding vehicles and steep terrain on either side of the road. However, we sighted a group of 19 Gaur at the edge of a *shola* and a tea plantation located between Chamaraj Tea Estate and Kundha Reservoir. The Gaur were unmindful of the people using the road and working in the surrounding tea gardens, which suggests that this bovid, if not hunted and if allowed sufficient habitat, can survive in the proximity of people.

Nilambur Hills and adjacent areas

This zone (Fig. 3) comprises the forest ranges of Karulai in Nilambur South Forest Division, Vazhikadavu, Nilambur and Edavanna in Nilambur North Forest Division, Thamrassery in Kozhikode Forest Division and Meppady in Wayanad South Forest Division. Our survey yielded sightings and indirect evidence of Elephant, Chital, Southern Plains Grey Langur and Indian Giant Squirrel.

The habitat in Karulai range (265 sq. km), which adjoins Mukurthi National Park in the east and is populated by just four *sholanaickan* tribal settlements with a population of *c.* 600 people, appears to be of good quality. The habitat is devoid of exotic weeds such as *Lantana camara*, *Parthenium hysterophorus* and *Eupatorium odoratum* while the abundance of species such as *Dendrocalamus strictus*, *Bambusa arundinacea*, *Terminalia belerica*, *T. tomentosa*, *Caryea arborea*, *Grewia tiliaefolia* and *Zizyphus xylopyrus* is suitable for large herbivores such as Gaur, Sambar and Chital. However, widespread poaching in the past as also in

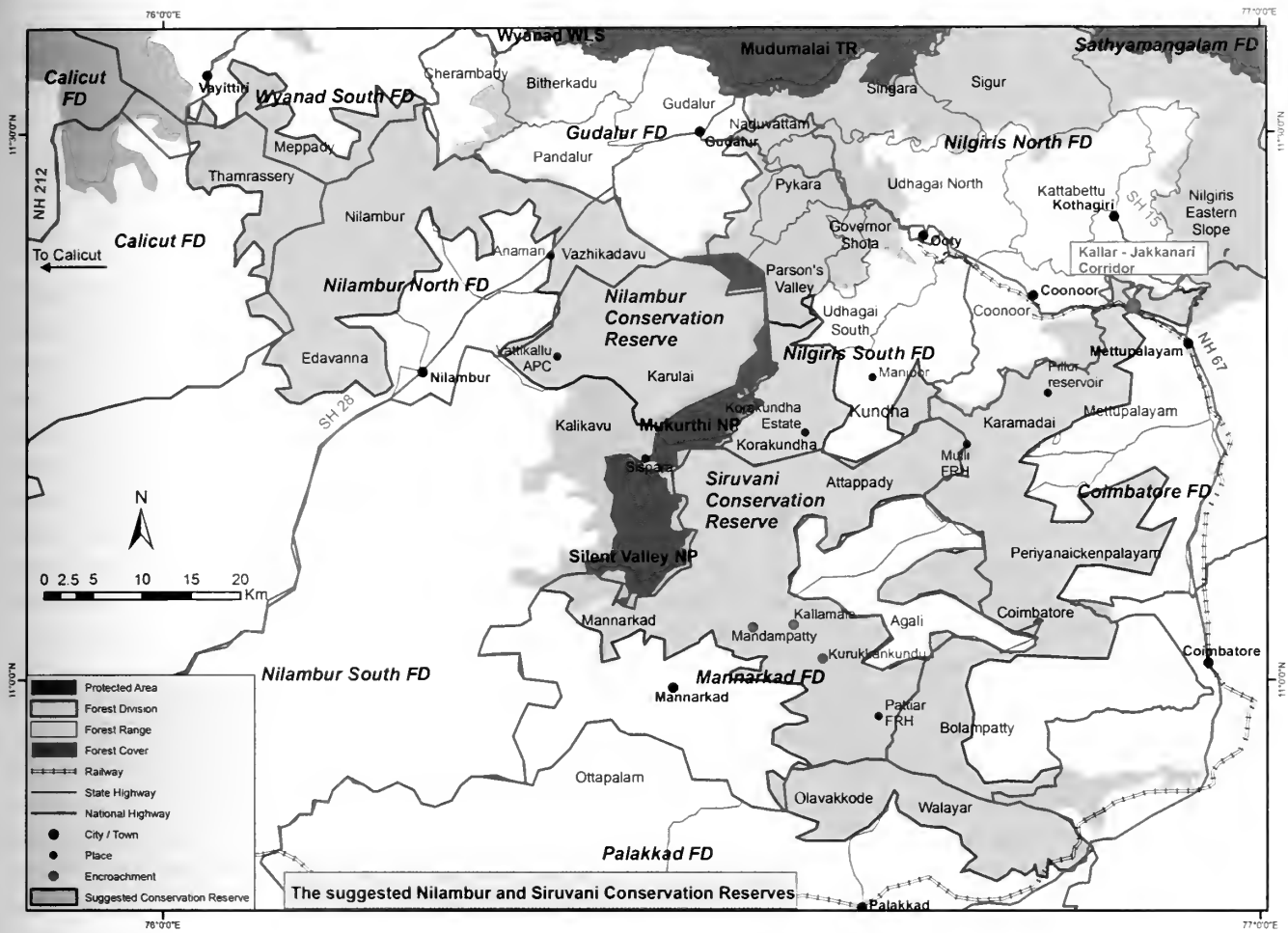


Fig. 3: The suggested Nilambur and Siruvani Conservation Reserves

the present may have resulted in the near elimination of the prey base in Karulai range. Our drive of 38 km and walk of 4 km yielded only a sighting of one elephant herd and a few groups of Southern Plains Grey Langur. We only heard a few Chital alarm calls during a night spent in Vattikallu anti-poaching camp. To the north lies Vazhikadavu range which has a large patch of rainforest habitat with a population of Lion-tailed macaques. Reliable anecdotal evidence suggests that elephants, sambar and wild pig cross the Gudalur-Nilambur road in the area of the rainforest. The landscape north of Nilambur North Forest Division is predominantly tea and reports of the occurrence of species such as the Elephant, Sambar, Wild Pig and Leopard in the tea estates adjacent to the Gudalur-Cherambadi road suggests the possibility that the patches of forests between Bitharkadu range and the road serve as stepping stones for wildlife movement (Bennett 2003). Efforts should be made to identify such stepping stones and protect them. North-west of Thamrassery and Meppady ranges, forest connectivity is broken by the busy Sultan Bathery – Kozhikode National Highway.

Mukurthi and Silent Valley National Parks and Wyanad Wildlife Sanctuary

We also surveyed Mukurthi and Silent Valley National Parks and Wyanad Wildlife Sanctuary to document the status of large mammals within these protected areas and compared the areas with similar habitats outside. Table 1 summarizes the survey effort and large mammal encounter rates within each range of Wyanad Wildlife Sanctuary and Silent Valley – Mukurthi National Parks.

Abundance of *Lantana camara*, *Eupatorium odoratum* and profuse regeneration of *Cassia fistula*, whose leaves are unpalatable to ungulates, were observed on both sides of the survey route in Tholpetty range of Wyanad Wildlife Sanctuary, which is connected to Nagarahole Tiger Reserve in the north and Brahmagiri Wildlife Sanctuary to the west. Drives inside Muthanga (connected to Bandipur TR to the north-east and Benne range of Mudumalai Tiger Reserve in the east), Sultan Bathery (connected to Bandipur Tiger Reserve in the east) and Kurchiad ranges (connected to Begur and Gundre ranges of Bandipur Tiger Reserve) in Wyanad

Wildlife Sanctuary yielded many sightings of large herbivores and many indirect evidences of large carnivores such as the Tiger and Dhole. The highest large mammal encounter rates were in Sultan Bathery range (Table 1). However, the absence of speed-breakers on the six kilometre stretch of the Sultan Bathery – Mysore road which passes through Muthanga range is a recipe for road kills. Since the ban on night traffic through Bandipur Tiger Reserve in mid-2009, vehicles from Kerala line up at the Muthanga gate causing further disturbance to the movement of wildlife. We recommend the shifting of this gate from its present location at the inter-state border to six kilometres within Kerala where the forests begin.

DISCUSSION

Establishment of large, contiguous protected areas and community participation in the protection and management of wildlife are crucial to ensure the long-term survival of wildlife. The aim of setting up conservation reserves is to provide a flexible and effective management system for wildlife conservation without compromising the needs of local communities. Involvement of the local communities would go a long way in promoting and sustaining programs such as regeneration of native species in exotic plantations and strengthening anti-poaching measures. We specify the extension of Mudumalai Tiger Reserve and identify two areas within the southern and south-western Nilgiri Biosphere Reserve where prey and predator recovery should be facilitated with the specific objective of enabling the tigers to reside and breed.

Suggested extension to Mudumalai Tiger Reserve

We suggest the inclusion of Mukurthi National Park, parts of Naduvattam range in Nilgiris South Forest Division, Sigur, Singara, Nilgiris Eastern Slope Ranges in Nilgiris North Forest Division and the newly established Sathyamangalam Wildlife Sanctuary within Mudumalai Tiger Reserve (Fig. 2). Bitharkadu (67 sq. km) and Gudalur (118 sq. km) ranges (Gudalur FD) may not be included within the Tiger Reserve but special management attention in the form of conservation education should be directed at the people of these two ranges, to enlist their support for conservation as poachers from these areas are often reported to operate in the nearby forests. Sigur and Naduvattam ranges are crucial for connecting Mudumalai Wildlife Sanctuary with Mukurthi National Park. There exist historical records of the occurrence of Nilgai *Boselaphus tragocamelus* and Chinkara *Gazella bennettii* in the Sathyamangalam region (Pythian-Adams 1951). Blackbuck is still common in Sathyamangalam Wildlife Sanctuary, Sigur range and the adjacent Moyar range of Bandipur Tiger Reserve. We believe that the Four-horned Antelope, which occurs in the adjacent Sigur range, may also be occurring in Sathyamangalam Wildlife Sanctuary. If Chinkara and Nilgai are reintroduced in this fairly well-protected stretch of habitat, where the factors responsible for their original extirpation may no longer operate, the uniqueness of this landscape will be further enhanced. If this were to be realized, nowhere else in the global range of the Tiger would one find such an assemblage of large mammal prey, ranging from four species of peninsular antelopes, three species of forest deer, a species each of wild cattle, wild pig and mountain ungulate and four primate species.

Table 1: Survey effort and large mammal encounter rates within each range of Wayanad Wildlife Sanctuary and Silent Valley – Mukurthi National Parks

Species	Tholpetty drive (18 km)	Muthanga drive (28 km)	Sultan Bathery drive (44 km)	Kurchiad drive (51 km)	Silent Valley – Mukurthi walk (50 km)
Tiger	0.05	0	0.02	0.01	0.02
Elephant	0.11	0.42	0.59	0.09	0.02
Gaur	0.16	0	2.27	0.74	0.02
Sambar	0.16	1.10	0.15	0	0
Chital	7.16	2.00	6.38	0.39	0
Indian Muntjac	0	0.03	0	0.03	0
Nilgiri Tahr	0	0	0	0	0.02
Wild Pig	0	0	0.04	0.13	0
Southern Plains Grey Langur	1.05	0.28	0.68	0.07	0
Nilgiri Langur	0	0	0	0	0.08
Lion-tailed Macaque	0	0	0	0	0.02
Bonnet Macaque	0.27	0	0.27	0	0
Indian Giant Squirrel	0	0.03	0	0.05	0.06

Our sighting of a tiger and its feral buffalo kill occurred near Thengumarahada village, which is situated on the right bank of Moyar river in Nilgiris Eastern Slope Range. The land in the village was originally given to a few families of the *badaga* community on a lease of 100 years. However, they sub-leased their property to outsiders and relocated to cities. After 30 years or so, the Government may have to decide on whether to renew the lease or allow forests and wildlife to take over the village area again. The existence of this village, which is likely to grow into a small town, poses several potential problems to this tiger landscape.

We suggest the regulation of traffic along the Dimbam-Sathyamangalam road by constructing functional speed breakers along the six kilometers between the base of the mountain (Balari Amman temple) and the edge of the forest boundary, the relocation of the Special Task Force camp to control poaching around Kollegal and Coimbatore Forest Divisions and the use of the existing camp by anti-poaching personnel of the Forest Department and trainees of Mettupalayam Forestry College. We strongly urge the scrapping of the proposal to build a railway track between Sathyamangalam and Chamarajanagar and an all weather road between Sathyamangalam and Sirur connecting Ooty/Gudalur as they will forever destroy the last bit of wilderness in the lower Nilgiri Plateau. The problem of lack of regeneration of palatable species such as *Bauhinia racemosa*, *Gmelina arborea*, *Grewia tiliaefolia*, *Lannea coromandelica*, *Terminalia belerica*, *Zizyphus mauritiana* and *Z. xylocarpus* should be addressed by growing thousands of these species in nurseries for several years and planting them along with the onset of the monsoon using *Lantana* thickets as a biofence. Incentive-driven voluntary resettlement of the people living in Mudumalai and Nelakottai ranges should be carried out at the earliest so as to create disturbance-free prey rich areas for the tiger. Connectivity between Mukurthi National Park and Mudumalai forests (Sigur Plateau) can be strengthened by not allowing major tourism development between Gudalur and Naduvattam, by acquiring failed tea estates in this corridor area and by stopping firewood extraction by people from Gudalur. In this context, the possibility of growing firewood species in existing agricultural and waste lands in Gudalur FD needs to be explored so as to meet the growing firewood needs of Gudalur township. It is also important to acquire farms at the junction of Masinagudi, Kargudi and Gudalur ranges, which are not under cultivation, to prevent them from being used as hideouts for poachers. The final notification of the extension of Mukurthi National Park needs to be passed at the earliest. This will include part of Nilgiri Peak, Pothimund and Kundah Reserved Forests.

Establishment of Conservation Reserves

Siruvani Conservation Reserve

The forests of the Siruvani hills (Fig. 3), to the south-east of Mukurthi National Park and to the east of Silent Valley National Park, are important not just to biodiversity conservation, but are also catchments of the Siruvani reservoir, which provides water to hundreds and thousands of people in Coimbatore city. Nilgiri Tahr is reported from a number of locations such as Muthukulam and Vellingirimala within this landscape. Securing these wildlife habitats for conservation would not only ensure connectivity in a west-east direction between Silent Valley National Park and the forests of Coimbatore Forest Division, but also connectivity to extensive forest areas to the north of the Nilgiri Plateau. Around 1,400 sq. km of forested area in Mannarkad, Agali and Attappady ranges in Mannarkad Forest Division, Olavakkode and Walayar ranges in Palakkad Forest Division, parts of Bolampatty, Periyanaickenpalayam, Karamadai and Mettupalayam ranges in Coimbatore Forest Division and Kundha, Korakundha and Udhagai South ranges in Nilgiris South Forest Division could be included under the suggested Siruvani Conservation Reserve. There are two potential routes for the movement of animals from the Siruvani Hills to the adjoining forest areas.

Corridor 1: The connectivity to the east and north-east of Korakundha towards the Eastern Ghats is through the forested areas of Kundha, Attappady, Karamadai and Mettupalayam ranges. The Kallar-Jakkanari corridor in Mettupalayam range (Fig. 3) seems to be the only transit route for large mammals to move between the forests south of the Mettupalayam-Ooty highway (Coimbatore Forest Division, Mannarkad and Palakkad Forest Divisions) and rail track towards Sirumugai range in Coimbatore Forest Division, Nilgiris Eastern Slopes, Sigur range in Nilgiris North Forest Division and Sathyamangalam Wildlife Sanctuary. The existing connectivity is highly threatened by intense human land use impeding the movement of wildlife such as Gaur and Elephant. Tiger use of this corridor is extremely rare. The heavy traffic on the Mettupalayam-Ooty and Kothagiri highways is another major problem in this corridor. There are plans by the Tamil Nadu Forest Department to acquire some agricultural lands south of the corridor but an 800 m long flyover at the base of the hills for vehicles on both the highways is a must.

Corridor 2: Siruvani Hills to Silent Valley National Park through Agali and Mannarkad ranges of Mannarkad Forest Division is much shorter (less than 10 km) and it passes mostly through the evergreen forests and across grasslands. The habitat connectivity appears intact but there are disturbances in the form of encroachments in the intervening

areas such as Mandampatty and Kurukkankundu settlements which are presently preventing the free movement of large mammals between Siruvani Hills and Silent Valley National Park. This route may be ideal and crucial for the movement of large mammals between Siruvani Hills and Silent Valley National Park but for the encroachments and poachers living within. As a result, large mammal use of this corridor is exceedingly rare. The removal of these encroachments is therefore of vital importance for large mammals to commence using this corridor. On a two kilometre walk to Kurukkankundu hill top through forest and grasslands where bamboo and other species such as silver oak have been planted, we could only see indirect evidence of Elephant and Sambar. Several other encroached areas such as Puliyarai, Kuruvanpadi, Thumbappara and Kallamala in Agali range which presently act as barriers for large mammal movement across this landscape have also been identified during our surveys.

Nilambur Conservation Reserve

Nilambur South and North Forest Divisions occupy the lowlands immediately west of Mukurthi National Park, and to the north-west of Silent Valley National Park. We suggest the demarcation of around 900 sq. km of forested area as the Nilambur Conservation Reserve which includes Karulai range in Nilambur South Forest Division and parts of Vazhikadavu, Nilambur and Edavanna ranges in Nilambur North Forest Division as well as narrow stretches of forests in Meppady and Thamaraserry forest ranges in Wyanad South and Kozhikode Forest Divisions respectively. The major reason for the near absence of large mammals in this tract is primarily due to poaching which needs to be addressed on a priority basis.

CONCLUSION

Wildlife areas in the southern parts of the Nilgiri Biosphere Reserve are linked to the forests to the north (Mudumalai Tiger Reserve) in terms of continuous forest cover; yet a few critical links are extremely narrow and continue to be highly threatened by anthropogenic factors. Establishment of the Siruvani and Nilambur Conservation Reserves on the suggested model will help consolidate the narrow links of forest and revive wildlife populations which are now mainly restricted to Mukurthi and Silent Valley National Parks. This will also facilitate the dispersal of wildlife between protected areas. If well-protected, these two reserves can easily support a minimum of 50 tigers which can add to the existing population of around 250 adult tigers north of the suggested Conservation Reserves (Jhala *et al.* 2008).

Recent developments regarding conservation in this landscape have been very encouraging as in the decision of the Ministry of Environment and Forests to deny clearance to the establishment of the Indian Neutrino Observatory Project in Singara. The proposed site was in the buffer zone of Mudumalai Tiger Reserve which in conjunction with Bandipur and Nagarahole Tiger Reserves forms one of the key tiger landscapes. This conservation victory is the result of efforts by local non-governmental organizations backed by the Tamil Nadu Forest Department. The recent verdict by the Madras High Court to ban construction activities and demolish illegal commercial and private establishments along the Singara Elephant Corridor is also a significant boost for conservation in the area. NGOs such as WWF-India, Nilgiri Wildlife, and Environmental Association and Wildlife Trust of India were responsible for this verdict in favour of wildlife. We hope that the Tamil Nadu Government will be able to establish the corridor as directed by the High Court.

The establishment of Mudumalai Tiger Reserve along the suggested lines will require coordinated efforts of officials from the Tamil Nadu Forest Department, the Government of Tamil Nadu, the National Tiger Conservation Authority, local non-governmental organizations as well as the support of the local people and their elected representatives. An immediate priority is to establish the Mudumalai Foundation, as required by the recently amended Wildlife (Protection) Act, which could provide the legal basis to collect and utilize tourism revenues and other funds allotted for management. Such an independent body can also take care of the welfare of the tribals, local villagers, staff, mahouts and tribal anti-poaching watchers. If correctly established, Mudumalai Tiger Reserve will be peerless in the country for the diversity of its habitat, flora, fauna and ethnic communities. It can easily support a minimum population of 70 adult tigers along with various other endangered species such as the Orange-finned Mahseer *Tor moyarensis*, Mugger *Crocodylus palustris*, King Cobra *Ophiophagus hannah* and Great Hornbill *Buceros bicornis*. The long-term goal for the inter-state tiger landscape where Mudumalai Tiger Reserve is located, should be to have a minimum population of 300 adult tigers along with a thriving population of mega-herbivores, such as the Asian Elephant and Gaur.

ACKNOWLEDGEMENTS

We are grateful to the Ministry of Environment and Forests, Government of India, for financial support and encouragement, and to the State Forest Departments of Kerala and Tamil Nadu for permission, support and cooperation during field surveys. We thank N. Mohanraj and A. Desai for

assistance in planning survey routes and providing information about the landscape. We also thank V.K. Uniyal, W.S. Suiting, R. Srivastava, S. Ramasubramanian, K. Soundarapandian, M. Banerjee, N. Sathish, S. Sivadas, B.P. Varghese, C. Rajendran, K. Ummer, M. Sreedharan Nair, K.K. Sunil Kumar, A.R. Sasikumar, I. Anwardeen, J. Mathew, B.N. Nagarajan, Vimal and N. Dilip for all help and support rendered in the field.

REFERENCES

Bennett, A.F. (2003): Linkages in the landscape: The role of corridors and connectivity in wildlife conservation. IUCN, Gland, Switzerland and Cambridge, U.K.

Dinerstein, E., C. Loucks, E. Wikramanayake, J. Ginsberg, E. Sanderson, J. Seidensticker, J. Forrest, G. Bryja, A. Heydlauff & S. Klenzendorf (2007): The fate of wild tigers. *Bioscience 57*: 508-514.

Jhala, Y.V., R. Gopal & Q. Qureshi (2008): Status of tigers, co-predators and prey in India. National Tiger Conservation Authority, Government of India, New Delhi and Wildlife Institute of India, Dehradun.

Karanth, K.U. (2001): The Way of the Tiger. Natural history and conservation of the endangered big cat. Voyageur Press MN, U.S.A. and Centre for Wildlife Studies, Bangalore.

Nicholson, F.A. (1887): Madras District Manuals. Vol. 2. Ed: H.A. Stuart, Coimbatore, Madras Presidency.

Pythian-Adams, E.G. (1951): Jungle memories. Part IX – antelope and deer. *J. Bombay Nat. Hist. Soc. 50*: 1-12.

Sanderson, E., J. Forrest, C. Loucks, J. Eisenberg, E. Dinerstein, J. Seidensticker, P. Leimgruber, M. Songer, A. Heydlauff & T. O'Brien (2006): Setting priorities for the conservation and recovery of wild tigers: 2005-2015. WCS, WWF, Smithsonian and NFWF-STF, New York.

■ ■ ■

TIME BUDGET AND ACTIVITIES PATTERN OF CAPPED LANGURS *TRACHYPITHECUS PILEATUS* IN PAKKE WILDLIFE SANCTUARY, ARUNACHAL PRADESH, INDIA

G.S. Solanki[1] and Awadhesh Kumar[2]

[1]Department of Zoology, Mizoram University, Tanhril Campus, Aizawl 796 009, Mizoram, India. Email: gssolanki02@yahoo.co.in

[2]Department of Forestry, North Eastern Regional Institute of Science & Technology, Nirjuli 791 109, Arunachal Pradesh, India. Email: tpileatus@gmail.com

Time allocation for activities in langurs are endorsed by environmental and habitat conditions. We studied time allocation for various activities by Capped Langurs *Trachypithecus pileatus* on daily, monthly, seasonal, and annual basis over one-year period in the Pakke Wildlife Sanctuary, Arunachal Pradesh, India. 90% of annual time budget was spent feeding and resting; the time devoted to resting was significantly higher ($P<0.01$) than that devoted to feeding. Seasonal variations ($P<0.05$) were found in both feeding and resting times; the maximum time devoted to feeding was 39% in the winter; the maximum time devoted to resting was 59% in the monsoon. The amount of time devoted to major activities in different months was significantly ($P<0.001$) different. Feeding time was maximum (43%) in December and minimum (33%) in May; the variations were found to be significant ($P < 0.01$). The only month with maximum time (43%) devoted to feeding was in December, maximum resting (63%) time was in August, and maximum travelling (8%) time was in February in comparison to other months and remaining time was distributed to other activities. The diurnal activity budget of capped langurs indicated a bimodal feeding pattern. The evening feeding regime was significantly higher ($P<0.05$) than the morning one. It was 42% in morning hours and 51% in the evening.

Key words: Time budgets, daily activity patterns, capped langurs, Pakke Wildlife Sanctuary

INTRODUCTION

The Colobines are a diverse group of primates of different body size, which occur in a wide range of habitats and behave differently in order to maintain time-energy balances (Clutton-Brock 1974; Marsh 1978, 1981; Li 1992; Li and Rogers 2004; Malik 1986; Kurup and Kumar 1993; Watanuki and Nakayama 1993; Menon and Poirier 1996). The Capped Langur *Trachypithecus pileatus* is an endangered colobine species, indigenous to the north-eastern part of India (Choudhury 1989; Srivastava 1999). Its global distribution is restricted to Bangladesh, north-western Myanmar, Bhutan and southern China (Roonwal and Mohnot 1977; Zhang *et al.* 1981; Khan and Ahsan 1986; Stanford 1991; Ahsan 1994; Srivastava 1999).

The manner in which an animal allocates its time to various essential activities provides a useful window to its overall ecological strategy. In particular, the optimum utilization of resources in the habitat is paramount for an animal's survival and reproduction. Day length is a limiting factor in natural populations and influences all aspects of behaviour in social animals, especially anthropoids – day active primates, which have to meet and maintain their physiological and social needs (Altmann 1980; Dunbar 1988, 1992; Janson 1992). This constraint exerts pressure on the animal for budgeting its available time in the most efficient manner (Pyke *et al.* 1977; Altmann 1980). The Colobines living in a diverse array of habitats, the biology and behaviour of this monkey species has not been studied except by Stanford (1991) in Bangladesh, and a short study by Gupta (1994) and Alfred *et al.* (1998) in Tripura, India. Here we present data from a one year study of daily activities of Capped langurs in Pakke Wildlife Sanctuary. We analyzed the time allotment for various activities on a daily, monthly, and seasonal basis for one group of Capped langurs. We also correlate the height on a tree at which langurs spent active time during feeding and other activities. The baseline data presented here will be useful for the strategic planning in terms of habitat evaluation and conservation of the species.

MATERIAL AND METHODS

Study Area

We conducted this study at the Pakke Wildlife Sanctuary, located between 26°55′-27°15′ N and 92°35′- 93° 09′ E in India. This Sanctuary covers a geographical area of 861.95 sq. km in the East Kameng district of Arunachal Pradesh. The Sanctuary is surrounded by rivers on three sides and its fourth side shares a common boundary with the Nameri National Park, in the state of Assam. This area receives an average annual rainfall of 2,545 mm. The mean annual maximum temperature is 28°C and the minimum is 19°C. Average relative humidity is 84%. The altitudinal variation ranges from 100 m to 2,040 m above sea level. The Sanctuary harbours different types of vegetation namely, tropical evergreen forests, tropical semi-evergreen forests and

subtropical forests (Champion and Seth 1968). 234 woody species of flowering plants have been recorded from lowland areas of the Sanctuary. Several rare and endangered species of flora and fauna inhabit the Sanctuary. Four species of primates (*Macaca mulatta*, *M. assamensis*, *Trachypithecus pileatus* and *Nycticebus bengalensis*) are found in the Sanctuary.

Study Group

We identified two groups of Capped Langurs *Trachypithecus pileatus* in the study area. We chose the one male–multi-female group to collect data on the allotment of time to different activities in their natural habitat. The study ranged from October 01, 2001 to September 15, 2002. The composition of the study group was 1 adult male, 5 adult females, 1 sub-adult, and 1 infant. The group was habituated to human observers.

We adopted an *ad libitum* focal animal sampling technique as per Altmann (1974). One of the authors followed the group from 06:00 hrs to 17:00 hrs each day, for a period of 14 days per month. Thus, the hours for direct contact with langurs were 1,680. The observations were recorded into two sessions namely, forenoon (06:00-11:30 hrs) and afternoon (11:30-17:00 hrs) on different focal animal in each session (Bartlett 1999). Samples were taken at five-minute intervals. Thus, twelve entries of the focal animal were recorded in an hour. The focal animal was selected among all adult members of the group to ensure a balanced representation of each adult individual. On two occasions during study the focal animal was out of view for >15 minutes; hence we selected another focal animal of similar age to continue the observations. Animals were identified on the basis of morphology and marks on their body. We divided the observation period into three seasons: winter (November-February), summer (March-May) and monsoon (June-October).

The activities of Capped Langurs were categorized into five major classes: feeding, resting, travelling, grooming, and miscellaneous activity such as aggression and social play. Analysis of Variance (ANOVA) was used to compare daily, monthly, and seasonal variations in the time spent on different activities, and Student's t-test for comparison of highest and lowest feeding during days and months (Simpson *et al.* 1960).

RESULTS

Annual time budget and activity pattern

The average annual time spent by a group in feeding was 36.16% (±2.45), in rest 53.41% (±7.27), in travelling 5.34% (±2.29), grooming 3.84% (±2.06), and in other activities it was 1.24% (±0.49). Resting and Feeding were the major activities; langurs spent 90% of their active time on them. However, at 54%, resting took up more time than feeding (t =3.892, d.f. =5, P <0.01). The time utilized for travelling, grooming and miscellaneous activities was small.

Monthly time budget and activity pattern

Monthly variation in the amount of time the langurs spent on different activities (Fig. 1) was significant (F = 3.996, d.f. =11, $P < 0.001$). Time spent for resting was more compared to that of other activities across months. Maximum resting time (63%) was in August and minimum was (42%) in December; the variations were significant (t = 7.653, d.f. = 27, P<0.001). Time spent on feeding was maximum (42.7%) in December and minimum (32.6%) in May; the variations were found to be significant (t = 4.032, d.f. = 27, P < 0.01). Langurs spent a far lower percentage of activity time travelling than feeding and resting. The travel time across months varied (F = 17.563, d.f. =11, $P < 0.001$), it was highest (8.3%) in February and lowest (1.87%) in August. Animals devoted very little time to grooming, but it varied significantly (F = 14.563, d.f. =11, $P < 0.001$) between different months. Miscellaneous activities like aggression and social play took up very little time, and monthly variations in both activities were insignificant.

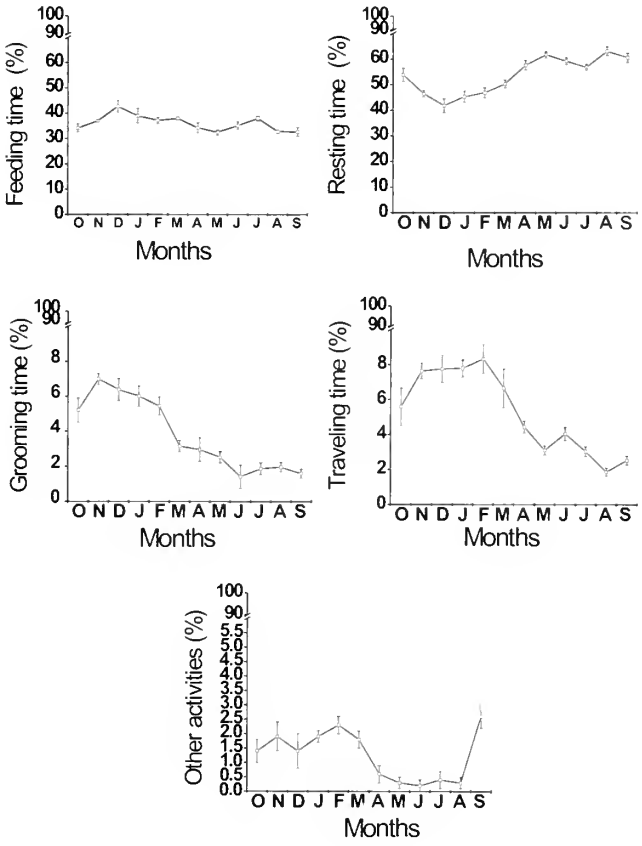


Fig. 1: Monthly variations in time (%) for different activities

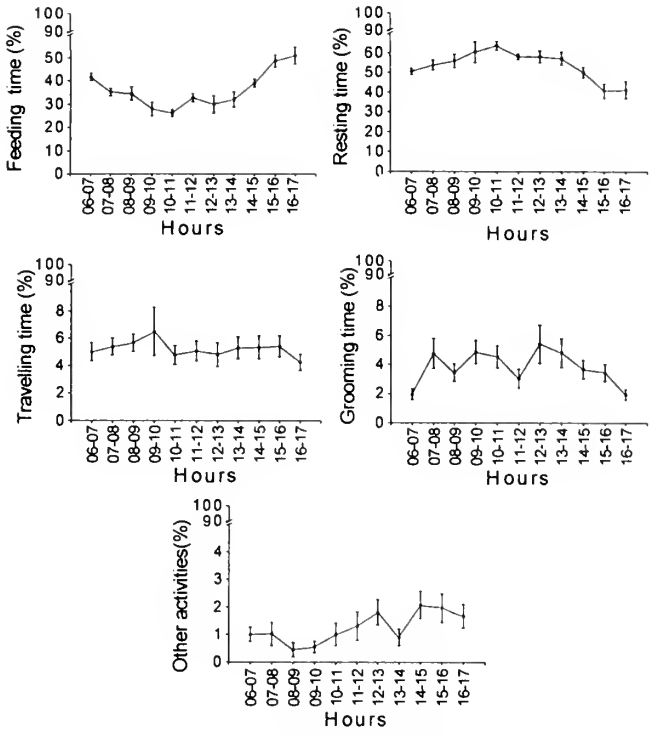


Fig. 2: Diurnal variation in time (%) for different activities

Diurnal time budget and activity pattern

The time allocation for activity classes during study period on an hourly basis is given in Fig. 2. Two major feeding peaks were recorded, the first occurred at early morning (06:00-07:00 hrs) and the second at evening (16:00-17:00 hrs). Time spent feeding during the evening peak was higher (51 ±13.4%) than that in morning (42±5.76 %). These two feeding peaks were significantly distinct ($t = 2.225$, d.f. = 23, $P < 0.05$). The morning feeding peak gradually declines and reaches its minimum between 10:00 to 11:00 hrs; thereafter, it gradually increases until the end of feeding activity of the day (Fig. 2). Langurs spent more time resting than in other activities, including feeding; it was 64% between 10:00-11:00 hrs that gradually decreased until the end of day (Fig. 2). Time spent travelling was nearly constant across the day. The maximum travelling (6.5%) occurred between 09:00-10:00 hrs (Fig. 2). Grooming time also varied throughout the day (Fig. 2). It was highest between 12:00-13:00 hrs. Insignificant time was spent on miscellaneous activities during day too (Fig. 2). Diurnal variation in the hourly time spent on different activities was significant ($F = 9.561$, d.f.= 10, $P < 0.001$) for feeding, resting, ($F = 5.220$, d.f. = 10, $P<0.001$), grooming ($F = 2.243$, d.f. =10, $P<0.01$), and for miscellaneous activities ($F = 1.878$, d.f. = 10, $P< 0.05$). Daily variations in time devoted travelling were insignificant.

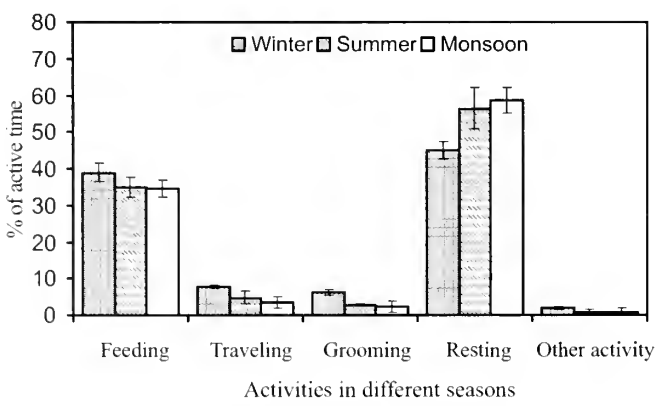


Fig. 3: Seasonal variation in time (%) for different activities

Seasonal time budget and activity pattern

Time allotment for the different activities in different seasons is presented in Fig. 3. Feeding and resting were major activities in all three seasons and the variations between them were significant (feeding: $F = 3.950$, d.f. = 2, $P< 0.05$, resting: $F = 14.929$, d.f. = 2, $P< 0.001$, travelling: $F = 13.464$, d.f. = 2, $P< 0.01$, grooming: $F = 13.889$, d.f. = 2, $P< 0.01$). Langur spent maximum time feeding (39%), travelling (7.88%), and grooming (6.21%) in winter. The season with the highest resting time was monsoon (58.66%).

DISCUSSION

In general, langurs spent by far the highest percentage of each day feeding (Kumar 2005). However, similar to many other folivorous primates (Fleagle 1988), the study animals spent more time resting than feeding or travelling. Optimal foraging theory predicts that animals should organize their feeding activities such that they can balance with energy expenditure (MacArthur and Planka 1966; Pyke *et al.* 1977). Capped Langurs rested for 54% of days surveyed (Fig.1) and leaves accounted for 68% of their annual diet (Kumar 2005; Solanki *et al.* 2008), reflect their folivore nature. Da Silva (1992, 1994) reported that folivores with diets of unusually low nutritional quality should spend more time resting than those with higher quality diets. She related the feeding time with condition of the habitat. The time spent on feeding (36%) in this study was similar to that reported for the same langur species by Gupta (1994) in Tripura, another part of north-east India, and by Stanford (1991) in Bangladesh, but the time spent on resting was higher in this study.

Biological, physical and climatic factors also influence the time budget pattern of capped langurs. The availability of dietary resources appears to influence the monkey's daily and seasonal activity budgets. In a study conducted by Solanki *et al.* (2008) it was found that 68% of the langur diet consisted of leaves and 61% of the total leaves ingested were young

leaves. Young leaves on analysis were found to be rich in protein by Kumar and Solanki (2004); leaves and flowers were the major food items of Capped Langurs at our site (Kumar 2005; Solanki *et al* 2008). Results of the study conducted by Gupta and Kumar (1994) on *Trachypithecus phayrei* and that of Alfred *et al.* (1998) on Capped Langur also support our results. The young leaves, the protein-rich food item in the habitat, become an important factor for budgeting feeding pattern. Vegetation in the area is predominantly evergreen to semi-evergreen type, hence young leaves remain available throughout the year in different quantities but in February, March and April young leaves come in flushes (Solanki *et al.* 2008). In our study, the group of Capped Langurs showed two feeding peaks (Fig. 2), whereas a study on *Presbytis thomasi* elsewhere showed three feeding peaks (Kunkun 1986). The less feeding, more resting and two feeding peaks reflect the good habitat condition and food resource availability.

Other than habitat condition, the animals' biological activities also affect the allotment of time. Time in winter allotted for feeding, grooming and travel was more than in monsoon. In a study conducted by Solanki *et al.* (2007), it was found that langurs exhibit two mating seasons namely, winter and summer. Winter is the longer mating season, during this period langurs undergo socialization or pairing, and mating activities; the energy demand increases, hence grooming, travel and feeding is more than in the other two seasons (Fig. 3). During monsoon, uninterrupted rains for days together reduce the availability of time for travelling, grooming and feeding; animals confined themselves to rest.

Capped langurs prefer trees of 20-25 m height for resting and sleeping at night (Choudhury 1990). Capped langurs at our study site preferred 10-15 m feeding height from forest stratum for the three major activities (feeding, resting and travelling); a preferred height of 9-11 m as reported for a Capped Langur study conducted in forests in Tripura, India (Das Gupta 2006). Vertical structure of plant community provides a physical framework for which many forms of animal life are adapted. Increase in vertical structure means more resources and living space (Smith and Smith 2000). Terminal branches between 10-15 m height provide more food material than other regions of the tree. It was assessed by Solanki *et al.* (2008) in a study where they recorded that langur spent 44% of the feeding time in thicker terminal canopy. Studies on different species of primate in different part of the north-eastern region in India indicate that the primates prefer different activity/feeding height: Golden Langur feeds at an average tree height of 15 to 21 m (Mukherjee and Saha 1974), Pig-tailed Macaques at 8-10 m height, and Western Hoolock at 6-8 m height (Das Gupta 2006). The different feeding height in primates may be attributed to the tree size, and distribution of food items. This aspect was not studied here but needs to be addressed in detail. The available information on this aspect indicates that time budget activity is dependent on habitat condition, food availability, and feeding height on the food trees. These findings are important piece of information on the behavioural patterns of this Langur species and expand our information on its ecology. Such findings can aid in designing the management action plans for habitat and for better survival and conservation of the species.

ACKNOWLEDGEMENTS

We gratefully acknowledge the Ministry of Environment and Forests, Government of India, for providing financial support for the study. The Director, North Eastern Regional Institute of Science & Technology (NERIST) and the Head, Department of Forestry, are also acknowledged for providing all the facilities required for the study. We also thank the Principal Chief Conservator of Forest, Government of Arunachal Pradesh, for granting permission to work and the DFO, Forest Rangers, forest guards, and special thanks to Mr. Narayan Mogar, Field attendant, in the project along with the official staff of the Sanctuary for cooperation during the period of study. Sincere thanks are also extended to various reviewers for their positive suggestions to shape the manuscript.

REFERENCES

Ahsan, M.F. (1994): Feeding ecology of the primates of Bangladesh. *In*: Thierry, B., J.R. Anderson, J.J. Roeder & N. Herrenschmidt (Eds): Current Primatology, 1: Ecology and Evolution. Universite Louis Pasteur: Strasbourg.

Alfred, J.R.B., S. Chaudhuri & A. Murmu (1998): The capped langur, *Presbytis pileatus*, of Tripura, India: Some aspects on its behavioural ecology. (abstract) XVII Congress of the International Primatological Society. University of Antananrivo, Madagascar.

Altmann, J. (1974): Observational study of behaviour: Sampling methods. *Behaviour 49*: 227-267.

Altmann, J. (1980): Baboon Mothers and Infants. Harvard University Press. Cambridge.

Bartlett, T.Q. (1999): Feeding and ranging behaviour of the white-headed gibbon (*Hylobates lar*) in Khai Yai National Park, Thailand. Ph.D. thesis, Washington University. Pp. 1-192.

Champion, H.G. & S.K. Seth (1968): A Revised Survey of Forest Types of India. New Delhi: Government of India.

Choudhury, A. (1989): Ecology of the capped langur (*Presbytis pileatus*) in Assam, India. *Folia Primatologica 52*: 88-92.

Choudhury, A. (1990): Some observations on the behaviour of capped langur (*Presbytis pileatus*) in Assam India. *Tiger Paper 17*: 23-26.

CLUTTON-BROCK, T.H. (1974): Activity patterns of red colobus (*Colobus badius tephrosceles*). *Folia Primatologica 21*: 161-187.

DAS GUPTA, S.D. (2006): Conservation ecology of the endangered diurnal primates and gaur in Trishna Wildlife Sanctuary, Tripura. Ph.D. thesis, Submitted to Forest Research Institute (Deemed University), Dehradun.

DA SILVA, G.L. (1992): The western black-and-white colobus as a low energy strategist: activity budgets, energy expenditure and energy intake. *J. Anim. Ecol. 61*: 79-91.

DA SILVA, G.L. (1994): Diet of *Colobus polykomos* on Tiwai Island: Selection of food in relation to its seasonal abundance and nutritional quality. *Int. J. Primatol. 15*: 655-680.

DUNBAR, R.I.M. (1988): Primate social systems. Ithaca, New York, Comstock Publishing Associates. Croom Helm Limited. Pp. 251-253.

DUNBAR, R.I.M. (1992): A model for the gelada socio-ecological system. *Primates 16*: 69-83.

FLEAGLE, J.G. (1988): Primate Adaptation and Evolution. New York: Academic Press.

GUPTA, A.K. (1994): Status and conservation of non-human primates in Tripura, India. *In*: Thierry, B., J.R. Anderson, J.J. Roeder & N. Herrenschmidt (Eds): Current Primatology Volume 1: Ecology and Evolution. Universite Louis Pasteur: Strausbourg.

GUPTA, A.K. & A. KUMAR (1994): Feeding ecology and conservation of the Phayre's leaf monkey *Presbytis phayrei* in northeast India. *Biol. Conser. 69*: 301-306.

JANSON, C.H. (1992): Evolutionary ecology of primate social structure. *In*: Smith, E.A. & B. Winterhalder (Eds): Evolutionary ecology and human behaviour. Aldine de Gruyter, New York. pp. 95-130.

KHAN, M.A.R. & M.F. AHSAN (1986): The status of the primates in Bangladesh and a description of their forest habitats. *Primate Conser. 7*: 102-108.

KUMAR, A. (2005): Studies on Ecological and Behavioural Aspects of Capped langur, *Trachypithecus pileatus* (Blyth, 1843) in Pakhui Wildlife Sanctuary, Arunachal Pradesh, India. Ph.D. thesis Submitted to North Eastern Hill University, Shillong, India.

KUMAR, A. & G.S. SOLANKI (2004): A rare feeding observation on water lilies (*Nymphaea alba*) by the capped langur, *Trachypithecus pileatus*. *Folia primatol. 75(3)*: 157-159.

KUNKUN, J.G. (1986): Ecology and behavior of *Presbytis thomasi* in northern Sumatra. *Primates 27*: 151-172.

KURUP, G.U. & A. KUMAR (1993): Time budget and activity patterns of the lion-tailed macaque (*Macaca silenus*). *Int. J. Primatol. 14*: 27-39.

LI, ZY. (1992): Time budget of *Presbytis leucocephalus*. *Acta. Theriology Sin. 12*: 7-13.

LI, ZY. & E. ROGERS (2004): Habitat quality and activity budgets of white-headed langurs in Fusui, China. *Int. J. Primatol. 25*: 41-51.

MACARTHUR, R.H. & E.R. PLANKA (1966): On optimal use of a patchy environment. *Am. Nat. 100*: 603-609.

MALIK, I. (1986): Time budgets and activity patterns in free-ranging rhesus monkeys. *In*: Else J.G. & P.L. Lee (Eds): Primate Ecology and Conservation. Cambridge University Press, Cambridge, UK. pp. 105-114.

MARSH, C.W. (1978): Time budget of Tana River red colobus. *In*: D.J. Chivers & J. Herbert (Eds): Recent Advances in Primatology. Academic Press, London. pp. 250-251.

MARSH, C.W. (1981): Time budget of Tana River red colobus. *Folia Primatol 35*: 30-50.

MENON, S. & F.E. POIRIER (1996): Lion-tailed macaques (*Macaca silenus*) in a disturbed forest fragment: activity patterns and time budget. *Int. J. Primatol. 17*: 969-985.

MUKHERJEE, R.P. & S.S. SAHA (1974): The golden langur (*Presbytis geei* Khajutria, 1956) of Assam. *Primates 15*: 327-340.

PYKE, G.H., H.R. PULLIAM & E.L. CHARNOV (1977): Optimal foraging: A selective review of theory and tests. *Quarter. Rev. Biol. 52*: 137-154.

ROONWAL, M.L. & S.M. MOHNOT (1977): Primates of South Asia: Ecology, Sociobiology, and Behavior. Harvard University Press Cambridge, UK.

SIMPSON, G.G., A. ROE & R.C. LEWONTIN (1960): Quantitative Zoology. Harcourt, Brace and Company, New York.

SMITH, R.L. & T.M. SMITH (2000): Elements of Ecology. San Franciso: Benjamin/ Cummings. Science Publishing, San Francisco, USA. Pp. 1140.

SOLANKI, G.S., A. KUMAR & B.K. SHARMA (2007): Reproductive strategies in *Trachypithecus pileatus* in India. *Int. J. Primatol. 28(5)*: 1075-1083.

SOLANKI, G.S., A. KUMAR & B.K. SHARMA (2008): Feeding ecology of (*Trachypithecus pileatus*) in India. *Int. J. Primatol. 29*: 173-182.

SRIVASTAVA, A. (1999): Primates of Northeast India. Megadiversity Press, Bikaner, Rajasthan, India.

STANFORD, C.B. (1991): The capped langur in Bangladesh: Behavioural ecology and reproductive tactics. *Contributions to Primatology 26*: 1-179.

WATANUKI, Y. & Y. NAKAYAMA (1993): Age difference in activity pattern of japanese monkeys: Effects of temperature, snow, and diet. *Primates 34*: 419-430.

ZHANG, Y-Z., S. WANG & G-Q. QUAN (1981): On the geographical distribution of primates in China. *J. Human Evol. 10*: 215-226.

■ ■ ■

EFFECTS OF PLANTATIONS AND HOME-GARDENS ON TROPICAL FOREST BIRD COMMUNITIES AND MIXED-SPECIES BIRD FLOCKS IN THE SOUTHERN WESTERN GHATS

Swati Sidhu[1,3], T.R. Shankar Raman[1,4] and Eben Goodale[2]

[1]Nature Conservation Foundation, 3076/5, 4th Cross, Gokulam Park, Mysore 570 002, Karnataka, India.
[2]Field Ornithology Group of Sri Lanka, Department of Zoology, University of Colombo, Colombo, Sri Lanka. Current address: Section of Ecology, Behavior and Evolution, Division of Biological Sciences, University of California, San Diego, La Jolla CA 92093, USA. Email: eben.goodale@gmail.com
[3]Email: swati@ncf-india.org
[4]Email: trsr@ncf-india.org

Conservation scientists and policy makers are increasingly aware of the role countryside habitats play in supporting tropical fauna in modern landscapes. We studied the value of different land-uses by examining composition of tropical bird communities and mixed-species bird flocks in human-altered landscapes of Thattekad and the Anamalai Hills, situated in two different altitudes, in the southern Western Ghats. Sixteen line transects distributed across tropical rainforests, shade plantations of coffee and cardamom, timber monocultures of teak, tea plantations, and home-gardens were surveyed for bird flocks, vegetation structure, foliage profile, and canopy attributes. Results indicate that tea plantations were extremely altered habitats, supporting few rainforest species and were devoid of mixed-species bird flocks. Teak monocultures had high species density but were less conducive for rainforest species that require a well-developed and structurally more complex habitat. While bird species richness varied little across land-uses, there was significant variation in community composition, with some sensitive bird species absent from all altered habitats. Coffee plantations with surviving rainforest fragments and cardamom plantations with more native shade trees that mimicked a forest habitat supported more rainforest bird species both in communities and flocks. Maintenance of these shade plantations and restoration of forest fragments is recommended, while their conversion into a poor, more open habitat (tea, teak) is strongly discouraged for bird conservation in fragmented landscapes.

Key words: land-use changes, countryside habitat, Rainforest bird community, mixed-species bird flocks, southern Western Ghats

INTRODUCTION

Globally, deforestation continues to threaten tropical rainforests (Wright and Muller-Landau 2006) that are believed to contain two-thirds of the world's plant and animal species (Raven 1988). Current threats to the rainforests include habitat loss and degradation due to developmental activities, logging, conversion to agriculture and various monoculture plantations (DeFries *et al.* 2005), which leads to fragmentation and isolation of the remnant forest tracts (Laurance and Bierregaard 1997). In addition, land-use pressures in the tropics are impinged upon by high population growth rates and poverty in these regions (Bhagwat *et al.* 2008). Such threats are believed to disrupt ecological processes by way of affecting native forest communities (Koh *et al.* 2004; Sodhi *et al.* 2008).

For high population regions of the world, huge patches of primary forests cannot always be conserved as protected areas (Thiollay 1995). The role and protection of human-modified landscapes becomes extremely important in such cases. Countryside habitats, as they are called, include managed plantations, agricultural land, home-gardens, fallows, and forest remnants (Daily *et al.* 2001). A land-use providing sufficient shade tree cover, habitat connectivity, and supplementary native food resources surrounding a protected forest can increase the conservation potential of remnant forest habitats by supporting larger populations of animal species (Laurance *et al.* 2002; DeFries *et al.* 2005; Raman 2006; Sekercioglu *et al.* 2006; Bhagwat *et al.* 2008).

Effects of habitat fragmentation or degradation on bird communities are well-researched. Studies have shown species richness and abundance to decrease with more intensive management of agroforests (Thiollay 1995; Scales and Marsden 2008) with higher extinction rates of forest dependent avifauna as a consequence of deforestation (Brooks *et al.* 1997; Castelletta *et al.* 2000). Deforestation affects occupancy dynamics of bird species by forest area reduction and isolation of remaining patches (Ferraz *et al.* 2007). Waltert *et al.* (2005) stressed the importance of over-storey tree density in tropical land-use systems for maintenance of resident forest bird populations and found natural forests to be important for bird conservation more than any other form of forest exploitation. Studies also show a great proportion of native forest species to survive in the countryside with potential for species movement between forest habitats, thus emphasizing the importance of such habitats (Greenberg *et*

al. 1997; Hughes *et al.* 2002; Bhagwat *et al.* 2008; Ranganathan *et al.* 2008).

Along with studying bird communities of agrosystems, social interactions between species such as 'mixed-species bird flocks' (Buskirk 1976; Morse 1977), referred to as flocks hereafter, must also be considered. The influence of forest degradation on social interactions among birds such as flocks, although well-studied in Neotropics (Stouffer and Bierregaard 1995; Maldonado-Coelho and Marini 2004), remains poorly understood in the tropical rainforests of Asia (but see Lee *et al.* 2005; Sridhar and Sankar 2008). Flocks are known to have high species participation, hold territories and exist year-round, which makes them vulnerable to disturbances caused by fragmentation (Munn and Terborgh 1979; Thiollay 1994). It is important to assess the ability of different land-uses to support native bird communities and flocks to determine the relative conservation potential of various land-uses. This is needed to plan habitat and landscape management that strives for a balance between economic and ecological needs.

The Western Ghats hill range of India is among the global biodiversity hotspots (Myers *et al.* 2000) and is also recognised as an Endemic Bird Area (Stattersfield *et al.* 1998). This region has been severely modified by humans historically, with the middle and higher elevations altered into a mosaic of disturbance regimes containing forest fragments of varying size, habitat-quality, and degree of isolation, interspersed among monoculture plantations of timber trees such as alien *Eucalyptus* sp. or native teak (*Tectona grandis*), plantations of coffee (*Coffea arabica*, *C. canephora*) and cardamom (*Elettaria cardamomum*) with shade trees, and tea plantations with hardly any shade left (Congreve 1942; Nair 1991; Mudappa and Raman 2007).

Studies from the Western Ghats have demonstrated how bird communities vary in different types of plantations in relation to characteristics such as habitat structure, distance from forest, and proportion of native or alien tree species (Pramod *et al.* 1997; Bhagwat *et al.* 2005; Raman 2006; Bhagwat *et al.* 2008; Ranganathan *et al.* 2008). In the southern Western Ghats, earlier studies looking at the effects of habitat fragmentation in this region focused on differences in bird community structure and flock composition among fragments of varying sizes and isolation (Raman 2001; Sridhar and Sankar 2008). However, survival of bird species in fragments also depends on quality of the land-use matrix around these fragments (Gascon *et al.* 1999; Stouffer *et al.* 2006; Raman 2006), and therefore, it is important to study this matrix's effectiveness to support forest bird species.

We studied changes in bird communities and flocks of the southern Western Ghats along a habitat gradient from relatively undisturbed forests to plantations with varying agricultural intensities situated at two altitude zones in the southern Western Ghats. In order to understand changes in bird community structure and flock composition, size, and density along a gradient of land-use types, we formulated the following key questions

1. How is the habitat structure different in different land-uses?

2. Does bird community structure and composition change in relation to land-use and habitat structure?

3. Does flock encounter rate, size, and composition change in relation to land-use and habitat structure?

We use the results to assess the relative impact of various land-use types on bird conservation and management in the southern Western Ghats.

STUDY AREA

This study was carried out at two sites, namely Thattekad and Anamalai Hills, in the southern Western Ghats. The southern Western Ghats is the region south of the Palghat Gap at 11° N in the Western Ghats, a 1,600 km long hill chain running parallel to India's west coast from 8° N to 21° N (Mani 1974; Pascal 1988).

The Thattekad site (10° 10'-10° 15' N, 76° 65'-76° 78' E) is comprised of Thattekad Bird Sanctuary and Malayatoor Reserved Forest. The 25.16 sq. km bird sanctuary spans an altitudinal range of 50-250 m and is bordered by Periyar and Kuttampuzha rivers on two sides. Two-thirds of its area is under teak and mahogany plantations, with the rest containing disturbed tropical evergreen, semi-evergreen, and moist deciduous forests, *Ochlandra travancorica* reed brakes, grasslands with rock outcrops, and human-settlements (Sugathan and Vargheese 1996). The Reserved Forest in Malayatoor has disturbed tropical semi-evergreen forest and teak plantations. The mean annual rainfall is around 3,000 mm, three-fourths of which falls during south-west monsoon (Sugathan and Vargheese 1996).

The Anamalai Hills are a major conservation area in the southern Western Ghats (Raman 2006). The study sites here were concentrated on the Valparai plateau and Vazhachal Forest division (10° 27'-10° 35' N, 76° 82'-76° 90' E), adjoining the Anamalai Tiger Reserve and Parambikulam Wildlife Sanctuary. The altitude varies between 800 m and 1,100 m above sea level. The natural vegetation of this region, classified as tropical wet evergreen forest of the *Cullenia exarillata – Mesua ferrea – Palaquium ellipticum* type receives a mean annual rainfall of around 3,500 mm, particularly during south-west monsoon between June and September (Pascal 1988). The Valparai plateau contains 220 sq. km of tea, coffee, and cardamom plantations surrounded

by protected areas and reserved forests (Mudappa and Raman 2007). Vazhachal is a Reserved Forest adjoining the Valparai plateau with intervening tribal settlement, coffee and tea plantations, and an inter-state road passing through.

METHODOLOGY

Transects and stratification

Tropical bird communities are difficult to sample and in order to maximize our effort on the time spent sampling we used line transects (Karr 1981; Whitman *et al.* 1997; Thiollay 1999). The line transect method was also chosen so as to obtain a reasonable sample of flocks along with data on bird communities. Eight transects were laid in each study site (see description of transects in Table 1) and were identified based on preliminary surveys in 2007. All transects were around 2 km long (except TFC, 1.5 km length) and were >250 m from one another. Transects were grouped under three broad strata:

Table 1: Description of all transects in study sites

Site	Strata	Code / Location	Description
Thattekad	Forest	TFA, Thattekad Bird Sanctuary	Transect on tar-road with low elevation evergreen forest on either side; disturbed due to firewood collection.
		TFB, Thattekad Bird Sanctuary	Transect along a footpath and forest trail; forest encompasses rocky outcrops and bamboo clumps; disturbed due to firewood and bamboo collection.
		TFC, Malayatoor Reserved Forest	Transect on a forest trail; runs very close to a river on one side for at least one-third the length.
	Buffer	TBA, Thattekad Bird Sanctuary (Teak Plantation)	Transect on a dirt road passing through teak plantation, evergreen forest with proximity to a river.
		TBB, Thattekad Bird Sanctuary (Teak Plantation)	Transect on dirt road passing through teak plantation with proximity to a water body. Some native vegetation present but heavily disturbed; understorey is dense shrubby to open.
		TBC, Malayatoor Reserved Forest (Teak Plantation)	Transect on a tar-road with much vehicular movement; teak buffer with some riverine vegetation in certain places and other trees, mostly *Bombax* sp.; a small stream cutting through the transect; abuts the Reserved Forest having disturbed evergreen vegetation and bamboo clumps.
	Village	TVA, Thattekad Bird Sanctuary (Home-garden)	Transect on tar-road with heavy traffic; human habitation with mostly home gardens having jackfruit, coconut, cocoa, coffee, and rubber (*Hevea* sp.) plantations.
		TVB, Thattekad Bird Sanctuary (Home-garden)	Transect on tar-road and on footpath; tribal village with home gardens having rubber, pineapple, jackfruit, coconut, *Ailanthus malabaricus*, and Areca nut plantations.
Anamalai Hills	Forest	VFA, Vazhachal Reserved Forest	Transect on tar-road; around 400 × 50 sq. m of forest cut for power line along road; firewood collection but mature rainforest vegetation; a reservoir 200 m away and parallel to the transect line.
		VFB, Vazhachal Reserved Forest	Transect on tar-road; mature rainforest vegetation; wider openings for power line than VFA with clearings along road sides.
		VFC, Indira Gandhi Wildlife Sanctuary	Transect on tar-road; forest relatively undisturbed; 200 × 50 sq. m of forest with bamboo and canopy openings.
	Buffer	VBA, Vazhachal (Malakkiparai Coffee Plantation)	Transect on tar-road; coffee plantation with mix of exotic and native shade trees; has interspersed rainforest fragments.
		VBB, Valparai (Uralikkal Coffee Plantation)	850 m of transect line passing through dirt road and rest on tar-road; coffee plantation with mostly exotic shade trees; has interspersed rainforest fragments and a Eucalyptus plantation.
		VBC, Valparai (Surulimalai Cardamom Plantation)	Transect on dirt road; cardamom plantation with native shade trees; also has 250 × 50 sq. m of coffee plantation under native shade trees.
	Village	VVA, Valparai (Malakkiparai Tea Plantation)	Transect line on a footpath; tea plantation with very sparse shade of alien tree, Silver Oak *Grevillea robusta*.
		VVB, Valparai (Uralikkal Tea Plantation)	Transect line on a footpath; tea plantation with very sparse shade alien tree, Silver Oak *Grevillea robusta*.

A, B, C represent replicates in particular strata

Fig. 1(a-f): Pictures representing the land-use surveyed during this study (clockwise from top left): a. relatively undisturbed rainforest, b. cardamom plantation, c. coffee plantation, d. teak monoculture, e. home-garden, f. tea plantation

i. forest: relatively undisturbed or moderately disturbed mature native forest vegetation in Thattekad and the Anamalai Hills.

ii. buffer: land-use of relatively moderate intensity represented by plantations with substantial tree cover such as teak monocultures in Thattekad and shade-coffee, and shade-cardamom plantations in the Anamalai Hills.

iii. village: intensive agricultural areas with human-habitations having little or highly altered tree cover as represented by home gardens in Thattekad and tea plantations in the Anamalai Hills (Table 1, Fig. 1).

Many transects were on tar-roads, seldom more than 3 m wide; few had occasional clearings along roadsides. The effects of roads on bird abundance vary with bird species, road type, season, and distance from the road (Develey and Stouffer 2001). The results reported, therefore, can be considered as a conservative measure of actual bird richness or abundance.

Vegetation sampling

Point-centred quarter method (PCQ, Krebs 1989) was used for collecting data on basal area and density of trees

greater than 30 cm girth at breast height (GBH) with 15-20 points sampled per transect. The points were distributed at 100 m intervals along each transect line and located 10-15 m away from the line with consecutive samples placed alternating on the left and right side. As it was not possible to obtain PCQ data on one transect TVA, because it entailed entering houses and private property; we counted trees in quadrats visually estimated from the line to be 5 m × 5 m at every 100 m. The GBH of these trees could not be recorded. Shrub density was measured by counting all shrubs taller than 30 cm in height inside a 2 m × 2 m quadrat at every PCQ point. Other vegetation parameters measured were canopy height, canopy cover, canopy overlap, and vertical stratification (Raman *et al.* 1998; Raman and Sukumar 2002). These were collected at 40 points, located 50 m apart (37 m apart for TFC) along the transect line, with 20 points (15 for TFC) being away from the transect corresponding to PCQ plots and the rest on edge of the transect line so as to include effect of clearings of canopy along roads and footpaths. Canopy height estimation was practiced using a broken branch of known length and flipping it visually in air factoring the visual effect of distance away from the observer. Canopy cover was measured using a spherical densiometer. Canopy overlap above the transect was ranked from 0 to 3; 0 for no canopy directly overhead; 1 when there were branches or foliage overhead but they did not meet; 2 when the branches or foliage met but the sky was still visible through them; and 3 when the sky was no longer visible through the overhead foliage. Vertical stratification (distribution of foliage at different vertical levels) was assessed by recording presence of foliage in height classes (in metres) of 0-1, 1-2, 2-4, 4-8, 8-16, 16-24, 24-32, and >32 m in an imaginary vertical cylinder of 0.5 m radius around the observer.

Bird and flock sampling

SS spent five weeks to familiarize with bird identification, calls, songs, and distance estimation prior to onset of data collection. Data on bird communities and flocks were gathered from January to May 2008, spanning winter and breeding season when both migrants and residents were present in the study area. All transects were walked four times except VFA which was walked five times. Effort was made to walk the line transects at a consistent steady pace and to finish it more or less in two hours time. All birds seen or heard were recorded with an estimated distance of the bird from the observer in different distance classes in metres: 0-5, 5-10, 10-15, 15-20, 20-30, 30-50, 50-100, 100-150, and >150 m; size of the class becoming bigger as distance increases from the observer. Birds flying overhead or detected on the transect line were grouped under distance category 0. Birds were observed using 8 × 42 Nikon binoculars with a 6.3° field of vision and identified using Grimmett *et al.* 1998. All birds were noted under the distance category where they were first detected.

A flock was defined as an association of individuals of a minimum two bird species moving together for more than 5 minutes. We do not include bird aggregations such as those formed on fruiting trees. Whenever a mixed-species flock was encountered, it was observed for as long as it was visible up to a maximum of 30 minutes, after which transect survey continued at usual pace. All birds seen or heard in a flock were recorded within the same distance category as estimated for the first bird seen or identified. Transect were surveyed between 06:30 hrs and 11:30 hrs, but were usually finished within two hours of the starting time. Time spent on transects varied, with the average time spent per transect being 103 minutes. Surveying village transects took less time due to paucity of birds, whereas sites took longer to survey when more flocks or a large flock were encountered.

Data analysis

We used the ecological software KREBSWIN (Krebs 1989) to estimate mean tree density and basal area from PCQ data and corresponding standard errors for each transect. For each point on a transect the number of vertical classes (0-8) with foliage were added up to calculate vertical stratification. This number was averaged for all 40 points to produce an index of vertical stratification for a transect. The coefficient of variation of this index was used to represent habitat heterogeneity (Raman *et al.* 1998).

To calculate distribution of foliage in a specific vertical class along an entire transect, the presence-absence data on foliage in that vertical class was pooled for the transect across all 40 sampled points to yield a percentage value, and these percentages were arcsine transformed before statistical analysis. Means and standard errors of canopy cover, canopy overlap, and canopy height were estimated from replicate measurements in each transect.

To look for statistically significant differences in vegetation among sites (Thattekad and Anamalai Hills) and strata (forest, buffer, and village) we conducted a 2-factor Analysis of Variance (ANOVA) with site and strata as fixed factors. Due to correlations among eight vegetation variables considered, the vegetation data were summarized using Principal Components Analysis (PCA) into two uncorrelated factors. The analysis was performed using SPSS/PC+ software version 14.0, SPSS Inc., Chicago (Bryman and Cramer 1997). The factor matrix was rotated using Varimax method to aid in interpretation. The composition of trees on TVA was very similar to that on TVB and therefore for analysis we used the

same basal area estimates of TVB for TVA in the PCA (see section 2.3).

All recorded bird species were classified into rainforest and open-forest species (Ali and Ripley 1983; Grimmett *et al.* 1998; Raman 2006). Rainforest birds were those that occurred naturally in undisturbed rainforests, whereas open-forest species were those that occurred in drier, more open habitats along the Western Ghats. Water birds were excluded from analysis. Bird community variables of interest were: bird species richness and bird species abundance estimated separately for all, rainforest species, and open-forest species. Individual-based rarefaction analysis was performed for overall bird species richness for standardized number of individuals using program ECOSIM (Gotelli and Colwell 2001). We also estimated bird species density (following terminology of Gotelli and Colwell 2001) as the average number of bird species per transect and bird species abundance as the number of individuals per transect (both separately for all, rainforest species, and open-forest species). Differences in bird species density and abundance (values averaged across repeat surveys) were assessed by 2-factor analysis of variance with site and strata as factors (Zar 1999).

To measure variation in bird community composition among various transects, we used Program PRIMER (version 5.2.2, Primer-E, Plymouth, UK; Clarke and Gorley 2001) to compute a pair-wise matrix of Bray-Curtis dissimilarity. This was used for non-metric Multi-dimensional Scaling (MDS) ordination to represent bird community compositional variation among transects. Significance of variation in community composition was assessed using Analysis of Similarities (ANOSIM) with a 2-factor crossed layout of sites and strata (Clarke and Warwick 1994).

Flocks were categorized as complete flocks (with total count of all participant species and individuals) and incomplete flocks (all individuals were not visible or could not be counted before the flock moved away or was lost). Flock variables of interest were: number of species and individuals participating in flocks of all, rainforest, and open-forest species. Only data from complete flocks were used for analyses. Differences in the number of species and individuals in complete flocks (values averaged across replicate flocks) were assessed by 2-factor analysis of variance with site and strata as factors (Zar 1999). Tea plantations were devoid of flocks during the survey period, and only two incomplete flocks were encountered in home-gardens. Therefore, we do not include village transects for analysis. We also calculated flock encounter rate as the number of flocks encountered per transect for all transects surveyed.

The effects of habitat structure on bird community and flock structure was assessed using multiple regression with PCA factor scores taken as independent variables representing habitat structure in the analyses. Dependent variables used were (for all, rainforest, and open forest species, separately) the number of bird species per transect, number of individuals per transect, species per complete flock, and individuals per complete flock. All analyses were performed using SPSS software with a backward stepwise procedure for selection of statistically significant effects (Zar 1999).

RESULTS

Variation in habitat structure of different land-uses

Distribution of foliage in different vertical categories differed markedly with land-use type. In the Thattekad site, two-factor analysis of variance (ANOVA) revealed statistically significant differences across the three habitat strata ($F_{2,40} = 34.07$, $P < 0.001$), as well as eight vertical layers ($F_{7,40} = 37.95$, $P < 0.001$), with a statistically significant interaction between the two factors ($F_{14,40} = 2.60$, $P < 0.01$). The percentage foliage distribution in different vertical categories in teak plantations and village transects was mostly lower when compared with forest transects. There was hardly any foliage above 32 m in teak plantation and above 24 m in village home gardens. In the Anamalai Hills, similarly, there were statistically significant differences across the three strata ($F_{2, 40} = 159.2$, $P < 0.001$), as well as eight vertical layers ($F_{7, 40} = 28.9$, $P < 0.001$), with a statistically significant interaction between the two factors ($F_{14,40} = 7.87$, $P < 0.001$). The coffee and cardamom plantations in Valparai had poor foliage distribution between 1-2 m, 2-4 m, 4-8 m and 8-16 m when compared with forest transects here. These transects, especially cardamom, had comparable foliage to forests in higher canopy above 16 m. Tea plantations almost always had some foliage on ground and some foliage in 16-24 m category. There was hardly any foliage in-between these two categories or above 24 m.

Other vegetation features also differed in relation to site and land-use (2-factor ANOVA, Table 2). All variables showed statistically significant differences across strata, whereas tree density, canopy cover, canopy overlap, and shrub density showed statistically significant differences across sites as well. Besides canopy height, shrub density, and habitat heterogeneity, other variables also showed a statistically significant interaction between site and strata (Table 2). In Thattekad, tree density in teak plantations was comparable with that in forest transects, however, basal area, canopy height, canopy cover, and canopy overlap were all lower than in forest transects. Home gardens, on the other hand, had much higher tree density but lower basal area when compared to buffer or forest transects. They also had high habitat

heterogeneity and less canopy height, canopy cover, canopy overlap, and shrub density. In the Anamalai Hills, tea and buffer transects had lower values than forest transects for all variables except habitat heterogeneity.

Principal components analysis of eight vegetation variables extracted two components, PC1 and PC2, which together explained 83.6% of cumulative variance in the dataset with PC1 alone accounting for 69.67 % of variance. PC1 had large positive weightings for basal area (0.858), canopy height (0.942), canopy cover (0.972), canopy overlap (0.971), vertical stratification (0.970), and shrub density (0.630) and a large negative weighting for habitat heterogeneity (-0.819). PC2 had large positive weighting only for tree density (0.963). Eigen values for PC1 and PC2 were

Table 2: Comparison of habitat structure in different transects.

Transect	Tree density (stems/ha)	Basal area (m^2/ha)	Canopy height (m)	Canopy cover (%)	Canopy overlap index	Shrub density (stems/plot)	Habitat heterogeneity (% CV)
TBA	466	38.78	21.68	76.53	1.4	10.85	8.41
	(5.9)	(8.04)	(1.2)	(2.1)	(0.1)	(0.9)	
TBB	335.8	28.21	19.88	72.9	1.48	11.84	6.16
	(5.0)	(6.05)	(1.0)	(3.6)	(0.08)	(2.2)	
TBC	334	23.84	18.08	67.35	1.2	8.24	7.32
	(4.9)	(5.97)	(0.9)	(2.8)	(0.08)	(0.8)	
TFA	323	40.67	19.28	79.63	1.53	10.65	9.97
	(4.1)	(8.25)	(1.9)	(3.1)	(0.16)	(1.5)	
TFB	206	47.91	28.63	81.3	1.65	9.6	6.04
	(2.6)	(7.57)	(1.5)	(2.3)	(0.09)	(1.2)	
TFC	366	40.58	27	83.93	1.58	15.67	5.54
	(6.2)	(8.20)	(1.5)	(1.9)	(0.09)	(2.9)	
TVA	2340	25.19	10.55	37.8	1.23	6.61	11.67
	(174.8)	(9.51)	(1.3)	(3.4)	(0.13)	(1.4)	
TVB	2087	25.19	12.08	58.33	1.05	7.18	9.51
	(59.3)	(9.51)	(1.2)	(4.1)	(0.10)	(1.7)	
VBA	278	35.62	19.8	65.38	1.2	5.8	9.91
	(3.5)	(7.07)	(1.9)	(3.4)	(0.11)	(0.8)	
VBB	362	42.11	20.48	51.68	1.05	4.55	10.28
	(4.6)	(13.10)	(2.5)	(3.6)	(0.12)	(0.5)	
VBC	236	57.89	28.98	70.6	1.45	2.2	7.58
	(2.9)	(2.04)	(1.9)	(2.6)	(0.10)	(0.4)	
VFA	668	67.61	29.25	85.2	1.63	5.95	6.85
	(8.5)	(20.15)	(1.9)	(2.9)	(0.09)	(0.8)	
VFB	547	52.98	26.5	82.03	1.58	7.85	7.67
	(6.9)	(9.54)	(2.2)	(3.2)	(0.11)	(0.7)	
VFC	425	65.33	36.28	85.43	1.7	8.75	6.74
	(5.4)	(26.29)	(1.6)	(1.8)	(0.08)	(0.5)	
VVA	72.1	6.24	2.88	10.28	0.23	2.55	11.23
	(0.9)	(2.18)	a(0.9)	(1.5)	(0.07)	(0.2)	
VVB	65.4	6.87	3.28	9.35	0.23	3.3	10.73
	(0.8)	(2.11)	(1.0)	(0.9)	(0.07)	(0.2)	
ANOVA results Factor							
Site, $F_{1,10}$	177.48***	1.84 (NS)	0.01 (NS)	19.1**	27.09***	23.17**	1.00 (NS)
Strata, $F_{2,10}$	92.98***	29.8***	32.17***	77.27***	67.29***	7.31**	7.5**
Site×Strata, $F_{2,10}$	200.05***	8.89**	3.9 (NS)	11.01**	19.26***	0.43 (NS)	0.79 (NS)

The values given in the table are means with standard error in parentheses
* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS – non significant

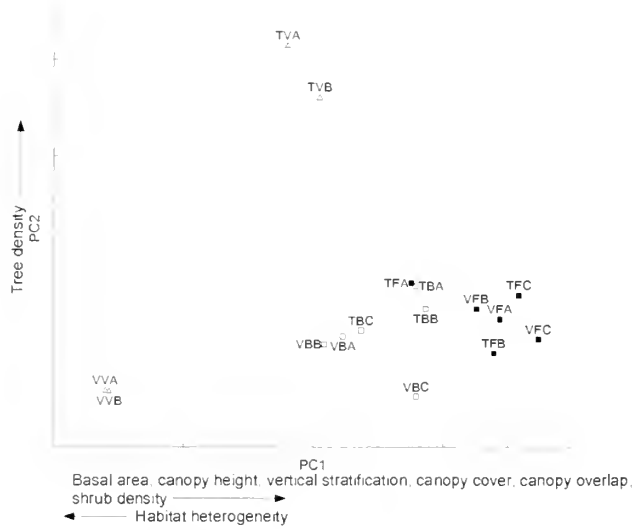


Fig. 2: Ordination of transects on principal component factor axes based on vegetation variables. Forest, buffer, and village transects are represented by dark-squares, open-squares, and open-triangles, respectively

5.573 and 1.112, respectively. The ordination of transects representing different strata on these two factor scores confirms the above-mentioned trends; the village strata (home gardens in Thattekad and tea plantation transects in Anamalai Hills) lie separated from the rest of the transects representing poor development of foliage, canopy closure, and woody plant density in spite of having highest number of stems per hectare in the case of the Thattekad home gardens (Fig. 2). The forest transects in both sites (with the exception of TFA) have higher scores on PC1 than the buffer transects that occupy intermediate positions between village and forest transects (Fig. 2).

Bird species richness and density in different land-uses

A total of 145 bird species and 6,247 individuals were recorded on transects (Appendix). In Thattekad, 122 bird species and 3,210 individuals were recorded with rainforest species constituting 56.6% (69) of all species and 63.4% (2034) of all individuals. In the Anamalai hills, 103 bird species and 3,037 individuals with rainforest species constituting 64.1% (66) of all species and 78.8% (2,394) of all individuals. Rarefaction analysis for Thattekad transects do not show a clear pattern of difference in relation to land-use type for species richness per 200 individuals at confidence interval (CI) of 95%: forest = 49.23 (37-64); buffer = 47.97 (38-60), village = 42.98 (36-51). In the Anamalai Hills, tea transects were poorest in species richness for a comparable sample of 200 individuals at 95% CI: forest = 42.28 (35-50), buffer = 44.74 (35-54), village = 29.38 (27-31).

Bird species density (number of all, rainforest and open-forest species per transect), varied statistically significantly

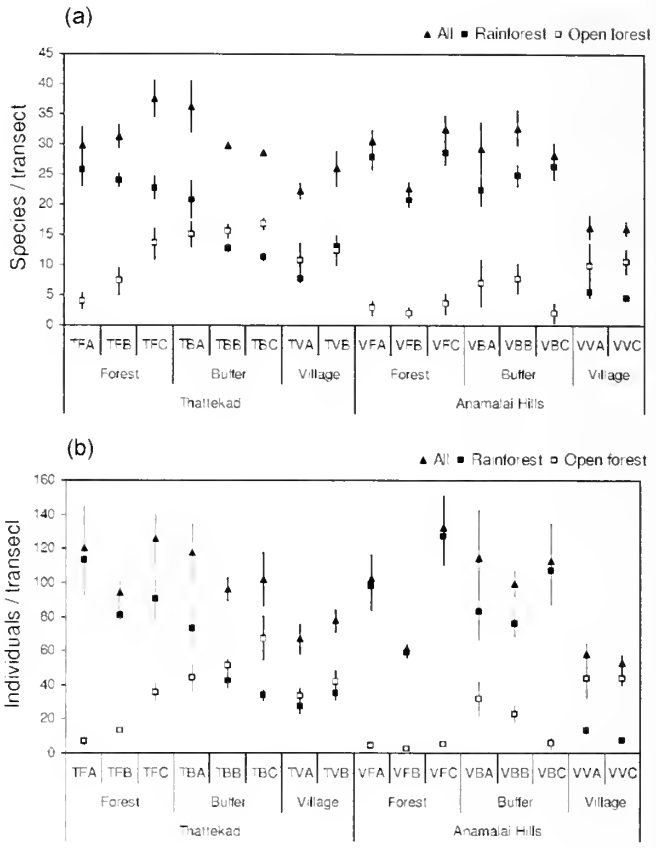


Fig. 3: Species density (a) and abundance (b) of all, rainforest, and open forest bird species, in Thattekad and Anamalai Hills.

across the three habitat strata mainly because forest and buffer transects had higher values than village transects (Fig. 3, Table 3). The average species density of all birds and open forest birds was higher in Thattekad than the Anamalai Hills, especially in buffer habitats, contributing to statistically significant site effect (Table 3). Interestingly, rainforest bird

Table 3: Results of 2-factor analysis of variance of the average bird community structure variables across transects in the study sites

Variable	Site, $F_{1,10}$	Strata, $F_{2,10}$	Site × Strata, $F_{2,10}$
Bird species density (number of species/transect)			
All	5.687*	12.108**	0.929 (NS)
Rainforest	1.177 (NS)	31.195***	5.894*
Open-forest	17.664**	7.259**	3.388 (NS)
Birds abundance (individuals/transect)			
All	0.907 (NS)	7.602*	0.480 (NS)
Rainforest	0.333 (NS)	15.366**	2.723 (NS)
Open-forest	7.009*	12.666**	4.478*

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS – non significant

species density did not differ statistically significantly between sites, but showed a statistically significant interaction between site and strata: it decreased across the habitat gradient from forest to buffer and then village in Thattekad but did not differ substantially between forest and buffer habitats in the Anamalai Hills, although still being lowest in the village transects (Fig. 3a).

Bird species abundance of all, rainforest and open-forest species showed a similar trend as bird species densities (Fig. 3b). Open-forest species showed statistically significant interaction between strata and site. In the Anamalai Hills, open-forest bird abundance was similar in forests and buffers, and higher in village transects, whereas Thattekad had similarly high open-forest bird abundance in buffer and village transects compared to forests. The cardamom transect in the Anamalai Hills (VBC) had higher proportion of rainforest species, as well as individuals in its bird community. In general, forest transects had a greater proportion of rainforest species while open forest species were represented more in buffer and village, especially tea plantation transects.

Bird species composition in relation to land-use

The MDS ordination in Fig. 4 graphically depicts similarity in bird community composition among sites. Compositional variation appears related to altitude/site (separation between Thattekad transects from Anamalai Hills transects) as well as land-use (village transects occupied extreme, while buffer occupied intermediate positions relative to forest transects in each site). The Anamalai Hills tea plantation transects differed substantially in bird species composition from all the other transects and were similar only to each other. Results of ANOSIM showed statistically significant differences in bird community composition between sites (Global $R = 0.919$, $P = 0.003$) as well as among land-use types (Global $R = 0.918$, $P = 0.001$). Pair-wise comparisons between each pair of habitat strata indicated statistically significant variation between forests and buffer ($R = 0.889$, $P = 0.01$), buffer and village ($R = 0.917$, $P = 0.01$), and forest and village ($R = 1$, $P = 0.01$).

Changes in flock size, composition, and encounter rate in different land-uses

A total of 101 flocks were recorded (58 complete and 43 incomplete flocks). Of the total 145 species, 82 species (56.6%) participated in flocks at least once. On average, complete flocks contained 9 (±0.56 SE) species and 23.2 (±1.67 SE) individuals, overall. In Thattekad, a mean number of 8.6 (±0.80 SE) species and 22.9 (±2.37) individuals participated in the 29 complete flocks recorded, whereas in the Anamalai Hills, the mean participation was 9.4 (±0.79)

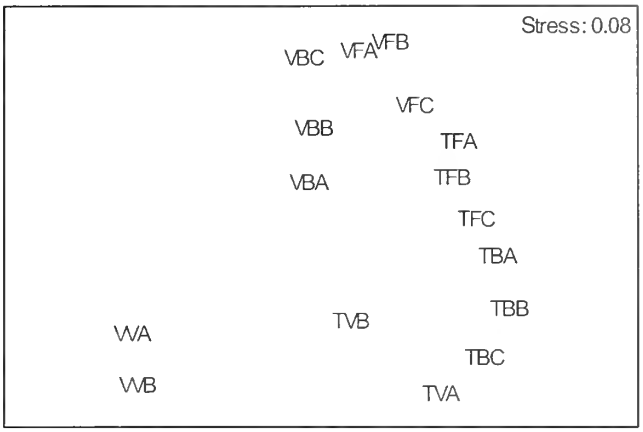


Fig. 4: Variation in bird community composition across transects illustrated by non-metric multidimensional scaling (MDS) ordination. The closer two transects are, the more similar they are in their bird communities

species and 23.5 (±2.39) individuals in the 29 complete flocks recorded. Out of 48 rainforest species participating in the flocks, 35 were residents, 7 were endemic residents, and 6 were migrants. In Thattekad, 43 of 63 (68.3%), and in the Anamalai Hills, 45 of 66 (68.2%) rainforest bird species recorded, participated in flocks. Flock encounter rate was higher in the Anamalai Hills (forest = 1.95 flocks/transect; buffer = 2.67 flocks/transect) when compared to Thattekad (forest = 1.59 flocks/transect; buffer = 1.66 flocks/transect). Buffer transects in both sites had higher flock encounter rate than forest transects.

Figure 5 depicts variation in flock size variables across forest and buffer transects in Thattekad and the Anamalai Hills. Rainforest species always contributed more to flock composition than open-forest species in higher altitude site of the Anamalai Hills; but the trend reversed in case of teak plantations in Thattekad showing higher participation of open-forest species and individuals, with TBA being an exception to this. The number of rainforest species in flocks showed statistically significant variation between sites and land-use types (Table 4) with rainforest species participation being higher in forest as compared to buffer transects. Site variation appears primarily due to low representation of rainforest species in flocks in Thattekad buffer transects when compared to Anamalai Hills (Fig. 4). The number of open forest species and individuals in flocks showed primarily a site variation, being higher in Thattekad than Anamalai Hills in comparable land-use types (Table 4, Fig. 5).

Relationships with vegetation structure

A backward stepwise multiple-regression analysis indicated (Table 5) a statistically significant positive relationship between bird species density (all birds and

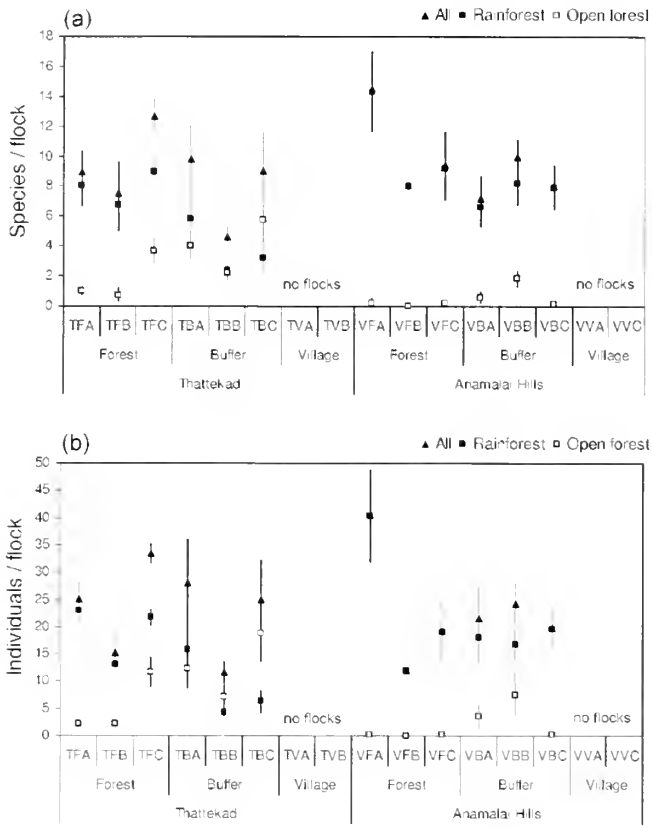


Fig. 5: Number of all, rainforest, and open forest bird species (a) and individuals (b) per complete flock, in Thattekad and Anamalai Hills

rainforest birds) per transect and PC1 which represented canopy variables, vertical foliage structure, basal area, and habitat heterogeneity (negative). Open-forest bird species density showed no statistically significant relationship with either principal component. Abundance of all and rainforest bird species was statistically significantly positively (P = 0.003) related to PC1, while abundance of open-forest species was significantly negatively correlated to PC1 (P = 0.044, Table 5).

Number of rainforest bird species per complete flock showed a highly statistically significant positive relationship with PC1 and a negative relationship with PC2 ($P < 0.037$). Number of individuals of rainforest birds per complete flock was also found to be statistically significantly related to PC1 ($P < 0.005$). Number of open-forest species and individuals per complete flock showed no statistically significant relationship with either PC1 or PC2 (Table 5).

Table 4: Results of 2-factor analysis of variance of the average flock structure variables across transects in the study sites

Variable	Site, $F_{1,8}$	Strata, $F_{1,8}$	Site × Strata, $F_{1,8}$
Flock size (number of species/complete flock)			
All	0.235 (NS)	1.792 (NS)	0.011 (NS)
Rainforest	7.334*	9.160*	0.247 (NS)
Open-forest	10.477*	3.795 (NS)	0.995 (NS)
Flock abundance (number of individuals/complete flock)			
All	0.001 (NS)	0.199 (NS)	0.008 (NS)
Rainforest	2.016 (NS)	2.687 (NS)	0.242 (NS)
Open-forest	7.810*	4.661 (NS)	0.550 (NS)

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS – non significant

DISCUSSION

In view of continued threat to bird species from deforestation (Brash 1987; Collar *et al.* 1994; Balmford 1996), many studies have focused on understanding survival of these forest species in human-modified landscapes and the influence of quality of habitat matrix that exists around remaining forest patches (Askins and Philbrick 1987; Stouffer and Bierregaard 1995; Luck and Daily 2003). Similar to earlier studies from tropical forests, the present study found notable changes in bird community structure and composition across different land uses. Flock composition is also known to be affected as a result of changes in habitat, microclimate, and in local bird community (Johns 1986; Thiollay 1995; Stouffer and Bierregaard 1995; Mason 1996; Marsden 1998; Lee *et al.* 2005; Sridhar and Sankar 2008). This is also broadly evidenced in the present study where complex and more developed habitat structure of forests and plantations such as cardamom and coffee with more native shade trees support more rainforest species in bird communities and flocks.

Habitat structure differences in land-uses

Habitat complexity in terms of vertical foliage profile and structural development was higher in forests when compared with other land-uses. This is supported by other studies where intensification of land-use accompanies structural simplification (Michon and Mary 1990; Garcia-Fernandez and Casado 2005) especially in canopy and understory layers (Greenberg *et al.* 2008), followed by habitat homogeneity (Thiollay 1995; Scales and Marsden 2008). This study finds lower foliage in mid-storey and canopy layers of teak, coffee, and cardamom plantations which show a foliage profile intermediate to forests and villages (tea plantations and home-gardens). Also, cardamom and coffee plantations had lower shrub density as under-storey vegetation was cleared to plant the cash crops (Raman 2006). In general, forests had higher canopy connectivity, tree density, basal area, and shrub density. In non-forest habitats studied,

cardamom plantations under native rainforest shade trees provided a habitat structure more similar to rainforests, as reported earlier from studies in the Western Ghats (Raman and Sukumar 2002; Raman 2006). Similarly, coffee plantations under native shade tree species in tropics are known to resemble neighbouring forest structure (Bhagwat *et al.* 2008), and this structural property has potential for biodiversity conservation (Anand *et al.* 2008). Among more intensive forms of land-use, home gardens had more developed habitat structure and vertical distribution of foliage than tea plantations. Home-gardens were mosaics of arecanut palm, coconut palm, jackfruit trees or other crop tree species forming a canopy over densely-planted woody understory (cocoa, coffee), and usually adjoined monocultures of rubber or *Ailanthus malabaricus* with closely planted thin stems (thus accounting for the high tree density but low basal area). Ranganathan *et al.* (2008) studied agricultural systems in Western Ghats of Karnataka similar to home-gardens surveyed in the present study and found arecanut plantations with woody understory to have similar vertical complexity of habitat as managed forests.

Although previous studies examining avian diversity in different land-uses in the Western Ghats have looked at teak, arecanut, cocoa, coffee, and cardamom plantations (Beehler *et al.* 1987; Bhagwat *et al.* 2005; Raman 2006; Anand *et al.* 2008; Ranganathan *et al.* 2008), there are no published reports on habitat structure and avian conservation values of tea plantations. Tea plantations are a major form of land-use in the Western Ghats accounting for over 119,000 ha, having increased by 6,200 ha (5.5%) in the period 2000-2006 (Mudappa and Raman 2007; Tea Board Statistics, http://www.teaboard.gov.in). These plantations are dense monocultures of tea bushes with sparse canopy of a single alien tree species planted in rows (silver oak *Grevillea robusta*, native to Australia) at 12 m spacing. The higher habitat heterogeneity of tea plantations can be attributed to the variability induced by large tracts of tea shrubs maintained at a uniform height of about a metre and with no foliage at all in higher vertical classes alternating with points with more foliage directly below silver oak trees. Tea plantations are intensively managed year-round with cycles of agro-chemical application, pruning, and harvest of leaves. In relation to other plantations studied thus far in the Western Ghats, the results of this study indicate that tea plantations are the most extreme in terms of alteration of habitat relative to rainforests.

Changes in bird community and composition

We found more bird species and individuals in the lower altitude site of Thattekad than in the higher altitude site of the Anamalai Hills. Thattekad teak buffers supported more open-forest species and individuals, leading to statistically significant differences between sites. When we looked at similarity of bird community composition across strata in both altitudes, we found bird communities to be more similar within a given site/altitude than across. The effect of habitat modification was apparent as bird community differed between land-use types at both the sites.

Looking at bird community composition represented

Table 5: Relationships between bird community and flock variables with habitat components (PC1 and PC2) taken as independent variables in backward stepwise multiple regression analysis

Dependent variable	Standardized regression coefficient, Beta (*P*)		R^2	*F*	*df*	*P*
	PC1	PC2				
Total bird species per transect						
All	0.786 (0.000)	-	0.619	22.7	1, 14	0.000
Rainforest species per transect	0.803 (0.000)	-	0.645	25.43	1, 14	0.000
Open-forest species per transect	-	-	-	-	-	-
Total individuals per transect						
All	0.692 (0.003)	-	0.479	12.86	1, 14	0.003
Rainforest individuals per transect	0.773 (0.000)	-	0.597	20.78	1, 14	0.000
Open-forest individuals per transect	-0.508 (0.044)	-	0.258	4.878	1, 14	0.044
Species per complete flock						
Rainforest species per flock	0.761 (0.000)	-0.352 (0.037)	0.657	15.356	2, 13	0.000
Open-forest species per flock	-	-	-	-	-	
Individuals per flock						
Rainforest individuals per flock	0.698 (0.005)	-	0.407	11.27	1, 14	0.005
Open-forest individuals per flock	-	-	-	-	-	-

by rainforest bird species versus open-forest bird species, the number of rainforest species and individuals decreased along the habitat gradient from forest to buffer and then villages. Teak plantations of Thattekad, in general, had more open-forest species and thus seem to support fewer rainforest species when compared to coffee and cardamom plantations of the Anamalai Hills. Among the non-forest habitats, cardamom plantation appears to be the best kind of land-use in its ability to support rainforest species and discouraging open-forest species.

The overall species richness and abundance did not vary much between forests and buffers but the composition of bird community was different as species characteristic of primary and mature forests get replaced by species of disturbed or open-forests (Daniels *et al.* 1990; Estrada *et al.* 1997; Lawton *et al.* 1998; Raman 2001; Lindell *et al.* 2004; Waltert *et al.* 2005; Harvey and Villalobos 2007). Bhagwat *et al.* (2008), in a literature review, compared agrosystems (such as coffee, cocoa, forest rubber, and banana plantations) with forest and found high species richness (92%) compared to forests while lower similarity (52%, Jaccard index) with forest community. Raman (2006) in an earlier study in the southern Western Ghats found that only 59-67% of species present in shade coffee plantations were rainforest species, the balance being species of more open habitats. In another study from the Western Ghats, Ranganathan *et al.* (2008) found arecanut plantations to retain 90% of bird species that were also found associated with regional forests.

Individual bird species may show varying responses to different land-use systems. In Thattekad, open-forest species such as Southern Coucal *Centropus [sinensis] parroti*, Oriental Magpie-robin *Copsychus saularis*, Red-whiskered Bulbul *Pycnonotus jocosus*, and Rufous Treepie *Dendrocitta vagabunda* were found to be more abundant in teak buffers and home-gardens than in forests. The Jungle Babbler *Turdoides striata*, another open-forest species, was found only in teak plantations. Rainforest species such as Malabar Barbet *Megalaima malabarica*, Flame-throated Bulbul *Pycnonotus gularis*, and Yellow-browed Bulbul *Iole indica* decreased in abundance from forest to buffer and than villages. The Grey-headed Bulbul *Pycnonotus priocephalus*, a rainforest species endemic to Western Ghats, and the Malabar Trogon *Harpactes fasciatus* was found only in forests. Lesser Hill Myna *Gracula indica*, Greater Racket-tailed Drongo *Dicrurus paradiseus*, and White-cheeked Barbet *Megalaima viridis* were the rainforest species found to be common throughout, irrespective of the land-use type. In the Anamalai Hills, Red-whiskered Bulbul, Oriental Magpie-Robin, Common Tailorbird *Orthotomus sutorius*, Indian Jungle Crow *Corvus [macrorhynchos] culminatus*, Rufous-backed Long-tailed Shrike *Lanius schach erythronotus*, and Chestnut-headed Bee-eater *Merops leschenaulti*, along with an open-forest migrant Blyth's Reed-warbler *Acrocephalus dumetorum*, were found to be more common in tea plantations. They were less frequent or absent in buffer habitats and forests. Rainforest species such as Asian Fairy Bluebird *Irena puella*, Brown-cheeked Fulvetta *Alcippe poioicephala*, and Yellow-browed Bulbul along with two rainforest migrants, Large-billed Leaf-warbler *Phylloscopus magnirostris*, and Rusty-tailed Flycatcher *Muscicapa ruficauda*, decreased in abundance from forest to buffer and were never found in tea plantations. One rainforest species, Indian Scimitar Babbler *Pomatorhinus [schisticeps] horsfieldii*, was found to be more common in tea plantations than in coffee, cardamom or forests. Small Sunbird *Leptocoma minima*, a Western Ghats endemic, preferred forests and buffers over tea plantations.

Differences in flock size, composition, and encounter rate

Participation of species in flocks was observed to be lower than that found in an earlier study in the southern Western Ghats where 87 out of 109 species participated in flocks (Sridhar and Sankar 2008). The previous study compared forest fragments of different sizes, whereas we sampled on more open roads or dirt tracks leading to more open-forest species and a greater number of species recorded outside of flocks. Flock size overall did not seem to be affected considerably by land-use although other studies suggest that overall species participation in flocks decreases with habitat degradation and changes in bird community (Bierregaard and Lovejoy 1989; Maldonado-Coelho and Marini 2004; Lee *et al.* 2005; Sridhar and Sankar 2008). The number of rainforest species that participated in flocks, however, did vary significantly by land-use in our study. Rainforest species, in general, contributed more to the flocks than open-forest species, which could explain the near absence of flocks from heavily-modified habitats such as tea and home-gardens, which support very low number of rainforest species and a higher proportion of open-forest species in their bird community. As flocks are species-rich (and, in some Neotropical areas, even hold interspecific territories), they may be vulnerable to changes in habitat structure, microclimate, and bird community (Munn and Terborgh 1979; Bierregaard and Lovejoy 1989; Thiollay 1992; Hutto 1994; Jullien and Thiollay 1998; Stratford and Stouffer 1999). Flocks can therefore be used as indicators of disturbance (Maldonado-Coelho and Marini 2004) with the number of rainforest versus open-forest species taken as a measure of the ability of particular land-use type to support the complex interactions that lead to formation of flocks.

Flock encounter rate was found to be much higher in

the higher altitude site. Buffer transects in both altitudes showed higher flock encounter rate than the forests. This may possibly be due to better visibility in the buffer plantations that had more open habitat relative to forest (particularly in mid-storey layers). Another reason for this could be the higher visibility for predators (e.g., raptors) as well and therefore an increased tendency of bird species to occur in flocks (Thiollay 1999). A flock was usually sighted shortly before or soon after hearing or sighting a raptor species (S. Sidhu, unpublished data).

Effect of habitat modification on bird community and flocks

Bird community and flock composition were observed to differ with land-use and seem to be affected by habitat alterations. Among different land-uses, tea plantations turned out to be the poorest in habitat structural complexity, which was reflected in their highly altered bird community composition and complete absence of flocks. The home-gardens surveyed in the present study also had poorer habitat complexity. When compared to TVA, the other home garden (TVB) was found to support more rainforest species and two incomplete flocks were observed. This difference in bird composition between similar land-uses could be due to the latter site being located in a small tribal village surrounded on all sides by forest.

Structural complexity and similarity with forest habitat were seen to positively influence rainforest birds in the community and flocks. Cardamom, coffee, and teak plantations seem to hold more species than severely modified land-use represented by tea plantations and home gardens. When comparing among different buffer habitats, cardamom and coffee fared better than teak in supporting a greater proportion of the respective rainforest species at that altitude. This is supported by studies showing that more forest species can be supported by a mix of cultivated and native shade trees (Taylor *et al.* 1993; Thiollay 1995; Greenberg *et al.* 1997; Powell and Bjork 2004; Sekercioglu *et al.* 2006). Beehler *et al.* (1987) in an earlier study in Eastern Ghats, India, found teak monoculture to be a poor habitat for birds. TBA was the only teak buffer showing higher rainforest bird species in flocks. It had patches of relatively undisturbed rainforests interrupting the plantation. These forest patches are necessary as they act as refuges for species that are sensitive to changes in land-use (Sekercioglu *et al.* 2006). In a study by Faria *et al.* (2000) from Brazil that compared bird communities in a landscape dominated by natural forest (<6% under cocoa plantation) with a landscape dominated by cocoa plantations, bird communities were found to be richer in the former landscape indicating the landscape-level influence of forest cover and proximity.

Many studies have reported the importance of natural shade trees in coffee and cardamom as they support greater number of forest bird species (Estrada *et al.* 1997; Mudappa and Raman 2007; Sodhi *et al.* 2008). Beehler *et al.* (1987) also observed that coffee plantations with companion tracts of remnant forest maintain healthy population of birds. Similarly, the coffee plantations we sampled had interspersed forest fragments and native shade trees along with exotic ones and this supports more rainforest species which then participate in flocks. Anand *et al.* (2008) observed bird species richness and abundance in coffee plantations to increase with increase in basal area of native tree species and decline with increasing distance from contiguous forest. Thus, at landscape level, plantations with native shade trees and forest fragments are extremely important to retain as they act as a support system for sensitive species and provide better connectivity between different land-uses. Planting more native tree species in these plantations and restoring the degraded forest fragments will add to value of the habitat. Habitat managements must discourage further conversion of these into monocultures or their extreme modification into tea plantations.

ACKNOWLEDGEMENTS

We are indebted to American Institute of India Studies, Ford Foundation, and Nadathur Conservation Trust for support that enabled this study. We thank Tamil Nadu and Kerala Forest Departments and officers, especially Messrs Sukhdev, V.S. Varughese, K. Varadharajan, Nirmal John, G. Sivamani for research permits and support in Anamalai Tiger Reserve and Thattekad Bird Sanctuary. Our thanks to Dinesh and Moorthy for field assistance. We are also extremely grateful to M. Ananda Kumar, Divya Mudappa, and P. Jeganathan for their help and suggestions in various stages of the project and K.V. Eldhose, and R. Sugathan for help at Thattekad.

REFERENCES

Ali, S. & S.D. Ripley (1983): Handbook of the Birds of India and Pakistan. Compact edition. Oxford University Press, Delhi. Pp. 737.

Anand, M.O., J. Krishnaswamy & A. Das (2008): Proximity to forests drives bird conservation value of coffee plantations: Implications for certification. *Ecol. Appl. 18*: 1754-1763.

Askins, R.A. & M.J. Philbrick (1987): Effect of changes in regional forest abundance on the decline and recovery of a forest bird community. *Wilson Bull. 99*: 7-21.

Balmford, A. (1996): Extinction filters and current resilience: the significance of past selection pressures for conservation biology. *Trends Ecol. Evol. 11*: 193-196.

BEEHLER, B.M., K.S.R.K. RAJU & S. ALI (1987): Avian use of man-disturbed forest habitats in the Eastern Ghats, India. *Ibis 129*: 197-211.

BHAGWAT, S.A., C.G. KUSHALAPPA, P.H. WILLIAMS & N.D. BROWN (2005): The role of informal protected areas in maintaining biodiversity in the Western Ghats of India. *Ecol. Soc. 10(1)*: 8.

BHAGWAT, S.A., K.J. WILLIS, H.J.B. BIRKS & R.J. WHITTAKER (2008): Agroforestry: a refuge for tropical biodiversity? *Trends Ecol. Evol. 23(5)*: 261-267.

BIERREGAARD (JR.), R.O. & T.E. LOVEJOY (1989): Effects of forest fragmentation on Amazonian understory bird communities. *Acta Amazón. 19*: 215-241.

BRASH, A.R. (1987): The history of avian extinction and forest conversion on Puerto Rico. *Biol. Conserv. 39*: 97-111.

BROOKS, T.M., S.L. PIMM & N.J. COLLAR (1997): Deforestation Predicts the Number of Threatened Birds in Insular Southeast Asia. *Conserv. Biol. 11(2)*: 382-394.

BRYMAN, A. & D. CRAMER (1997): Quantitative data analysis with SPSS for Windows: a guide for social scientists. Routledge, London.

BUSKIRK, W.H. (1976): Social systems in a tropical forest avifauna. *Am. Nat. 110(972)*: 293-310.

CASTELLETTA, M., N.S. SODHI & R. SUBARAJ (2000): Heavy extinctions of forest avifauna in Singapore: Lessons for biodiversity conservation in Southeast Asia. *Conserv. Biol. 14(6)*: 1870-1880.

CLARKE, K.R. & R.N. GORLEY (2001): Primer v 5: User Manual/Tutorial. PRIMER-E. Plymouth Marine Laboratory, Plymouth.

CLARKE, K.R. & R.M. WARWICK (1994): Change in Marine Communities: An Approach to Statistical Analysis and Interpretation. Plymouth Marine Laboratory, Plymouth. Pp. 859.

COLLAR, N.J., M.J. CROSBY & A.J. STATTERSFIELD (1994): Birds to Watch 2: The World list of Threatened Birds. BirdLife International, Cambridge. Pp. 407.

CONGREVE, H.R.T. (1942): The Anamalais. Associated Printers, Madras. Pp. 151.

DAILY, G.C., P.R. EHRLICH & G.A. SANCHEZ-AZOFEIFA (2001): Countryside Biogeography: Use of human-dominated habitats by the avifauna of Southern Costa Rica. *Ecol. Appl. 11(1)*: 1-13.

DANIELS, R.J.R., M. HEGDE & M. GADGIL (1990): Birds of man-made habitats: the plantations. *Proc. Indian Acad. Sci. 99*: 79-89.

DEFRIES, R., A. HANSEN, A.C. NEWTON & M.C. HANSEN (2005): Increasing isolation of protected areas in tropical forests over the past twenty years. *Ecol. Appl. 15(1)*: 19-26.

DEVELEY, P.F. & P.C. STOUFFER (2001): Effects of roads on movements by understory birds in Mixed-species flocks in Central Amazonian Brazil. *Conserv. Biol. 15(5)*: 1416-1422.

ESTRADA, A., R. COATES-ESTRADA & D.A. MERITT (JR) (1997): Anthropogenic landscape changes and avian diversity at Los Tuxtlas, Mexico. *Biodiversity Conserv. 6*: 19-43.

FARIA, D., R.R. LAPS, J. BAUMGARTEN, M. CETRA (2006): Bat and bird assemblages from forests and shade cacao plantations in the two contrasting landscape in the Atlantic forest of the southern Bahia, Brazil. *Biodiversity Conserv. 15*: 587-612.

FERRAZ, G., J.D. NICHOLS, J.E. HINES, P.C. STOUFFER, R.O. BIERREGAARD (JR) & T.E. LOVEJOY (2007): A large-scale deforestation experiment: effects of patch area and isolation on Amazon birds. *Science 315*: 238-241.

GARCIA-FERNANDEZ, C. & MA. CASADO (2005): Forest recovery in managed agroforestry systems: the case of benzoin and rattan gardens in Indonesia. *For. Ecol. Manage 214*: 158-169.

GASCON, C., T.E. LOVEJOY, R.O. BIERREGAARD, J.R. MALCOLM (JR), P.C. STOUFFER, H.L. VASCONCELOS, W.F. LAURANCE, B. ZIMMERMAN, M. TOCHER & S. BORGES (1999): Matrix habitat and species richness in tropical forest remnants. *Biol. Conserv. 91*: 223-229.

GOTELLI, N.J. & R.K. COLWELL (2001): Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecol. Letters 4*: 379-391.

GREENBERG, R., BICHIER P. & J. STERLING (1997): Bird populations in rustic and planted shade coffee plantations of Eastern Chiapas, Mexico. *Biotropica 29*: 501-514.

GREENBERG, R., I. PERFECTO & S.M. PHILPOTT (2008): Agroforests as model systems for tropical ecology. *Ecology 89*: 913-914.

GRIMMETT, R., C. INSKIPP & T. INSKIPP (1998): Birds of the Indian Subcontinent. Oxford University Press, New Delhi. Pp. 384.

HARVEY, C.A. & J.A.G. VILLALOBOS (2007): Agroforestry systems conserve species-rich but modified assemblages of tropical birds and bats. *Biodiversity Conserv. 16*: 2257-2292.

HUGHES, J.B., G.C. DAILY & P.R. EHRLICH (2002): Conservation of tropical forest birds in countryside habitats. *Ecol. Letters 5*: 121-129.

HUTTO, R.L. (1994): The composition and social organization of mixed-species flocks in a tropical deciduous forest in Western Mexico. *Condor 96*: 105-118.

JOHNS, A.D. (1986): Effects of selective logging on the ecological organization of a peninsular Malaysian rainforest avifauna. *Forktail 1*: 65-79.

JULLIEN, M. & J-M. THIOLLAY (1998): Flocking behaviour of foraging birds in a neotropical rain forest and the antipredator defence hypothesis. *Ibis 140*: 382-394.

KARR, J.R. (1981): Surveying birds in the tropics. *Studies in Avian Biology 6*: 548-553.

KOH, L.P., R.R. DUNN, N.S. SODHI, R.K. COLWELL, H.C. PROCTOR & V.S. SMITH (2004): Species coextinctions and the biodiversity crisis. *Science 305*: 1632-1634.

KREBS, C.J. (1989): Ecological Methodology. Harper and Row, New York. Pp. 654.

LAURANCE, W.F. & R.O. BIERREGAARD (JR.) (1997): Tropical Forest Remnants: Ecology, Management, and Conservation of fragmented communities. University of Chicago Press, Chicago. Pp. 616.

LAURANCE, W.F., T.E. LOVEJOY, H.L. VASCONCELOS, E.M. BRUNA, R.K. DIDHAM, P.C. STOUFFER, C. GASCON, R.O. BIERREGAARD (JR.), S.G. LAURANCE & E. SAMPAIO (2002): Ecosystem decay of Amazonian forest fragments: a 22 year investigation. *Conserv. Biol. 16(3)*: 605-618.

LAWTON J.H., D.E. BIGNELL, B. BOLTON, G.F. BLOEMERS, P. EGGLETON, P.M. HAMMOND, M. HODDA, R.D. HOLT, T.B. LARSEN, N.A. MAWDSLEY, N.E. STORK, D.S. SRIVASTAVA & A.D. WATT (1998): Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. *Nature 391*: 72-76.

LEE, T.M., M.C.K. SOH, N. SODHI, L.P. KOH & S.L-H. LIM (2005): Effects of habitat disturbance on mixed species bird flocks in a tropical sub-montane rainforest. *Biol. Conserv. 122*: 193-204.

LINDELL, C.A., W.H. CHOMENTOWSKY & J.R. ZOOK (2004): Characteristics of bird species using forest and agricultural land covers in southern Costa Rica. *Biodiversity Conserv. 13*: 2419-2441.

LUCK, G.W. & G.C. DAILY (2003): Tropical countryside bird assemblages: Richness, composition, and foraging differ by landscape context. *Ecol. Appl. 13*: 235-247.

MALDONADO-COELHO, M. & M.A. MARINI (2004): Mixed-species bird flocks from Brazilian Atlantic forest: the effects of forest fragmentation and seasonality on their size, richness and stability. *Biol. Conserv. 116*: 19-26.

MANI, M.S. (1974): Ecology and biogeography of India. Dr. W. Junk Publishers, The Hague. Pp. 773.

MARSDEN, S.J. (1998): Changes in bird abundance following selective logging on Seram, Indonesia. *Conserv. Biol. 12*: 605-611.

MASON, D. (1996): Responses of Venezuelan understorey birds to selective logging, enrichment strips, and vine cutting. *Biotropica* 28: 296-309.

MICHON, G. & F. MARY (1990): Transforming traditional homegardens. Pp. 169-185. *In*: Landauer, K. and M. Brazil (Eds): Tropical Home

Gardens. United Nations University Press, Tokyo.

MORSE, D.H. (1977): Feeding behavior and predator avoidance in heterospecific groups. *BioScience 27*: 332-339.

MUDAPPA, D. & T.R.S. RAMAN (2007): Rainforest restoration and wildlife conservation on private lands in the Western Ghats. Pp. 210-240. *In*: Shahabuddin, G. and M. Rangarajan (Eds): Making Conservation Work. Permanent Black, Ranikhet, Uttaranchal.

MUNN, C.A. & J.W. TERBORGH (1979): Multi-species territoriality in Neotropical foraging flocks. *Condor 81*: 338-347.

MYERS, N., R.A. MITTERMEIER, C.G. MITTERMEIER, G.A.B. DA FONSECA, J. KENT (2000): Biodiversity hotspots for conservation priorities. *Nature 403*: 853-858.

NAIR, S.C. (1991): The Southern Western Ghats: a biodiversity conservation plan. INTACH, New Delhi. Pp. 92.

PASCAL, J.P. (1988): Wet evergreen forests of the Western Ghats of India: ecology, structure, floristic composition and succession. Institut Français de Pondichèry, Pondicherry. Pp. 345.

POWELL, G.V.N. & R.D. BJORK (2004): Habitat linkages and the conservation of tropical biodiversity as indicated by seasonal migrations of Three-wattled Bellbirds. *Conserv. Biol. 18*: 500-509.

PRAMOD, P., R.J.R. DANIELS, N.V. JOSHI & M. GADGIL (1997): Evaluating bird communities of Western Ghats to plan for a biodoversity friendly development. *Curr. Sci. 73(2)*: 156-162.

RAMAN, T.R.S. (2001): Effect of slash-and-burn shifting cultivation on rainforest birds in Mizoram, North-east India. *Conserv. Biol. 15(3)*: 685-698.

RAMAN, T.R.S. (2006): Effects of habitat structure and adjacent habitats on birds in tropical rainforest fragments and shaded plantations in the Western Ghats, India. *Biodiversity Conserv. 15*: 1577-1607.

RAMAN, T.R.S. & R. SUKUMAR (2002): Responses of tropical rainforest birds to abandoned plantations, edges and logged forest in the Western Ghats, India. *Anim. Conserv. 5*: 201-216.

RAMAN, T.R.S., G.S. RAWAT & A.J.T. JOHNSINGH (1998): Recovery of tropical rainforest avifauna in relation to vegetation succession following shifting cultivation in Mizoram, North-east India. *J. Appl. Ecol. 35*: 214-231.

RANGANATHAN, J., R.J.R. DANIELS, M.D.S. CHANDRAN, P.R. EHRLICH & G.C. DAILY (2008): Sustaining biodiversity in ancient tropical countryside. *Proc. Natl. Acad. Sci., USA 105*: 17852-17854.

RAVEN, P.H. (1988): Our diminishing tropical forests. Pp. 119-122. *In*: Wilson, E.O. (Ed): Biodiversity. National Academy Press, Washington DC.

SCALES, B.R. & S.J. MARSDEN (2008): Biodiversity in small-scale tropical agro-forests: a review of species richness and abundance shifts and the factors influencing them. *Environ. Conserv. 35(2)*: 160-172.

SEKERCIOGLU, C.H., S.R. LOARIE, F.O. BRENES, P.R. EHRLICH & G.C. DAILY (2006): Persistence of forest birds in the Costa Rican agricultural countryside. *Conserv. Biol. 21(2)*: 482-494.

SODHI, N.S., M.R.C. POSA, T.M. LEE & I.G. WARKENTIN (2008): Effects of disturbance and loss of tropical rainforest birds. *Auk 125(3)*: 511-519.

SRIDHAR, H. & K. SANKAR (2008): Effects of habitat degradation on mixed-species bird flocks in Indian rain forests. *J. Trop. Ecol. 24*: 135-147.

STATTERSFIELD, A.J., M.J. CROSBY, A.J. LONG & D.C. WEGE (1998): Endemic bird areas of the world: priorities for biodiversity conservation. Birdlife International Conservation, Cambridge.

STOUFFER, P.C. & R.O. BEIRREGAARD (JR.) (1995): Use of Amazonian forest fragments by understorey insectivorous birds. *Ecology 76(8)*: 2429-2445.

STOUFFER, P.C., R.O. BIERREGAARD (JR.), C. STRONG & T.E. LOVEJOY (2006): Long-term landscape change and bird abundance in Amazonian rainforest fragments. *Conserv. Biol. 20*: 1212-1223.

STRATFORD, J.A. & P.C. STOUFFER (1999): Local extinctions of terrestrial insectivorous birds in a fragmented landscape near Manaus, Brazil. *Conserv. Biol. 13(6)*: 1416-1423.

SUGATHAN, R. & A.P. VARGHESE (1996): A review of the birds of the Thattekkad bird sanctuary. *J. Bombay Nat. Hist. Soc. 93(3)*: 487-506.

TAYLOR, P.D., L. FAHRIG, K. HENEIN & G. MERRIAM (1993): Connectivity is a vital element of landscape structure. *Oikos 68*: 571-573.

THIOLLAY, J-M. (1992): Influence of selective logging on bird species diversity in a Guianan rainforest. *Conserv. Biol. 6(1)*: 47-63.

THIOLLAY, J-M. (1994): Structure, density and rarity in an Amazonian rainforest bird community. *J. Trop. Ecol. 10*: 449-481.

THIOLLAY, J-M. (1995): The role of traditional agroforests in the conservation of rain forest bird diversity in Sumatra. *Conserv. Biol. 9(2)*: 335-353.

THIOLLAY, J-M. (1999): Frequency of mixed-species flocking in tropical forest birds and correlates of predation risk: an inter-tropical comparison. *J. Avian Biol. 30*: 282-294.

WALTERT, K., S. BOBO, N.M. SAINGE, H. FERMON & M. MÜHLENBERG (2005): From forest to farmland: Habitat effects on Afrotropical forest bird diversity. *Ecol. Appl. 15(4)*: 1351-1366.

WHITMAN, A.A., J.M. HAGAN & N.V. BROKAW (1997): A comparison of two bird survey techniques used in a subtropical forest. *Condor 99*: 955-965.

WRIGHT, S.J. & H.C. MULLER-LANDAU (2006): The Future of Tropical Forest Species. *Biotropica 38(3)*: 287-301.

ZAR, J.H. (1999): Biostatistical Analysis. Prentice-Hall, New Jersey. Pp. 663.

■ ■ ■

Appendix 1: List of bird species, codes, and average relative abundance (abundance of a species / abundance of all species, represented as percentage for a transect) in the three main habitat strata across the two study sites (Thattekad and Anamalai Hills)

Common names	Scientific name	Codes	Thattekad			Anamalai Hills		
			Forest	Buffer	Village	Forest	Buffer	Village
Asian Brown Flycatcher	*Muscicapa dauurica**	OF/M	0.13	0.00	0.32	0.00	0.40	0.00
Blue-headed Rock-thrush	*Monticola cinclorhynchus**	OF/M	0.00	0.00	0.00	0.00	0.17	0.23
Black-naped Oriole	*Oriolus chinensis**	OF/M	0.28	0.77	0.00	0.07	0.16	0.00
Brown Shrike	*Lanius cristatus*	OF/M	0.00	0.00	0.16	0.06	0.07	0.00
Blyth's Reed-warbler	*Acrocephalus dumetorum*	OF/M	0.06	0.33	0.16	0.72	1.40	14.42
Blue-throated Flycatcher	*Cyornis rubeculoides*	OF/M	0.00	0.07	0.00	0.00	0.00	0.00
Common Rosefinch	*Carpodacus erythrinus**	OF/M	0.00	0.00	0.00	0.00	0.72	0.00
European Golden Oriole	*Oriolus oriolus**	OF/M	0.27	0.32	2.50	0.06	0.00	0.00
Asian Koel	*Eudynamys scolopaceus*	OF/R	0.19	0.58	0.91	0.00	0.00	0.00
Ashy Prinia	*Prinia socialis*	OF/R	0.00	0.00	0.00	0.00	0.00	1.50
Ashy Woodswallow	*Artamus fuscus*	OF/R	0.06	0.41	2.12	0.00	0.00	0.00
Indian Pygmy Woodpecker	*Dendrocopos nanus**	OF/R	0.64	0.67	0.37	0.13	0.30	0.00
Blue-faced Malkoha	*Phaenicophaeus viridirostris**	OF/R	0.00	0.07	0.00	0.00	0.00	0.00
Brown Fish-owl	*Ketupa zeylonensis*	OF/R	0.09	0.00	0.00	0.00	0.00	0.00
Black-hooded Oriole	*Oriolus xanthornus**	OF/R	0.52	4.32	0.56	0.00	0.00	0.00
Black-rumped Flameback	*Dinopium benghalense**	OF/R	0.61	1.59	1.90	0.07	0.08	0.47
Brahminy Kite	*Haliastur indus*	OF/R	0.13	0.00	0.00	0.07	0.00	0.00
Blue-winged Leafbird	*Chloropsis cochinchinensis**	OF/R	0.16	0.32	0.32	0.00	0.00	0.00
Chestnut-headed Bee-eater	*Merops leschenaulti*	OF/R	0.13	0.74	0.00	0.33	0.51	6.49
Common Hawk Cuckoo	*Hierococcyx varius**	OF/R	0.07	1.78	1.61	0.00	0.00	0.00
Coppersmith Barbet	*Megalaima haemacephala**	OF/R	0.63	0.16	0.00	0.00	0.00	0.00
Common Hoopoe	*Upupa epops*	OF/R	0.06	0.07	0.00	0.00	0.00	0.21
Common Iora	*Aegithina tiphia**	OF/R	0.60	0.23	0.00	0.07	0.17	0.00
Common Kestrel	*Falco tinnunculus*	OF/R	0.00	0.00	0.00	0.00	0.00	0.70
Common Myna	*Acridotheres tristis**	OF/R	0.48	2.12	3.49	0.00	0.15	1.29
Common Tailorbird	*Orthotomus sutorius**	OF/R	0.18	0.73	1.45	0.00	1.20	3.45
Common Woodshrike	*Tephrodornis pondicerianus**	OF/R	0.13	0.00	0.00	0.00	0.00	0.00
Crested Treeswift	*Hemiprocne coronata*	OF/R	0.00	0.00	0.16	0.00	0.00	0.00
Indian Scops-owl	*Otus bakkamoena*	OF/R	0.07	0.08	0.00	0.06	0.07	0.00
Grey-headed Starling	*Sturnia malabarica**	OF/R	1.67	0.52	0.48	0.00	0.07	0.00
Grey-bellied Cuckoo	*Cacomantis passerinus*	OF/R	0.00	0.00	0.00	0.00	0.07	0.00
Greater Coucal	*Centropus sinensis**	OF/R	1.26	2.69	4.61	0.53	0.16	4.04
Great Tit	*Parus major**	OF/R	0.00	0.47	0.00	0.00	0.00	0.00
House Sparrow	*Passer domesticus*	OF/R	0.00	0.00	0.00	0.00	0.00	0.21
Indian Cuckoo	*Cuculus micropterus*	OF/R	0.06	1.37	0.00	0.00	0.00	0.00
Jungle Babbler	*Turdoides striata**	OF/R	0.65	14.16	1.02	0.00	0.00	0.00
Jungle Myna	*Acridotheres fuscus**	OF/R	0.13	0.00	0.00	0.00	0.00	0.86
Jungle Owlet	*Glaucidium radiatum**	OF/R	0.06	0.78	0.00	0.06	0.00	0.00
Indian Jungle Crow	*Corvus (macrorhynchos) culminatus**	OF/R	1.27	3.17	12.14	1.20	0.99	7.04
Loten's Sunbird	*Cinnyris lotenius**	OF/R	0.15	0.08	0.67	0.00	0.00	0.00
Long-tailed Shrike	*Lanius schach*	OF/R	0.00	0.00	0.00	0.00	0.00	2.40
Mottled Wood-owl	*Strix ocellata*	OF/R	0.00	0.00	0.19	0.00	0.00	0.00
Oriental Magpie-robin	*Copsychus saularis**	OF/R	0.06	1.77	3.08	0.06	0.52	6.46
Plum-headed Parakeet	*Psittacula cyanocephala**	OF/R	1.09	0.97	0.32	0.00	0.76	0.21
Pied Bushchat	*Saxicola caprata*	OF/R	0.00	0.00	0.00	0.00	0.00	2.48
Plain Prinia	*Prinia inornata*	OF/R	0.00	0.00	0.00	0.00	0.00	0.21
Purple-rumped Sunbird	*Leptocoma zeylonica**	OF/R	0.00	0.37	0.00	0.00	0.00	0.00
Purple Sunbird	*Cinnyris asiaticus**	OF/R	0.00	0.00	0.97	0.14	0.16	0.23
Rock Pigeon	*Columba livia*	OF/R	0.00	0.57	0.00	0.00	0.00	0.00
Rose-ringed Parakeet	*Psittacula krameri*	OF/R	0.00	0.15	0.00	0.00	0.00	0.00
Rufous Treepie	*Dendrocitta vagabunda**	OF/R	1.00	4.56	3.75	0.00	0.00	0.00

Appendix 1: List of bird species, codes, and average relative abundance (abundance of a species / abundance of all species, represented as percentage for a transect) in the three main habitat strata across the two study sites (Thattekad and Anamalai Hills) (*contd.*)

Common names	Scientific name	Codes	Thattekad			Anamalai Hills		
			Forest	Buffer	Village	Forest	Buffer	Village
Red-vented Bulbul	*Pycnonotus cafer**	OF/R	0.00	0.35	0.81	0.00	0.00	0.00
Red-whiskered Bulbul	*Pycnonotus jocosus**	OF/R	0.57	2.00	4.30	0.44	9.38	22.10
Red-wattled Lapwing	*Vanellus indicus*	OF/R	0.06	0.24	0.00	0.00	0.00	0.00
Stork-billed Kingfisher	*Pelargopsis capensis*	OF/R	0.00	0.26	0.35	0.00	0.00	0.00
Shikra	*Accipiter badius*	OF/R	0.00	0.00	0.00	0.00	0.00	0.23
Small Minivet	*Pericrocotus cinnamomeus**	OF/R	0.98	0.00	0.97	0.00	0.00	0.00
Spotted Dove	*Streptopelia chinensis*	OF/R	0.22	0.40	0.56	0.13	0.85	2.42
Streak-throated Woodpecker	*Picus xanthopygaeus**	OF/R	0.00	0.23	0.00	0.00	0.00	0.23
Tickell's Blue Flycatcher	*Cyornis tickelliae*	OF/R	0.00	0.00	0.16	0.00	0.00	0.00
White-breasted Waterhen	*Amaurornis phoenicurus*	OF/R	0.00	0.32	0.56	0.00	0.00	0.47
White-throated Kingfisher	*Halcyon smyrnensis*	OF/R	0.54	1.75	1.05	0.00	0.15	0.23
Yellow-footed Green-pigeon	*Treron phoenicopterus*	OF/R	0.45	0.00	0.00	0.00	0.00	0.00
Small Sunbird	*Leptocoma minima**	RF/E	2.02	0.44	1.61	11.28	6.23	0.23
Grey-headed Bulbul	*Pycnonotus priocephalus**	RF/E	0.35	0.00	0.00	0.00	0.00	0.00
Malabar Parakeet	*Psittacula columboides**	RF/E	1.41	0.78	1.77	1.20	2.98	0.00
Malabar Grey Hornbill	*Ocyceros griseus**	RF/E	4.52	2.45	1.69	2.98	1.94	0.45
Nilgiri Flycatcher	*Eumyias albicaudatus**	RF/E	0.00	0.00	0.00	0.07	0.00	0.00
Indian Rufous Babbler	*Turdoides subrufa*	RF/E	0.18	0.00	0.00	0.14	0.29	0.70
Ceylon Frogmouth	*Batrachostomus moniliger*	RF/E	0.13	0.00	0.00	0.00	0.00	0.00
White-bellied Blue Flycatcher	*Cyornis pallipes**	RF/E	0.88	0.14	0.00	0.39	0.00	0.00
White-bellied Treepie	*Dendrocitta leucogastra**	RF/E	0.00	0.43	0.00	1.24	0.29	0.00
Ashy Drongo	*Dicrurus leucophaeus**	RF/M	0.39	0.31	0.65	0.20	0.22	0.00
Brown-breasted Flycatcher	*Muscicapa muttui*	RF/M	0.13	0.00	0.00	0.00	0.00	0.00
Forest Wagtail	*Dendronanthus indicus*	RF/M	0.00	0.00	0.00	0.00	0.33	0.00
Greenish Warbler	*Phylloscopus trochiloides**	RF/M	2.30	2.77	3.43	2.49	4.54	2.23
Grey Wagtail	*Motacilla cinerea*	RF/M	0.00	0.00	0.00	0.32	0.15	0.21
Indian Blue Robin	*Luscinia brunnea*	RF/M	0.00	0.00	0.00	0.07	0.00	0.00
Large-billed Leaf-warbler	*Phylloscopus magnirostris**	RF/M	1.61	0.29	0.00	4.29	0.69	0.00
Rusty-tailed Flycatcher	*Muscicapa ruficauda**	RF/M	0.16	0.00	0.00	1.19	0.23	0.00
Verditer Flycatcher	*Eumyias thalassinus**	RF/M	0.00	0.00	0.00	0.07	0.00	0.00
Western Crowned Warbler	*Phylloscopus occipitalis**	RF/M	0.00	0.00	0.00	1.75	4.05	0.00
Asian Fairy-bluebird	*Irena puella**	RF/R	3.15	0.99	1.34	6.50	1.98	0.00
Asian Paradise Flycatcher	*Terpsiphone paradisi**	RF/R	0.42	0.08	0.00	0.26	0.17	0.00
Blue-bearded Bee-eater	*Nyctyornis athertoni*	RF/R	0.00	0.09	0.00	0.00	0.00	0.00
Black-capped Bulbul	*Pycnonotus melanicterus**	RF/R	4.09	1.59	0.16	1.75	0.31	0.00
Brown-cheeked Fulvetta	*Alcippe poioicephala**	RF/R	2.58	0.07	0.00	5.16	1.18	0.00
Besra Sparrowhawk	*Accipiter virgatus*	RF/R	0.00	0.00	0.00	0.06	0.08	0.00
Hume's Hawk-owl	*Ninox obscura*	RF/R	0.00	0.00	0.19	0.00	0.00	0.00
Black Baza	*Aviceda leuphotes*	RF/R	0.00	0.07	0.00	0.00	0.00	0.00
Himalayan Black Bulbul	*Hypsipetes leucocephalus**	RF/R	0.00	0.00	0.00	0.00	0.59	0.00
Black Eagle	*Ictinaetus malayensis*	RF/R	0.00	0.00	0.00	0.00	0.15	0.00
Black-lored Yellow Tit	*Parus xanthogenys**	RF/R	0.44	0.00	0.00	0.84	1.21	0.21
Black-naped Blue Monarch	*Hypothymis azurea**	RF/R	0.90	0.21	0.00	0.26	0.25	0.00
Bronzed Drongo	*Dicrurus aeneus**	RF/R	1.79	3.53	1.05	1.93	1.79	0.00
Pied Flycatcher-shrike	*Hemipus picatus**	RF/R	0.09	0.07	0.16	0.32	0.94	0.00
Ceylon Small Barbet	*Megalaima rubricapillus**	RF/R	4.52	0.42	1.21	0.58	1.39	0.21
Common Flameback	*Dinopium javanense**	RF/R	0.00	0.33	0.00	1.71	1.31	0.23
Crested Goshawk	*Accipiter trivirgatus*	RF/R	0.00	0.07	0.00	0.19	0.17	0.00
Crested Serpent-eagle	*Spilornis cheela*	RF/R	0.31	0.28	0.16	0.79	1.39	1.07
Dark-fronted Babbler	*Rhopocichla atriceps**	RF/R	4.00	0.00	0.00	3.00	2.00	0.00
Dollarbird	*Eurystomus orientalis**	RF/R	0.14	0.28	0.00	0.00	0.00	0.00
Square-tailed Drongo-cuckoo	*Surniculus lugubris*	RF/R	0.07	0.00	0.16	0.00	0.00	0.00
Emerald Dove	*Chalcophaps indica**	RF/R	0.14	0.37	0.00	0.46	0.16	0.00

Appendix 1: List of bird species, codes, and average relative abundance (abundance of a species / abundance of all species, represented as percentage for a transect) in the three main habitat strata across the two study sites (Thattekad and Anamalai Hills) (*contd.*)

Common names	Scientific name	Codes	Thattekad			Anamalai Hills		
			Forest	Buffer	Village	Forest	Buffer	Village
Gold-fronted Leafbird	*Chloropsis aurifrons**	RF/R	1.14	0.84	0.00	0.47	1.94	0.00
Grey-headed Canary-flycatcher	*Culicicapa ceylonensis**	RF/R	0.09	0.07	0.16	1.59	1.48	0.00
Grey-headed Fish-eagle	*Ichthyophaga ichthyaetus*	RF/R	0.00	0.00	0.00	1.19	0.00	0.00
Green Imperial-pigeon	*Ducula aenea*	RF/R	2.67	0.80	0.81	0.25	0.00	0.00
Greater Flameback	*Chrysocolaptes lucidus**	RF/R	1.68	0.53	0.70	0.79	0.92	0.00
Great Pied Hornbill	*Buceros bicornis*	RF/R	0.00	0.00	0.00	0.00	0.08	0.00
Grey Junglefowl	*Gallus sonneratii*	RF/R	1.25	1.89	0.56	0.58	0.46	0.21
Greater Racket-tailed Drongo	*Dicrurus paradiseus**	RF/R	10.18	10.14	7.77	5.40	2.29	0.00
Common Hill-Myna	*Gracula religiosa**	RF/R	5.86	2.45	3.23	4.23	2.37	0.21
Heart-spotted Woodpecker	*Hemicircus canente**	RF/R	1.09	0.26	0.00	0.07	0.39	0.00
Indian Scimitar-babbler	*Pomatorhinus (schisticeps) horsfieldii**	RF/R	0.00	0.00	0.00	1.10	1.52	5.76
Large Woodshrike	*Tephrodornis gularis**	RF/R	0.16	1.00	0.00	1.26	1.33	0.00
Lesser Yellownape	*Picus chlorolophus**	RF/R	0.69	0.48	0.35	0.13	0.08	0.00
Little Spiderhunter	*Arachnothera longirostra**	RF/R	2.23	0.14	0.65	1.36	0.23	0.00
Malabar Trogon	*Harpactes fasciatus**	RF/R	0.42	0.00	0.00	0.79	0.00	0.00
Mountain Imperial-pigeon	*Ducula badia*	RF/R	0.95	0.07	0.00	2.25	1.97	0.23
Malabar Whistling-thrush	*Myophonus horsfieldii*	RF/R	0.84	0.24	0.00	3.13	1.20	1.99
Oriental Honey-buzzard	*Pernis ptilorhyncus*	RF/R	0.07	0.17	0.00	0.06	0.00	0.00
Orange-headed Thrush	*Zoothera citrina**	RF/R	0.06	0.21	0.00	0.00	0.22	0.00
Oriental White-eye	*Zosterops palpebrosus**	RF/R	0.00	0.00	0.16	0.97	3.00	0.00
Ceylon Green-pigeon	*Treron pompadora*	RF/R	0.73	0.14	0.00	0.00	0.65	0.00
Nilgiri Flowerpecker	*Dicaeum concolor**	RF/R	3.01	2.26	1.96	3.46	4.15	0.23
Puff-throated Babbler	*Pellorneum ruficeps*	RF/R	0.19	0.00	0.00	0.07	0.00	0.00
Red Spurfowl	*Galloperdix spadicea*	RF/R	0.06	0.07	0.00	0.00	0.15	0.21
Rufous Woodpecker	*Micropternus brachyurus**	RF/R	0.06	0.00	0.00	0.00	0.00	0.00
Orange Minivet	*Pericrocotus flammeus**	RF/R	1.67	0.00	1.61	2.26	5.54	0.00
Speckled Piculet	*Picumnus innominatus**	RF/R	0.13	0.00	0.00	0.07	0.42	0.00
Velvet-fronted Nuthatch	*Sitta frontalis**	RF/R	0.26	0.00	0.00	1.09	1.56	0.00
Vernal Hanging-parrot	*Loriculus vernalis**	RF/R	4.42	2.24	2.85	2.54	2.27	0.00
White-bellied Woodpecker	*Dryocopus javensis*	RF/R	0.06	0.08	0.00	0.14	0.00	0.00
White-cheeked Barbet	*Megalaima viridis**	RF/R	6.49	5.89	6.91	4.93	6.79	4.22
Yellow-browed Bulbul	*Iole indica**	RF/R	3.43	0.44	1.37	6.38	4.88	0.00
Whiskered Tern	*Chlidonias hybrida*	WB/M	0.26	0.09	0.19	0.00	0.00	0.00
Bronze-winged Jacana	*Metopidius indicus*	WB/R	0.00	0.00	0.37	0.00	0.00	0.00
Oriental Darter	*Anhinga melanogaster*	WB/R	0.00	0.17	0.75	0.00	0.00	0.00
Great Egret	*Egretta alba*	WB/R	0.00	0.00	0.00	0.00	0.00	0.88
Intermediate Egret	*Egretta intermedia*	WB/R	0.06	0.00	1.45	0.00	0.00	0.00
Indian Pond-heron	*Ardeola grayii*	WB/R	0.00	0.15	1.63	0.00	0.08	1.84
Little Cormorant	*Phalacrocorax niger*	WB/R	0.06	0.34	0.56	0.00	0.00	0.00
Lesser Whistling-duck	*Dendrocygna javanica*	WB/R	0.00	0.00	0.37	0.00	0.00	0.00
River Tern	*Sterna aurantia*	WB/R	0.32	0.24	0.00	0.00	0.00	0.00
Total number of individuals			1372	1261	577	1286	1305	446

* Flocking species

Codes: OF=Open-forest species, RF=Rainforest species, WB=Water-birds, R=Resident, E=Endemic, M=Migrant

■ ■ ■

BREEDING BIOLOGY OF THE HILL SWALLOW *HIRUNDO DOMICOLA* IN WESTERN GHATS, INDIA

P. Balakrishnan[1]

[1]Division of Conservation Ecology, Sálim Ali Centre for Ornithology and Natural History, Anaikatty, Coimbatore 641 108, Tamil Nadu, India. Present Address: Wildlife Research and Conservation Trust, c/o Anupallavi, Chungathara, Nilambur 679 334, Malappuram, Kerala, India.
Email: baluperoth@gmail.com

The breeding biology of Hill Swallow *Hirundo domicola* – which has been previously considered as a subspecies of Pacific Swallow *Hirundo tahitica* – was studied from 2002 to 2005 in Silent Valley National Park and Muthikkulam Reserve Forests, Western Ghats, India. Nesting of the species was observed from November to April with peak egg-laying during February-March. Nests were placed in the walls of tunnels/culverts and on the roofs of buildings. The clutch size averaged 2.44 eggs, and was found to be low in nests placed in buildings (2.07 eggs) compared to those in tunnels/culverts (2.71 eggs). Average incubation period was 15.78 days and nestling period was 19.1 days. Nest attentiveness and duration of the on- and off-bouts increased with the progress of incubation. Nesting success rate was higher than the average of tropical species but lower than the temperate hirundines. The main known causes of nest failure were predation and nest falling. In general, many life history traits (including clutch size, developmental periods and parental care) of *H. domicola* varied from its conspecific House Swallow *H. tahitica*, and thus support the recent separation of it as a distinct species.

Keywords: breeding biology, Hirundinidae, *Hirundo domicola*, *Hirundo tahitica*, life history, parental care, tropics

INTRODUCTION

The Family Hirundinidae includes *c.* 84 species of passerines widely distributed in both temperate and tropical habitats (Turner and Rose 1989; Turner 2004). These birds are highly aerial and exclusive insectivores (Turner 2004). Little is known of the biology and ecology of many hirundines, especially tropical species. But several temperate species like Barn Swallow *Hirundo rustica*, Cliff Swallow *Petrochelidon pyrrhonota* and Tree Swallow *Tachycineta bicolor* are well-known and used as models in a large number of ecological studies (see reviews in Turner 2004). Available information on the reproductive traits of hirundines that breed in the tropics shows significant variation from the typical traits of tropical birds (Hails 1984; Ali and Ripley 1987; Turner 2004). Many of them have large a clutch size and longer developmental periods compared to that of temperate birds (Ali and Ripley 1987; Turner 2004).

Pacific Swallow *Hirundo tahitica* (Ali and Ripley 1987; Grimmett *et al.* 1999) is one of the 17 hirundines occurring in South Asia (Rasmussen and Anderton 2005) and constitute two disjunctly distributed subspecies (*Hirundo tahitica javanica* and *Hirundo tahitica domicola*). Based on the morphological, vocal and ecological differences, these subspecies were recently recognised (Rasmussen and Anderton 2005) as two distinct species, namely House Swallow *Hirundo tahitica* and Hill Swallow *Hirundo domicola*. The House Swallow is a common bird known from Andamans, Myanmar, Malay Peninsula and Indonesia (Ali and Ripley 1987; Turner 2004). Hill Swallows are sedentary residents distributed in the grassy slopes around plantations and human habitation in southern Western Ghats (from south Karnataka through Nilgiris and Kerala) and Sri Lanka from 700-2,400 m (Ali and Ripley 1987; Turner 2004; Rasmussen and Anderton 2005). Jathar and Rahmani (2006) also listed Hill Swallow as one of the birds endemic to the South Asian mainland and Sri Lanka. The breeding biology of House Swallow has been well-studied in Malaysia (Hails 1984). However, relatively little is known about Hill Swallows except for the descriptions of breeding seasonality, nests and clutch size (Ali and Ripley 1987; Turner 2004).

This paper describes the breeding biology and life history of Hill Swallow and compares this information with the available data for House Swallow and other hirundines. Aspects considered include timing of breeding, nest-site characteristics, nest measurements, clutch size, developmental periods, growth rates, parental care strategies, nesting success and causes of nest failures.

STUDY AREA

Data were collected from two study areas: in Silent Valley National Park (11° 00'-11° 15' N; 76° 15'-76° 35' E; area: 89.52 sq. km, hereafter: Silent Valley) during January 2003 to May 2005, and Muthikkulam Reserve Forest (10° 56'-10° 59' N; 76° 41'-76° 45' E; area: 63.83 sq. km, hereafter: Muthikkulam) during September 2002 to April 2004. Both the sites are located in the south-western corner

of the Nilgiri Biosphere Reserve in the Western Ghats of India. In both the areas, the terrain is undulating and hilly, with elevation ranging from 658 to 2,383 m above msl at Silent Valley, and 610 to 2,065 m above msl at Muthikkulam. Both sites are similar in vegetation types, dominated by the west coast tropical evergreen forest followed by the southern montane wet temperate forest, and grasslands restricted mainly to the higher slopes and hill tops (Nair and Balasubramanyan 1985; Basha 1999; Balakrishnan 2007). Both sites experience similar and typical tropical climate, with mean annual temperature below 27°C and mean annual rainfall above 4,500 mm. However, the north-east monsoon is slightly heavier in Muthikkulam compared to that of Silent Valley. In Silent Valley, the breeding sites were found in the remnants of the abandoned hydro-electric project (tunnels and buildings) at Sairandhri. The study site at Muthikkulam included the surroundings (about 5 sq. km) of the Siruvani dam with several abandoned and partially occupied (by officials of forest and irrigation departments) buildings, tunnels and culverts.

METHODS

Nests were located by following the activities of adult birds (regular to and fro movement to probable breeding sites, carrying food or nest materials, etc.) or by searching potentially suitable habitats (building, culverts, tunnels, etc.). Once found, contents of the nests were checked using a mirror and torch on a pole. Nests were inspected every 1-2 days or everyday during the transition of nesting stages with the help of field assistants to determine the breeding phenology and nest fate. Clutch initiation dates were determined either by direct observation of egg laying or by calculations made using known hatching dates and mean developmental periods. Clutch size was measured as the final number of eggs laid and duration of developmental period was calculated based on visual inspection of nests. Seven chicks from three nests were weighed on alternate days (from day 1 to 19) using Pesola spring balances to determine the growth rates. After nest success or failure, height of the nest above ground, nest measurements such as nest diameter, cup diameter, outer nest depth and cup depth were recorded, and nest thickness based on standard methods was calculated (Soler *et al.* 1998).

To assess parental care patterns and nest attentiveness, the birds' incubation behaviour during early (1-8 days) and late incubation (9-16 days) period by hourly watches at nests following standard methods (Nolan 1978; Halupka 1994; Norment 1995) was measured. Day-light hours (6:00 to 18:00 hrs) were divided into four sections (06:00-09:00, 09:00-12:00, 12:00-15:00 and 15:00-18:00 hrs) and observations were made in each section to control for variation in incubation behaviour during the day (Nolan 1978; Smith and Montgomerie 1992; Conway and Martin 2000a). The parameters measured or calculated were nest attentiveness (per cent time spent on the nest incubating eggs), on-bout duration (mean incubation bout duration in minutes) and off-bout duration (mean time spent away between two incubation visits in minutes) based on standard methods (Kendeigh 1952; Conway and Martin 2000a). Similarly, provisioning rates (number of feeding visits/hr) during early (1-6 days), mid (7-13days) and late (14-19 days) nestling periods were also recorded by hourly watches at nests. The total observation period was 133 hrs, which include 114 hrs during incubation and 19 hrs during nestling period. As the birds were not colour-marked or sexed, data presented are combined parental investment of both males and females.

Nests that produced at least one fledgling were considered as successful nests. Hatching, nestling and breeding success were defined as: the probability that eggs laid would hatch, the probability that hatchlings would fledge, and the probability that eggs laid would survive from laying to fledging, respectively. Daily nest survival and nest success rates were calculated based on Mayfield method (Mayfield 1975). Daily nest survival and nest success rates were calculated separately for the reproductive phases, study sites and substrate types. Standard errors for survival rates were calculated based on the methods described in Johnson (1979). All tests were two tailed, and differences were considered significant at $p < 0.05$. Mean ±SD values are reported throughout. All statistical analyses were performed by using SPSS 10.0 (SPSS Inc.).

RESULTS

Timing of breeding

A total of 36 Hill Swallow nests during 2002 to 2005 were located and monitored; 21 nests in Silent Valley and 15 nests in Muthikkulam. In Muthikkulam, the earliest first egg-laying date was November 23 (November 23 and February 06 for 2002-03 and 2003-04 breeding seasons, respectively), while it was February 09 (February 12, February 18, and February 09 for 2003, 2004 and 2005 breeding seasons, respectively) in Silent Valley. Except for three nests observed at Muthikkulam during November-December 2002, all the nesting attempts were during February-April and peak egg-laying occurred during February-March at both sites (Fig. 1).

Nests and nest sites

All the breeding sites were located within an elevation

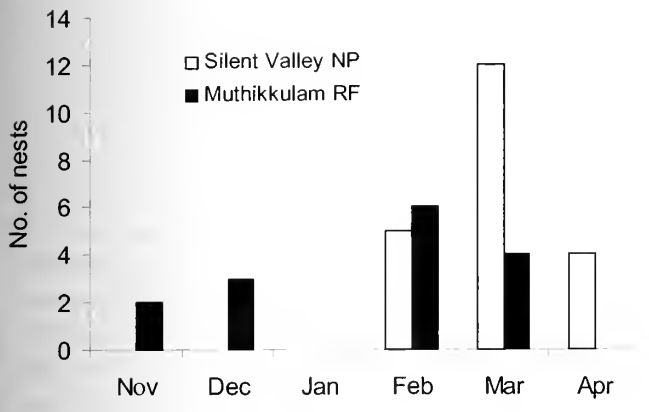


Fig. 1: Timing of monthly clutch initiation (n = 36) from early November to late May 2002-2005, for Hill Swallows at Silent Valley National Park and Muthikkulam Reserve Forest

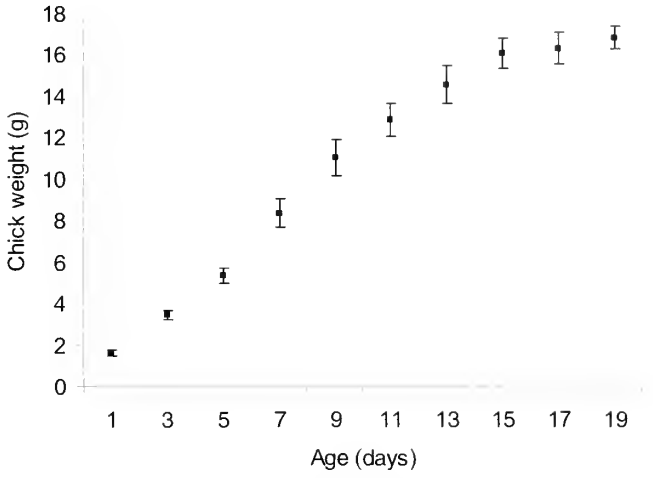


Fig. 2: Growth rate (mass) of Hill Swallow nestlings as a function of age

range of 800 to 1,200 m above msl. Of the 36 nests examined in this study, 17 were built on rock surfaces (under overhangs) in man-made tunnels, four on the wall of culverts and 15 on roofs of abandoned buildings. All the nests placed on buildings were single nests, but the nest sites in tunnels and culverts also comprised of small colonies of 3-5 nests. All the nests were cup-shaped (nest diameter: 11.43 ±0.72 cm, cup diameter: 8.59 ±0.71 cm, outer nest depth: 7.84 ±0.71 cm, cup depth: 5.2 ±0.72 cm, nest thickness: 1.42 ±0.32 cm) made with mud pellets as major structural constituent. Dried grasses, moss, pteridophyte roots and lichens were also used in the structural layer, mostly in nests placed in tunnel/culvert sites. The amount of these materials was considerably minimal in the nests placed in buildings. However, in the building sites, the mud cups were supported by a mud foundation built in the lower portion of the ceiling beams. These foundations were made with powdery mud (different from the material of the cup) which has terracotta-like hardness upon drying. Feathers were used as the inner lining layer in all nests. Addition of feather was also observed during the early incubation stage. Both sexes participated in the nest construction and birds often reused old nest sites with certain amount of repair. Time required for nest construction was not estimated because majority of the nests were found during the late construction period or other reproductive stages. We observed a pair take seven days to repair an old nest at a building site.

Nest morphometry significantly varied between the nesting substrates (building vs. tunnel/culvert nests) and between nests with different clutch sizes (Table 1). The nests were placed 2.06 ±0.39 m above ground (range: 1.58-2.7 m). Nest heights significantly varied between the building sites (2.49 ±0.20 m, range: 1.9-2.7 m, n = 15) and tunnel/culvert sites (1.76 ±0.09 m, range: 1.58-1.9 m, n = 21) (t = -14.64, p < 0.001). All the nest sites were in the vicinity of water (<15 m).

Clutch size, developmental periods and growth rates

The mean clutch size was 2.52 ±0.51 in Silent Valley (n = 21) and 2.33 ±0.49 in Muthikkulam (n = 15), while for all clutches together it was 2.44 ±0.5 (20 nests with 2 eggs and 16 nests with 3 eggs). Clutch size was significantly smaller in building nests (2.07 ±0.26 eggs, n = 15) than in tunnel/culvert nests (2.71 ±0.46 eggs, n = 21; t = 4.89, p < 0.001).

Table 1: Measurements of Hill Swallow nests

Nest size variables	Tunnel/culvert nests N = 13	Building nests N = 9	*F*	*P*	Nest with two eggs N = 11	Nest with three eggs N = 11	*F*	*P*
Nest diameter (cm)	11.78 ±0.59	10.92 ±0.58	11.544	0.003	10.90 ±0.53	11.96 ±0.42	27.139	0.001
Cup diameter (cm)	8.79 ±0.75	8.30 ±0.57	2.763	0.112	8.23 ±0.67	8.95 ±0.57	7.547	0.012
Outer depth (cm)	8.25 ±0.39	7.24 ±0.66	20.546	0.001	7.34 ±0.63	8.35 ±0.33	21.994	0.001
Cup depth (cm)	5.73 ±0.34	4.43 ±0.23	99.047	0.001	4.61 ±0.44	5.79 ±0.33	49.911	0.001
Nest thickness (cm)	1.50 ±0.34	1.31 ±0.28	1.793	0.196	1.34 ±0.36	1.50 ±0.28	1.512	0.233

Table 2: Breeding parameters of Hill Swallows at Silent Valley National Park and Muthikkulam Reserve Forest

Parameter	Silent Valley	Muthikkulam	Pooled
No. of eggs	53 (21)	35 (15)	88 (36)
No. of hatchlings	36 (15)	17 (8)	53 (23)
No. of fledglings	26 (10)	13 (6)	39 (16)
Hatching success (%)	67.92	48.57	60.23
Fledging success (%)	72.22	37.14	73.58
Breeding success (%)	49.06	37.14	44.32
% of successful nests	47.62	40.00	44.44

Values in parentheses are number of nests

The average length of incubation period from laying the last egg to hatching was 15.78 ±0.97 days (range: 14-17 days, n = 9 nests). The mean duration of on- and off-bouts in early incubation (1-8 days) was 11.89 ±5.88 min (range: 2-28 min, n = 60 hrs) and 16.89 ±7.95 min (range: 2-41, n = 60 hrs), and during late incubation (9-16 days) was 18.46 ±7.74 min (range: 5-43 min, n = 54 hrs) and 21.07 ±9.32 min (range: 2-58 min, n = 54 hrs), respectively. Nest attentiveness averaged 39.64% (n = 60 hrs) on early incubation and 55.77% (n = 54 hrs) during late incubation.

Hatching was synchronous in all nests monitored. The number of nestlings in a brood averaged 2.3 ±0.47 (n = 23 nests) and they reached a peak mass of 16.79 ±0.57 gm (n = 7 nestlings) on day 19 (Fig. 2). The average nestling period from the hatching to first leaving of the fledglings from the nest was 19.1 ±0.88 days (range: 18-21 days, n = 10 nests). Both male and female birds fed the young ones simultaneously. Provisioning rates during early (1-6 days), mid (7-13 days) and late (14-19 days) nestling days were 7.67 ±2.73 (n = 6 hrs), 14.33 ±2.16 (n = 6 hrs), 20.19 ±2.87 (n = 7 hrs) trips/hr, respectively. The total nesting period (incubation and nestling periods together) was 34.75 ±1.67 days (range: 33-38, n = 8 nests). The juveniles returned to the nests with parents for roosting for about 6.5 ±1.29 days (range: 5-8 days, n = 4 nestlings) after first leaving of the nest.

Nesting success and causes of mortality

Of the 36 nests monitored during this study, 16 (44.44%) successfully fledged young, on average, 2.44 ±0.51 young per successful nest. Hatching (% eggs hatched), fledging (% hatched chicks fledging) and breeding success (% eggs fledged) for all nests monitored were 60.23%, 73.58% and 44.32%, respectively. Hatching and fledging success rates considerably varied between study sites (Table 2). Daily survival rates significantly varied between the different reproductive stages and between the nesting sites (Table 3). Chick survival rates were slightly higher than the egg survival rates (Table 3), and breeding failures during chick-rearing occurred when the chick was, on average, 4.33 ±1.86 days old (range: 3-8 days). The overall Mayfield nest success rate for all nests monitored was 26.07%. There was not much variation in the Mayfield nest success rates between study sites: 27.66% in the Silent Valley and 24.05% in the Muthikkulam. However, Mayfield success rates varied significantly between nesting sites: from 18.7% in the tunnel/culvert nests to 37.42% in the building nests (Table 3).

Fourteen (70%) of the 20 nest failures were due to the predation of eggs (10 nests) and nestlings (4 nests). The identity of predators could be recognized in only one nest, in which the Indian Garden Lizard *Calotes versicolor* consumed the entire contents of the nest during incubation stage. Four nests failed due to the nest falling during the early incubation stage. Nestlings of two nests were also lost due to the attack of red ants. No infanticide, egg or nestling desertion, starvation, partial egg or brood loss and brood parasitism were observed during the study.

Table 3: Daily nest survival rates and nest success of Hill Swallows for different reproductive phases, study locations and nesting sites in Western Ghats

	Exposure days	No. of nests	No. of nests failed	Daily nest survival (±SE)	% nest success
Reproductive phases (all data pooled)					
Incubation	273	36	13	0.952 ±0.013	46.31
Nestling	254	23	7	0.972 ±0.010	58.64
Overall nesting	527	36	20	0.962 ±0.008	26.07
Study locations					
Silent Valley	303	21	11	0.964 ±0.011	27.66
Muthikkulam	224	15	9	0.960 ±0.013	24.05
Nesting sites					
Tunnel/culvert	276	21	13	0.953 ±0.013	18.70
Building	251	15	7	0.972 ±0.010	37.42

DISCUSSION

Hirundines show significant geographic variation in the timing of breeding. In subtropics and tropics nesting is limited to the wet season when insects are most abundant or can occur almost throughout the year, sometimes with peaks during rains (Turner 2004). Majority of the species in India breed chiefly during March-July (Ali and Ripley 1987). In Silent Valley, breeding of Hill Swallows is restricted to the dry season (February-April) which is consistent with the records (March-May) of Ali and Ripley (1987) from southern India. In Muthikkulam, a few nests were recorded in November-December and this indicates the start of early breeding in this site as reported (December-June) for Sri Lanka (Ali and Ripley 1987). It is not clear whether the heavy north-east monsoon in Muthikkulam compared to Silent Valley is associated with the early breeding of Hill Swallows at this site. Due to the preference of elusive sites for nest placement, it is likely that a few nests went undiscovered during this study. However, no recently used nests were found in the tunnels/culverts or buildings examined. Significant regional variation in the timing of breeding was also reported for conspecific *H. tahitica* (Andamans: May-June, Myanmar: March-May, Malaysia: January-August, Philippines: July-October) (Hails 1984; Ali and Ripley 1987; Turner 2004). Thus, further studies are required to understand the factors (including abundance of insects, rainfall, etc.) resulting in the geographic variation in the timing of breeding of Hill Swallows.

Most species of swallows are known to use artificial structures for roosting and nesting, and this feature has given new opportunities for population expansion and range expansion in many species (Hails 1984; Ali and Ripley 1987; Oatley 2002; Jackson and Spottiswoode 2004; Turner 2004). Hill Swallows are also known to attach their nests to a variety of structures including wall or rock-face, under road culverts or in tunnels, and most commonly under eaves or against ceiling beams and rafters in houses (Ali and Ripley 1987). All the nests recorded during this study were also placed in man-made structures (tunnels, culverts and buildings). Nest structure of Hill Swallows is typical to that of other species (see Hails 1984; Ali and Ripley 1987; Turner 2004). The nests built in tunnels/culverts are often larger than the nests in buildings and these nests had larger clutch size compared to the latter. However, this advantage was not reflected in the breeding productivity (Table 3).

Hirundines in the temperate habitats normally lay 3-6 eggs and sometimes up to 8 eggs (Turner 2004), however, the normal clutch size in the tropics is 2-5 eggs (Ali and Ripley 1987; Turner and Rose 1989; Turner 2004). The average clutch size (2.44 ±0.5, mode = 2 eggs) of Hill Swallow is the smallest reported for the swallows breeding in mainland India (*Hirundo rustica*: 4-6 eggs, *H. smithii*: 3-5 eggs, *H. flavicola*: 3-4 eggs, *H. daurica*: 3-5 eggs, *H. striolata*: 3-5 eggs; Ali and Ripley 1987). The mean clutch size of Hill Swallows is also significantly lower than that of the conspecific House Swallow *Hirundo tahitica* in Malaysia (mean = 2.98 ±80 eggs, mode = 3 eggs, range = 2-5 eggs; Hails 1984) and the median clutch size (3.5 eggs) reported for the passerines in India (Ali and Ripley 1987; Pramod and Yom-Tov 2000). In many hirundines seasonal decline of clutch size is reported (Hails 1984; Sakraoui *et al.* 2005; Turner 2004), however, this could be attributed to the late breeding of young inexperienced birds which normally lay small clutches (Turner 2004). Although such seasonal declines are not identified, variation in the clutch sizes between the nesting substrates (tunnel/culverts v/s buildings) is prominent in Hill Swallows.

Estimates of incubation (15.78 ±0.97 days) and nestling periods (19.1 ±0.88 days) obtained in this study are slightly lower than that of *H. tahitica* (Hails 1984), but within the range of general patterns reported for hirundines (Turner 2004). Hirundines are known to grow slowly compared to other passerines (Turner 2004). The growth rate of *H. domicola* was similar to that of *H. tahitica* (Hails 1984) and typical of other hirundines (Turner 2004).

There are some conspicuous differences in the parental care between *H. domicola* and conspecific *H. tahitica*. In the case of latter, only female incubated the eggs (Hails 1984), whereas both sexes of *H. domicola* actively participated in all the breeding activities including nest construction, incubation and feeding young (see also Ali and Ripley 1987). Nest attentiveness (per cent time spent on the nest incubating eggs) was also significantly higher in *H. domicola* (39.64% and 55.77% for early and late incubation periods, respectively) compared to that of *H. tahitica* (36.9%, Hails 1984). High nest attentiveness and male's participation in the incubation could be due the low ambient temperature at the study sites (<27 °C) compared to that of *H. tahitica* nest sites (>30 °C). The length of on- and off-bouts increased by the progress of incubation, which indicates that, the nest trips decreased in the late incubation stage and the longer on-bouts were preceded by long off-bouts and vice-versa. For the entire incubation period, on- and off-bout durations ranged between 2-43 min and 2-58 min, respectively. Similar intra- and inter-specific variations in parental effort are reported for several species (Conway and Martin 2000a) which is attributed by a number of factors such as temperature needs of the developing embryos, nutritional requirements of parents and predation pressure (Conway and Martin 2000a,b; Deeming 2002; Fontaine and Martin 2006). However, it is difficult to decipher

the reasons for these variations in Hill Swallow due to low sample sizes, failure to control for the clutch sizes and lack of data on the temporal variations in micro-climate.

As reported for the conspecific *H. tahitica* (Hails 1984), the hatching and fledgling success rates were significantly higher in *H. domicola* compared to other tropical birds (Stutchbury and Morton 2001). However, high hatching (90% or more) and fledgling success (38-80%) rates are commonly reported for most species of hirundines (Turner 2004) and the species build nests in caves and man-made structures (Lack 1954). The overall nesting success (Table 3) calculated based on the Mayfield method was also slightly higher than the average success rates (<23%) reported for tropical species but lower than the temperate (27-60%) species (Robinson *et al.* 2000; Stutchbury and Morton 2001). Nests placed in tunnel/culvert sites experienced more failures compared to the nests in building and this may be due to the apparently high inaccessibility of the nests placed in latter.

Predation at the nests was reported minimal in majority of the hirundine species studied (Earlé 1989; Jackson and Spottiswoode 2004; Turner 2004). However, fourteen of the 20 nest failures of Hill Swallows were characterised by the disappearance of eggs or nestlings. Eggs disappeared from 10 nests (in one instance the broken eggs were found on ground below the nest) and nestling from four nests. The only predation event observed was by the Garden Lizard *Calotes versicolor*, which consumed the eggs from nest placed in a building site. In two nests, the nestlings were found dead due to the attack of red ants. Other potential predators/destructors observed at the breeding sites include snakes (e.g., Indian Rat Snake *Ptyas mucosa*), owls (unidentified species) and several species of bats. Bats (Indian False Vampire Bat *Megaderma lyra*) and lizards (*Gekko gecko* or *Gekko stentor*) are reported as important predators of *H. tahitica* (see Hails 1984). However, further intensive studies using advanced methods (e.g., video surveillance monitoring) are required to identify the nest predators of *H. domicola*. Another major cause of nest failure was the nest falling during incubation, which is commonly reported for several species of hirundines (Hails 1984; Oatley 2002; Jackson and Spottiswoode 2004). Oatley (2002) also noted that the durability of the nests may depend on the quality and composition of the mud used for nest construction. This indicates that the availability of suitable wet mud may be an important factor determining the outcome of breeding in hirundines.

In conclusion, the results of the present study provide further evidence that members of the Family Hirundinidae show substantial variation in the reproductive traits which are apparently atypical of tropical birds (e.g., longer developmental periods). However, the clutch size recorded in this study is the lowest record for the genus. The many differences in the life history traits (clutch size, developmental periods and parental care) enumerated herein also support the recent erection (Rasmussen and Anderton 2005) of *H. domicola* as a distinct species from *H. tahitica*.

ACKNOWLEDGEMENTS

This paper is dedicated to the memory of the late Dr. Ravi Sankaran, whose encyclopedic knowledge of cave-dwelling birds and his passion for avian conservation were so generously shared. For helpful discussions, support and comments, I would like to thank V.S. Vijayan, L. Vijayan, P.A. Azeez, P. Pramod, K.S.A. Das, D. Mukherjee, S. Manchi, T.V. Sajeev, A.P. Zaibin and T.N. Bindu. I am greatly indebted to Krushnamegh Kunte and C. Spottiswoode for help with literature and Karuppusamy, Jose, Mohandas, Sainudheen, Krishnan and Mari for their assistance in the field. I thank Kerala Forest Department for permissions and logistic support during this study. Data for this paper was collected as a part of a project funded by the Ministry of Environment and Forests, Government of India. Critical comments by T.N. Bindu and the anonymous referees were helpful in improving the manuscript.

REFERENCES

Ali, S. & S.D. Ripley (1987): Handbook of the birds of India and Pakistan. Compact ed. Oxford University Press, New Delhi.

Balakrishnan, P. (2007): Status, distribution and ecology of the Grey-headed Bulbul *Pycnonotus priocephalus* in the Western Ghats, India. Ph.D. thesis, Bharathiar University, Coimbatore.

Basha, S.C. (1999): Forest types of Silent Valley. Pp. 109-116. *In*: Manoharan, T.M., S.D. Biju, T.S. Nayar & P.S. Easa (Eds): Silent Valley Whispers of Reason. Kerala Forest Department, Thiruvananthapuram.

Conway, C.J. & T.E. Martin (2000a): Effects of ambient temperature on avian incubation behaviour. *Behavioral Ecology 11*: 178-188.

Conway, C.J. & T.E. Martin (2000b): Evolution of passerine incubation behaviour: influence of food, temperature, and nest predation. *Evolution 54*: 670-685.

Deeming, D.C. (2002): Behavior patterns in incubation. Pp. 63-99. *In*: Deeming, D.C. (Ed): Avian incubation: behavior, environment and evolution. Oxford University Press, Oxford.

Earlé, R.A. (1989): Breeding biology of the Red-breasted Swallow *Hirundo semirufa*. *Ostrich 60*: 13-21.

Fontaine, J.J. & T.E. Martin (2006): Parent birds assess nest predation risk and adjust their reproductive strategies. *Ecology Letters 9*: 428-434.

Grimmett, R., C. Inskipp & T. Inskipp (1999): Birds of the Indian Subcontinent. Christopher Helm, A & C Black Ltd, London.

Hails, C.J. (1984): The breeding biology of the Pacific Swallow *Hirundo tahitica* in Malaysia. *Ibis 126*: 198-211.

Halupka, K. (1994): Incubation feeding in the Meadow Pipit *Anthus pratensis* affects female time budget. *Journal of Avian Biology*

25: 251-253.

JACKSON, H.D. & C. SPOTTISWOODE (2004): Breeding biology and taxonomy of the Red-breasted Swallow, *Hirundo semirufa*, in Zimbabwe. *Ostrich 75*: 5-10.

JATHAR, G.A. & A.R. RAHMANI (2006): Endemic birds of India. *Buceros 2(2&3)*: 1-54.

JOHNSON, D.H. (1979): Estimating nest success: the Mayfield method and an alternative. *Auk 96*: 651-661.

KENDEIGH, S.C. (1952): Parental care and its evolution in birds. *Illinois Biology Monographs 22*: 1-358.

LACK, D. (1954): The Natural Regulation of Animal Numbers. Clarendon Press, Oxford.

MAYFIELD, H. (1975): Suggestions for calculating nest success. *Wilson Bulletin 87*: 456-466.

NAIR, P.V. & K. BALASUBRAMANYAN (1985): Long-term environmental and ecological impact of multipurpose river valley projects. KFRI Research Report 26. Kerala Forest Research Institute, Peechi.

NOLAN, V. (1978): The ecology and behavior of the Prairie Warbler *Dendroica discolor*. *Ornithological Monographs 26*: 1-595.

NORMENT, C.J. (1995): Incubation patterns in Harris' Sparrows and White-crowned Sparrows in the Northwest Territories, Canada. *Journal of Field Ornithology 66*: 553-563.

OATLEY, T. (2002): Striped swallows, Africa: *Birds and Birding 7(1)*: 20-22.

PRAMOD, P. & Y. YOM-TOV (2000): The breeding season and clutch size of Indian passerines. *Ibis 142*: 75-81.

RASMUSSEN, P.C. & J.C. ANDERTON (2005): Birds of South Asia: the Ripley Guide. Lynx Editions, Barcelona.

ROBINSON, W.D., T.R. ROBINSON, S.K. ROBINSON & J.D. BRAWN (2000): Nesting success of understorey forest birds in lowland Panama. *Journal of Avian Biology 31*: 151-164.

SAKRAOUI, R., W. DADCI, Y. CHABI & J. BANBURA (2005): Breeding biology of Barn Swallows *Hirundo rustica* in Algeria, North Africa. *Ornis Fennica 82*: 33-43.

SMITH, H.G. & R. MONTGOMERIE (1992): Male incubation in barn swallows: the influence of nest temperature and sexual selection. *Condor 94*: 750-759.

SOLER, J.J., MOLLER, A.P. & M. SOLER (1998): Nest-building, sexual selection and parental investment. *Evolutionary Ecology 12*: 427-441.

STUTCHBURY, B.J.M. & E.S. MORTON (2001): Behavioral Ecology of Tropical Birds. Academic Press, London.

TURNER, A.K. (2004): Family Hirundinidae (swallows and martins). Pp. 602-685. *In*: del Hoyo, J., A. Eliott & D.A. Christie (Eds): Handbook of the Birds of the World. Vol. 9. Lynx Editions, Barcelona.

TURNER, A. & C. ROSE (1989): A Handbook to the Swallows and Martins of the World. Christopher Helm, London.

■ ■ ■

PATRICK RUSSELL AND NATURAL HISTORY OF THE COROMANDEL

ANANTANARAYANAN RAMAN[1]

[1]Charles Sturt University & E. H. Graham Centre for Agricultural Innovation, PO Box 883, Orange, NSW 2800, Australia.
Email: araman@csu.edu.au

Russell's Viper *Daboia russelii* occurs almost in all South Asian countries and is a major cause of human fatality. The biological name of this reptile celebrates Patrick Russell (1726-1805), a Scottish surgeon and naturalist, who worked in the Madras Presidency. He initiated the formal study of snakes of India. Patrick Russell accompanied his younger brother Claud Russell, from Edinburgh to Visakapatnam on the Coromandel Coast, when Claud was offered the post of Administrator of Visakapatnam in 1781. From Visakapatnam, Patrick travelled south to meet Johann Gerhard König at Tarangampadi in June 1781. On König's death in June 1785, the Governor of Madras offered the post of Botanist-Naturalist to Patrick till then held by König. Russell accepted the position in November 1785 and worked in the Coromandel until 1789. On acceptance of the job, Russell's first dictates were to catalogue the economically useful plants of Madras and to publish König's scientific notes. Snakes were a problem in the Madras Presidency, especially in rural areas. To enable people to distinguish the poisonous from the non-poisonous, Russell developed and distributed an advisory notice that included illustrations of the mouth parts of common snakes and descriptions as to whether they were poisonous or not. During his stay in the Madras Presidency, Russell as a medical practitioner, supported Tanjore pills, a locally made, purported remedy for snake bites, although he rejected its validity later, after his return to London. He presented the bamboo pith material (*tabashir*), an established source of silica, at the Royal Society meeting in 1790. While in the Coromandel, Russell gathered information about the habits and reputations of several snakes and their local names. He tested their venomous nature. He used Linnean criterion referring to the presence (or absence) of abdominal and sub-caudal scuta to separate his first collection of 43 snake taxa. He determined three genera: *Boa*, *Coluber*, and *Anguis*. Russell established *Katuka-rekula-poda* (Telugu) as a venomous snake, next in toxicity only to the spectacled Indian Cobra *Naja naja*. Testing the clinical features of bites of venomous snakes in dogs and chicken, he described the neurotoxic and haemorrhagic manifestations of viper venoms. He donated his collection of snake skins to the British Museum (Natural History), London. He published the first volume of his book AN ACCOUNT OF INDIAN SERPENTS COLLECTED ON THE COAST OF COROMANDEL in 1796; the first and second parts of the second volume appeared in 1801 and 1802. The third and fourth parts of second volume were published, after his death, in 1807 and 1809. Edward Nicholson (Surgeon, Madras Medical Establishment, Bangalore (now Bengaluru)), who wrote a major treatise on Indian snakes (1874), values Russell as a pioneer in Indian Zoology.

Key words: Alexander Russell, Claud Russell, Coromandel, *Daboia russelii*, Johann Gerhard König, *Katuka-rekula-poda*, Madras Presidency, Patrick Russell, Russell's Viper, *tabashir*, Tanjore pills, *Vipera russelli*, Visakapatnam, William Roxburgh

INTRODUCTION

The Russell's Viper *Daboia russelii* (Shaw et Nodder) (previously *Vipera russelli*) (Adler *et al.* 2000) occurs almost in all southern and south-eastern Asian countries and is a major cause of human fatality. Russell's Viper and Common Cobra bites account for 75% of deaths in Sri Lankan farms (Goldfrank *et al.* 2002). The venom of *D. russelii* has evoked considerable interest in medicine. Its precoagulant activity has been thoroughly studied to understand the mechanism of blood clotting in humans. Up to 70% of the protein venom is phospholipase. Clinical effects of phospholipase are haemolysis, rhabdomyolysis, pre-synaptic neurotoxicity, vasodilatation, and shock. Russell's Viper venom induces renal failure. The venom composition varies depending on the geography of distribution of the reptile, indicating subspecific variation in the taxon (Jayanthi and Gowda 1988; Tsai *et al.* 1996). Based on multivariate morphometric and mitochondrial-DNA data, the Thailand taxon, *D. russelii siamensis*, is now recommended to be treated as a separate species: *Daboia siamensis* (Thorpe *et al.* 2007). The other recognized subspecies are *D. russelii formosensis* (Taiwan), *D. russelii limitis* (Indonesia), *D. russelii pulchella* (Sri Lanka), *D. russelii nordicus* (northern India) (Mallow *et al.* 2003). Such variations also reflect the way in which pain and suffering manifest in humans; in Myanmar when bitten by Russell's Viper conjunctival oedema occurs, those in southern India suffer acute pituitary infarction, and those in Sri Lanka and southern India suffer rhabdomyolysis, neurotoxicity, and even ischemic strokes. Death occurs mainly due to shock, pituitary and intracranial haemorrhage, gastrointestinal haemorrhage and renal necrosis (Warrell 1989).

The biological name of this reptile celebrates Patrick Russell, a Scottish surgeon and naturalist, who worked in the Madras Presidency in the 18th century (Anonymous 1811). He pioneered the formal study of Indian snakes.

BIOGRAPHY

Patrick Russell (Fig. 1) was born in Edinburgh on February 06, 1726; he completed his schooling and university education in Edinburgh, and graduated with an MD like his elder-half brother Alexander Russell. Alexander was a medical officer in an English factory in Aleppo (36°10' N, 37°15' E; the Ottoman Empire; now in Syria). On Alexander's return to UK, Patrick succeeded him in 1750. He endeared himself so well with the locals that the *Badshah* of Aleppo honoured that he could wear a turban — a rare privilege accorded to a non-Turk (Hawgood 1994). Alexander Russell was gathering information for a book on the natural history of Aleppo in 1756 and he sought Patrick to pursue the subject further. Driven by the affection for his brother, Patrick documented the natural history of Aleppo and transmitted information regularly to Alexander settled in Britain. For instance, Patrick meticulously recorded the details and consequences of a series of earthquakes that rocked Aleppo in 1759. His letters to Alexander describing seismology of Aleppo earthquakes are published in the *Philosophical Transactions of the Royal Society* ('Of the late earthquakes in Syria', 1760, 9: 437). Between 1760 and 1762, Aleppo experienced severe bouts of plague. When other British medical officers avoided treating the sick, Patrick voluntarily treated them, although his employment was only with the English factory. He treated so many of the afflicted that he got to know the etiology of the disease well. He recorded his observations meticulously. In 1767, he sent a note on 'inoculation for smallpox' as practiced by the Arabs, which was read in the meeting of the Royal Society of London on May 05, 1768 ('On the inoculation in Arabia', 1768, *Phil. Trans. Roy. Soc. 12*: 529). He returned to Edinburgh in 1772, travelling leisurely through Italy and France. He planned to settle in Edinburgh and set up medical practice, when his and Alexander's friend-and-colleague John Fothergill suggested that Patrick should practice medicine in London. Patrick practiced medicine in London for nearly a decade. During this period he was elected a Fellow of the Royal Society. A nomination was filed with the Royal Society (Stearns 1954; p. 85), stating:

'Patrick Russell of Buckingham Street York Buildings, Doctor of Physic, being desirous of the honour of becoming a Fellow of the Royal Society, we whose Names are underwritten do recommend him from our personal knowledge as very likely to become a useful and valuable member, being well-skilled in many branches of Natural knowledge.'

C. Morton, Jos Banks, James Stuart, John R. Forster, A. Dalrymple, S. Fleming, Dan Solander, James Welsh, Matt Roper, William Hunter, S. Horsley, Will Russell, Robert Melvill, Robert Mylne, N. Maskelyne, Thos Dickson, George Forster, J. Lloyd, and Ph. Duval. — Dated April 04, 1777.

Fig. 1: Patrick Russell

Russell was elected to the Royal Society Fellowship on November 27, 1777.

Patrick Russell accompanied his sick younger brother Claud Russell (Note: spelt 'Claud' and 'Claude' by different authors), who was offered the post of Administrator of Visakapatnam in Madras Presidency, ruled by the English East-India Company (EEIC) in 1781. While in Visakapatnam, Patrick travelled south, along the Coromandel, to meet Johann Gerhard König at Tarangampadi (Tranquebar) in June 1781. On König's death in Jegrenatpuram near Tarangampadi in June 1785, the Governor of Madras offered the post of Botanist–Naturalist to Patrick held by König. On Claud's insistence Patrick accepted the post in November 1785, worked in the Coromandel until 1791. On return to London, he spent his time writing his scientific findings for professional journals (e.g., Russell 1800; Russell and Home 1804). Russell died after brief illness in London on July 02, 1805. He was never married. In his will, he solicited that his property be administered by Sir Hugh Inglis, Josiah Porcher, and his brother Claud. Fulfilling his desire, he was buried in Marylebone burial site in a modest manner on July 08, 1805. A eulogy in the *European magazine and London Review* (Anonymous 1811) speaks highly of the character of Patrick Russell ('Russell', hereafter).

CONTRIBUTIONS TO SCIENCE IN THE COROMANDEL: FACTS AND SUPPLEMENTARY REMARKS

On accepting the Botanist–Naturalist post in Madras Presidency, Russell's first task was to catalogue the economically useful plants of Madras. He drew a proposal to achieve it. A principal dictate to Russell on his Coromandel

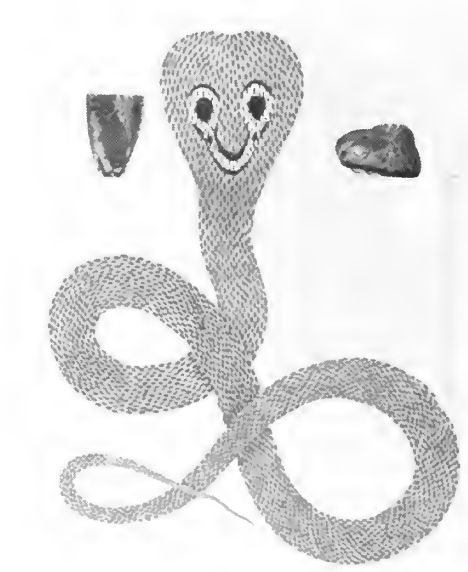


Fig. 2: An illustration from 'An Account of Indian Serpents Collected on the Coast of Coromandel, Containing Descriptions and Drawings of each Species, Together with Experiments and Remarks on their Several Poisons', 1796

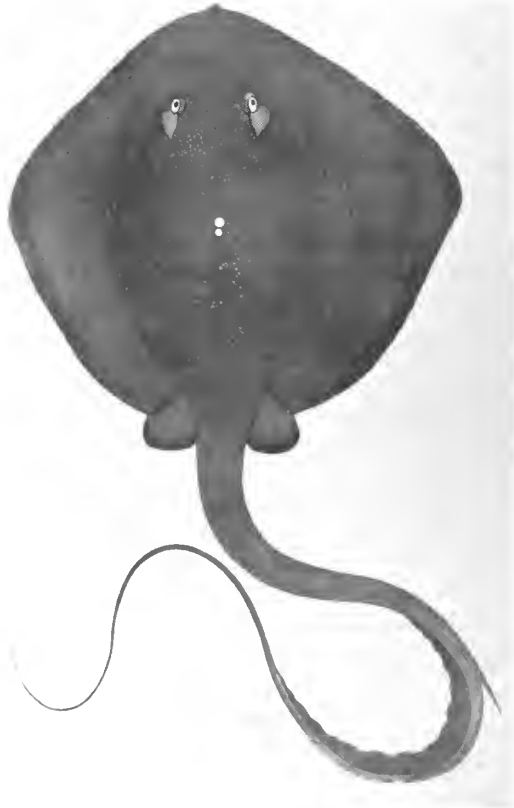


Fig. 3: An illustration from 'Descriptions and Figures of Two Hundred Fishes; Collected at Visakapatnam on the Coast of the Coromandel', 1803

employment was to publish König's scientific notes. Joseph Banks (1743-1820), British Botanist and founder of the 'Society of Dilettanti' (the predecessor of the Royal Society of London), was nominated to supervise the publication project. That the budget needed to publish König's scientific notes, Patrick insisted, was to be provided by Banks. By the time the budget proposal arrived in Madras from Banks and approved by EEIC, it was 1789 and Russell had resigned. William Roxburgh was appointed to that position. Russell seems to have been well disposed towards Roxburgh, which is evident in the generously worded preface (foreword-?) he wrote in Roxburgh's AN ACCOUNT OF THE PLANTS OF THE COAST OF COROMANDEL (Roxburgh 1795-1820). Most vitally, Russell played a significant role in convincing British botanists, Joseph Banks in particular, that a network of naturalists reporting to Kew should be established in India.

Snakes were a problem in Madras Presidency, especially in rural areas. To enable people to distinguish the poisonous from the non-poisonous, Russell developed an advisory notice that included descriptions and illustrations of the mouth parts of common snakes. In this context, Russell developed a strategy to use the ICS (Indian Civil Service) machinery to obtain information and previously collected data on India's natural history. In high likelihood this strategy inspired Edward Green Balfour to obtain climate data and details on the loss of forest cover in southern India nearly 50 years later (Balfour 1849; Grove 1996; Raman 2009). In 1787, Russell impressed on the Directors of Madras Council to distribute questionnaires seeking information on snakes. The results were summarized, synthesized, and developed into the notice, which was printed and distributed throughout the Presidency by the Government.

In the late 18th century southern India, *vaidya* (local medical practitioners) used Tanjore Pills to treat snake poisoning. Government chemists tested and found that this pill included mercury, arsenic, black pepper, and a few other unidentifiable materials (see Nair 2005). Russell, for some reason, developed faith in these pills, although his friend and colleague William Duffin, a surgeon practicing in Vellore, disputed the usefulness and validity of these pills[A]. Russell argued 'efficacy was a matter of difficult discussions' and remained favourably disposed towards it; he also argued that further tests should confirm its usefulness (see Appendix). Russell worked on the plague manuscript, which he had drafted while in Aleppo, and sent the finalized version to his associates William Robertson, Adam Ferguson, and Adam Smith in UK in 1787, possibly seeking their review and remarks. This manuscript was published as A TREATISE OF THE PLAGUE by G.G. & J. Robinson in London in 1791, after his return to London. In addition to vital medical details, this volume[A] includes other useful information such as quarantine regulations and weather in the context of the disease.

By 1789 Patrick had accumulated a significant collection of fishes and plants, which he deposited with the East-India Company's Museum. On March 11, 1790, he presented at the Royal Society 'An account of the *tabasheer*, a medicine in high repute in many parts of the East'. *Tabashir*, the soft pith material from bamboo culms, was considered of extraordinary value in India. This presentation, later published in the *Philosophical Transactions of the Royal Society* in 1790 (*16*: 653), was first submitted as a letter to Joseph Banks, President of the Royal Society. Russell orally presented the details of *tabashir* and displayed specimens of pith material of *Bambusa arundinacea* (Retz.) Willd. (Poaceae) from which *tabashir* was obtained. Worthwhile it would be here to refer to the study of *tabashir* by Jacques Louis Macie (who changed his name to James Smithson in 1802) published in the *Philosophical Transactions of the Royal Society* in 1721, which determined *tabashir* as the near-pure form of silex (pure form of silica). *Tabashir* occurs in the nodes of the female trees of *B. arundinacea* and includes silica at about 90%; it also includes iron (as peroxide), calcium, alumina (aluminium oxide), choline (a species of B-complex vitamins), and betaine (a neutral compound with positively charged cationic functional group). Traditional medical practice of India values *tabashir* as an expectorant, tonic, stimulant, aphrodisiac, and uses it in treatment of blood-borne tuberculosis, bronchitis, and asthma (Puri 1970). Blended minerals render *tabashir* as an effective remineralizing agent useful in treatments of osteoarthritis and osteoporosis (Karnick 1975).

Patrick Russell's favourite brother Alexander died in the UK in 1768 leaving his notes on the natural history of Aleppo unfinished and the proposed volume unpublished. Patrick Russell completed the task and published NATURAL HISTORY OF ALEPPO as two volumes with G.G. & J. Robinson in London in 1794: the first volume carried Alexander Russell's name as the author (although Patrick Russell did much work on this volume, he has preferred to refer himself as the 'editor'), whereas the second carried his name as the author. While in the Coromandel, Russell was concerned with the lack of any systematic knowledge of snakes and the effects of snakebites. He gathered information about the habits and reputations of several snakes and their local names. He tested their venomous nature. He used the Linnean criteria of the presence or absence of abdominal and of sub-caudal scuta to separate his first collection of 43 snake taxa. He determined three genera in this collection, namely *Boa* (Squamata: Boideae), *Coluber* (Squamata: Colubridae), and *Anguis* (Squamata: Anguidae). He also came across a poisonous snake, referred in Telugu as *Katuka-rekula-poda*,[B] (Vijayaraghavan 1998). He included an illustration of this reptile in his book, which was later described as *Coluber russelli* by George Shaw and Fredrick Nodder (British Museum, Natural History, London) in NATURALISTS MISCELLANY (1797), subsequently revised as *Vipera russelli* in 1890 (see David and Dubois 2001). The current valid binomial is *Daboia russelii*. This came to be known as Russell's viper.

Russell established that *Katuka-rekula-poda* is a venomous snake, next in toxicity only to the spectacled cobra (*Naja naja*). Testing the clinical features of bites of venomous snakes in dogs and chicken, he described the neurotoxic and haemorrhagic manifestations of viper venoms. On return to UK, he donated his collection of snake skins to the British Museum (Natural History), London. He published the first volume of his book AN ACCOUNT OF INDIAN SERPENTS COLLECTED ON THE COAST OF COROMANDEL in 1796; the first and second parts of the second volume appeared in 1801 and 1802 (Appendix). The third and fourth parts of second volume were published after his death in 1807 and 1809. On December 22, 1796, a copy of Patrick Russell's AN ACCOUNT OF INDIAN SERPENTS COLLECTED ON THE COAST OF COROMANDEL (Fig. 2) was presented to the Royal Society along with the first of two volumes AN ACCOUNT OF THE PLANTS OF THE COAST OF COROMANDEL written by William Roxburgh, which included an introduction by Russell. Russell's last book DESCRIPTIONS AND FIGURES OF TWO HUNDRED FISHES; COLLECTED AT VIZAGAPATAM

[A]This version is available in Anonymous (1811). Chakrabarti (2006) provides a different version: In September 1788, William Duffin – a surgeon in Vellore and a few other local western-medical practitioners wrote a rejoinder to the Madras Hospital Board, relaying the following message 'although the results of tests conducted by Government Chemists on *Tanjore Pills* were convincing, some of the materials contained in them were to be reconsidered for a general recommendation for public use'. Duffin *et al.* sought the government to publish details of ingredients of *Tanjore pills*. James Anderson submitted a report to the Government on *Tanjore Pills* listing its ingredients in November 1788; his report referred to arsenic as a major component. Because of arsenic, Anderson did not recommend use of these pills. Anderson's recommendation was disputed by William Duffin, now the Head Surgeon in Madras Hospital (date unavailable). Duffin argued that despite arsenic, he found the pills beneficial in a majority of patients he had treated, and added that he had earlier transmitted his findings to Patrick Russell, Physician-Botanist to the English East-India Company, who, in turn, had transmitted details of the *Tanjore pills* to the *Royal Society* in London. Duffin further argued that he was conducting experiments with the pills to establish its use. However, Russell in his volume on Indian snakes published in London in 1796 revised his stand on these pills describing that his experiments with these pills were inconclusive, and the pills were ineffective.

[B]The name *Katuka-rekula-poda* (*Telugu*) of the reptile what came to be known later as *Daboia russelii* raises the question of the knowledge of snakes in general and that of Russell's viper in particular in India of pre-English days. Long passages on snakes exist in the *Suśrutasamhitâ*'s KALPASTHÂNA (Meulenbeld 1999): chapter 4 refers to a classification system, nature of poisons, and symptoms of poisoning (pp. 292-294); chapter 5 refers to treating venomous snake bites (pp. 294-295).

ON THE COAST OF THE COROMANDEL (Fig. 3) was published by G & W Nicol in London in 1803.

CONCLUSION

Russell employed an Indian (name unavailable) from Visakapatnam to illustrate snakes and fishes for his books. He has the following to say about the skill of the artist: "A native painter whom I retained in my employment has made progressive improvement in this line. Endured by nature with a quick eye, patient and docile, he quickly learned in a short time to delineate so accurately the parts pointed out to him that his figures howsoever deficient in art and grace, may in general be relied on in respect to fidelity in representation." (Chaitanya 1994; p. 105).

Albert C.L.G. Günther's THE REPTILES OF BRITISH INDIA (1864) is the first, systematically organized, fauna volume on Indian snakes. Edward Nicholson (1874) (Surgeon, Army Medical Department, Madras Presidency, Bangalore) says the following in the preface of his volume INDIAN SNAKES: AN ELEMENTARY TREATISE ON INDIAN OPHIOLOGY WITH A DESCRIPTIVE CATALOGUE OF THE SNAKES FOUND IN INDIA AND THE ADJOINING COUNTRIES dated April 1874: "I cannot omit to mention Russell's ACCOUNT OF INDIAN SERPENTS, 1796; however antique and unfitted for the guidance of the student, it will always be of interest as the work of a pioneer in Indian zoology."

ACKNOWLEDGEMENTS

D. Wujastyk (Institut für Südasien-, Tibet- und Buddhismuskunde, Universität Wien, A-1090 Vienna, Austria) and B. Vijayaraghavan (*Çennai* Snake Park Trust, Madras, India) helpfully supplied different published papers. D. Wujastyk, B. Vijayaraghavan, and T.N. Ananthakrishnan (Minneapolis, Minnesota, USA) read the final draft and offered useful remarks. I am grateful to them for their kindness.

REFERENCES

ADLER, K., H.M. SMITH, S.H. PRINCE, P. DAVID & D. CHIZAR (2000): Russell's viper: *Daboia russelii* not *Daboia russelli*, due to classical Latin rules. *Hamadryad* (The Centre for Herpetology, Madras Crocodile Bank Trust) *25*: 83-85.

ANONYMOUS (1811): Memoirs of the life and writings of Patrick Russell, M.D., F.R.S. *The European Magazine and London Review 59-60*: 3-8.

BALFOUR, E.G. (1849): Notes on the influence exercised by trees in inducing rain and preserving moisture. *Madr. Jour. Lit. Sci. 25*: 402-448.

CHAITANYA, K. (1994): A history of Indian painting: modern period. Abhinav Publications, New Delhi.

CHAKRABARTI, P. (2006): "Neither of meate nor drinke, but what the Doctor alloweth": medicine amidst war and commerce in eighteenth-century Madras. *Bull. Hist. Med. 80*: 1-36.

DAVID, P. & A. DUBOIS (2001) A herpetological analysis of Shaw and Nodder's *Vivarium Naturae* or *The Naturalist's Miscellany* (1789-1813), a 24-volume series on natural history. *Newsl. Bull. Internat. Soc. Hist. Bibliog. Herpet. 2*: 5-39.

GOLDFRANK, L.R., N.E. FLOMENBAUM, N.A. LEWIN, M.A. HOWLAND, R.S. HOFFMAN & L.S. NELSON (2002): Goldfrank's toxicologic emergencies (7th Edition). McGraw-Hill, Sydney.

GROVE, R.H. (1996): Green imperialism: colonial expansion, tropical island Edens and the origins of environmentalism, 1600-1860. Cambridge University Press, Cambridge.

HAWGOOD, B.J. (1994): The life and viper of Dr. Patrick Russell M.D., F.R.S. (1727-1805): physician and naturalist. *Toxicon 32*: 1295-1304.

JAYANTHI, G.P. & T.V. GOWDA (1988): Geographical variation in India in the composition and lethal potency of Russell's viper (*Vipera russelli*) venom. *Toxicon 26*: 257-264.

KARNICK, C.R. (1975): On comparative values of Indian and Chinese medicinal plants. *Pharmaceut. Biol. 15*: 2028-2046.

MALLOW, D., D. LUDWIG & G. NILSON (2003): True vipers: natural history and toxicology of Old World vipers. Krieger Publishing Company, Malabar, Florida. 359 pp.

MEULENBELD, G.J. (1999): A history of Indian medical Literature. Volume XV: Ia and Ib. Groningen Oriental Studies–III, Egbert Forsten, Groningen.

NAIR, S.P. (2005): Native collecting and natural knowledge (1798–1832): Raja Serfoji II of Tanjore as a 'Centre of Calculation'. *Jour. Roy. Asiat. Soc. Gt Brit. and Irel. (Third Series), 15*: 279-302.

PURI, H.S. (1970): Indian medicinal plants used in elixirs and tonics. *Pharmaceut. Biol. 10*: 1555-1566.

RAMAN, A. (2009): Climate-change studies and reforestation efforts in the eighteenth and nineteenth century peninsular India. *Internat. Jour. Ecol. Environ. Sci. 35*: 281-287.

ROXBURGH, W. (1795-1820): Plants of the coast of Coromandel. Three volumes. Bulmer & Co., London [Reprinted by: Bishen Singh Mahendra Pal Singh, 1981, Dehradun].

RUSSELL, P. (1800): An account of two cases, showing the existence of the small-pox and the measles in the same person at the same time; and an Account of a case of ague in a child in utero. *Trans. Med. Chirurg. 2*: 90.

RUSSELL, P. & E. HOME (1804): Observations on the orifices found in certain poisonous snakes, situated between the nostril and the eye, with some remarks on the structure of those orifices; and the description of a bag connected with the eye, met with in the same snakes. *Phil. Trans. Roy. Soc. 94*: 70-76.

STEARNS, R.P. (1954): Fellows of the Royal Society in North Africa and the Levant, 1662–1800. *Notes and Rec. Roy. Soc. Lond. 11*: 75-90.

THORPE, R.S., C.E. POOK & A. MALHOTRA (2007): Phylogeography of the Russell's viper (*Daboia russelii*) complex in relation to variation in the colour pattern and symptoms of envenoming. *Herpet. Jour. 17*: 209-218.

TSAI, I.H., P.J. LU & J.C. SU (1996): Two types of Russell's viper revealed by variation in phospholipases A2 from venom of the subspecies. *Toxicon 34*: 99-109.

VIJAYARAGHAVAN, B. (1998): A brief history of Indian Ophiology. Snake Studies: India — CSPT Occasional Paper # 1, Çennai Snake Park Trust (CSPT), Rajbhavan Post, Madras.

WARRELL, D.A. (1989): Snake venoms in science and clinical medicine 1. Russell's viper: biology, venom and treatment of bites. *Trans. Roy. Soc. Trop. Med. Hyg. 83*: 732-740.

Appendix

Notes on Patrick Russell's volumes on snakes and fishes

An Account of Indian Serpents Collected on the Coast of Coromandel, containing descriptions and drawings of each species, together with experiments and remarks on their several poisons. Volume 1. George Nicol, London, 1796. 90 pages, 46 plates (44 colour) [Presented to the Hon. The Court of Directors of the East-India Company, and published by their Order, under the Superintendence of the Author. Imperial Folio. 3l. 13s. 6d. Boards]

A continuation of an Account of Indian Serpents Collected on the Coast of Coromandel. Volume 2. George Nicol, London, 1801.

In Volume 1, Russell describes 43 species of snakes belonging to the *Boa*, *Coluber*, and *Anguis*. He also describes the anatomy of the mouth and the poison fangs, the experiments he conducted to estimate the role of snake bites, and details of various remedies. He describes 43 species belonging to the three Linnean genera of *Boa*, *Coluber*, and *Anguis* plus information on their poison apparatus, wherever applicable. At that point of time, his volume of immense use for the people of Madras presidency (and India) in recognizing the poisonous ones from the non-poisonous. Out of the 43 described only seven were poisonous, He comments: " ... nor does the venom of any appears to be nearly as active as that of the rattle-snake. The general effects of the progress of the poison appear to be pain and subsequent contraction of the part wounded, paralysis, stupor, vomiting, convulsions, and death. These symptoms, however, are subject to occasional variations, according to the strength and other circumstances of the bitten animal, and appear to be considerably retarded by violent, exercise after being bitten." He trialled on chicken, rabbits, and dogs, and he found that larger the animal, the greater length of time occurred before its death: in one or two instances, dogs recovered; a bitten horse and pig survived. One of his key findings is that the artificial insertion of poison is much less dangerous than when the wound is inflicted by the snake itself. Chicken wounded by poisoned lancets generally died: but the dogs that were subjected to artificial-insertion experiment recovered, some without any symptoms, and the rest with slight symptoms. The most celebrated remedy in India for the bite of a serpent is the Tanjore pill, the principal active ingredient in which is white arsenic; of which each pill, of six grains, contains about three-fourths of a grain. This was given to several dogs and chickens after having been bitten, but of these the greater number died; and in the few that recovered, the action of the medicine was so very equivocal as to destroy all confidence in it: the same may be said of the application of the actual cautery, and of alkaline and acid caustics. A few cases are given of the effects of the bite of serpents on the human species. The symptoms appear to have been very severe, and occasionally to have terminated fatally; in those that ended successfully, the Tanjore pill, Madeira wine, and eau de luce were administered separately or united, with seemingly good effects.

Descriptions and figures of two hundred fishes; collected at Vizagapatam on the coast of the Coromandel. 2 volumes, George & W Nicol, London, 1803.

A pioneering work illustrated by a native artist. Russell was stimulated by Banks to study the fishes of the Coast of Coromandel north of Madras: "Sir Joseph Banks, who honoured me with his correspondence, suggested how defective the history of Indian Fishes was in Europe at that time, and encouraged me to proceed" (Preface). 'The drawings of this Collection (*sic* 'in this volume'), as before mentioned, were executed by a native of India; and by the advice of artists at home have undergone only a few slight corrections' (Preface). The engravings are by Heath, others by Neele and 2 or 3 by Skelton, but for the greater part by Reeve. Due to environmental conditions Russell was unable to have the plates coloured, which was his original intention, like he had done with his previously published work on the snakes of India. 'In a hot climate, the colours of fish are more rapidly fugitive after death than in serpents. They escape while the painter is adjusting his palette...' (Preface).

■ ■ ■

STUDY OF JUVENILE AND ADULT GROWTH, AND BEHAVIOURAL CHARACTERISTICS OF *POECILOCERUS PICTUS* (FABRICIUS) FEEDING ON *CALOTROPIS GIGANTEA* UNDER LABORATORY CONDITIONS

MADHAVI V. SAWANT[1,2], SHINEY PETER[1,3], K.R. KHARAT[1,4] AND B.P. HARDIKAR[1,5]

[1]Department of Zoology, KET's V.G. Vaze College, Mulund (E), Mumbai 400 081, Maharashtra, India.
[2]Email: smadhaviv@gmail.com
[3]Email: shiney.mathen@gmail.com
[4]Email: krkharat@hotmail.com
[5]Email: hbhagyashree07@gmail.com

Insects are reared to study various aspects of their life cycle, behaviour and metabolism and for experimentation with insecticides. In the present investigation, the newly hatched nymphs of *Poecilocerus pictus* (Fabricius) feeding on *Calotropis gigantea* were reared to adulthood in a laboratory to evaluate the developmental and behavioural characteristics. On the basis of the experimental observations, it was concluded that under constant laboratory conditions they could be grown and maintained for a longer period of time with maximum growth in length and weight. Under optimum laboratory conditions, a strong correlation was observed between length and weight, in addition to extended longevity and shortened nymphal periods.

Key words: *Poecilocerus pictus*, longevity, feeding, aggressiveness, nymphal periods, correlation coefficient

INTRODUCTION

Many industries need insects for research projects as they develop insecticides, or insect resistant plant varieties for organic farming and similar needs. A few species of grasshopper sometimes occur in large numbers and cause serious damage to vegetable crops and landscape ornamentals. One species most commonly causing damage is the Painted Grasshopper *Poecilocerus pictus* (Fabricius, 1775) (Orthoptera: Acridoidea: Pyrgomorphidae), distributed in South East Asia; it is a large grasshopper. The most noticeable feature of this grasshopper is its long jumping hind legs, which enable it to leap more than 20 times its body length. It mainly feeds on the shrubby plants of Family Asclepiadaceae – *Calotropis procera* and *Calotropis gigantea*. By the time the insects reach adulthood the *Calotropis* sp. is completely denuded, and the grasshopper migrates to adjacent supplementary host plants. *P. pictus* is an economic pest in Pakistan and India where it is reported to damage a number of food plants, including aubergine, citrus, cucurbits, potatoes and tomatoes (Garod 2009). Sayed *et al.* (1994) studied the effects of different food plants on the rate of consumption, development and survival of *Poecilocerus pictus* under laboratory conditions. The results indicated that the rate of development of *P. pictus* was faster on *Calotropis* sp. followed by cotton, nerium, champa, pomegranate, maize, jamun, tomato, rose sesame, shoeflower, sugarcane, and lemon. Incidental observations indicate that *P. pictus* are not easy to kill with insecticides, once they become large. One has to ensure that the insecticide is sprayed directly on the insects as the insecticide residue remaining on sprayed plants is not adequate to kill the grasshoppers.

Poecilocerus pictus sequesters and stores secondary metabolites – cardenolides – obtained from *Calotropis* sp., its food plant, in the secretion of the defensive glands and other parts of the body. Cardenolide content in different tissues of gravid females has been analysed, and statistically significant differences in its levels have been detected in the metathoracic scent gland, ovary and egg, which were found to sequester higher concentrations of cardenolides (Pugalenthi and Livingstone 1995). The cardenolides are not toxic to the grasshoppers, but they make them unpalatable to predators, and become an important part of a grasshopper's defence system.

To study plant-insect relation and tolerance of the insect to the toxins in the evolutionary path and its regulation to avoid serious damage to crop and ornamental plants, it is important to rear insects under laboratory conditions for a longer period, as their availability in the wild/natural habitat is restricted from late July to early November. In the present investigation, we reared the *Poecilocerus pictus* (Fabricius) in the laboratory to maintain a year round supply and to get a disease-free population. Information on the life cycle of *P. pictus* are important parameters to rear the insects in laboratory. While rearing this species in laboratory significant parameters within its life cycle, such as oviposition, developmental biology of immature stages, adult longevity, behaviour and growth in terms of length and weight were evaluated against their growth and behaviour in natural habitat.

MATERIAL AND METHODS

Collection and rearing

Adult *P. pictus* and their nymphs were collected during August-October (2006-2009) from an area located on the outskirts of Mumbai from an infested *Calotropis gigantea*. The adults and nymphs were separated and kept in separate cages. Adult insects collected directly from their natural habitat were labelled as 'Group I', and the nymphs reared to adulthood in the laboratory as 'Group II'.

Sexes were identified and their growth parameters (length and weight) were noted. Newly emerged nymphs were caged over moist soil in the laboratory. A standard system was developed for routine maintenance of *P. pictus*.

Sufficiently ventilated plastic baskets (45×30×45 cm) with a fine mesh structure, offering protection and excellent light transmission, were used as growth chambers. Two wooden rods were placed horizontally inside these chambers to support the moulting stage of the insects. Chambers were provided with 8 to 10 cm of soil bed (mixture of moist soil or clay and sand), which provided moisture as well as surfaces on which to rest and oviposit. There was an opening (45 x 30 cm) covered with polyvinyl sheath for introducing food. Temperature fluctuations and relative humidity within rearing chambers were measured every day throughout the period of growth using a thermometer and thermo-hydrograph respectively. The nymphs were exposed to photoperiod of 12 to 14 hours per day by keeping these chambers in maximum daylight.

Nymphs were fed on fresh leaves of *C. gigantea*. The amount and time of feeding was standardized by trial and error method, after observing their feeding behaviour; 7-9 gm (wet weight) of fresh and thoroughly washed leaves per chamber, thrice a day, after an interval of 8 hrs. Leaves were kept away from direct sunlight to avoid drying.

To study the developmental stages, 8 sets of 5 to 6 newly hatched first instar nymphs were placed in the growth chamber. As sexual dimorphism was not obvious in nymphal stages, they were tagged with whitener (as 1, 2, 3...). The sexes were identified only after maturation. These nymphs were left undisturbed to feed, moult, and eventually metamorphose into adults. After every moult the instar was renumbered. All the stages were observed daily till maturation and further till death to determine longevity. Exuviae were removed as they appeared and the duration of each instar with total number of instars and nymphal periods in days were recorded.

Within 24 hrs of the last moult, adults were separated. Batches of 5 to 6 males and 3 females were placed separately in well-ventilated 5 rearing chambers having similar conditions maintained as in growth chambers. Pre-oviposition, oviposition and post-oviposition periods in adult females, and courtship and mating behaviour in males were studied. Preliminary observations of mating and egg-laying behaviour were carried out by observing the individual until the end of the desired behaviour (Ganehiarachchi and Fernando 2006) and duration of time for the behaviour was recorded (n = 15).

Morphology and Morphometry

Morphological features of the eggs, nymphs and adults were examined under magnifying lens. Length and breadth of each egg pod, egg, and nymph from group 'I' and adults from both the groups were measured using dividers and millimeter scale (Ganehiarachchi and Fernando 2006). Weight of fully-grown adults from both the groups was also recorded; they were placed in closed pre-weighed Petri-plates, to restrict their movements while weighing. Weights were recorded using a digital analytical balance calibrated with IDEMI certified weights.

Perception of odour by human volunteers

P. pictus has a noxious odour as well as bright yellow bands on its body which probably act as repellent for predators. *P. pictus* odour is more noxious than that of *Calotropis* sp. The degree of noxiousness of the odour was evaluated as described elsewhere (Idowu and Idowu 1999). Ten insects at different developmental stages were placed in different conical flasks covered with foil. The flasks were numbered 1-3 corresponding to (1) instar 2, (2) instar 5, and (3) adult stages. The flasks were thoroughly shaken before presentation. The order of presentation of flasks was changed for each volunteer. A time gap of 30 minutes was allowed between presentations of samples. The perception of odour by 38 human volunteers was recorded as follows:

1) Very Strong: immediate response
2) Strong: within 5 - 15 seconds
3) Weak: within 20 - 25 seconds
4) No effect: The volunteer did not perceive the odour

The intensity of the odour was allotted 3, 2, 1 and 0 scores respectively.

Statistical analysis

Results obtained were statistically analyzed using student's t-test and expressed as Mean ±SD of the experimental observations.

For all comparisons, significance was determined at $P \leq 0.05$. Linear regression (Curxpt software) and Correlation coefficient between length and weight of grasshoppers in Group I and II were analysed.

Fig. 1: Nymph *Poecilocerus pictus*

Fig. 2: Adult *Poecilocerus pictus*

RESULTS

A. Behaviour patterns

1. Defensive Behaviour

Both nymphs and adults showed defensive behaviour. Their aposematic coloration informs potential predators that they are poisonous or unpalatable. The immature grasshopper differs in appearance from the adults. Nymphs (Fig. 1) typically are completely bright yellow with black and red spots all over the body, whereas adults (Fig. 2) have bright yellow and blue stripes alternately on whole body, including antennae and legs. Hind wings of adult grasshoppers are bright scarlet-red to orange, in sharp contrast to the often drab brown with blackish blue mosaic pattern of the forewings. When disturbed, they take to the air, diverting attention to the brightly coloured and flashy hind wing, and disappear from sight by folding their wings, landing, and cryptically blending into the background. Nymphs (as they cannot fly), and sometimes adults, hide behind leaves and rod placed inside the chamber or hop and drop themselves from whatever they are holding and hop away from the site. Nymphs forcibly eject a secretion stored in the salivary system, closely associated with the crop and midgut, several times, over 30 cm, in the direction of the disturbance. The Nymphs simultaneously contract the abdomen to force air out of the spiracles accompanied with a peculiar sound. In case of adults, the secretion flows down the sides of the body along lateral grooves into the spiracles of the second abdominal segment where it mixes with air to form a repellent froth.

Table 1: Perception of the odour of the body of *P. pictus* by human volunteers

Sample	Percentage of respondents stating how they perceive the odour of *P. pictus* n=38 (100%)			
	Very strong	Strong	Weak	No smell
2nd instar	13.16*	31.58*	52.63*	2.63*
5th instar	21.05**	47.37**	31.58*	0.00 (NS)
Adult	31.58**	65.79**	2.63*	0.00 (NS)

*: Statistically Significant, **: Highly Significant, NS: Statistically not significant

Perception of odour of *P. pictus* by human volunteers: The odour of the secretion was instantly recognized by human volunteers as strong and repulsive. The response of the volunteers indicated that a significantly different odour (t-test, P>0.005, Table 1) is produced by *P. pictus* which is low in 2nd instar, intermediate in 5th, and high in the adult. Incidental observation also showed that the secretion led to allergic reactions, such as redness and rash on skin, at times swelling and eye irritation (data not shown).

2. Feeding

Nymphs of *P. pictus* were successfully reared on *Calotropis gigantea* in the laboratory. Wet and fresh leaves were preferred by nymphs over dry and stored leaves, as fresh leaves were juicy with latex. Positive reaction towards odour of food and light was also observed. Average food consumption of male and female in nymphal period was 2 gm and 4.45 gm per individual per day respectively. Feeding rate increased during day time (between 10:00 and 12:00 hrs). Feeding rate was highest during the second instar in both sexes, males: 2.88 gm and females: 5.15 gm per day per individual.

3. Moulting

Temperature of 29°C ±3 and 40-50% of relative humidity was noted. All embryos of a single pod of *P. pictus* wriggled out one after another within several minutes. After shedding the membrane the young grasshoppers stood upright and were able to jump away. *P. pictus* was reared in captivity from 1st instar to adult; the moulting time was noted. During each moult it held firmly to the wooden stick placed in the chamber and then wriggled out of the skin. The process lasted for 4-7 hours. The nymphs were more susceptible to

infestation during moulting a variety of flies and ants. Red mites were often seen as external parasites on *P. pictus*.

Wing pads of first to third instar hoppers were borne saddle-like over the thorax. Wing pads of fourth and fifth instar hoppers were pointed backward over the abdomen and differed only in size. In the fourth instar, wing pads were relatively small and extended only to the first abdominal segment, while in the fifth instar they were large and extended past the second abdominal segment. During the final moult, when nymphs moult to an adult, the freshly formed wings looked pinkish red, delicate, and shorter than the actual wings of the adult. Within 2-2½ hours they appeared as long as in complete adult stage, showing the blue, green, yellow mosaic pattern with a brown end, and stronger (strong enough to fly) than the imago.

The new adult had fully functional wings but was not immediately ready to reproduce. The female had a pre-oviposition period of 15-30 days during which she increased in weight till the first batch of eggs matured.

Individual variation in the duration of instars within Group II was not statistically significant (P=0.05). The variation in period of each instar, total nymphal periods and number of instars between males and females of Group II was statistically significant (P=0.05).

The entire nymphal period averaged 25 days for males and 34 days for females. Each instar took four to five days to complete development except for the last instar, which took seven to ten days. Adult longevity of males averaged 266 days, and that of females 273 days (Table 2).

4. Mating and Oviposition

Caged females of *P. pictus* usually became receptive to courting males 2-5 days after their final moult, or even sooner when crowded with 6 males in a growth chamber. The males can copulate 5-10 days after the final ecdysis. Males attracted females both visually and acoustically, by short flights, flashing their brightly coloured wings, snapping them together, or both, producing a distinct sound (crepitation). Males also attracted females by stridulation (scraping the hind femur against the forewing). Female body coloration faded after copulation. Table 3 includes number of clasping males (1-5 individuals), number of copulations of females before oviposition (2-17), and average mating time (3-14 hrs).

Abdominal ends of gravid females bend in an angle and at that stage they were more lethargic. Oviposition started 15-30 days after the final moult and 13-25 days post-copulation for all 15 females, and was stimulated by wetting the sand.

Female had two pairs of valves (triangle shapes) at end of abdomen to dig in sand during egg laying. Each female laid one or, rarely, two egg pods, with an average of 126 eggs per egg pod. The egg pods were laid 2-3 inches deep in the soil bed that the female deposited from her abdomen. The egg-pod of *P. pictus* was elongated, soft, fragile and bent near the base. A stout pod forms from frothy glue and soil surrounding the eggs; froth was lacking between the eggs. The frothy material probably protected the eggs from parasites, desiccation and mechanical hazards.

Eggs (Fig. 3) varied in size, colour, and shell sculpturing. Eggs were cylindrical, elongated and some were

Table 2: Moulting periods of *P. pictus* in Group II, reared at a temperature of 78.8 -89.6 °F (26-32 °C) and 30-40% relative humidity, and fed on diet of fresh green leaves of *C. gigantea*

Stage (n=42)	Male (in days)	Female (in days)
Instar 1	4.0	4.0
Instar 2	4.3	3.8
Instar 3	4.1	3.9
Instar 4	5.0	4.5
Instar 5	7.7	7.3
Instar 6	-	10.1
Total nymphal period	25.1	33.6
Average adult longevity	266	273

Table 3: Copulation behaviour in *P. pictus* of Group II (n=15), which includes number of clasping males/mating, number of times female copulates before oviposition and average copulation/mating in hours

Sr. No.	No. of clasping males/mating	No. of times female copulates before oviposition	Mean±SD copulation/ mating time (in hrs)
1	3	11	6±1.37
2	4	12	9±1.41
3	2	5	12±0.74
4	1	7	10±0.39
5	5	9	8±1.26
6	4	2	3±1.98
7	3	4	10±0.45
8	4	9	9±1.47
9	2	10	12±0.10
10	2	15	11±0.50
11	1	17	14±0.80
12	2	6	9±1.56
13	3	8	7±0.91
14	3	7	6±2.08
15	4	13	12±0.34
Range	1-5 individuals	2-17 times	3-14 hrs
Mean± SD	2.87±1.187	9±4.123	9.2±2.883

Fig. 3: *P. pictus* eggs separated from egg pod

slightly bent. They were yellow to dark brown in colour. The egg-wall showed a mosaic hexagonal pattern.

Maximum egg pod length was 7.89 cm; mean egg breadth and length was 7.59 mm and 0.9 mm respectively. After oviposition, the blue-green coloration of the body stripes of the female changed to light green.

B. Growth parameters

Lengths and weights

Using linear measurements of the body, linear relationships have been demonstrated graphically in *P. pictus* between the body weight and length (Figs 4-7). Male and female grew to a maximum adult size of 7.55 ±0.83 cm and 11.23 ±1.41 cm in length, and 3.19 ±0.41 gm and 6.73 ±0.51 gm of wet weight, respectively, under laboratory conditions. Whereas, males and females collected from natural habitat (Group 1) had a maximum size of 6.17 ±0.76 cm, 8.32 ±0.96 cm in length, and 2.23 ±0.24 gm, 4.73 ±0.47gm of wet weight, respectively.

The variation in weight as well as length of female grasshoppers in Groups I and II was statistically significant (Table 4, $P \leq 0.05$), whereas the variation in mean length of the male grasshoppers between both the groups was not significant. The variation in the mean weight of males in both the habitats is statistically significant (Table 4, $P \leq 0.05$). Females in both the groups were larger than males. Lengths as well as weights of adult females were greater, statistically, than those of the adult males (Table 4) at $P \leq 0.05$. Fig. 8 shows

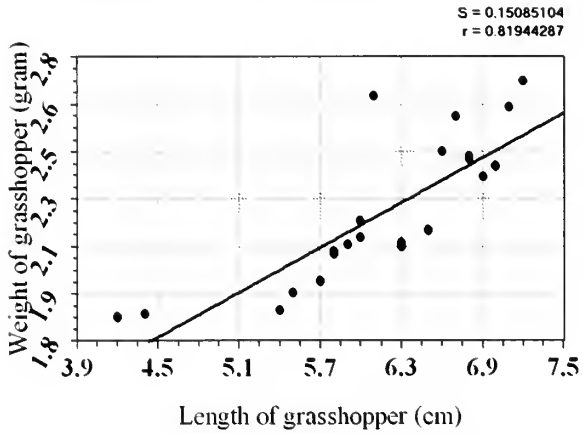


Fig. 4: Regression graph for Group I 'Male'

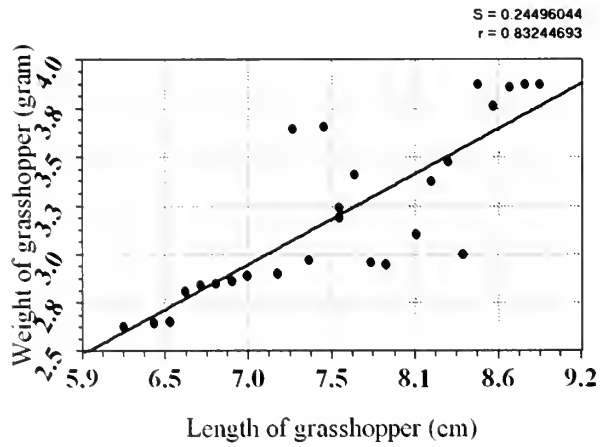


Fig. 5: Regression graph for Group II 'Male'

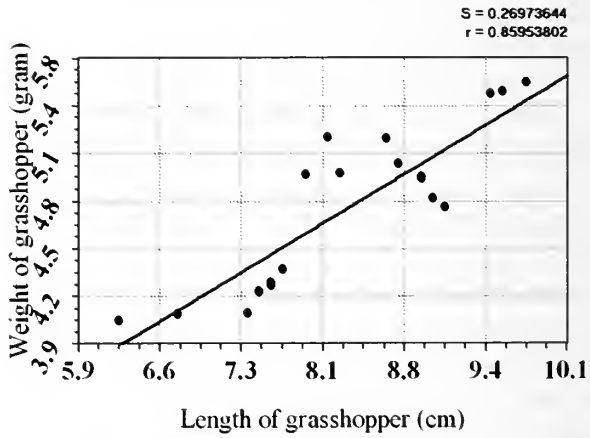


Fig. 6: Regression graph for Group I 'Female'

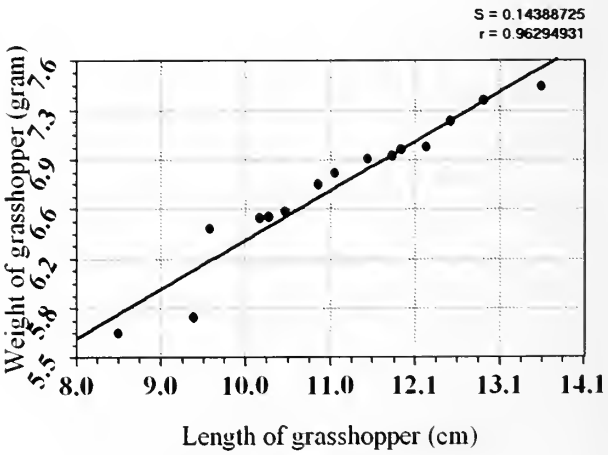


Fig. 7: Regression graph for Group II 'Female'

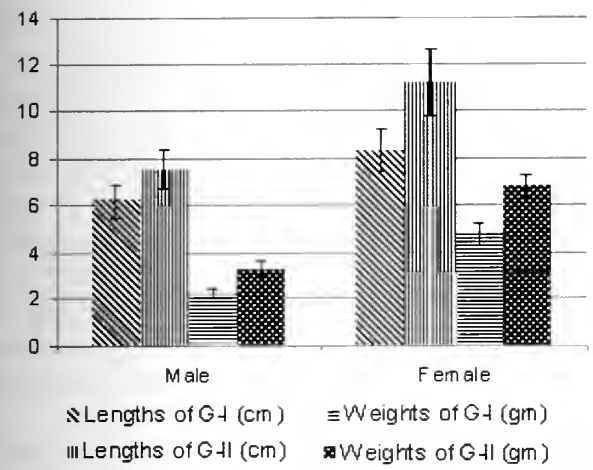


Fig. 8: Variation in mean length (cm) and weight (gm) with SD for Groups I and II

variations in mean length and weight with standard deviation of all groups (Group I and II).

In any organism body length and weight are partially correlated with each other. In the present study, there was perfect positive correlation in Group II 'females' (r= 0.962949), and partial positive correlation (r= 0.859538, 0.832446, 0.81944 respectively) in Group II 'males', and Group I 'males and females' (Table 5).

DISCUSSION

In the present investigation, behavioural study, growth pattern with the length and weight correlations are studied together. The biology and behaviour of *P. pictus* were described by some entomologists and zoologists in various parts of India and Pakistan (Delvi and Pandian 1972a; Sayed *et al.* 1994; Singhal 1976; Parihar 1971; Butani 1975). However, many of these studies are limited either to reproduction or food consumption and assimilation rates.

We observed that laboratory fed adult males *P. pictus* were more active than their counterparts in natural conditions. This is probably because adults in natural habitat stick to the stems of host plant sucking the latex (as nymphs have voraciously defoliated the leaves), and the laboratory reared *P. pictus* were fed only on fresh leaves and the stems were not available for them to hold onto. Further observation was that nymphs eject the secretion forcibly several times in the direction of a disturbance, whereas in adults the secretion flows down the sides of the body along lateral grooves into the spiracles of the second abdominal segment where it mixes with air to form a repellent froth which was in accordance with the observations reported by Qureshi and Ahmad (1970). Perception of the odour of *P. pictus* by human volunteers was studied for the first time. The study showed that the odour of *P. pictus* was offensive and unpleasant. A similar description was used for the odour of related grasshoppers by Whitman (1990). The study has also shown that the production of odour was maximum in adults. Gupta (1978) has reported that sex pheromones are secreted in metathoracic and first 2 segments of the abdomen by female *P. pictus*. Gillott (2003) reported that secretions of accessory glands in male grasshopper include noxious chemicals and various bio-molecules. Adult *P. pictus* also produces appreciable volume of defensive secretion (Qureshi and Wahid 1969). Production of pheromones and defensive secretion might have contributed to the volume of odour. We have noted repellent and irritant responses of the defensive secretion of *P. pictus* on human beings with rashes and allergic reaction on skin. Qureshi and Wahid (1969) have described repellent, irritant and lethal effects of the defensive secretion of *Poecilocerus pictus* in laboratory experiments on fish, reptiles, birds and mammals, but not on human beings.

It was clearly evident from our results that feeding rate of the second instar nymphs in both the sexes was highest (2.88 gm/day in males and 5.15 gm/day in female); female nymphs were observed to consume twice the amount of food than male nymphs. During the period of investigation average food consumption of adult male and female was 2 gm and 4.45 gm/day/individual respectively. Contradicting our results, Delvi and Pandian (1972b) reported that adult males consume more food than adult females, i.e., 904 mg/gm body weight per day in males and, 662 mg/gm body weight per day in females. Sayed *et al.* (1994) reported that *P. pictus* (feeding on *Calotropis* sp.) adult female consumes 9.37 gm

Table 4: Lengths and weights of *P. pictus* in Groups I and II

Group	Mean length	Mean weight	No. of observations
Group I Male	6.17±0.76 (NS)	2.23±0.24*	n=25
Group II Male	7.55±0.83 (NS)	3.19±0.41*	n=27
Group I Female	8.32±0.96**	4.73±0.47**	n=20
Group II Female	11.23±1.41**	6.73±0.51**	n=15

*: Statistically Significant, **: Highly Significant, NS: Statistically not significant

Table 5: Correlation Coefficient between mean lengths and weights in Groups I and II

Group	Correlation Coefficient
Group I Male	0.81944
Group II Male	0.832446
Group I Female	0.859538
Group II Female	0.962949

food plant per day. Singhal (1976) studied consumption and assimilation rates and reported higher consumption and assimilation rates in males than females. However, consumption rates are higher in females than in males in our observation, probably because they have to prepare themselves for oviposition. Photopositive responses and positive reaction towards the odour of food is evident in our results and is in agreement with that reported by Abdullah and Siddiqui (1971). We observed no cannibalism in laboratory reared *P. pictus* which was reported by Parihar (1974).

According to Delvi and Pandian (1972a) and Butani (1975) hatching occurs during March-April, by August the insects undergo six moults to become adult; oviposition occurs during September-October, and death by early December. In our study, hatching extended till August, there were six nymphal stages for females and only five were noted in males at a temperature of 29 ±3°C. The adults survived in healthy conditions till March. Parihar (1971) mentioned six nymphal stages at 30-35 °C, and six or seven stages at 25°C.

The nymphal period in laboratory condition was 25.1 days for males and 33.6 days for females, whereas as mentioned by Butani (1975) the adults appear 4-6 weeks later, i.e., within 28-42 days. The decrease in nymphal periods under laboratory conditions may be probably due to adequate food, temperature and humidity. Muthukrishnan and Delvi (1974) had reported that reduced supplies of *Calotropis gigantea* produce a number of negative effects on *Poecilocerus pictus*, such as heavy mortality (42% at 25% ration of *Calotropis gigantea* against 11% at 100% ration of *Calotropis gigantea*), extension of larval period (from 75 days to 113 days), and an increase in the number of instars (from 6 to 7).

Copulation and oviposition in *Poecilocerus pictus* took place more or less in similar pattern with very few variations as reported by Sheri (1976), Raziuddin *et al.* (1977) and Parihar (1974, 1984). There was a slight degree of variation in number of days in which the males and females become ready for copulation after their emergence as adults, number of clasping males, number of copulations of females before oviposition, average mating time and number as well as structure of egg-pods and egg. In addition, the phenomenon of males attracting females in their reproductive stages by visual and acoustic stimuli was also observed.

The growth efficiency, in our experiments was higher in females as their weights are higher than males in both laboratory conditions and natural habitat. Singhal (1976) worked on growth efficiency ratios, which were higher in females than in males. A female and male grew to a maximum size of 5.1 ±2.3 and 2.7 ±1.8 gm wet weight on the 236th and 218th day of life respectively. Males are correlated with the maximum weight attained (2.6 gm); females attain 5.0 gm in a similar life span (about 265 days at 26 °C) Delvi and Pandian (1972b). Weight gain was higher in laboratory conditions (average 3.19 gm for males and 6.73 gm for females).

The behaviour pattern and life cycle of laboratory reared *P. pictus* was found to be more or less similar to already cited reports. The noteworthy observations in the present study were of longevity of adults and shortening of nymphal periods to 25.1-33.6 days, with the body achieving maximum length and weight resulting in a perfect positive correlation of these parameters.

REFERENCES

Abdullah, M. & S. Siddiqui (1971): The discovery of geotaxis in *Poecilocerus pictus* (F.) (Orthoptera: Acrididae, Pyrogomorphinae). *Dtscli. Entomol. Z. 18*: 199-205.

Butani, D.K. (1975): Insect pests of fruit crops and their control: melons. *Pesticides 9(12)*: 39-43.

Delvi, M.R. & T.J. Pandian (1972a): Ecological energetics of a population of the grasshopper *Poecilocerus pictus. Abstr. 14th Int. Congr. Ent.* Canberra 1972. 196 pp.

Delvi, M.R. & T.J. Pandian (1972b): Rates of feeding and assimilation in the grasshopper *Poecilocerus pictus. J. Ins. Phys. 18*: 1829-1843.

Ganehiarachchi, G.A.S.M. & I.V.S. Fernando (2006): Biology of *Pyrilla perpusilla* Walker (Homoptera: Lophopidae), A pest of sugarcane in the west zone of Sri Lanka. *J. Entomol. 3(1)*: 26-33.

Garod, S. (2009): Continent-hopper flies into UK uninvited. http:// www.inthenews.co.uk /news/uk/continent-hopper-flies-into-uk-uninvited $1336268.htm or www.inthenews.co.uk.

Gillott, C. (2003): Male Accessory Gland Secretions: Modulators of Female Reproductive Physiology and Behavior. *Annu. Rev. Ento. 48*: 163-184.

Gupta, B.D. (1978): Sex pheromone of *Poecilocerus pictus* (Fabricus) (Acridoidea: Pyrogomorphidae): 1. Experimental identification and external morphology of the female sex pheromone gland. *Biochem Exp Biol. 14(2)*: 143-148.

Idowu, A.B. & O.A. Idowu (1999): Pharmacological properties of the repellent secretion of *Zonocerus variegates* (L.) (Orthoptera: Pyrgomorphidae). *Rev. Biol. Trop. 47(4)*: 1015-1020.

Muthukrishnan, J. & M.R. Delvi (1974): Effect of ration levels on food utilisation in the grasshopper *Poecilocerus pictus. Oecologia 16(3)*: 227-236.

Parihar, D.R. (1971): Effect of constant temperature on development of eggs and hoppers of the Aak grasshopper, *Poecilocerus pictus* (Fabricius) (Acridoidea: Pyrgomorphidae). *Proc. Zool. Soc. 24*: 61-76.

Parihar, D.R. (1974): Some observations on the life-history of aak grasshopper, *Poecilocerus pictus* (Acridodea [sic]: Pyrgomorphidae) at Jodhpur, Rajasthan, India. *J. Zool. Soc. India 26*: 99-129.

Parihar, D.R. (1984): Structure of egg-pods and eggs in a grasshopper *Poecilocerus pictus* (Acridoidea: Pyrgomorphidae). *J. Anim. Morphol. Physiol. 31*: 79-88.

Pugalenthi, P. & D. Livingstone (1995): Cardenolides (heart poisons) in the painted grasshopper *Poecilocerus pictus* F. (Orthoptera: Pyrgomorphidae) feeding on the milkweed *Calotropis gigantea* L. (Asclepiadaceae). *J. New York Entomol. Soc. 103(2)*: 191-196.

QURESHI, S.A. & I. AHMAD (1970): Studies on the functional anatomy and histology of the repellent gland of *Poecilocerus pictus* (F.) (Orthoptera: Pyrgomorphidae). *Proc. Royal Soc. Lon. (A) 45*: 149-155.

QURESHI, S.A. & M.A. WAHID (1969): Pharmacology, chemistry and behaviour of the repellent fluid of poisonous grasshopper, *Poekilocerus pictus* (Fabricius) (Pyrgomorphidae; Acridoidea Orthoptera). *Pakist. J. Biochem. 2*: 50-54.

RAZIUDDIN, M., T.R. KHAN & S.B. SINGH (1977): Observations on the sexual behaviour and oviposition in the female grasshopper, *Poecilocerus pictus* Fabr. (Acridoidea; Pyrgomorphidae). *Zool. Anz. 198*: 63-67.

SAYED, T.S., M.S. AWAN & G.H. ABRO (1994): Effect of food plant on the biology of *Poecilocerus pictus* Fab. food consumption and rate of development. *Pakist. J. Zool. 26(2)*: 105-108.

SHERI, A.N. (1976): Reproduction of a common grasshopper *Poikilocerus pictus* Fabricius. *Pakist. J. agric. Sci. 13*: 37-40.

SINGHAL, R.N., L.K. VATS & J.S. SINGH (1976): Food-energy budget for the aak grasshopper, *Poecilocerus pictus* (Fabr.) (Acrididae: Orthoptera). *Indian J. Ecol. 3*: 119-124.

WHITMAN, D.W. (1990): Grasshopper Chemical Communication. Pp. 357-391. *In*: Chapman, R.F. & A. Joern (Eds): Biology of Grasshopper. John Wiley & Sons, New York.

■ ■ ■

VARIABILITIES IN DIFFERENT BODY MEASUREMENTS OF THE HORSESHOE CRAB, *CARCINOSCORPIUS ROTUNDICAUDA* (LATREILLE) COLLECTED FROM SETIU AND GELANG PATAH HABITATS IN PENINSULAR MALAYSIA

T.C. Srijaya[1,3], P.J. Pradeep[2], S. Mithun[1,4], Anuar Hassan[1,5], Faizah Shaharom[1,6] and Anil Chatterji[1,7]

[1]Institute of Tropical Aquaculture, University Malaysia Terengganu, 21030, Kuala Terengganu, Malaysia.
[2]Department of Oral Pathology & Oral Medicine and Periodontology, Faculty of Dentistry Building, University of Malaya, 50603 Kuala Lumpur, Malaysia. Email: pradeep85pj@yahoo.com
[3]Email: sreejayamol@yahoo.com
[4]Email: mithunsugun@gmail.com
[5]Email: anuar@umt.edu.my
[6]Email: faizah@umt.edu.my
[7]Email: anilch_18@yahoo.co.in

Comparisons of the body weight of two populations of *Carcinoscorpius rotundicauda* (Latreille) showed that the body weight of the crabs collected from Setiu was greater (males=145+18.06 gm; females=250+13.79 gm) than the crabs collected from Gelang Patah (males=126+18.25 gm; females=170+21.79 gm). Regression coefficients (b-value) differed significantly among groups and ranged from 0.41 (females of Setiu) to 2.93 (males of Gelang Patah). Length-weight relationship did not follow isometric growth except the total length and body weight relationship of males of Gelang Patah population. Maximum growth in weight was recorded for males from Setiu population where the increment in weight was found to be double as compared to the increment in total length (b=2.12). Maximum regression coefficient values were recorded in males of Gelang Patah population (b=2.93) which showed that the increment in body weight was greater than increment in carapace width confirming a significant relationship. Relationships between total lengths and carapace length and width with body weight for females from Setiu population showed isometric growth.

Key words: Variabilities, body measurements, horseshoe crab, *Carcinoscorpius rotundicauda*, Peninsular Malaysia

INTRODUCTION

Marine organisms in more stable environments show isometric growth which helps these organisms to adapt to a functional equilibrium of their body parts (Bas 1964). Geographically widespread marine organisms can experience variation in both environmental and anthropogenic impacts across their ranges that can differentially influence the expression of life history traits and population dynamics in different populations (Chatterji 1994). Several reports show that the size of an individual of the same species significantly changes with change in the environmental conditions where osmotic stress conditions play an important role on the normal physiology of the animals (Tarnowska *et al.* 2009). The study of morphological variations of marine organisms inhabiting different areas of their ranges is one of the directions of investigation for taxonomic diagnostic criteria.

Carcinoscorpius rotundicauda (Latreille), a eurytopic species, is adapted to extreme environmental conditions, like the low salinity or the extremely high summer temperatures of the sea. They belong to the benthic community and prefer calm sea or an estuary with muddy sand bottom (Grant 1984; Kelsey and Hassall 1989). Most of the biogenic activities of the horseshoe crab occur in the open ocean. The Asian species of horseshoe crab migrate towards the shore throughout the year to breed (Chatterji 1994). Although detailed information on the complete life cycle of the animal is not yet known, it is generally believed that the animal inhabits the littoral zone of the sea, for most part of its life. Among four extant species of horseshoe crab, *C. rotundicauda* has been reported to thrive well in low saline areas and as such considered to be a mangrove species (Mikkelsen 1988; Chatterji 1994).

Although ample data regarding the morphometric characteristics of *C. rotundicauda* have been published (Chatterji *et al.* 1988), there is no information available in literature regarding the hypothesis of environment-mediated morphometric changes in populations of this species collected from different habitats. The objective of this study was to analyze possible morphometric variations, including length and weight relationships, among populations of the horseshoe crab, *C. rotundicauda* (Latreille) collected from two different environments, namely Setiu (Terengganu) and Gelang Patah (Johor) in Peninsular Malaysia, to demonstrate the effects of different ecological habitats on the growth of the animal.

MATERIAL AND METHODS

Live horseshoe crabs, *C. rotundicauda* (Latreille) were collected along the eastern coast of Peninsular Malaysia at Setiu (Terengganu) (5° 42' 60" N; 102° 42' 0" E) and western coast at Gelang Patah (Johor) (1° 21' 4" N; 103° 32' 33" E) during November 2008 and June 2009 (Fig. 1). The salinity

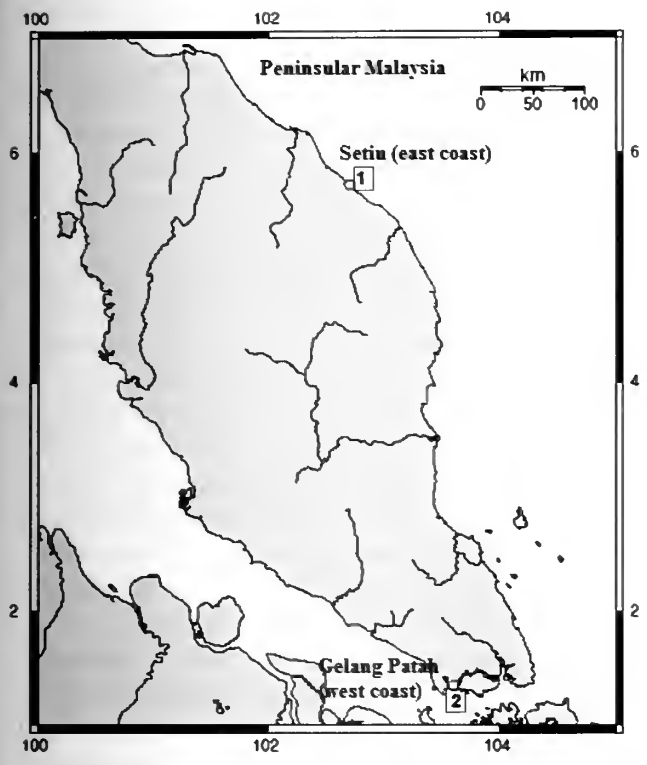


Fig. 1: Locations of the sampling sites: (1) Setiu and (2) Gelang Patah, Johor

of Setiu was within a range of 20-25 ppt, whereas that of Gelang Patah is 31-33 ppt during November to June (Zaleha *et al.* 2006). Samples were collected with the help of local fishermen using gill nets 25 m long and 6 m wide, with 10 mm mesh size. All collected crabs were brought to the laboratory and kept in two separate fibreglass tanks of 5,000 litre capacity provided with continuous circulation of seawater. Total length (tip of the carapace to tip of the telson), carapace length, carapace width and telson length of each specimen were recorded to the nearest millimetre using Vernier Callipers. Weights of the specimens were determined to 0.1 gm on a monopan balance (electronic). Horseshoe crabs were then grouped according to sex and sample location.

Length and weight data were analysed according to the method of LeCren (1951) and Chatterji (1976), log transformed and the regression of log length to weight calculated by least square method. The equation $ln W = ln a + b\ ln L$ was calculated separately for each group and a straight line was fitted to scatter diagram using SPSS 11.5 version software. Covariance Analysis (Chatterji 1976) was used to describe differences, if any, in the regression of *ln* weight on *ln* total length, *ln* carapace length, *ln* carapace width and *ln* telson length of the two populations of the horseshoe crab.

After logarithmic transformation of the data, slopes of the regression lines between body weight (BW) on total length, carapace length, carapace width and telson length

Table 1: Mean of different body measurements of the horseshoe crab collected from two different habitats

Parameters	Setiu		Gelang Patah	
	Males	Females	Males	Females
Total length	307 ±16.41	313 ±30.52	277 ±16.89	307 ±15.92
Carapace length	139 ±8.39	169 ±5.47	136 ±5.82	153 ±10.23
Carapace width	150 ±8.03	173 ±6.70	148 ±6.58	159 ±7.01
Telson length	178 ±9.64	188 ±4.55	149 ±10.96	163 ±13.01
Body weight	145 ±18.06	250 ±13.79	126 ±18.25	170 ±21.79

taken as an independent variable and expressed as $ln W = ln a + b\ ln L$. The comparison between slopes was carried out by means of ANOVA ($P < 0.05$). Two tests among the samples of each period were made: (1) slope comparisons between different morphometric relationships with weight to identify possible differences in time, and (2) test of allometry to observe the type of allometry and the changes that could have taken place in two populations. The significance of all regressions was tested by ANOVA, being significant for $P < 0.05$ (Sokal and Rohlf 1979).

RESULTS

Total sample size of the horseshoe crab was 308 from Setiu, ranging from 270 to 333 mm in total length and 112-178 gm in weight for males (N=133), and 241 to 389 mm in length and 225-356 gm in weight for females (N=175). Total sample size was 318 crabs from Gelang Patah ranging from 229 to 323 mm in length and 83-200 gm in weight for males (N=140), and 280 to 352 mm in length and 137-222 gm in weight for females (N=178).

In the Setiu crab population mean body weights were greater in males (145 ±18.06 gm) and females (250 ±13.79 gm) than crabs collected from Gelang Patah (males=126 ±18.25 gm; females=170 ±21.79 gm) (Fig. 2). Other measurements like total length, carapace length, carapace width and telson length in both sexes of Setiu population also showed relatively higher values as compared to crabs of Gelang Patah (Table 1).

A summary of the regression analysis between the body weights with different body measurements along with their test of significances of Setiu and Gelang Patah populations are presented in Table 2. Regression coefficients (b-values) differed significantly among groups and ranged from 0.41

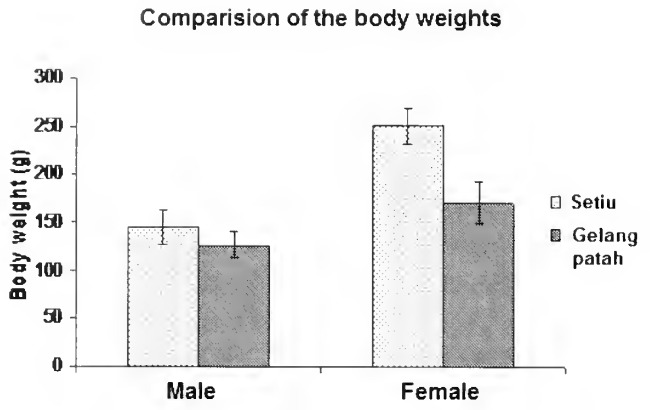


Fig. 2: A comparison of the body weights of the two populations collected from Setiu and Gelang Patah (Johor)

(females of Setiu) to 1.84 (females of Gelang Patah). b-values calculated for each group separately indicated deviance from isometric growth except for the total length and body weight relationships of males of Gelang Patah (r=0.90) (Table 2).

Logarithmic transformation of these data presented in Table 2 yielded a straight line and represented the calculated regression line. Maximum growth in weight was recorded in females of Setiu population where the increment in body weight was double as compared to the increment in total length (b=2.12) (Table 2). Maximum value of 'b' (2.93) recorded for the body weight-carapace width relationship in males of Gelang Patah population which showed that the increment in body weight was more than the increment in carapace width with high significance level. Regression analysis for other relationships showed that the growth in body weight with remaining parameters were isometric. In all crabs collected from Gelang Patah, the b-values were higher except for the body weight and telson length relationship of males of Setiu (Table 2) that showed that in Gelang Patah population the growth of all body measurements were relatively of lower magnitude.

DISCUSSION

Length-weight relationships are one of the most important tools in fisheries research. They help in converting growth-in-length equations to growth-in-weight for use in stock assessment models, estimating of biomass from length observations, estimating the condition of the fish, and comparing the life histories of species from different regions (Froese and Pauly 1998; Moutopoulos and Stergiou 2000). The length-weight relationship also has numerous practical applications in fishery biology and equation derived from such relationship helped in converting one parameter into another which is often required during monitoring of field measurements. The length-weight relationships are also helpful in getting valuable information on general well-being of the fish, their physiological changes, variation in growth in relation to environmental factors, and also their breeding biology (Chatterji *et al.* 1994).

The length-weight relationships observed between total lengths with body weight have been statistically significant ($p<0.05$) in the male and female Horseshoe crab *Tachypleus gigas* (Müller) collected from the north-east coast of India. In females, an increase in weight was isometric (Vijayakumar *et al.* 2000). The body weight – total length relationship in *T. gigas* was observed to be linear where the increase in the body weight was of higher magnitude than that of total length of the animals (Vijayakumar *et al.* 2000). In *T. gigas*, the body weight increased very sharply within the length range of 300-400 mm. The body weight – carapace length relationship shows a sharp increase in body weight, whereas the carapace length increases marginally in the specimens within the size from 100-200 mm with a linear relationship (Vijayakumar *et al.* 2000). Vijayakumar *et al.* (2000) further reported that the body weight – carapace width relationship in *T. gigas* was same as in the case of body weight and

Table 2: Regression analysis of different relationships along with their test of significance

Sex	Habitat	BW:TL	BW:CL	BW:CW	BW:Tel
Male	Setiu	*ln*Y= -3.12+2.12 *ln*X (r=0.81)	*ln*Y= -1.60+1.75 *ln*X (r=0.68)	*ln*Y= -2.44+2.11 *ln*X (r=0.80)	*ln*Y= -2.31+1.99 *ln*X (r=0.73)
	Gelang Patah	*ln*Y= -3.36+ 2.23 *ln*X (r=0.90)	*ln*Y= -4.04+2.88 *ln*X (r=0.71)	*ln*Y= -4.26+2.93 *ln*X (r=0.80)	*ln*Y= -1.82+1.81 *ln*X (r=0.86)
Female	Setiu	*ln*Y= 1.38+0.41 *ln*X (r=0.60)	*ln*Y= 0.38+0.91 *ln*X (r=0.30)	*ln*Y= 0.77+0.73 *ln*X (r=0.27)	*ln*Y= 0.97+0.63 *ln*X (r=0.08)
	Gelang Patah	*ln*Y= -2.36+1.84 *ln*X (r=0.57)	*ln*Y= -0.55+1.27 *ln*X (r=0.46)	*ln*Y= -2.31+2.06 *ln*X (r=0.53)	*ln*Y= -0.23+1.11 *ln*X (r=0.47)

TL=Total Length; CL=Carapace Length; CW=Carapace Width; Tel=Telson Length; BW=Body Weight

carapace length. In *T. gigas*, the increase in body weight has been directly related with carapace length and carapace width with equal degree of correlation (Vijayakumar *et al.* 2000).

In general, the rate of increase of body weight in the present study was more or less of equal magnitude as that of the total length. Females in the Setiu population showed a relatively higher increase in weight (250 ±13.79 gm) within the size range of 241-3 89 mm, whereas in Gelang Patah it was lower (170 ±21.79 gm) within 280-352 mm of total length. Similarly, males from Setiu (size range: 270-333 mm) also showed higher weight gain (145 ±18.06 gm) as compared to males of Gelang Patah (126 ±18.25 gm) ranging in size from 229 to 323 mm.

In all species of the horseshoe crab females are reported to be heavier than males (Chatterji *et al.* 1994). In the present study, males of both populations had shown exponential growth as relationships between total length – body weight, carapace length – body weight and carapace width-body weight yielded smooth curves. Similarly, females of both the populations exhibited linear growth which could probably be due to increase in soft tissue specially ovaries where most of the energy was diverted for building up these organs resulting in slow growth of other body parts (Chatterji 1976).

Chatterji *et al.* (1988) reported that the weight of females *C. rotundicauda* collected from the Sunderbans area of West Bengal (India) showed relatively a lower weight gain as compared to males up to the size of 130 mm. It was higher in females after the size range of 130 mm as compared to males. The length-weight relationship data of females of *T. gigas* show that the weight of females increases gradually more than the cube of the carapace length whereas in males, the relationship did not follow the cube law (Chatterji *et al.* 1988). In juveniles of *Tachypleus tridentatus* and *C. rotundicauda*, prosomal width and wet weight were measured at weekly intervals to obtain growth data (Lee and Morton 2005). A positive allometric growth (b = 2.97) was estimated, which indicated that body weights gained by *T. tridentatus* and *C. rotundicauda*, were faster than the growth of prosomal width after each ecdysis.

The use of non-linear least-squares regression techniques for allometric modelling has been strongly supported by Zar (1968), and Hayes and Shonkwiler (1996). However, Xiao and Ramm (1994) concluded that the use of log-transformed data is appropriate for describing length-weight relationships in aquatic animals. In this study, the small sample sizes associated with several species are potentially problematic with respect to asymptotic variance properties of non-linear regression. Our choice of an allometric model was practiced as linear regression using log transformed data facilitated statistical comparisons of gender and habitat relationships, and allowed a single method to be applied to all specimens collected for the present study regardless of the sample size.

Fishing activities in Setiu has been increased dramatically in the last few years as compared to Gelang Patah. As a consequence of increase in the number of trawlers as well as gear size, and improvements in accompanying technology, the spawning grounds are continuously disturbed. This could be one of the reasons for shifting to an alternate breeding ground that might not be conducive to the species as such affecting the slower growth rate among new recruiting population of Gelang Patah.

There could be substantial physiological differences among the two populations of *C. rotundicauda* owing to individual acclimatization of the species or genetically fixed adaptations. As far as morphometric and physiological analyses are concerned, seasonal sampling appears to be insufficient for understanding the physiological performance of *C. rotundicauda* under different environmental conditions since there are probably also some short-term variations in these parameters. Therefore, monthly sampling to collect more information would be recommended in future studies.

ACKNOWLEDGEMENTS

The authors (MS & PPJ) are thankful to University Malaysia Terengganu for providing research assistantships whereas (AC) is grateful to University for the award of a Principal Research Fellowship.

REFERENCES

Bas, C. (1964): Aspectos del crecimiento relativo en peces del Mediterráneo occidental. *Investigacion Pesquera, Barcelona 27*: 13-19.

Chatterji, A. (1976): Studies on the Biology of Some Carps. Ph.D. Thesis, Aligarh Muslim University, Aligarh, 122 pp.

Chatterji, A. (1994): The Indian Horseshoe Crab – A Living Fossil. A Project Swarajya Publication, 157 pp.

Chatterji, A., J.K. Mishra, R. Vijaykumar & A.H. Parulekar (1994): Length-weight relationship of the Indian horseshoe crab, *Tachypleus gigas* (Müller). *Indian Journal of Fisheries 41(2)*: 58-60.

Chatterji, A., R. Viyayakumar & A.H. Parulekar (1988): Growth and morphometric characteristics of the horseshoe crab, *Carcinoscorpius rotundicauda* (Latreille) from Canning (West Bengal), India. *Pakistan Journal of Scientific and Industrial Research 31(5)*: 352-353.

Grant, J. (1984): Sediment microtopography and shorebird foraging. *Marine Ecological Progress Series 19*: 293-296.

HAYES, J.P. & J.S. SHONKWILER (1996): Analyzing mass-independent data. *Physiological Zoology 69*: 974-980.

FROESE, R. & D. PAULY (1998): Concepts, Design and Data Sources. Fishbase, ICLARM, Manila. Pp. 90-96.

KELSEY, M.G. & M. HASSALL (1989): Patch selection by dunluin on a heterogenous mudflat. *Ornis Scandinavica 20*: 250-254.

LECREN, E.D. (1951): The length-weight relationship and seasonal cycle in gonad conditions and weight in perch, *Perca fluviatalis*. *Journal of Animal Ecology 20*: 210-219.

LEE, C.N. & B. MORTON (2005): Experimentally derived estimates of growth by juvenile *Tachypleus tridentatus* and *Carcinoscorpius rotundicauda* (Xiphosura) from nursery beaches in Hong Kong. *Journal of Experimental Marine Biology and Ecology 318 (1)*: 39-49.

MIKKELSEN, T. (1988): The Secret in the Blue Blood. Science Press Beijing, China. 124 pp.

MOUTOPOULOS, D.K. & K.I. STERGIOU (2000): Length-weight and length-length relationships of fish species from the Aegean Sea (Greece). *Journal of Applied Ichthyology 18*: 200-203.

SOKAL, R.R. & F.J. ROHLF (1979): Biometry. Principles and statistical methods of biological research. H. Blume, Madrid. 832 pp.

TARNOWSKA, K., M. WOLOWICZ, A. CHENUIL & F. JEAN-PIERRE (2009): Comparative studies on the morphometry and physiology of European populations of the lagoon specialist, *Cerastoderma glaucum* (Bivalvia). *Oceanologia 51(3)*: 437-458.

VIJAYAKUMAR, R., S. DAS, A. CHATTERJI & A.H. PARULEKAR (2000): Morphometric characteristics in the horseshoe crab, *Tachypleus gigas* (Arthropoda: Merostomata). *Indian Journal of Marine Science 29*: 333-335.

XIAO, Y. & D.C. RAMM (1994): A simple generalized model of allometry, with examples of length and weight relationships for 14 species of ground fish. *Fisheries Bulletin 92*: 664-670. Washington D.C.

ZALEHA, K., B.M. SATHIYA & N. IWASAKI (2006): Zooplankton in east coast of Peninsular Malaysia. *Journal of Sustainability Science and Management 1(2)*: 87-96.

ZAR, J.H. (1968): Calculation and miscalculation of the allometric equation as a model in biological data. *BioScience 18*: 1118-1120.

■ ■ ■

Journal of the Bombay Natural History Society, 107(2), May-Aug 2010 135-145

FLORISTIC DIVERSITY AND TAXONOMIC PROFILE OF THE VEGETATION OF ACHANAKMAR-AMARKANTAK BIOSPHERE RESERVE, CENTRAL INDIA

K.P. Singh[1,3], Achuta Nand Shukla[1,4] and J.S. Singh[2,5]

[1]Botanical Survey of India, Central Regional Centre, 10 Chatham Lines, Allahabad 211 002, Uttar Pradesh, India.
[2]Department of Botany, Banaras Hindu University, Varanasi 221 005, Uttar Pradesh, India.
[3]Email: krishna.p.singh@gmail.com
[4]Email: achutbsi@gmail.com
[5]Email: singh.js1@gmail.com

Vegetation of the Achanakmar-Amarkantak Biosphere Reserve (AABR) represents tropical mixed deciduous, tropical moist deciduous, and dry scrub and thorn forest, ravines, grasslands and aquatic types. The collections from the area and their subsequent critical study have resulted in the documentation of 1,011 species, distributed under 571 genera and 134 families of flowering plants. Out of these, 755 species under 432 genera and 104 families belong to dicots and the remaining 256 species under 139 genera and 30 families to monocots. Further analysis of data indicated that Family Poaceae is the most diverse and is represented by 112 species, followed by Fabaceae with 76 spp., Asteraceae with 72 spp., Cyperaceae with 40 spp., Acanthaceae with 36 spp. etc. At generic level, the genus *Cyperus* comprised maximum number of 15 species, followed by *Ficus* with 12 spp., *Crotalaria* with 12 spp., *Ipomoea* with 11 spp., *Cassia* with 11 spp., etc. A large number of species growing in this area are of medicinal and economic value and used by local inhabitants. The floristic diversity of the AABR has been analysed for the first time. A brief account of area, climatic conditions, vegetation types, medicinal and economic plants, analysis of flora and causes of threat to the flora are discussed.

Key words: Floristic diversity, vegetation types, Achanakmar-Amarkantak Biosphere Reserve, Central India

INTRODUCTION

Central India with diverse and luxuriant floristic wealth has been considered as one of the prominent biogeographic provinces in the country. For conservation of the rich biological diversity of the region, Achanakmar-Amarkantak Biosphere Reserve (AABR) was established on March 30, 2005 (Sahu and Singh 2008), with a total area of 3,835.51 sq. km. Out of this, Achanakmar-Amarkantak Wildlife Sanctuary with an area of 551.15 sq. km comprises of the core zone (Shukla and Singh 2007) and remaining 3,284.36 sq. km buffer zone of the reserve. It is located between 22°15'-22°58' N and 81°25'-82° 5' E in Anuppur and Dindory districts of Madhya Pradesh and Bilaspur district of Chhattisgarh. The Biosphere Reserve area includes Maikal hill ranges, the junction of Vindhyan and Satpura hill ranges. The area experiences typical monsoon climate with three distinct seasons: summer from March to June, rainy from June to October and winter from November to February. The mean annual temperature ranges between 21°C and 31°C. Due to altitudinal and latitudinal locations, the climate of the reserve is comparatively cooler than the other districts of central India. December and January are the coldest months when minimum temperature reaches up to 1°C while the hottest months are May and June. The mean temperature in January is about 21°C and in May temperature rises between 31°C and 33°C. The area experiences pre-monsoon showers at the end of May and monsoon from July to August which diminishes by October. The average annual rainfall is about 1,900 mm which is received largely from South-West monsoon. Sporadic winter rains are common in December and January while dew fall continues up to March. The altitude varies from 450 to 1,102.27 m above msl with the highest point being Damgarh (1,102.27 m). Due to high annual rainfall coupled with high relative humidity and suitable temperatures, the reserve harbours diverse and luxuriant growth of flora. The soils of the area are generally lateritic, alluvial and black cotton types, derived from granite, gneisses and basalts. Black cotton soil occurs in the environs of Dindori-Pendra road and also along Narmada river. In parts of Amarkantak, laterite occurs mainly as capping above the Deccan trap. Loosely packed and gritty red soil is also found on hill tops. Alluvial soils are found along the major drainage channels and rivers. Alluvial soils and black cotton soils are the most fertile for agriculture in the area.

MATERIAL AND METHODS

Vegetation of the AABR shows great diversity due to varied topographic, climatic, and edaphic conditions. Sal forest is predominant in the area (Misra 1953) and shows compositional variability in response to anthropogenic disturbances (Sahu *et al.* 2008). Sal forests are found on laterite trap and crystalline rocks in most hilly part which covers the southern central as well as south-western part in Lamni and Achanakmar ranges of Wildlife Sanctuary in

Bilaspur forest division, Karanjia range in Dindori forest division and Pendra range of North-Bilaspur division. This area is therefore known as Sal valley. However, on plateaus and slopes, the vegetation composition invariably changes and mixed forests are formed.

Intensive plant explorations and in-depth surveys of the reserve were made from 2004 to 2008. Specimens were collected from different localities of the reserve, namely Kapildhara, Kabirchabutra, Mai-ki-Bagia, Sonemuda, Durgadhara, Lamni, Acahanakmar, Kota, Karanjia, Jagatpur, Antaria, Chaparwa, etc. The specimens have been deposited in the herbarium of Botanical Survey of India, Allahabad (BSA).

Major Habitats

The survey of the area indicated the following major habitats; a brief description of these and their vegetation is given below:

1. **Tropical mixed deciduous forest**: These forests occur on the gentle slopes of hills and valleys and are predominant in localities like Laxmandhara, Gumaghati, Kabir, Karanjia, Chaparwa and Lamni. The forest has three layers, namely trees, shrubs and herbs intermingled with climbers. The dominant tree species include *Acacia catechu*, *A. leucophloea*, *A. nilotica* subsp. *indica*, *Ailanthus excelsa*, *Anogeissus latifolia*, *Azadirachta indica*, *Bauhinia purpurea*, *Bombax ceiba*, *Bridelia retusa*, *Buchanania lanzan*, *Butea monosperma*, *Careya arborea*, *Cassia fistula*, *Cassine glauca*, *Cordia dichotoma*, *Dalbergia paniculata*, *Diospyros malabarica*, *Emblica officinalis*, *Ficus arnottiana*, *F. benghalensis*, *F. racemosa*, *F. religiosa*, *Flacourtia indica*, *Garuga pinnata*, *Grewia* spp., *Haldinia cordifolia*, *Lagerstroemia parviflora*, *Lannea coromandelica*, *Leucanea leucocephala*, *Madhuca longifolia* subsp. *latifolia*, *Mangifera indica*, *Mimusops elengi*, *Ougeinia oojeinensis*, *Pongamia pinnata*, *Pterocarpus marsupium*, *Schleichera oleosa*, *Shorea robusta*, *Sterculia urens*, *Terminalia alata*, *T. arjuna*, *T. bellerica*, *T. chebula*, *Zizyphus oenoplia*, *Z. xylopyrus*, etc.

The **shrub** layer is usually formed by species like *Cassia auriculata*, *Carissa opaca*, *Lantana camara*, *Ixora pavetta*, *Flacourtia indica*, *Helicteres isora*, *Prosopis juliflora*, *Woodfordia fruticosa*, *Vitex negundo*, *Euphorbia nivulia*, *Nyctanthes arbor-tristis*, etc.

The common climber species found on trees and shrubs or sometimes spreading on the ground include *Abrus precatorius*, *Ampelocissus latifolia*, *A. tomentosa*, *Aristolochia bracteata*, *Atylosia scarabaeoides*, *Cocculus hirsutus*, *Cissampelos pareira* var. *hirsuta*, *Cuscuta reflexa*, *Cayratia trifolia*, *Gymnema sylvestre*, *Hemidesmus indicus*, *Mucuna pruriens*, *Pergularia daemia*, *Tinospora cordifolia*, etc.

Herbs and grasses are abundant in open forest pockets or on forest margins, and include *Anisomelos indica*, *Cassia tora*, *Heteropogon contortus*, *Hyptis suaveolens*, *Iseilema laxum*, *Leonotis nepetaefolia*, *Tephrosia purpurea*, *Themeda quadrivalvis* , etc.

On dry ridges, tree species like *Boswellia serrata*, *Euphorbia nivulia*, *Nyctanthes arbor-tristis*, *Sterculia urens*, etc. are found.

Dendrocalamus strictus, a common bamboo, often occurs in patches in the forest. Similarly, *Tectona grandis* also occurs in small patches. *Alangium salvifolium*, *Diospyros melanoxylon*, *Ficus racemosa*, *F. religiosa*, *F. virens*, *Terminalia alata*, *T. arjuna* are commonly found along the perennial streams and moist ravines.

2. **Tropical moist deciduous forest**: This type of vegetation is found usually in Amarkantak, Jaleshwar, Kapildhara, Rajendragram and Antaria areas. These forests are dominated by pure stands of Sal *Shorea robusta*. In open areas, mixed forests of semi-deciduous nature occur. Important constituents of these forests are *Aegle marmelos*, *Anogeissus latifolia*, *Bambusa arundinacea*, *Bauhinia purpurea*, *B. vahlii*, *Bridelia retusa*, *Butea monosperma*, *Careya arborea*, *Dillenia pentagyna*, *Ficus* spp., *Gardenia gummifera*, *Gmelina arborea*, *Haldinia cordifolia*, *Imperata cylindrica*, *Kydia calycina*, *Lagerstroemia parviflora*, *Mallotus philippensis*, *Mangifera indica*, *Phoenix acaulis*, *Pongamia pinnata*, *Pterocarpus marsupium*, *Schleichera oleosa*, *Tamarindus indica*, *Terminalia alata*, *Wendlandia tinctoria*, *Woodfordia fruticosa*, etc.

3. **Scrub and thorn forests**: This type of vegetation is found in Achanakmar, Jalda, Chaparwa, Kuba, Kota, Bokrakachar areas. These forests occur on exposed steep hill slopes and ridges, where drier conditions prevail. The biotic interferences and excessive grazing pressure has resulted in sparse tree layers and discontinuous vegetation, while shrubs become comparatively dense. These are characterized by stunted growth and many stemmed trees and shrubs with small thorny bushes. The common species recorded in this area are *Acacia* spp., *Balanites aegyptiaca*, *Butea monosperma*, *Calotropis gigantea*, *Calotropis procera*, *Carissa opaca*, *Euphorbia neriifolia*, *Mimosa himalayana*, *Woodfordia fruticosa*, etc.

4. **Ravinous vegetation**: The banks of Narmada and Son rivers are extremely undulated, and are characterized by innumerable ravines merging into the river bank and extending all along the course. The banks of these ravines and steeps contain some common species like *Butea monosperma*, *Tribulus terrestris*, etc. The flat river bank areas are used for cultivation and the common tree species found here are *Acacia nilotica* subsp. *indica*, *Bauhinia racemosa*,

Carissa opaca, *Euphorbia neriifolia*, *Flacourtia indica*, *Mallotus philippensis*, *Mimosa himalayana*, *Prosopis juliflora*, *Vitex negundo*, *Zizyphus mauritiana*, etc. Climbers and twines are represented by *Bauhinia vahlii*, *Caesalpinia bonduc*, *Cayratia trifolia*, *Celastrus paniculata*, *Cissampelos pareira* var. *hirsuta*, *Combretum nanum*, *Gymnemma sylvestre*, *Hemidesmus indicus*, *Ichnocarpus frutescens*, and many species of families Cucurbitaceae and Convolvulaceae. The herbaceous species are also common in the area and are represented by *Acanthospermum hispidum*, *Blainvillea acmella*, *Dicoma tomentosa*, *Echinops echinatus*, *Pulicaria angustifolia*, *Rungia repens*, *Tribulus terrestris*, *Withania somnifera*, *Zornia gibbosa*, etc. The grass cover consists of *Alloteropsis cimicina*, *Andropogon pumilus*, *Apluda mutica*, *Digitaria* spp., *Aristida* spp., *Heteropogon contortus*, *Themeda quadrivalvis*, etc.

5. **Grasslands**: Grasslands are found in places where forest has been cleared or in the plain areas. Grass vegetation is found usually in Gadasarai, Pendra, Karanjia, Jagatpur, Gorakhpur and Kota areas. Some common species found in these places are *Alloteropsis cimicina*, *Apluda mutica*, *Bothriochloa pertusa*, *Brachiaria ramosa*, *Cenchrus ciliaris*, *Chloris dolichostachya*, *Cynodon dactylon*, *Dichanthium annulatum*, *Rottboellia exaltata*, *Saccharum spontaneum*, *Setaria glauca*, *Sorghum halepense*, *Sporobolus diander*, *Themeda quadrivalvis*, *Vetiveria zizanioides*, *Digitaria* spp., *Echinochloa* spp., *Eragrostis* spp., *Panicum* spp., etc.

6. **Aquatic vegetation**: AABR is not rich in aquatic vegetation which occurs only in artificial places developed due to stagnant water of River Narmada at Amarkantak, Johilla at Jaleshwar, Son at Sonemuda, and small ditches. The aquatic vegetation comprises *Azolla pinnata* and *Lemna perpusilla* as free floating hydrophytes; *Ceratophyllum aurea* and *C. demersum* as submerged; *Hydrilla verticillata*, *Potamogeton nodosus*, *P. octandrus* and *Vallisneria spiralis* with floating shoots and *Aponogeton natans*, *Marsilea minuta*, *Monochoria vaginalis*, *Nelumbo nucifera*, *Nymphaea nouchali*, *N. pubescens* with floating leaves. Several other species like *Aeschynomene indica*, *Alternanthera sessilis*, *Ammania baccifera*, *A. multiflora*, *Bacopa monnieri*, *Coix gigantea*, *C. lacryma-jobi*, *Cyperus distans*, *C. nutans*, *C. pangorei*, *Echinochloa colona*, *Eleocharis dulcis*, *E. geniculata*, *Eriocaulon cinereum*, *Fimbristylis tetragona*, *Hoppea dichotoma*, *Hygrophila auriculata*, *Ischaemum rugosum*, *Ludwigia octovalvis*, *Panicum paludosum*, *Phragmites vallitoria*, *Phyla nodiflora*, *Polygonum barbatum*, *P. glabrum*, *Ranunculus scleratus*, *Rotala indica*, *R. rotundifolia*, *Schoenoplectus articulatus*, *Schoenoplectus mucronatus* and *Typha angustifolia* are found in marshy places.

Floristic Diversity

Saxena (1970) recorded 602 species of angiosperms from Amarkantak area to which Lal and Kumar (1999) added 6 species. Based on our own collections as well as earlier records (Mishra 1990; Verma *et al.* 1993; Mudgal *et al.* 1997; Singh *et al.* 2001; Khanna *et al.* 2001) the flora of the reserve presently comprises 1,011 species of flowering plants, distributed in 571 genera and 134 families. In addition, 2 species of gymnosperms, 35 species of pteridophytes, 28 species of bryophytes, 43 species of fungi and 120 species of lichens have also been recorded from the reserve. The present status of different groups of plants found in the biosphere reserve is given in Table 1.

Table 1: Status of different groups of plants in AABR

Name of the groups	Family	Genera	Species
Angiosperms	134	571	1011
Dicots	104	432	755
Monocots	30	139	256
Gymnosperms	2	2	2
Pteridophytes	17	25	35
Bryophytes	12	21	28
Fungi	16	36	43
Lichens	22	42	120
Total	187	697	1239

An analysis of vascular flora indicates that out of a total of 134 families in the Biosphere Reserve, 104 families (77.61%) belong to dicotyledons while 30 families (22.38%) belong to monocotyledons. Out of the total 571 genera, 432 genera are of dicotyledons (75.65 %), while 139 are of monocotyledons (24.34 %). Likewise, out of a total of 1,011 species, 755 (74.67%) are dicotyledons, while 256 (25.32%) are monocotyledons. A conspectus of families of flowering plants in AABR with number of genera and species is presented in Table 2.

Analysis of families in Table 2 reveals interesting information pertaining to the diversity of species and genera in the biosphere reserve as shown below.

(i) Species diversity under families:

Families with 1 species = 43
Families with 2 species = 26
Families with 3 species = 10
Families with 4-10 species = 31
Families with 11-20 species = 12
Families with 21-30 species = 6
Families with 31-50 species = 3
Families with 51-112 species = 3

Table 2: Families are arranged according to the number of species

Family	No. of Genera	No. of Species
Poaceae	65	112
Fabaceae	33	76
Asteraceae	45	72
Cyperaceae	11	40
Acanthaceae	19	36
Lamiaceae	17	31
Rubiaceae	18	25
Malvaceae	10	24
Convolvulaceae	8	24
Caesalpiniaceae	7	22
Euphorbiaceae	10	22
Scrophulariaceae	13	21
Verbenaceae	11	19
Orchidaceae	13	19
Tiliaceae	5	18
Solanaceae	9	18
Amaranthaceae	9	17
Moraceae	4	17
Apocynaceae	11	16
Commelinaceae	6	14
Apiaceae	9	13
Lythraceae	5	12
Cucurbitaceae	6	12
Mimosaceae	4	11
Asclepiadaceae	8	9
Zingiberaceae	5	9
Araceae	6	9
Rhamnaceae	4	8
Vitaceae	5	8
Combretaceae	4	8
Boraginaceae	5	8
Polygonaceae	2	8
Dioscoreaceae	1	8
Ranunculaceae	4	7
Oleaceae	2	7
Urticaceae	6	7
Liliaceae	6	7
Sterculiaceae	5	6
Oxalidaceae	2	6
Rutaceae	5	6
Myrtaceae	4	6
Eriocaulaceae	1	6
Brassicaceae	3	5
Polygalaceae	1	5
Caryophyllaceae	3	5
Anacardiaceae	5	5
Onagraceae	1	5
Gentianaceae	4	5
Lentibulariaceae	5	5
Bignoniaceae	4	5
Nyctaginaceae	4	5
Annonaceae	3	4
Sapindaceae	4	4
Campanulaceae	2	4
Amaryllidaceae	2	4

Table 2: Families are arranged according to the number of species (*contd.*)

Family	No. of Genera	No. of Species
Menispermaceae	3	3
Flacourtiaceae	2	3
Burseraceae	3	3
Meliaceae	3	3
Leeaceae	1	3
Rosaceae	3	3
Melastomataceae	2	3
Chenopodiaceae	2	3
Loranthaceae	3	3
Ulmaceae	3	3
Dilleniaceae	1	2
Capparaceae	2	2
Portulacaceae	1	2
Hypericaceae	1	2
Bombacaceae	2	2
Malpighiaceae	2	2
Celastraceae	2	2
Droseraceae	1	2
Cactaceae	1	2
Molluginaceae	2	2
Primulaceae	2	2
Myrsinaceae	2	2
Sapotaceae	2	2
Ebenaceae	1	2
Menyanthaceae	1	2
Gesneriaceae	2	2
Pedaliaceae	2	2
Lauraceae	1	2
Hydrocharitaceae	2	2
Musaceae	2	2
Cannaceae	2	2
Agavaceae	1	2
Smilacaceae	1	2
Juncaceae	1	2
Arecaceae	1	2
Potamogetonaceae	1	2
Nymphaeaceae	1	1
Papaveraceae	1	1
Violaceae	1	1
Bixaceae	1	1
Elatinaceae	1	1
Dipterocarpaceae	1	1
Zygophyllaceae	1	1
Geraniaceae	1	1
Tropaeolaceae	1	1
Balsaminaceae	1	1
Simaroubaceae	1	1
Moringaceae	1	1
Crassulaceae	1	1
Haloragidaceae	1	1
Lecythidaceae	1	1
Punicaceae	1	1
Trapaceae	1	1
Turneraceae	1	1
Passifloraceae	1	1

Table 2: Families are arranged according to the number of species (*contd.*)

Family	No. of Genera	No. of Species
Caricaceae	1	1
Begoniaceae	1	1
Alangiaceae	1	1
Stylidaceae	1	1
Lobeliaceae	1	1
Plumbaginaceae	1	1
Orobanchaceae	1	1
Aristolochiaceae	1	1
Piperaceae	1	1
Proteaceae	1	1
Casuarinaceae	1	1
Salicaceae	1	1
Burmaniaceae	1	1
Costaceae	1	1
Iridaceae	1	1
Hypoxidaceae	1	1
Taccaceae	1	1
Pontederiaceae	1	1
Pandanaceae	1	1
Typhaceae	1	1
Alismataceae	1	1
Limnocharitaceae	1	1
Aponogetonaceae	1	1
Zannichelliaceae	1	1
Total = 134	571	1011

(ii) Generic diversity under families:

Families with 1 genus = 61
Families with 2 genera = 21
Families with 3 genera = 9
Families with 4-5 genera = 19
Families with 6-10 genera = 13
Families with 11-20 genera = 8
Families with 21-40 genera = 1
Families with 41-65 genera = 2

Most families had 1, 2 or 4-10 species, each; only 6 families had more than 30 species each. Only 11 families had more than 10 genera each, while most families had 1, 2, 4-5 or 6-10 genera, each.

Analysis of species diversity within genera is also interesting as shown below.

(iii) Species diversity under genera:

Genera with 1 species = 372
Genera with 2 species = 103
Genera with 3 species = 37
Genera with 4 species = 16
Genera with 5-10 species = 33
Genera with 11-15 species = 5

The majority of genera had 10 species, each. The above analysis of families and genera indicates a marked amount of higher-order diversity. In other words, disappearance of a few species may substantially impact at the level of genera/families.

In order of dominance, the grass family Poaceae ranks first with 112 species belonging to 65 genera. It is followed by Fabaceae with 76 species, Asteraceae with 72 species, Cyperaceae with 40 species, Acanthaceae with 36 species, Lamiaceae with 31 species, etc. as shown in Table 2.

Within Poaceae, *Eragrostis* is the dominant genus and was represented by 9 species followed by *Panicum* with 6 species, *Setaria*, *Sporobolus*, and *Digitaria* with 5 species each, *Pennisetum* and *Bothriochloa* with 4 species each. Within Fabaceae, *Crotalaria* is the dominant genus with 12 species, followed by *Indigofera* with 7 species, *Alysicarpus*, *Desmodium* with 6 species each, *Vigna* with 5 species and *Flemingia* with 4 species.

Blumea is the dominant genus, within Asteraceae, with 8 species, followed by *Conyza* with 5 species, *Sonchus* with 4 species, *Gnaphalium* with 3 species. *Acanthospermum*, *Adenostemma*, *Blainvillea*, *Blumeopsis*, *Caesulia*, *Centipeda*, *Cosmos*, *Crassocephalum*, *Cythocline*, *Eclipta*, *Elephantopus*, *Erigeron* are known by a single species each.

Within Cyperaceae, *Cyperus* is the dominant genus with 15 species, followed by *Fimbristylis* with 5 species, *Carex* with 4 species, *Eleocharis*, *Pycreus* with 3 species each.

The species diversity at generic level is also equally interesting. The sedge genus *Cyperus* is the largest and is represented by 15 species, followed by *Ficus* with 12 species, *Crotalaria* with 12 species, *Ipomoea* and *Cassia* with 11 species each, etc. as shown in Table 3.

Diversity of the Biosphere Reserve is also enriched by the presence of 17 monotypic genera. They are *Schleichera*, *Limonia*, *Haldina*, *Blumeopsis*, *Ougeinia*, *Pongamia*, *Woodfordia*, *Caesulia*, *Hemidesmus*, *Nicandra*, *Oroxylum*, *Colebrookea*, *Tamarindus*, *Ricinus*, *Gloriosa*, *Apluda* and *Thysanolaena*. Besides, some genera represented in India by a single species are also found in the reserve. They are *Cissampelos*, *Aegle*, *Dodonaea*, *Diplocyclos*, *Centella*, *Blainvillea*, *Centipeda*, *Eclipta*, *Lagascea*, *Siegesbeckia*, *Tridax*, *Holarrhena*, *Rotula*, *Petalidium*, *Dunrauta*, *Tectona*, *Costus* and *Floscopa*.

In addition, many families are represented by single genus and species in the reserve. These are Nymphaeaceae, Papaveraceae, Violaceae, Bixaceae, Elatinaceae, Dipterocarpaceae, Zygophyllaceae, Geraniaceae, Tropaeolaceae, Balsaminaceae, Simaroubaceae, Moringaceae, Crassulaceae, Haloragidaceae, Lecythidaceae, Punicaceae, Trapaceae, Turneraceae, Passifloraceae, Caricaceae, Begoniaceae, Alangiaceae, Stylidaceae, Lobeliaceae, Plumbaginaceae, Orobanchaceae, Aristolochiaceae, Piperaceae, Proteaceae, Casuarinaceae, Salicaceae, Burmaniaceae, Costaceae, Iridaceae, Hypoxidaceae, Taccaceae, Pontederiaceae, Pandanaceae, Typhaceae, Alismataceae, Limnocharitaceae, Aponogetonaceae and Zannichelliaceae.

It is interesting to note that Leeaceae, Moringaceae, Begoniaceae, Ebenaceae, Menyanthaceae, Cannaceae and Eriocaulaceae which are represented by a single genus in India also occur in the biosphere reserve.

Gymnosperms: The wild Gymnosperms are not found in the area. Only species of *Pinus* and *Thuja* are cultivated by the state forest department in small patches in the reserve.

Pteridophytes: Pteridophytes are fairly well-represented in the Biosphere Reserve and grow in moist places usually as epiphytes or on land. At present, 35 species belonging to 25 genera and 17 families are recorded. Many species of pteridophytes like *Adiantum philippense*, *Lygodium flexuosum*, *Ophioglossum reticulatum*, etc. are used as medicinal plants by the local inhabitants and thus, becoming rare in the reserve due to over exploitation. The Family Thelypteridaceae comprises 5 species, followed by Selaginellaceae and Polypodiaceae with 4 species each, Pteridaceae with 3 species and Equisetaceae, Cheilanthaceae, Adiantaceae and Athyriaceae with 2 species each. Similarly dominant genera of the reserve are *Selaginella* with 4 species, followed by *Pteris* with 3 species, *Equisetum*, *Cheilanthus*, *Adiantum*, *Christella* and *Dryopteris* with 2 species each.

Bryophytes: Like lichens, Bryophytic vegetation is not so rich. The bryophytes grow usually in moist places on stones, tree trunks and ground in moist and shady places, particularly near streams and banks of rivers. Nath *et al.* (2007) studied the mosses from the area and recorded 28 species under 21 genera. The Family Hypnaceae comprises maximum number of 6 species, followed by Thuidiaceae with 4 species and Bryaceae with 3 species. Similarly, genera *Thuidium* and *Entodontopsis* contain 3 species each, followed by *Entodon* and *Fissidens* with 2 species each. Besides, Hepaticae and Hornworts are represented by 23 species under 18 genera from the area (Nath pers. comm.). Most of the Bryophytes belong to epiphytic forms and mosses are more predominant in Kapildhara locality.

Fungi and lichens: Fungi are not well worked out in the reserve. So far, only 43 species of macrofungi under 36 genera and 16 families are recorded from the area. Lichen flora of the area is also not rich as it is confined usually on Sal trees and boulders found in mixed or Sal forests in shady or moist places. The lichens also occur on stones present near streams, nullhas, waterfalls and river course. It is interesting to note that 45 species of lichens recorded were growing on Sal trees. This shows that *Shorea robusta* (Sal) is an excellent host tree for lichen growth in the reserve and justifies the observations made by Satya *et al.* (2005). Upreti *et al.* (2005) and Nayaka *et al.* (2007) recorded 120 species under 42 genera and 22 families from the reserve. The dominant Family was Physciaceae with 28 species, followed by Collemataceae and Pertusariaceae with 15 species each, Parmeliaceae with 14 species, Lecnoraceae with 12 species and Bacidiaceae with 5 species. Genera-wise analysis indicated that *Pertusaria* was represented by 14 species, followed by *Lecnora* with 12 species, *Leptogium* with 10 species, *Parmotrema*, *Heterodermia* and *Pyxine* with 6 species each, *Bacidia*, *Collema* and *Buellia* with 5 species each. Species like *Heterodermia diademata*, *Parmotrema praesorediosum*, *Parmotrema tinctorum*, etc. are used as spices and sold in the market by local Gond, Murea and Oraon tribes to earn their livelihood.

Table 3: Ten dominant genera of the AABR

Name of genera	Number of species
Cyperus	15
Ficus	12
Crotalaria	12
Ipomoea	11
Cassia	11
Blumea	8
Grewia	8
Indigofera	7
Eragrostis	7
Panicum	7

Invasive Alien Species

Invasive alien species are non-native organisms that cause or have the potential to cause harm to the environment, economies, or human health. The establishment and spread of these species threaten ecosystems, habitats, or species with economic/environmental harm. They are the second largest threat to plant diversity after habitat destruction. Total 106 invasive alien species belonging to 77 genera, distributed in 36 families were documented (Shukla *et al.* 2009). Majority of invasive alien species have been contributed by Tropical America (including South America) and Tropical Africa. Habit-wise analysis shows that the herbs were represented

by 80 species, shrubs by 12 species, twines by 7 species, climbers by 5 species, and trees by 2 species. In the alien flora of the reserve, Asteraceae is the most dominant family with 25 species, followed by Caesalpiniaceae with 7 species, Amaranthaceae with 7 species, etc. Maximum invasive species are found in wastelands (45 species), followed by cultivated land (17 species), river and pond banks (16 species), forests (13 species), road sides (9 species), aquatic habitats (4 species), and as parasites (2 species). *Lantana camara*, *Parthenium hysterophorus* and *Prosopis juliflora* in open dry places in the forest are the dominant invasive species of the reserve found growing luxuriantly in localities like Chaparwa, Kabirchabutra, Jaleswar, etc. Some parts of Achanakmar Wildlife Sanctuary, namely Jalda, Kuba and Kota are also infested by this species. The plain areas of the reserve like Karanjia, Jagatpur, Gadasari, etc. are highly infested by *Parthenium hysterophorus*, *Argemone mexicana*, *Xanthium indicum* and *Ageratum conyzoides*.

Economic Plants

Achanakmar-Amarkantak Biosphere Reserve (AABR) has a rich wealth of plants having economic potential as crop, timber, medicinal, ornamental and in ethnobotany (Bondya *et al.* 2006; Shukla *et al.* 2007). The sustainable utilization of these species may lead to the social and economic growth of the rural folks living in the area. Many wild plants occurring in the area are useful in different aspects of life of the common people. A variety of plant species found in the Biosphere Reserve are being used for various other purposes. They along with their uses are presented in Table 4.

Table 4: Some economically important plants

Species	Agricultural implement	Dye	Fibre	Fodder	Fuel	Gum	Timber	Medicinal	Wild edible
Abelmoschus manihot	-	-	-	-	-	-	-	-	+
Abrus precatorius	-	-	-	-	-	-	-	+	-
Abutilon indicum	-	-	-	-	-	-	-	+	-
Acacia catechu	-	+	-	-	+	-	+	-	-
Acacia nilotica subsp. *indica*	-	-	-	-	-	+	-	-	-
Achyranthes aspera	-	-	-	-	-	-	-	+	-
Adhatoda zeylanica	-	-	-	-	-	-	-	-	+
Aegle marmelos	-	-	-	-	+	-	-	+	+
Agave cantula	-	-	+	-	-	-	-	-	-
Albizia lebbeck	-	-	-	-	+	-	+	-	-
Albizia odoratissima	-	-	-	+	-	-	+	-	-
Albizia procera	+	-	-	-	-	-	-	-	-
Alternanthera sessilis	-	-	-	-	-	-	-	-	+
Amaranthus viridis	-	-	-	-	-	-	-	-	+
Ampelocissus latifolia	-	-	-	-	-	-	-	-	-
Anacardium occidentale	-	-	-	-	-	-	-	-	+
Andrographis paniculata	-	-	-	-	-	-	-	+	-
Anogeissus latifolia	-	-	-	-	-	-	-	+	-
Annona squamosa	-	-	-	-	-	-	-	+	-
Ardisia solanacea	-	-	-	-	-	-	-	-	-
Artocarpus heterophyllus	-	-	-	-	-	-	-	-	+
Artocarpus lakoocha	-	-	-	-	-	-	-	-	+
Asparagus racemosus	-	-	-	-	-	-	-	+	-
Azadirachta indica	-	-	-	-	+	-	+	+	-
Baliospermum solanifolium	-	-	-	-	-	-	-	-	+
Barleria prionitis	-	-	-	-	-	-	-	+	-
Bauhinia malabarica	-	-	-	-	-	-	-	-	+
Bauhinia racemosa	-	-	-	-	-	-	-	-	+
Bauhinia vahlli	-	-	+	+	-	-	-	-	+
Bauhinia variegata	-	-	-	+	+	-	+	+	+
Bidens biternata	-	-	-	-	-	-	-	+	-
Blumea lacera	-	-	-	-	-	-	-	+	-
Boehmeria platyphylla	-	-	-	-	-	+	-	-	-
Bombax ceiba	-	-	+	-	-	-	+	+	-
Boswellia serrata	-	-	-	-	-	+	-	+	-

Table 4: Some economically important plants (*contd.*)

Species	Agricultural implement	Dye	Fibre	Fodder	Fuel	Gum	Timber	Medicinal	Wild edible
Broussonesia papyrifera	-	-	+	-	-	-	-	-	-
Buchanania lanzan	-	-	-	-	-	-	-	+	+
Butea monosperma	-	+	-	-	-	-	-	-	-
Calotropis gigantea	-	-	-	-	-	-	-	+	-
Careya arborea	-	-	-	-	-	-	-	+	-
Carissa congesta	-	-	-	-	-	-	-	+	+
Cassia fistula	-	-	-	-	+	-	+	+	-
Cassia siamea	-	-	-	-	-	-	+	-	-
Celosia argentea	-	-	-	-	-	-	-	-	+
Centella asiatica	-	-	-	-	-	-	-	+	-
Chenopodium album	-	-	-	-	-	-	-	-	+
Cissampelos pareira	-	-	-	+	-	-	-	+	-
Cleome viscose	-	-	-	-	-	-	-	+	-
Clerodendrum serratum	-	-	-	-	-	-	-	+	-
Cocculus laurifolius	-	-	-	-	-	+	-	-	-
Colocasia esculenta	-	-	-	-	-	-	-	-	+
Corchorus aestuans	-	-	+	-	-	-	-	-	-
Corchorus capsularis	-	-	-	-	-	-	-	-	+
Cordia dichotoma	-	-	-	-	-	-	-	+	+
Crotalaria albida	-	-	-	-	+	-	-	-	-
C. tetragonal	-	-	-	+	+	-	-	-	-
Curcuma angustifolia	-	-	-	-	-	-	-	-	+
Cymbopogon martinii	-	-	-	+	-	-	-	-	-
Cyperus rotundus	-	-	-	-	-	-	-	+	-
Dalbergia latifolia	-	-	-	+	-	-	+	-	-
Dalbergia paniculata	-	-	-	-	-	-	+	-	-
Dalbergia sissoo	-	-	-	+	-	-	+	-	-
Datura innoxia	-	-	-	-	-	-	-	+	-
Delonix regia	-	-	-	-	-	-	+	-	-
Dendrocalamus strictus	-	-	-	+	-	-	-	-	+
Dillenia pentagyna	-	-	-	-	-	-	-	+	+
Dioscorea bulbifera	-	-	-	-	-	-	-	-	+
Dioscorea pentaphylla	-	-	-	-	-	-	-	-	+
Diospyros melanoxylon	-	-	-	-	-	-	-	+	-
Dodonaea angustifolia	-	-	-	-	-	-	-	+	-
Elephantopus scaber	-	-	-	-	-	-	-	+	-
Emblica officinalis	-	-	-	-	-	-	-	-	+
Eryngium foetidum	-	-	-	-	-	-	-	-	+
Eucalyptus maculata	-	-	-	-	-	-	+	-	-
Eucalyptus umbellata	-	-	-	-	-	-	+	-	-
Euphorbia neriifolia	-	-	-	-	-	-	-	+	-
Euphorbia pulcherrima	-	-	-	-	-	-	-	+	-
Evolvulus alsinoides	-	-	-	-	-	-	-	+	-
Ficus auriculata	-	-	-	-	+	+	+	-	+
Ficus benghalensis	-	-	-	-	-	-	-	+	+
Ficus carica	-	-	-	-	+	-	-	-	+
Ficus glomerata	-	-	-	-	-	-	-	-	+
Ficus hispida	-	-	-	-	-	-	-	+	+
Ficus microcarpa	-	-	-	-	-	-	-	+	-
Ficus palmata	-	-	-	-	-	-	-	-	+
Ficus racemosa	-	-	-	-	-	-	-	-	+
Ficus semicordata	-	-	-	-	-	-	-	-	+
Ficus tinctoria	-	-	-	-	-	-	-	-	+
Ficus virens	-	-	-	-	-	-	-	-	+
Flacourtia indica	-	-	-	-	-	-	-	+	+

Table 4: Some economically important plants (*contd.*)

Species	Agricultural implement	Dye	Fibre	Fodder	Fuel	Gum	Timber	Medicinal	Wild edible
Gardenia latifolia	-	-	-	-	-	-	-	+	-
Gloriosa superba	-	-	-	-	-	-	-	+	-
Gmelina arborea	-	-	-	-	-	-	+	-	-
Grevillea robusta	-	-	-	-	-	-	+	-	-
Grewia flavescens	-	-	-	-	-	-	-	-	+
Grewia hirsuta	-	-	-	-	-	-	-	+	-
Grewia rothii	-	-	-	-	-	-	-	-	+
Grewia serrulata	-	-	+	-	-	-	-	-	-
Gymnema sylvestre	-	-	-	-	-	-	-	+	-
Hardwickia binata	-	-	+	-	-	-	-	-	-
Hibiscus rosa-sinensis	-	-	-	-	-	-	-	+	-
Hibiscus sabdariffa	-	-	+	-	-	-	-	-	-
Helicteres isora	-	-	-	-	-	-	-	+	-
Hemidesmus indicus	-	-	-	-	-	-	-	+	-
Hiptage benghalensis	-	-	-	-	+	-	-	+	-
Holarrhena pubescens	-	-	-	-	-	-	-	+	-
Ipomoea aquatica	-	-	-	-	-	-	-	-	+
Ixora pavetta	-	-	-	-	-	-	-	+	-
Kydia calycina	-	-	-	-	-	-	+	+	-
Lannea coromandelica	-	-	-	-	-	+	+	+	-
Leucas cephalotes	-	-	-	-	-	-	-	+	-
Limonia acidissima	-	-	-	-	-	-	-	-	+
Litsea glutinosa	-	-	-	-	-	-	-	+	-
Madhuca longifolia var. *latifolia*	-	-	-	-	-	-	-	-	+
Mallotus philippensis	-	+	-	-	-	-	-	+	-
Mangifera indica	-	-	-	-	-	-	+	-	-
Melia azedarach	-	-	-	+	-	-	-	-	-
Mitragyna parvifolia	-	-	-	-	-	-	-	+	-
Momordica dioica	-	-	-	-	-	-	-	+	-
Momordica charantia	-	-	-	-	-	-	-	+	+
Moringa oleifera	-	-	-	-	-	-	-	+	+
Morus alba	-	-	-	-	-	-	-	-	+
Murraya koenigii	-	-	-	-	-	-	-	-	+
Nyctanthes arbor-tristis	-	+	-	-	-	-	-	+	-
Nymphoides indica	-	-	-	-	-	-	-	-	+
Oroxylum indicum	-	-	-	-	-	-	-	+	-
Ougeinia oojeinensis	-	-	-	-	-	-	+	-	-
Oxalis corniculata	-	-	-	-	-	-	-	-	+
Parkinsonia aculeata	-	-	-	-	+	-	-	-	-
Phoenix acaulis	-	-	-	-	-	-	-	-	+
Phoenix sylvestris	-	-	-	-	-	-	-	-	+
Phragmites vallitoria	-	-	-	+	-	-	-	-	-
Phyllanthus emblica	-	-	-	-	-	-	-	+	-
Pinus roxburghii	-	-	-	-	+	-	-	-	-
Plumbago zeylanica	-	-	-	-	-	-	-	+	-
Pongamia pinnata	-	-	-	-	-	-	-	+	-
Portulaca oleracea	-	-	-	-	-	-	-	-	+
Punica granatum	-	-	-	-	-	-	-	-	+
Radermachera xylocarpa	-	-	-	-	-	-	-	+	-
Ricinus communis	-	-	-	-	-	-	-	+	-
Saccharum spontaneum	-	-	-	+	-	-	-	-	-
Salix tetrasperma	-	-	-	-	-	-	-	+	-
Schleichera oleosa	-	-	-	-	-	-	+	-	-
Semecarpus anacardium	-	-	-	-	-	-	-	+	+
Shorea robusta	-	-	-	-	-	+	+	-	-

Table 4: Some economically important plants (*contd.*)

Species	Agricultural implement	Dye	Fibre	Fodder	Fuel	Gum	Timber	Medicinal	Wild edible
Sida acuta	-	-	-	-	-	-	-	+	-
Sida alba	-	-	-	-	-	-	-	+	-
Sida cordifolia	-	-	-	-	-	-	-	+	-
Solanum incanum	-	-	-	-	-	-	-	+	-
Solanum nigrum	-	-	-	-	-	-	-	+	+
S. torvum	-	-	-	-	-	-	-	-	+
Spermacoce hispida	-	-	-	-	-	-	-	+	-
Sphaeranthus indicus	-	-	-	-	-	-	-	+	-
Spilanthes paniculata	-	-	-	-	-	-	-	+	-
Sterculia urens	-	-	-	-	-	+	-	+	-
Sterculia villosa	-	-	-	-	-	-	-	+	-
Stereospermum chelonoides	-	-	-	-	-	-	-	+	-
Syzygium cumini	-	-	-	-	-	-	+	-	-
Syzygium jambos	-	-	-	-	-	-	-	-	+
Tamarindus indica	-	-	-	-	-	-	-	-	+
Tectona grandis	-	-	-	-	-	-	+	-	-
Tephrosia purpurea	-	-	-	-	-	-	-	+	-
Terminalia alata	-	-	-	-	-	-	+	-	-
Terminalia arjuna	-	-	-	-	-	-	-	+	-
Terminalia bellirica	-	-	-	-	-	-	-	-	-
Terminalia chebula	-	-	-	-	-	-	-	+	-
Thysanolaena maxima	-	-	-	+	-	-	-	-	-
Tinospora cordifolia	-	-	-	-	-	-	-	+	-
Trapa bispinosa	-	-	-	-	-	-	-	-	+
Trichodesma indicum	-	-	-	-	-	-	-	+	-
Tridax procumbens	-	-	-	-	-	-	-	+	-
Triumfetta rhomboidea	-	-	+	-	-	-	-	-	-
Ventilago denticulata	-	-	-	-	-	-	-	+	-
Vernonia cinerea	-	-	-	-	-	-	-	+	-
Vitex negundo	-	-	-	-	-	-	-	+	-
Vetiveria zizanioides	-	-	-	+	-	-	-	-	-
Wendlandia heynei	+	-	-	-	-	-	-	-	-
Woodfordia fruticosa	-	+	-	+	+	-	-	+	-
Wrightia tinctoria subsp. *rothii*	-	+	-	-	-	-	-	+	-
Xanthium indicum	-	-	-	-	-	-	-	+	-
Zizyphus mauritiana	-	-	-	+	-	-	-	+	+
Zizyphus rugosa	-	-	-	-	-	-	-	-	+
Zizyphus xylopyra	+	-	-	-	-	-	-	-	-

Rare and Threatened Species

Conservation of plant resources and its sustainable use is essential for human survival and is the prime objective of Convention on Biological Diversity (CBD). As such our knowledge on the rare and threatened plants is indeed poor. It is already mentioned that the area is rich in medicinal plants. Many species are collected on a large scale by the local communities and supplied to medicine men and traders in order to earn their livelihood. As a result, many species have become rare or threatened in the area. We do not have much quantitative data on rare and threatened species. However, Dubey *et al.* (2007) have listed many plant species under these categories. Some of these are provided here as ready reference for future workers to work on this. These are *Acorus calamus*, *Amorphophallus paeoniifolinus*, *Arisaema griffithii*, *Cordia macleodii*, *Didymocarpus pygmaea*, *Dioscorea pentaphylla*, *Drosera burmanni*, *Hymenodictyon orixense*, *Oroxylum indicum*, *Pandanus odoratissimus*, *Radermachera xylocarpa*, etc.

DISCUSSION

The present study revealed the occurrence of 1,011 species, distributed under 571 genera and 134 families of flowering plants. Two species of Gymnosperms, *Pinus* and *Thuja*, are found in the area. Pteridophytes are fairly well-

represented in the biosphere reserve and grow in moist places usually as epiphytes or terrestrial; at present 35 species belonging to 25 genera and 17 families are recorded. Bryophytic vegetation is not so rich only 28 species under 21 genera were recorded from the reserve. Fungi are not well worked out in the reserve so far, only 43 species of macrofungi under 36 genera are recorded from the area. Lichen flora of the area is also not rich as it is confined usually on Sal trees and boulders found in mixed or Sal forests in shady or moist places; total 120 species under 42 genera and 22 families were recorded from the reserve.

ACKNOWLEDGEMENTS

We thank the Director, Botanical Survey of India, Kolkata, for encouragement and facilities. One of the authors (A.N. Shukla) is also thankful to the Ministry of Environment and Forests, New Delhi, for financial assistance under Achanakmar-Amarkantak Biosphere Reserve project.

REFERENCES

Bondya, S.L., K.K. Khanna & K.P. Singh (2006): Ethnomedicinal uses of leafy vegetables from the folk-lore of Achanakmar-Amarkantak Biosphere Reserve (Madhya Pradesh and Chhattisgarh). *Ethnobotany 18*: 145-148.

Dubey, P.C., K.K. Khanna, R.L.S. Sikarwar & A.P. Tiwari (2007): Threat assessment of plant diversity in Amarkantak area. Pp. 55-79. *In*: Joshi, K.C. & A.K. Mandal (Eds): Research needs for Achanakmar-Amarkantak Biosphere Reserve.

Khanna, K.K., A. Kumar, R.D. Dixit & N.P. Singh (2001): Supplement to the Flora of Madhya Pradesh, Botanical Survey of India. Calcutta.

Lal, J. & A. Kumar (1999): Notes on some rare plants from Amarkantak (Madhya Pradesh). *J. Econ. Taxon. Bot. 23(3)*: 739-741.

Mishra, O.P. (1990): Addition to the flora of Amarkantak (M.P.). *J. Econ. Taxon. Bot. 14(1)*: 198-200.

Misra, R. (1953): The vegetation of Amarkantak. *Bull. Bot. Soc. Univ. Sagar. 8*: 1-2.

Mudgal, V., K.K. Khanna & P.K. Hajra (1997): Flora of Madhya Pradesh, Vol. 2, Botanical Survey of India, Calcutta. 681 pp.

Nath, V., A.K. Asthana & R. Kapoor (2007): Enumeration of the mosses in Amarkantak (Madhya Pradesh), India – I. *Taiwania. 52(2)*: 168-176.

Nayaka, S., Satya & D.K. Upreti (2007): Lichen diversity in Achanakmar Wildlife Sanctuary core area of proposed Amarkantak Biosphere Reserve, Chhattisgarh. *J. Econ. Taxon. Bot. 31(1)*: 133-142.

Sahu, P.K. & J.S. Singh (2008): Structural attributes of lantana-invaded forest plots in Achanakmar-Amarkantak Biosphere Reserve, Central India. *Curr. Sci. 95(4)*: 494-500.

Sahu, P.K., R. Sagar & J.S. Singh (2008): Tropical forest structure and diversity in relation to altitude and disturbance in a Biosphere Reserve in central India. *Applied Vegetation Science 11*: 461-470.

Satya, D.K. Upreti & S. Nayaka (2005): *Shorea robusta* – an excellent host tree for lichen growth in India. *Curr. Sci. 89(4)*: 594-595.

Saxena, H.O. (1970): The flora of Amarkantak, Madhya Pradesh. *Bull. Bot. Surv. India. 12(1-4)*: 37-66.

Shukla, A.N. & K.P. Singh (2007): Diversity of woody plants in Achanakmar-Amarkantak Biosphere Reserve, Central India, *Indian J. Forest. 31(2)*: 269-282.

Shukla, A.N., K.P. Singh & A. Kumar (2007): Ethnoveterinary uses of plants from Achanakmar-Amarkantak Biosphere Reserve, Madhya Pradesh and Chhattisgarh. *J. Non-Timber For. Prod. 14(1)*: 53-55.

Shukla, A.N., K.P. Singh & J.S. Singh (2009): Invasive Alien species of Achanakmar-Amarkantak Biosphere Reserve, Central India. *Proc. Natl. Acad. Sci. India, B, 79(4)*: 384-392.

Singh, N.P., K.K. Khanna, V. Mudgal & R.D. Dixit (2001): Flora of Madhya Pradesh, Vol.-3, Botanical Survey of India, Calcutta. 587 pp.

Upreti, D.K., S. Nayaka & Satya (2005): Enumeration of lichens from Madhya Pradesh and Chhattisgarh, India. *J. Appl. Biosci. 31(1)*: 55-63.

Verma, D.M., N.P. Balakrishnan & R.D. Dixit (1993): Flora of Madhya Pradesh. Vol. 1, Botanical Survey of India, Calcutta. 668 pp.

■ ■ ■

IMPACT OF LANDUSE CHANGES ON PLANT SPECIES DIVERSITY OF NOKREK BIOSPHERE RESERVE, MEGHALAYA, INDIA

S.D. Prabhu[1], S.K. Barik[2,3], H.N. Pandey[2,4] and R.S. Tripathi[2,5]

[1]Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk, Shaheed Bhagat Singh Road, Mumbai 400 001, Maharashtra, India. Email: swapnaprabhu@gmail.com
[2]North Eastern Hill University, Umshing Mawkynroh Shillong 793 022, Meghalaya, India.
[3]Email: sarojkbarik@gmail.com
[4]Email: pandeyhn@yahoo.com
[5]Email: tripathirs@yahoo.co.uk

The impact of land use changes driven by various anthropogenic disturbances on the taxonomic diversity of Nokrek Biosphere Reserve (NBR) in north-east India has been studied. Twelve ecosystems representing natural, semi-natural, man-managed and man-damaged ecosystems were identified. In total, 710 vascular plant species belonging to 465 genera and 140 families were recorded from these communities. The flora of the NBR exhibits saturation of eastern Asiatic elements. Although the elements from 11 biogeographical regions of the world were found in the flora of the undisturbed ecosystems of the NBR, Indo-Malayan, Himalayan and Indo-Burman elements dominated the flora constituting about 86% of the total species content. Ninety-nine threatened categories of species, including 43 endemics, were recorded from the NBR. The presence of a large number of rare taxa with small populations and habitat-specificity indicates the vulnerability of threatened category of species.

The taxonomic diversity of the secondary forest communities on mining areas and other man-made ecosystems has been drastically reduced. The pace of recovery in species diversity in the communities on the jhum fields was slow, as only 67% of the total species content could recover after 12 years of vegetation development.

Key words: Floristic elements, Taxonomic diversity, Endemic and threatened species, Rarity

INTRODUCTION

The impact of human activities on species diversity has attracted the interest of ecologists from both theoretical as well as applied perspectives (Stapanian *et al.* 1997). Clements (1936) viewed disturbance as a negative force that destroys climax assemblages and brings instability in the system, while Paine (1966), Huston (1979) and Lubchenco (1978) considered it as a positive force that might increase species diversity in the community by preventing competitive exclusion. The species richness has been correlated with natural disturbance by several workers (Grubb 1977; Connell 1978; Grime 1979; Huston 1979; Armesto and Pickett 1985). Connell (1978) proposed that the tree diversity in the rain forests would be greatest where disturbances are moderate in intensity and frequency. Similarly, Collins *et al.* (1995) and Molino and Sabatier (2001) argued that species richness should be highest at intermediate disturbance level when conditions favour the competitive species as well as disturbance-tolerant species. However, the impact of disturbances on diversity at landscape level is poorly understood.

The north-eastern region of India being situated in the transitional zone of Indian, Indo-Malayan and Indo-Chinese biogeographical zones has been a focal point of botanical attention since nineteenth century due to their floristic richness and high endemism. Under the *in situ* biodiversity conservation initiative, a large network of protected areas including 11 National Parks, 41 Wildlife Sanctuaries and 4 Biosphere reserves have been constituted in the region. Although a number of floristic studies have been carried out in the region (Hooker 1872-1897; Kanjilal *et al.* 1934-1940; Rao and Panigrahi 1961; Rao 1969a, b; Balakrishnan 1981-1983; Haridasan and Rao 1985-87), only a few studies have focused on protected areas (Kumar 1984; Tiwari *et al.* 1998; Jamir and Pandey 2003; Upadhaya *et al.* 2003). A detailed analysis of the impact of anthropogenic stresses on taxonomic and community diversity at landscape level has been hardly attempted (see Rao *et al.* 1990).

Nokrek, which was identified as a reservoir of a large variety of wild relatives of *Citrus* species cultivated throughout north-eastern India, was designated as National Park (NP) in 1986. The Nokrek Biosphere Reserve (NBR) was constituted by the Ministry of Environment and Forests, Government of India, in 1988. The Nokrek National Park was designated as the core zone and the surrounding community forests were treated as the buffer zone of NBR. This multipurpose buffer zone of the biosphere reserve provided an excellent site to assess the impact of human activities on species and ecosystem diversity at the landscape level. The present paper aims to examine how shifting cultivation and other human activities are influencing the ecosystem and taxonomic diversity of a tropical biosphere reserve at landscape level.

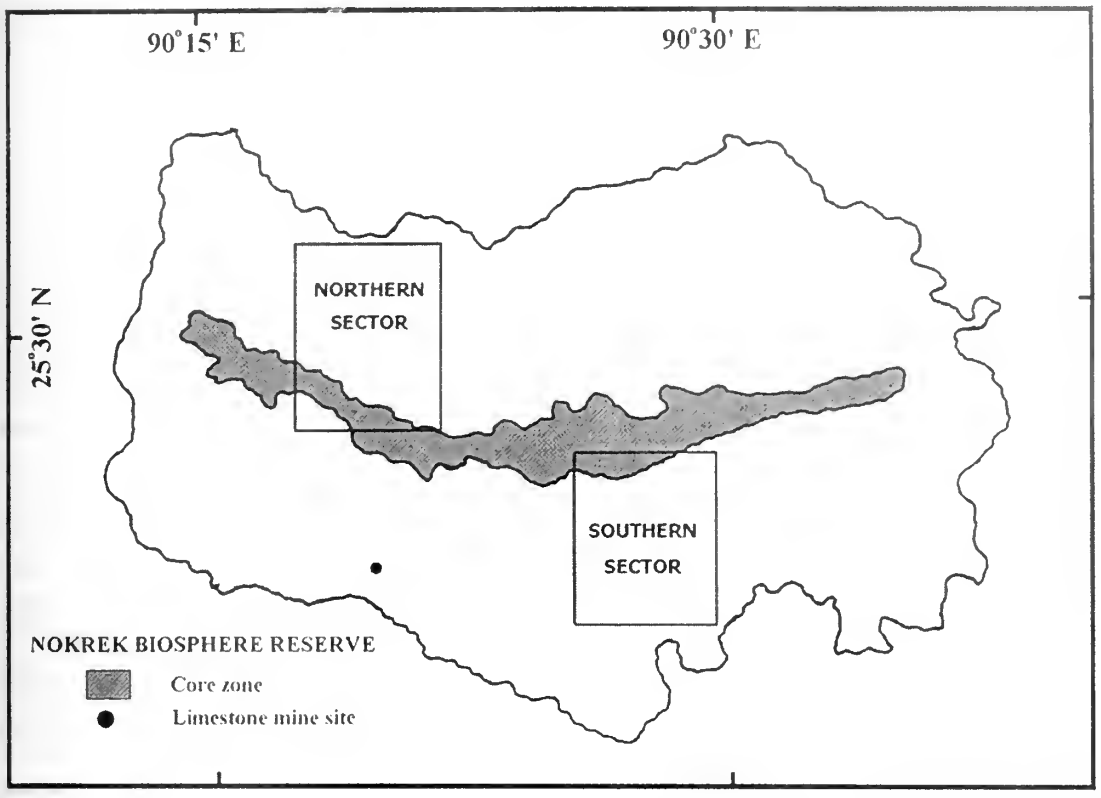


Fig. 1: Map of Nokrek Biosphere Reserve: core and buffer zone

Study site

The Nokrek Biosphere Reserve (NBR) is spread over an area of 820 sq. km covering parts of East Garo Hills, West Garo Hills and South Garo Hills districts of Meghalaya in north-east India. It lies between 90° 13'-90° 35' E and 25° 20'-25° 29' N (Fig. 1). It is situated on mountainous terrain of Tura ranges with altitude ranging from 149 m to 1,415 m above msl. The highest point of this ridge – the Nokrek Peak (1,415 m above msl) – lies within the core zone of the biosphere reserve, which is spread in east-west direction covering an area of 47.48 sq. km. The hill slopes in the northern aspect of the core zone are gentle compared to the southern flank where hills are very steep. The major rivers of the Garo Hills, namely Simsang, Dedari, Dareng and Ganol originate from the NBR. The buffer zone covering an area of 772.52 sq. km surrounds the core zone.

A total of 39,432 individuals belonging to the Garo tribe spread over 129 villages in the buffer zone depend heavily on the NBR for their sustenance as well as higher income generation. Various human activities that influence the vegetation of the BR are shifting cultivation, coal and limestone mining, and permanent agricultural and horticultural practices, such as settled paddy cultivation and planting of orchards, and tea gardens.

Climate

The area enjoys tropical monsoon climate with three seasons, namely summer, rainy and winter clearly distinguishable in a year. The summer season corresponds from March to April, rainy season from May to October and winter from November to February. Monsoon rains are received during April to October with occasional rainfall during November to March. The area receives an average annual rainfall of 3,012 mm.

The temperature varies from place to place depending on the aspect and altitude. The southern part of the BR is warmer than the northern part. The northern aspect of the NBR is the coldest area of the Garo Hills. The average daily temperature during the study period (2000-2003) ranged from 33.4 °C to 14.8 °C. The highest temperature 39 °C was recorded in April and the lowest was 10 °C in January and February. The mean minimum and mean maximum relative humidity for the same period was 23% and 98%, respectively.

Soil

The soil is sandy to loamy sand in texture and red, brown to dark brown in colour. It is acidic in nature throughout the core zone. Within the buffer zone, the lowest pH (4.02) was recorded in the coal mine areas and the highest pH (8.08)

in the limestone mining areas. The core zone soils are rich in organic matter and nutrients (N, P, K), compared to the buffer zone soils (Ralte *et al.* 2005).

METHODOLOGY

Identification of various ecosystems and selection of sampling sites

The landscape of the biosphere reserve is characterized by mountain peaks and plateaux, gentle to steep slopes, valleys and river basins, which supports diverse plant communities ranging from sub-tropical to tropical forests. The landscape in the buffer zone has been modified due to various anthropogenic activities such as shifting cultivation, mining, farming of horticultural crops and settled agriculture. Based on the physiography, vegetation characteristics, and nature and intensity of human activities, twelve terrestrial ecosystems were identified within the landscape of the NBR. These could be grouped into the following two major types based on the extent of human impact as a broad criterion. Each major type was further divided on the basis of vegetation characteristics and degree of human interference.

A. *Undisturbed landscape*
   1. Sub-tropical evergreen forests
   2. Tropical evergreen forests
   3. Tropical semi-evergreen forests
   4. Tropical moist deciduous forests
   5. Riverain forests

B. *Human-impacted landscape*
   a. Secondary communities
      6. Communities on shifting cultivation areas
      7. Bamboo groves
   b. Man-managed communities
      8. Orchards
      9. Paddy fields
      10. Tea gardens
   c. Communities on degraded areas
      11. Coal mining areas
      12. Limestone mining areas

The vegetation map of the BR (Roy *et al.* 2003) was used to depict different forest ecosystem types (Fig. 2) and the land use map was used to depict human impacted ecosystems within the BR (Fig. 3). The area under each of the major ecosystem types was determined (Table 1). Eight ecosystem types, namely tropical evergreen, sub-tropical evergreen and riverain forests, jhum fallows, bamboo groves, orchards, coal mining and limestone mining areas were studied in detail. The sampling sites were selected in the northern and the southern sides of the BR (Fig. 4). The two sites selected for the sub-tropical evergreen forest were located in the north-western side of the BR, close to the Nokrek peak in the core zone. The two sites of the tropical evergreen forest selected in the buffer zone of the BR were located on the southern side. The two sites selected for riverain forests were located on the bank of the two major rivers, namely Simsang and Dedari in the northern side of the BR. The shifting cultivation fallows of different ages, which were common in the northern side of the buffer zone, were grouped into four age groups: 10-12 year old, 6-8 year old, 3-4 year old and 1 year old fallows. Each of these four groups was studied by selecting two sites each. Two sites each were selected for orchards and bamboo groves in the northern side of the BR. The two coal mining sites and one limestone mining

Table 1: Ecosystem types in Nokrek Biosphere Reserve

Ecosystems	Location	Area (sq. km)	Area as percentage of the total BR area
Subtropical evergreen forests	Core zone	30.54	3.73
Tropical evergreen forests and Riverain forests	Core and buffer zone	137.71	16.79
Tropical semi-evergreen forests	Core and buffer zone	109.25	13.32
Tropical moist deciduous forests	Core and buffer zone	191.69	23.38
Abandoned shifting cultivation areas	Buffer zone	210.99	25.73
Bamboo groves	Buffer zone	15.66	1.91
Orchards	Buffer zone	9.55	1.16
Current shifting cultivation areas	Buffer zone	103.38	12.61
Settled paddy agriculture	Buffer zone	7.14	0.87
Coal mining areas	Buffer zone	-	-
Limestone mining areas	Buffer zone	-	-
Tea gardens	Buffer zone	-	-
Water bodies	Buffer zone	4.09	0.50
Total		820.0	100.00

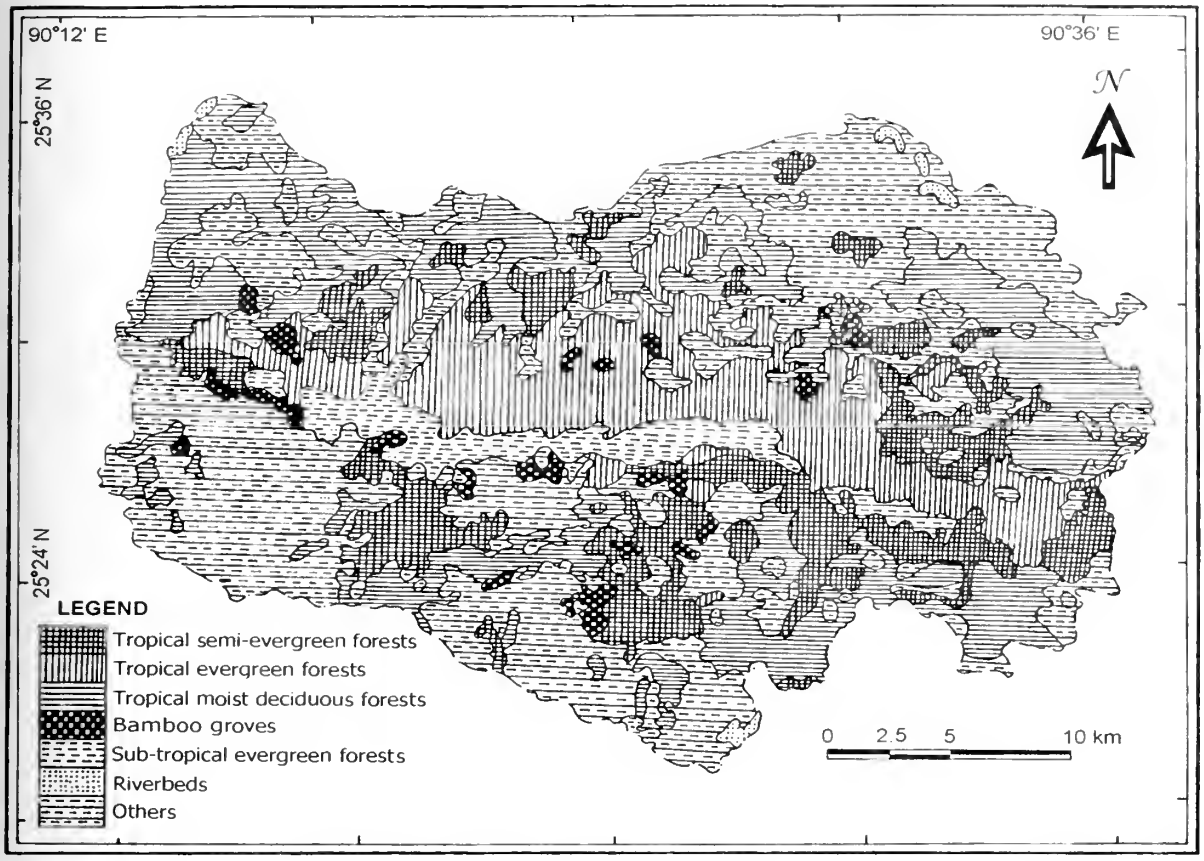


Fig. 2: Vegetation types of Nokrek Biosphere Reserve

site were located in the southern side of the BR. The altitude of these 21 sites ranged between 149 m and 1,415 m above msl (Table 2). The two replicate sites under each ecosystem type had similar elevation.

Collection and Identification of plant species

The voucher specimens were collected from the selected sites during the field surveys conducted over a period of three years from 2001. The collected specimens were identified with the help of local florae (Kanjilal *et al.* 1934-40; Haridasan and Rao 1985-87; Balakrishnan 1981-83) and were confirmed by matching the specimens with the herbaria of Botanical Survey of India, North-Eastern Circle, Shillong, Department of Botany, North-Eastern Hill University, Shillong and Central National Herbarium, Howrah.

Enumeration of endemic, rare and threatened taxa of the BR

The endangered, rare and endemic plant species were identified by consulting the available literature (Deb 1958; Balakrishnan 1981-83; Rao and Haridasan 1983; Das and Deori 1983; Haridasan and Rao 1985-1987; Kumar 1991; Kataki 1983; Chauhan 1983; Khan *et al.* 1997; Nayar and

Table 2: Ecosystems and sites selected for detailed study in Nokrek Biosphere Reserve

Ecosystems	Site code	Altitude (m)
Sub-tropical evergreen forest	SF-a	1,415
	SF-b	1,300
Tropical evergreen forest	TF-a	708
	TF-b	314
Riverain forest	RF-a	915
	RF-b	968
Jhum fallows (12-yr old)	J_{12}-a	1,100
	J_{12}-b	1,228
Jhum fallows (6-yr old)	J_6-a	1,078
	J_6-b	1,133
Jhum fallows (3-yr old)	J_3-a	1,226
	J_3-b	1,005
Jhum fallows (1-yr old)	J_1-a	1,120
	J_1-b	1,291
Bamboo groves	B-a	920
	B-b	828
Orchards	O-a	938
	O-b	831
Coal mine spoils	CM-a	250
	CM-b	314
Limestone mine spoils	LM	149

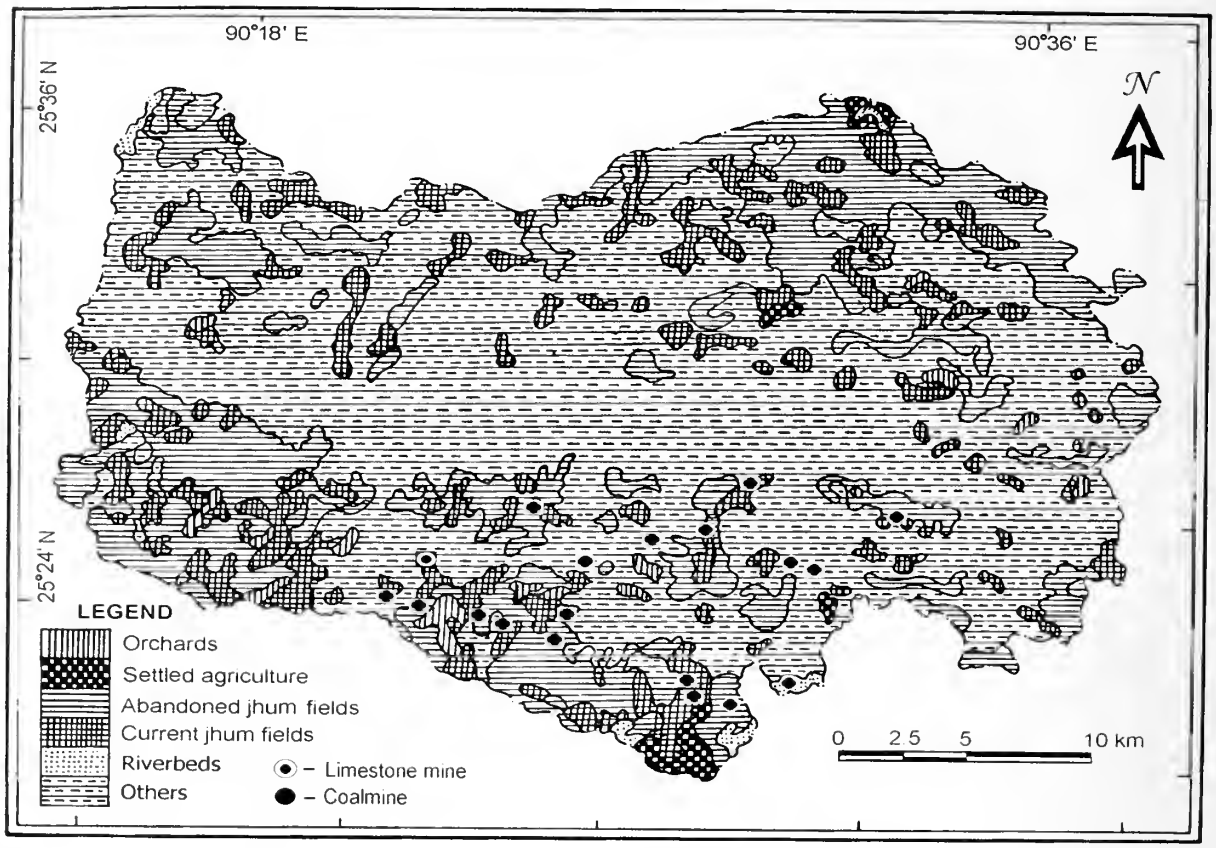


Fig. 3: Areas affected by various human activities within Nokrek Biosphere Reserve

Sastry 1990; Nayar 1996). The identified species were categorized into different forms of rarity following Rabinowitz (1981) and Rabinowitz *et al.* (1986). The species were classified according to the geographic range (wide vs. narrow), habitat specificity (broad vs. restricted), and population size (large vs. small), using the primary as well as available secondary data.

RESULTS

Taxonomic diversity

In total, 710 vascular plant species belonging to 465 genera and 140 families were recorded from the studied communities of the NBR. These included 678 angiosperms, 3 gymnosperms and 29 pteridophytes. The number of species, genera and families declined significantly from undisturbed climax communities to secondary communities with the lowest number of taxa on the mine spoils (Fig. 5). The total number of species in the undisturbed communities was 590 in contrast to 488 in the secondary communities on human impacted sites. The dominance of families also varied significantly among different communities. Though Rubiaceae was dominant in all the communities, Lauraceae, Orchidaceae and Rutaceae were better represented in the undisturbed communities, while Poaceae, Asteraceae, Fabaceae and Apiaceae dominated the human-impacted communities.

Among ecosystems studied, the three undisturbed tropical evergreen, sub-tropical evergreen and riverain forest communities together had the highest vascular plant species richness with 558 angiosperms, 29 pteridophytes and 3 gymnosperms. A total of 390 genera were recorded from these three forests, which included 366 angiosperms, 3 gymnosperms and 21 pteridophytes. At least 129 of these genera, i.e., *c.* 33% of the total genera recorded, were with congeneric species and 261 genera were represented by only one species. *Ficus* had the highest number of 12 species, followed by *Syzygium* with 10 species, *Litsea* with 7 species and *Castanopsis* and *Garcinia* with 5 species each. The total number of families recorded was 134, of which Rubiaceae (with 43 species and 30 genera), Poaceae (37 species, 29 genera), Euphorbiaceae (32 species, 21 genera), Lauraceae (28 species, 9 genera), Asteraceae (22 species, 16 genera), Orchidaceae (20 species, 16 genera) and Fabaceae (19 species, 14 genera) were the dominant families. There were 47 families that were represented by only a single species.

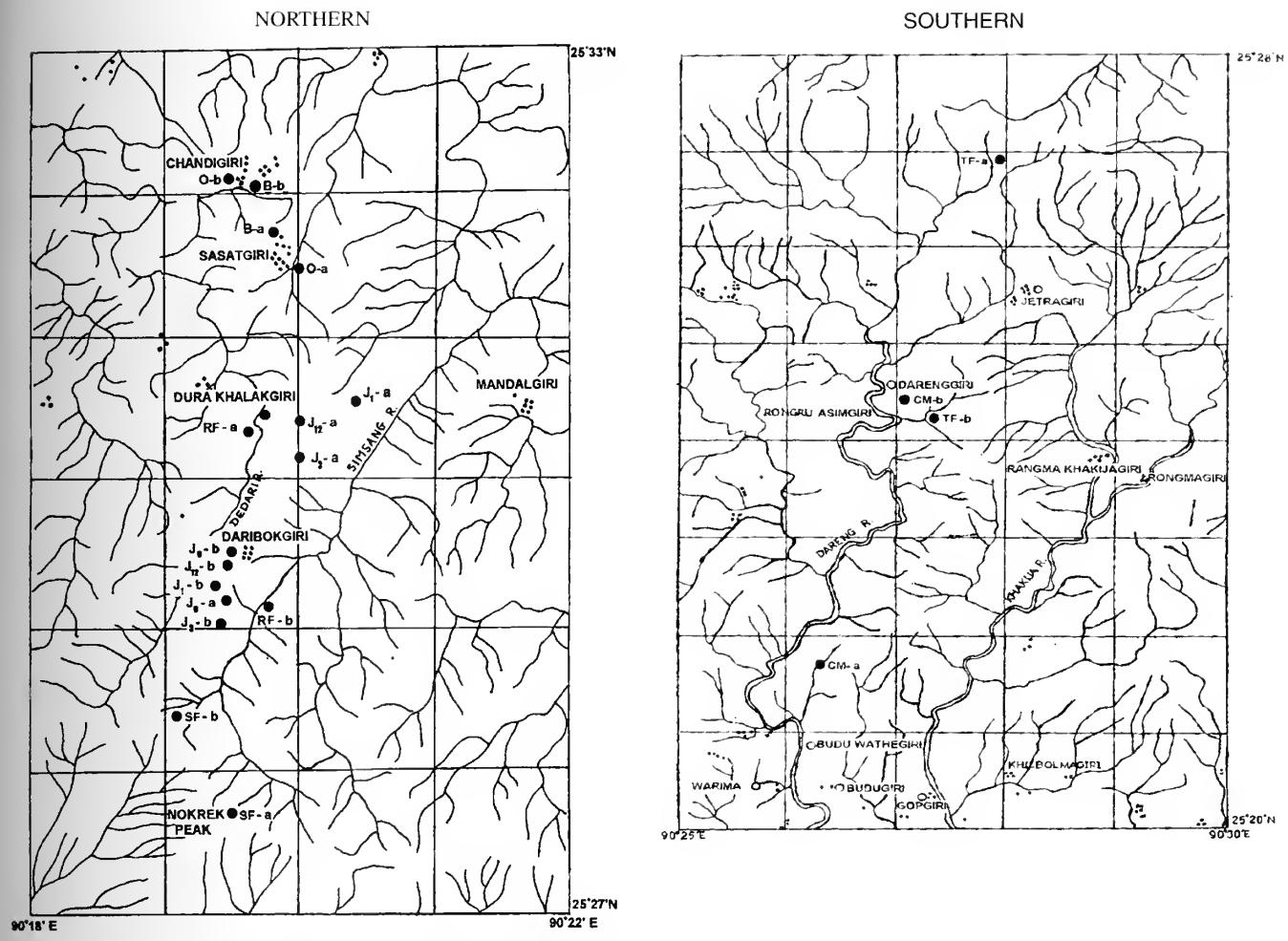


Fig. 4: Map showing the locations of the study sites in the northern and southern sides of the Nokrek Biosphere Reserve. ($SF_{a,b}$ – subtropical evergreen forests, $RF_{a,b}$ – riverain forests, $TF_{a,b}$ – tropical evergreen forests, $J_{12a,b}$ – Jhum fallows (12-yr. old), $J_{6a,b}$ - Jhum fallows (6-yr. old), $J_{3a,b}$ – Jhum fallows (3-yr. old), $J_{1a,b}$ - Jhum fallows (1-yr. old), $B_{a,b}$ – Bamboo groves, $O_{a,b}$ – Orchards, $CM_{a,b}$ – Coalmining areas, LM – Limestone mining areas)

The three forest communities had 88 families in common, 12 families were recorded exclusively from the subtropical evergreen forests, 5 from the tropical evergreen forests, and 4 families from the riverain forests. The three communities were also rich in primitive taxa. Some of these are *Actinodaphnae angustifolia*, *A. obovata*, *Beilschmiedia assamica*, *B. roxburghiana*, *Betula alnoides*, *Dillenia scabrella*, *Fissistigma verrucosum*, *Goniothalamus simonsii*, *Helicia excelsa*, *Helicia nilagirica*, *Holboellia latifolia*, *Houttuynia cordata, Knema angustifolia*, *Michelia oblonga*, *Myrica esculenta*, *Paramichelia baillonii*, *Polyalthia cerrasoides*, *Sarcandra glabra*, and *Talauma hodgsonii.*

Flora and floristic elements

The original flora of the NBR was confined to the undisturbed tropical evergreen, sub-tropical evergreen and riverain forests. The tropical elements were mainly present in tropical evergreen and riverain forests, whereas the subtropical evergreen forest had several tropical as well as temperate elements. The important tropical species were *Ardisia griffithii*, *Boehmeria macrophylla*, *Cinnamomum* spp., *Dysoxylum gobara*, *Elaeocarpus floribundus*, *Macropanax dispermus*, *Mesua ferrea*, *Pothos scandens*, *Raphidophora* spp., *Sarcosperma griffithii*, *Schefflera venulosa*, *Syzygium tetragonum*, *Toddalia asiatica* and *Xerospermum glabratum.* The temperate species abundant in the subtropical forests were *Acer oblongum*, *Aralia thomsonii*, *Betula alnoides*, *Castanopsis indica*, *Euonymus lawsonii*, *Ilex* spp., *Prunus cerrasoides*, *Rubus* spp., *Viburnum coriaceum* and *Viola sikkimensis*.

Most species found in NBR are eastern Asiatic elements from Sino-Himalayan, and Burma-Malayan regions. *Bruinsmia*, *Bulbophyllum*, *Camellia*, *Cymbidium* and *Kadsura* are Chinese and Himalayan genera, while *Balanophora*, *Cinnamomum*, *Engelhardtia*, *Litsea*, *Goniothalamus sesquipedalis*, *Miliusa*, *Pittosporum*, *Rubus*

and *Talauma* are the Burma-Malayan taxa. Presence of *Bischoffia javanica*, *Carallia bractiata*, *Firmiana colorata*, *Hedychium coccinium*, *Lithocarpus elegans*, *Spondias axillaris*, *Talauma hodgsonii*, *Travesia palmata* and *Vernonia volkamerifolia* in the flora of NBR indicates its affinity with Southeast Asian - Malaysian flora. A few Sino-Japanese elements, such as *Eurya accuminata* and *Pericampylos glaucus* were also present. In addition, it has several taxa from peninsular India such as *Dillenia indica*, *D. pentagyna*, *Ficus nervosa*, *Helicia nilagirica*, *Mastixia arborea*, *Munronia pinnata*, *Murraya koenigii* and *Syzygium cumini*.

The species of the undisturbed forests represented elements of 11 phytogeographical regions; 272 species belonged to Indo-Malayan region, 145 species to Himalayan region and 90 species to Indo-Burman region. These three elements together constituted about 86% of the total species content of the undisturbed forest communities. The remaining 8 phytogeographical regions were poorly represented (African 13, American 5, Andaman and Nicobar island 8, Australian 7, Brazilian 2, Indo-China 30, Sri Lanka 2 and Western Ghats 16), constituting only 14% of the total species.

Endemic species

The species endemic to north-east India, including the eastern Himalayas, are listed in Table 3. Out of the 43 endemic species recorded, 13 species are endemic only to the state of Meghalaya, 11 species are rare and 2 species, namely *Acer cappadocicum* and *Mastixia arborea* are considered as very rare species (Haridasan and Rao 1985-1987). Besides these, *Citrus latipes* (rare), *Fissistigma verrucosum* (rare), *Elaeocarpus acuminatus* (rare) and *Adinandra griffithii* (vulnerable) are listed in the Red Data Book of the Indian Plants (Nayar and Sastry 1990). Out of the total 17 endemics, 40% were trees, 8 species were shrubs, 3 species each were scandent shrubs, herbs, climbers and lianas, and 6 species were epiphytes.

Threatened species

Fifty-five species in the NBR belong to one or the other category of the threatened species (Table 3). *Beutia minor* (endangered), *Clerodendrum serratum* (vulnerable), *Hedychium coronarium* (endangered), *Paramichelia baillonii* (rare), *Rouwolfia serpentina* (endangered), *Syzygium grandis* (rare) are threatened in India, while other 44 species are rare and threatened in north-east India.

Rarity

Ninety-nine rare species were recorded from the NBR (Table 3). Majority (80) of these were in the undisturbed subtropical evergreen forest followed by riverain forests (54).

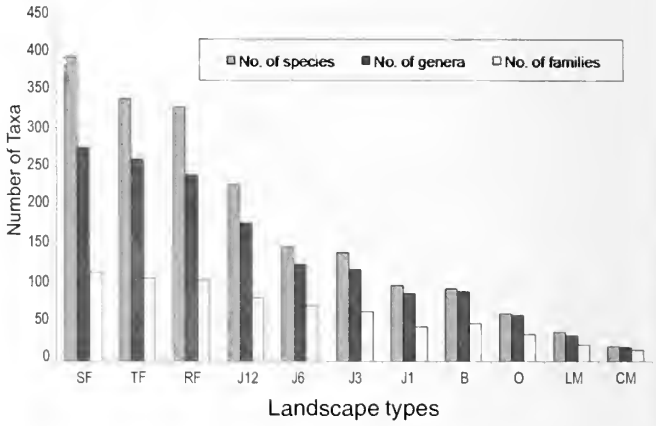


Fig. 5: Taxonomic diversity in different ecosystems of Nokrek Biosphere Reserve. SF – subtropical evergreen forests, RF – riverain forests, TF – tropical evergreen forests, J_{12} – Jhum fallows (12-yr old), J_6 – Jhum fallows (6-yr old), J_3 – Jhum fallows (3-yr old), J_1 – Jhum fallows (1-yr old), B – Bamboo groves, O – Orchards, CM – Coal mining areas, LM – Limestone mining areas

Trees contributed 41% to the rare flora followed by herbs (30%), shrubs (19%), climbers (6%) and lianas (4%). The most important form of rarity was the restricted habitat specificity (65 species) followed by small population size (63 species) and narrow geographic range (43 species). Two types of rarity, namely (i) narrow geographical range (endemics) - restricted habitat specificity - small populations, and (ii) wide geographical range (non-endemics) - restricted habitat - small populations, together constituted 41% of the rare flora of NBR (Fig. 6). The rare taxa with small populations outnumbered those with the large, dominant

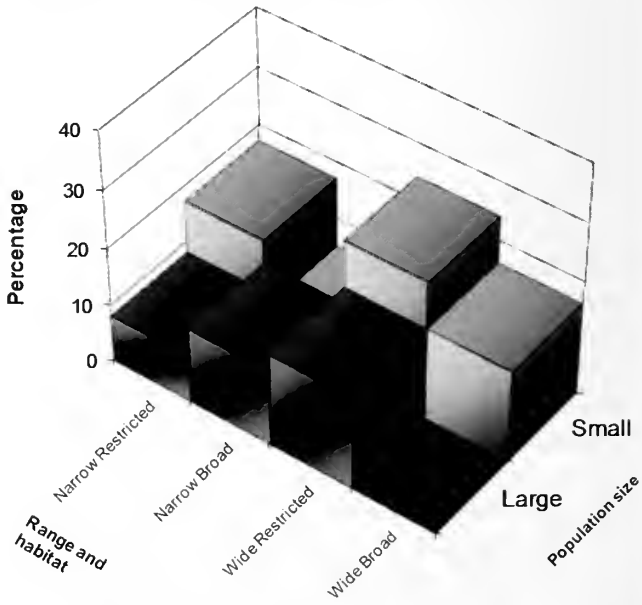


Fig. 6: Different forms of rarity in Nokrek Biosphere Reserve

Table 3: The status of endemic, rare and threatened plant species in Nokrek Biosphere Reserve
(SF – subtropical evergreen forests, TF – tropical evergreen forests, RF – riverain forests, J_{12} – Jhum fallows (12-yr old), J_6 – Jhum fallows (6-yr old), J_3 – Jhum fallows (3-yr old), J_1 – Jhum fallows (1-yr old), B – Bamboo groves, O – Orchards, CM – Coalmining areas, LM – Limestone mining areas)

Species	Family	Habit	SF	TF	RF	J_{12}	J_6	J_3	J_1	B	O	CM	LM	Status	G	H	P
Acer cappadociccum Gleditsch.	Aceraceae	T	+	-	-	-	-	-	-	-	-	-	-	E, VR	N	R	S
Adinandra griffithii Dyer	Theaceae	L	+	-	-	-	-	-	-	-	-	-	-	E, VU*	N	R	S
Aeschynanthus parasitica Cl.	Gesneriaceae	Ep	+	+	+	-	-	-	-	-	-	-	-	E, F	N	R	L
Aeschynanthus sikkimensis (Cl.) Stapf.	Gesneriaceae	Ep	+	+	-	-	-	-	-	-	-	-	-	E, R	N	R	S
Aeschynanthus superba Clarke	Gesneriaceae	Ep	+	+	+	-	-	-	-	-	-	-	-	E, F	N	R	S
Ardisia griffithii Clarke	Myrsinaceae	S	+	-	-	-	-	-	-	-	-	-	-	E, F	N	R	L
Baliospermum micranthum Muell.-Arg.	Euphorbiaceae	T	+	+	-	-	-	-	-	+	-	-	-	E, R	N	R	S
Boehmeria macrophylla D.Don	Urticaceae	S	+	+	+	-	-	-	-	-	-	-	-	E, F	N	R	L
Boehmeria sidaefolia Wedd.	Urticaceae	S	+	+	+	+	-	+	-	+	-	-	-	E, F	N	B	L
Bulbophyllum griffithii (Lindl.) Reich.	Orchidaceae	Ep	+	+	+	-	-	-	-	-	-	-	-	E, R	N	R	S
Camellia caduca Brandis	Theaceae	T	+	+	-	-	-	-	-	-	-	-	-	E, R	N	R	S
Capparis acutifolia Sw.	Capparidaceae	S	+	-	+	+	+	-	-	-	-	-	-	E, C	N	B	L
Ceropegia longifolia Wall.	Asclepiadaceae	Cl	-	-	-	+	-	-	-	-	-	-	-	E, F	N	R	S
Citrus aurantium Linn.	Rutaceae	S	+	-	-	-	-	+	-	-	-	-	-	E, R	N	B	S
Citrus latipes (Swingle) Tanaka	Rutaceae	T	+	-	-	-	-	-	-	-	-	-	-	E, R*	N	R	S
Citrus medica L.	Rutaceae	S	+	-	+	+	-	+	-	-	-	-	-	E, F	N	B	S
Drimycarpus racemosus (Roxb.) Hk.f.	Anacardiaceae	T	+	+	+	+	-	-	-	-	-	-	-	E, C	N	B	L
Elaeagnus conferta Roxb.	Elaeagnaceae	L	+	-	-	+	+	-	-	-	-	-	-	E, EN*	N	B	L
Elaeocarpus acuminatus Wall.ex Mast.	Elaeocarpaceae	T	+	-	+	-	-	-	-	-	-	-	-	E, R*	N	R	S
Erythroxylum kunthianum Wall. ex Kurz	Erythroxylaceae	T	+	-	-	+	-	-	-	-	-	-	-	E, F	N	R	S
Euonymus lawsonii Clarke & Prain	Celastraceae	T	+	-	+	+	-	-	-	-	-	-	-	E, F	N	B	L
Fissistigma verrucosum (Hook.f. & Th.) Merr.	Annonaceae	Sc	+	-	+	-	-	-	-	-	-	-	-	E, R*	N	R	S
Garcinia cowa Roxb. ex DC.	Clusiaceae	T	+	+	-	-	-	-	-	-	-	-	-	E, C	N	R	L
Gleditsia assamica Bor	Mimosaceae	T	-	-	+	+	+	-	-	-	-	-	-	E, C	N	B	L
Glochidion thomsonii Hk.f.	Euphorbiaceae	T	+	+	+	+	-	-	-	-	-	-	-	E, F	N	B	S
Goniothalamus simonsii Hk.f.&Th.	Annonaceae	T	+	+	+	-	-	-	-	-	-	-	-	E, F	N	R	S
Impatiens laevigata Hook.f.	Balsaminaceae	H	+	-	-	-	-	-	-	-	-	-	-	E, R	N	R	S
Impatiens porrecta Hook.f. & Th.	Balsaminaceae	H	+	-	-	-	-	-	-	-	-	-	-	E, R	N	R	L
Lasianthus hookeri Cl.ex Hk.f.	Rubiaceae	S	+	-	+	-	-	-	-	-	-	-	-	E, F	N	B	L
Lindera latifolia Hk.f.	Lauraceae	T	+	+	+	+	-	-	-	-	-	-	-	E, R	N	B	S
Litsea elongata (Nees) Hk.f.	Lauraceae	T	+	-	-	-	-	-	-	-	-	-	-	E, R	N	B	L
Litsea laeta Wall.ex Nees	Lauraceae	T	+	+	-	+	-	-	-	-	-	-	-	E, F	N	B	L
Millettia caudata (Benth.) Baker	Fabaceae	Sc	-	-	+	+	-	-	-	-	-	-	-	E, C	N	B	L
Paramignya micrantha Kurz.	Rutaceae	L	+	+	+	-	-	-	-	-	-	-	-	E, F	N	R	S
Pavetta subcapitata Hook.f.	Rubiaceae	S	-	-	+	-	-	-	-	-	-	-	-	E, C	N	R	S
Phaius flavus (Bl.) Lindl.	Orchidaceae	H	+	-	-	-	-	-	-	-	-	-	-	E, R	N	R	S
Piper griffithii C.DC.	Piperaceae	Cl	+	-	+	+	-	-	-	-	-	-	-	E, C	N	B	L
Piper peepuloides Roxb.	Piperaceae	Cl	+	-	+	-	-	-	-	-	-	-	-	E, VU	N	R	L
Prunus jenkinsii Hk.f.	Rosaceae	T	-	+	-	-	-	-	-	-	-	-	-	E, F	N	B	L

Table 3: The status of endemic, rare and threatened plant species in Nokrek Biosphere Reserve (*contd.*)
(SF – subtropical evergreen forests, TF – tropical evergreen forests, RF – riverain forests, J_{12} – Jhum fallows (12-yr old), J_6 – Jhum fallows (6-yr old), J_3 – Jhum fallows (3-yr old), J_1 – Jhum fallows (1-yr old), B – Bamboo groves, O – Orchards, CM – Coalmining areas, LM – Limestone mining areas)

Species	Family	Habit	SF	TF	RF	J_{12}	J_6	J_3	J_1	B	O	CM	LM	Status	G	H	P
Rhaphidophora calophyllum Schott.	Araceae	Ep	+	+	+	-	-	-	-	-	-	-	-	E, C	N	R	L
Rhaphidophora decursiva (Roxb.) Schott.	Araceae	Ep	+	+	+	-	-	-	-	-	-	-	-	E, C	N	R	L
Rubus khasianus Cardot	Rosaceae	Sc	+	-	+	+	+	+	-	-	-	-	-	E, C	N	B	S
Turpinia nepalensis W.& A.	Staphylaceae	T	-	+	+	-	-	-	-	-	-	-	-	E, F	N	B	L
Acer oblongum Wall.	Aceraceae	T	+	-	-	-	-	-	-	-	-	-	-	R	W	B	S
Actephila excelsa (Dalz.) Muell.-Arg.	Euphorbiaceae	S	-	+	-	-	-	-	-	-	-	-	-	VR	W	R	L
Aegynetia indica Linn.	Orobanchaceae	H	+	-	-	-	-	-	-	+	-	-	-	F	W	R	L
Agapetes veriagata (Roxb.) D.Don	Vacciniaceae	Ep	+	+	+	-	-	-	-	-	-	-	-	F	W	R	L
Anoectochillus roxburghii (Wall.) Lindl.	Orchidaceae	H	+	-	-	-	-	-	-	-	-	-	-	R	W	R	S
Aquilaria agallocha Roxb.	Thymeleaceae	T	-	+	-	-	-	-	-	-	-	-	-	EN*	W	R	L
Ardisia colorata Roxb.	Myrsinaceae	S	-	+	-	-	-	-	-	-	-	-	-	VR	W	R	S
Aristolochia cathcartii Hk.f.	Aristolochiaceae	Cl	+	-	+	-	-	-	-	-	-	-	-	R	W	B	S
Artocarpus gomezianus Wall.ex Trecul.	Moraceae	T	-	+	+	-	-	-	-	-	-	-	-	R	W	B	S
Balanophora dioica L.	Balanophoraceae	H	+	-	-	-	-	-	-	-	-	-	-	R	W	R	L
Begonia ovalifolia DC.	Begoniaceae	H	+	+	-	-	-	-	-	-	-	-	-	R	W	R	S
Begonia thomsonii A. DC.	Begoniaceae	H	+	+	-	-	-	-	-	-	-	-	-	R	W	R	S
Beilschmiedia assamica Meissn.	Lauraceae	T	+	-	-	-	-	-	-	-	-	-	-	R	W	R	L
Beutia minor Buch.-Ham.ex Baker	Fabaceae	S	-	-	-	+	-	-	-	-	-	-	-	EN*	W	B	S
Chirita oblongifolia (Roxb.) SinClair	Gesneriaceae	Ep	+	-	-	-	-	-	-	-	-	-	-	R	W	R	S
Clerodendrum hestatum (Roxb.) Lindl.	Verbenaceae	S	-	+	+	-	-	-	-	-	-	-	-	VU	W	R	S
Clerodendrum serratum (L.) Spreng	Verbenaceae	S	-	-	+	+	+	-	-	-	-	-	-	VU*	W	B	S
Croton oblongus Burm. f.	Euphorbiaceae	T	+	+	+	+	+	-	-	-	-	-	-	R	W	B	S
Cudrania fruticosa (Roxb.) Kurz.	Moraceae	T	-	+	-	-	+	-	-	-	-	-	-	VR	W	B	S
Dalhousiea bracteata (Grah. Ex Roxb.) Wt.	Fabaceae	Cl	-	-	+	-	-	-	-	-	-	-	-	R	W	R	L
Echinocarpus dasycarpus Benth.	Elaeocarpaceae	T	-	-	+	-	-	-	-	-	-	-	-	R	W	B	S
Euonymus fragidus Wall.	Celastraceae	T	+	-	+	-	-	-	-	-	-	-	-	R	W	R	S
Fagraea ceilanica Thunb.	Loganiaceae	Ep	-	-	+	-	-	-	-	-	-	-	-	R	W	R	S
Ficus consinna Miq.	Moraceae	T	-	-	+	-	-	-	-	-	-	-	-	R	W	B	S
Ficus subincisa Buch.-Ham.ex J. E.Sm.	Moraceae	T	+	-	+	+	-	-	-	-	-	-	-	VR	W	B	S
Ficus tinctoria var. *parasitica*	Moraceae	Ep	-	-	+	-	-	-	-	-	-	-	-	R	W	R	S
Gastrochilus acutifolius (Lindl.) O. Ktze.	Orchidaceae	Ep	+	-	+	-	-	-	-	-	-	-	-	R	W	R	S
Gloriosa superba L.	Liliaceae	H	+	-	-	-	-	-	-	-	-	-	-	VR	W	R	S
Gordonia excelsa Bl.	Theaceae	T	-	-	+	-	-	-	-	-	-	-	-	VR	W	R	S
Hedychium coronarium Koen. ex Retz.	Zingiberaceae	H	+	+	+	-	-	-	-	-	-	-	-	EN*	W	R	S
Helicia excelsa Bl.	Proteaceae	T	+	-	-	-	-	-	-	-	-	-	-	R	W	B	S
Hoya lobbii Hook.f.	Asclepiadaceae	Ep	+	-	-	-	-	-	-	-	-	-	-	R	W	R	L
Hoya parasitica Wall.	Asclepiadaceae	Ep	+	+	+	-	-	-	-	-	-	-	-	R	W	R	S
Impatiens chinensis L.	Balsaminaceae	H	+	+	+	-	-	-	-	-	-	-	-	R	W	R	L
Impatiens tripetala DC.	Balsaminaceae	H	+	-	+	-	-	-	-	-	-	-	-	R	W	R	L

Table 3: The status of endemic, rare and threatened plant species in Nokrek Biosphere Reserve (*contd.*)
(SF – subtropical evergreen forests, TF – tropical evergreen forests, RF – riverain forests, J_{12} – Jhum fallows (12-yr old), J_6 – Jhum fallows (6-yr old), J_3 – Jhum fallows (3-yr old), J_1 – Jhum fallows (1-yr old), B – Bamboo groves, O – Orchards, CM – Coalmining areas, LM – Limestone mining areas)

Species	Family	Habit	SF	TF	RF	J_{12}	J_6	J_3	J_1	B	O	CM	LM	Status	G	H	P
Lasia spinosa (L.) Thw.	Araceae	H	+	+	-	-	-	-	-	-	-	-	-	R	W	R	S
Luisia teretifolia Guad.	Orchidaceae	Ep	+	+	+	-	-	-	-	-	-	-	-	R	W	R	S
Lysionotus serratus D.Don	Gesneriaceae	Ep	+	+	+	-	-	-	-	-	-	-	-	R	W	R	S
Mastixia arboria Cl.	Cornaceae	T	-	+	-	-	-	-	-	-	-	-	-	VR	W	R	S
Meliosma wallichii Planch. ex Hk.f.	Sabiaceae	T	+	+	-	-	-	-	-	+	-	-	-	R	W	R	S
Melodenus monogynus Roxb.	Apocynaceae	L	+	-	+	+	+	-	-	-	-	-	-	R	W	B	S
Ophioglossum pedunculosum Desv.	Ophioglossaceae	H	+	-	-	-	-	-	-	-	-	-	-	R	W	R	S
Oxyspora cernua (Roxb.) Triana	Melastomataceae	Cl	-	+	-	+	-	-	-	-	-	-	-	R	W	R	S
Paramichelia baillonii (Pierre) Hu	Magnoliaceae	T	+	-	-	-	-	-	-	-	-	-	-	R*	W	R	S
Peperomia pellucida (L.) HBK.	Piperaceae	H	-	-	+	-	-	-	-	+	-	-	-	R	W	R	S
Picrasma javanica Bl.	Semaraubaceae	T	-	+	-	-	-	-	-	+	-	-	-	VU	W	B	S
Podocarpus nerifilia D.Don	Podocarpacaeae	T	+	-	-	-	-	-	-	-	-	-	-	R	W	R	S
Polyalthia simiarum (Hk.f. & Th.) Hk.f. & Th.	Annonaceae	T	+	+	+	-	-	-	-	-	-	-	-	R	W	B	S
Psychotria symplocifolia Kurz	Rubiaceae	S	+	-	-	-	-	-	-	-	-	-	-	VR	W	R	L
Rauvolfia serpentina (L.) Benth. ex Kurz.	Apocynaceae	S	-	-	+	-	-	-	-	-	-	-	-	EN*	W	B	S
Sapindus rarak DC.	Sapindaceae	T	+	+	+	-	-	-	-	-	-	-	-	R	W	B	S
Schleichera trijuga Wall.	Sapindaceae	T	+	+	-	-	-	-	-	-	-	-	-	R	W	R	L
Syzygium grandis (Wt.) Walp.	Myrtaceae	T	+	+	-	-	-	-	-	-	-	-	-	R*	W	R	L
Taxus baccata Linn.	Taxaceae	T	+	-	+	-	-	-	-	-	-	-	-	CR	W	R	S
Trema cannabina Lour.	Ulmaceae	T	-	-	-	+	-	+	-	-	-	-	-	VR	W	R	L
Trigonostemon semperflorens (Roxb.) Muell.-Arg.	Euphorbiaceae	S	-	+	-	-	-	-	-	-	-	-	-	R	W	R	L
Total			**72**	**44**	**52**	**22**	**8**	**5**	**-**	**6**	**-**	**-**	**-**				

Habit: Cl- Climber, Ep- Epiphyte, H- herb, S- shrub, Sc- scandent, T- tree;
Status: E- Endemic, EN- Endangered, CR- Critically endangered, VU- Vulnerable, R- Rare, VR- Very Rare, C- Common, F- Frequent;
G - Geographical range: N-narrow, W-wide;
H - Habitat specificity: R-restricted, B-broad;
P - Population size: S-small, L-large;
* Status in India (Nayar and Sastry 1990)

populations. The least form of rarity was the species with narrow geographical range - broad habitat specificity - small populations.

DISCUSSION

Forest and shifting cultivation are the two most important land uses in NBR, accounting for more than 95% of the total geographical area. Leaving aside the core zone, the entire buffer zone is affected by the shifting cultivation, accounting for 38% of the total area. After one- or two-year of cropping in a shifting cultivation cycle, the vegetation on abandoned fallows recovers and remains dominated by shorter life-forms till the 6th year of fallow. Beyond this period, trees dominate the community giving rise to secondary forests. As per the existing practice, once the forest attains the age of 12 years, the plot is felled for shifting cultivation and the cycle continues. The impact of mining on the vegetation though much more severe than any other human activity, is confined to a relatively small area. The impact of other factors responsible for forest degradation such as establishing orchards and tea gardening was inconspicuous due to their limited spread. All these activities have led to destruction of natural forests giving rise to a large number of plant communities with varying physiognomy, species and growth form composition, and structural organization. These differences in the community characteristics were related to their age, soil conditions and intensity, and frequency of disturbance under which they have developed.

Of the total 710 species recorded from the NBR, 368 species were common both to the disturbed and undisturbed communities, 222 species were confined only to the undisturbed communities and only 120 species were found exclusively in the disturbed communities in the buffer zone. Therefore, disturbance contributed 16.9% increase in the total species content of the NBR. On the other hand, 222 species (31.3% of the total species content) that were present in the undisturbed communities disappeared from the human impacted sites.

The total number of species recorded from the BR is very high, when compared to the earlier studies carried out in other parts of the state. For instance, Haridasan and Rao (1985-87) described 1,151 dicotyledonous species from the entire state of Meghalaya, Tiwari *et al.* (1998) reported 514 species from 56 sacred forests of the state, Jamir (2003) reported 395 species of vascular plants from three sacred groves of Jaintia Hills and Upadhaya *et al.* (2003) reported 437 vascular species from two other sacred groves of Jaintia hills. In a floristic survey of Balphakram Wildlife Sanctuary of Garo Hills, Kumar (1984) listed 770 plant species. One of the important causes of high species richness in the NBR is the high ecosystem diversity, created due to the combination of a host of anthropogenic as well as natural factors. Among the natural factors, geomorphic diversity of the landscape characterized by different slope angles and aspects, drainage patterns, and diverse physiographic features (Sarma 2002), geographical location and variations in the climatic condition due to a wide elevation gradient are important factors contributing to the species richness of the NBR. The presence of distinct strata in the undisturbed tropical and subtropical forests and complexity of the micro-environmental conditions in the communities (Barik *et al.* 1992), might have also contributed towards increase in species richness in the NBR.

Besides site characteristics and landscape histories, the availability of species in an ecosystem is the product of the biogeographical influences and evolutionary process (Meher-Homji 1989). The presence of different floral elements from as many as 11 biogeographical regions of the world in the flora of NBR due to its location at the confluence of the three major biogeographical regions has substantially contributed towards its species richness. The patterns of dominance exhibited by the members of Rubiaceae, Lauraceae, Orchidaceae, Rutaceae, Poaceae, Asteraceae, Fabaceae and Apiaceae in different communities were similar to that of the findings of Puri (1960), who worked on the dominant families of India. The high concentration of primitive taxa in the NBR is in conformity with the findings of Takhtajan (1969), who concluded that eastern Himalaya, Assam and upper Burma (now Myanmar) show high concentration of primitive angiosperms.

The endemic and threatened categories of species usually have specific and narrow ecological niches. Their restricted edaphic- and habitat-specificity makes them more vulnerable to extinction. The findings of the present study suggest that disturbance led to significant decrease in the number of rare species in the NBR, since only 3 rare species out of the total 99 were recorded from the disturbed communities. The presence of a large number of rare taxa with small populations and habitat-specificity indicates the vulnerability of the threatened categories of species in the NBR, and unless adequate protection measures are taken, these taxa could face extinction. Absence of species having narrow range, broad habitat and small populations in the flora confirms the conclusion of Rabinowitz *et al.* (1986), who stated that such condition of rarity was biologically unlikely.

Anthropogenic disturbances in the NBR have played an important role in converting the entire landscape of the buffer zone into a mosaic of heterogeneous patches of degraded communities at different stages of their development. Though the species diversity at mining sites

and other man impacted areas has been drastically reduced, the overall species richness in the NBR has increased. However, existence of the habitat-specialist species as well as species with small populations is highly threatened by these activities. On the jhum fields, although there was an increase in species richness in the communities during secondary succession, only 67% of the total species could recover after 12 years, depicting slow rate of natural recovery process. Therefore, the NBR may not be able to withstand the current level of anthropogenic pressure and in course of time, it may be converted into a landscape dominated by fragments of degraded forest patches.

ACKNOWLEDGEMENTS

The authors are grateful to the Ministry of Environment and Forests, Government of India, for the financial support under the Biosphere Reserve Programme (Sanction No.F.10/41/97-CS/BR dated 15.02.1999). Thanks are due to the Forest Department, Government of Meghalaya, for granting permission to undertake field study in the Biosphere Reserve. We thank the Forest Officers attached to the BR and villagers inhabiting the buffer zone of the BR for their help and cooperation. Thanks are also due to Dr. V. Ralte for her help in the field studies, and soil sampling and analysis.

REFERENCES

ARMESTO, J.J. & S.T.A. PICKETT (1985): Experiments on disturbance in old-field plant communities: impact on species richness and abundance. *Ecology 66*: 230-240.

BARIK, S.K., H.N. PANDEY, R.S. TRIPATHI & P. RAO (1992): Micro-environmental variability and species diversity in tree fall gaps in a sub-tropical broadleaved forest. *Vegetatio 103*: 31-40.

BALAKRISHNAN, N.P. (1981-83): Flora of Jowai and Vicinity, Meghalaya, Vol. I-II. BSI, Howrah, India.

CHAUHAN, A.S. (1983): Dwindling taxa of Meghalaya. Pp. 142-145. *In*: Jain, S.K. & R.R. Rao (Eds): An Assessment of Threatened Plants of India. Botanical Survey of India, Howrah, India.

CLEMENTS, F.E. (1936): Nature and structure of climax. *J. Ecol. 24*: 252-284.

COLLINS, S.L., S.M. GLENN & D.J. GIBSON (1995): Experimental analysis of intermediate disturbance and initial floristic composition: decoupling cause and effect. *Ecology 76*: 486-492.

CONNELL, J.H. (1978): Diversity in tropical rain forest and coral reefs. *Science 199*: 1302-1310.

DAS, S. & N.C. DEORI (1983): A census of endemic orchids of north-east India. Pp. 104-109. *In*: Jain, S.K. & R.R. Rao (Eds): An Assessment of Threatened Plants of India. Botanical Survey of India, Howrah, India.

DEB, D.B. (1958): Endemism and the outside influence on the flora of Manipur. *J. Bombay Nat. Hist. Soc. 55*: 313-317.

GRIME, J.P. (1979): Plant strategies and vegetation processes. John Wiley, Chichester.

GRUBB, P.J. (1977): The maintenance of species richness in plant communities: the importance of regeneration niche. *Bot. Rev. 52*: 107-145.

HARIDASAN, K. & R.R. RAO (1985-87): Forest Flora of Meghalaya, Vol. I-II. Bishen Singh Mahendra Pal Singh, Dehradun, India.

HOOKER, J.D. (1872- 1897): Flora of British India, Vol. I-VII. London.

HUSTON, M.A. (1979): A general hypothesis of species diversity. *Amer. Natural. 113*: 81-101.

JAMIR, S.A. & H.N. PANDEY (2003): Vascular plant diversity in sacred groves of Jaintia Hills in north-east India. *Biodiv. and Con. 12*: 1497-1510.

KANJILAL, U.N., P.C. KANJILAL, A. DAS, R.N. DE & N.L. BOR (1934-40): Flora of Assam. Vol. I-V. Government Press, Shillong, India.

KATAKI, S.K. (1983): Some rare plants in Khasi and Jaintia hills of Meghalaya. Pp. 104-109. *In*: Jain, S.K. & R.R. Rao (Eds): An Assessment of Threatened Plants of India. Botanical Survey of India, Howrah, India.

KHAN, M.L., S. MENON & K.S. BAWA (1997): Effectiveness of protected areas network in biodiversity conservation – a case study of Meghalaya state. *Biodiv. and Con. 6*: 853-868.

KUMAR, Y. (1984): Studies on the Flora of Balphakram Wildlife Sanctuary, Garo Hills. Ph. D. Thesis, North-Eastern Hill University, Shillong, India.

KUMAR, Y. (1991): Floristic studies in Balphakram Wildlife Sanctuary in Meghalaya – Rare, endemic or threatened flora. *J. Megh. Sci. Soc. 11-12*: 33-48.

LUBCHENCO, J. (1978): Plant species diversity in a marine intertidal community: importance of herbivore food preference and algal competitive abilities. *Amer. Natural. 112*: 23-39.

MEHER-HOMJI, V.M. (1989): History of vegetation of peninsular India. *Man and Envir. 13*: 1-10.

MOLINO, J.F. & D. SABATIER (2001): Tree diversity in tropical rain forests: a validation of intermediate disturbance hypothesis. *Science*: 1702-1704.

NAYAR, M.P. (1996): Hotspots of Endemic Plants of India, Nepal and Bhutan. TBGRI, Trivandrum, India.

NAYAR, M.P. & A.R.K. SASTRY (1990): Red Data Book of Indian Plants. Botanical Survey of India, Calcutta.

PAINE, R.T. (1966): Food web complexity and species diversity. *Amer. Natural. 100*: 65-75.

PURI, G.S. (1960): Indian Forest Ecology. Oxford Book & Stationary Co., New Delhi, India.

RABINOWITZ, D. (1981): Seven forms of rarity. Pp. 205-217. *In*: Synge, H. (Ed.): The Biological Aspects of Rare Plant Conservation. John Wiley and Sons, New York.

RABINOWITZ, D., S. CAIRNS & T. DILLON (1986): Seven forms of rarity and their frequency in the flora of the British Isles. Pp. 182-204. *In*: Soule, M. (Ed.): Conservation Biology: The Science of Scarcity and Diversity. Sinauer Associates, Sunderland, MA.

RALTE, V., H.N. PANDEY, S.K. BARIK, R.S. TRIPATHI & S.D. PRABHU (2005): Changes in microbial biomass and activity in relation to shifting cultivation and horticultural practices in subtropical evergreen forest ecosystem of north-east India. *Acta Oecol. 28*: 163-172.

RAO, A.S. (1969a): Orchids of Khasi and Jaintia Hills. Bulletin of Botanical Survey of India *11*: 115-123.

RAO, A.S. (1969b): The vegetation of the Khasi and Jaintia Hills. *In*: Proceedings of Pre-Congress Symposium and field study on Physical Geography of Eastern Himalaya and Meghalaya (1968). Guwahati, India. Pp. 92-102.

RAO, P., S.K. BARIK, H.N. PANDEY & R.S. TRIPATHI (1990): Community composition and tree population structure in a sub-tropical broad-leaved forest along a disturbance gradient. *Vegetatio 88*: 151-162.

RAO, R.R. & K. HARIDASAN (1983): Threatened plants of Meghalaya – A plea for conservation. *In*: Jain, S.K. & R.R. Rao (Eds): An Assessment of Threatened Plants of India. Botanical Survey of India, Howrah, India. Pp. 94-103.

RAO, R.S. & G. PANIGRAHI (1961): Distribution of vegetational types and their dominant species in Eastern India. *J. Ind. Bot. Soc. 40*: 274-285.

ROY, P.S., G. TALUKDAR, N. LELE & M.G. PORWAL (2003): Biodiversity Characterization at Landscape Level in Nokrek Biosphere Reserve. DBT-DOS Project, Phase IB, Indian Institute of Remote Sensing, Dehradun.

SARMA, K. (2002): Coal Mining and Its Impact on Environment of Nokrek Biosphere Reserve, Meghalaya. Ph. D. Thesis, North-Eastern Hill University, Shillong.

STAPANIAN, M.A., D.L. CASELL & S.P. CLINE (1997): Regional patterns of local diversity of trees: associated with anthropogenic disturbance. *For. Ecol. Manage. 93*:33-44.

TAKHTAJAN, A. (1969): Flowering Plants: Origin and Dispersal. Bishen Singh Mahendra Pal Singh and Otto Koeltz Science Publishers, India.

TIWARI, B.K., S.K. BARIK & R.S. TRIPATHI (1998): Biodiversity value, status, and strategies for conservation of sacred groves of Meghalaya, India. *Ecosys. Health 4*: 20-32.

UPADHAYA, K., H.N. PANDEY, P.S. LAW & R.S. TRIPATHI (2003): Tree diversity in sacred groves of the Jaintia Hills in Meghalaya, northeast India. *Biodiv. and Cons. 12*: 583-597.

■ ■ ■

NEW DESCRIPTION

ON THE GENUS *KANAKARAJIELLA* SUNDARARAJ & DAVID (HEMIPTERA: ALEYRODIDAE) WITH DESCRIPTION OF A NEW SPECIES

R. Sundararaj[1,2] and R. Pushpa[1,3]

[1]Institute of Wood Science & Technology, Malleshwaram, Bengaluru 560 003, Karnataka, India.
[2]Email: rsundararaj@icfre.org
[3]Email: pushpa_suderson@yahoo.com

The Whitefly genus *Kanakarajiella* Sundararaj & David is reviewed and is considered as a valid genus. A new species *Kanakarajiella rotunda* breeding on *Syzygium* sp. in Kumarapuram, Tamil Nadu, India, is described and illustrated. A key to the species of the genus *Kanakarajiella* is also given

Key words: Whiteflies, Hemiptera, *Kanakarajiella*

INTRODUCTION

David and Sundararaj (1993) established the genus *Kanakarajiella* with *Dialeurodes vulgaris* Singh as the type species and included three known species of *Dialeurodes*, namely *D. bassiae* David & Subramaniam, *D. cardamomi* David & Subramaniam and *D. pallida* Singh under this genus. Jensen (1999) analyzed the phylogenetic relationships within a large sample of the world's diversity of *Dialeurodes* Cockerell, including *K. vulgaris* and concluded that only the type species should remain under *Kanakarajiella* and placed the remaining three species under the genus *Singhiella* Sampson. Meganathan and David (1994) described one new species under the genus *Kanakarajiella*. Martin and Mound (2007) in their catalogue placed all the species of *Dialeuronomada*, *Gigaleurodes*, *Lankaleurodes*, *Kanakarajiella*, *Rabdostigma*, *Shanthiniae* under *Dialeurodes* with the note that future studies may reveal some or all of these to be valid genera. A study of the two species, so far, described under *Kanakarajiella* and description of a new species here justified the need to reinstate the generic status of *Kanakarajiella* as they differ distinctly from the species of *Dialeurodes* Cockerell by the absence of stipples or granules on the thoracic and the caudal tracheal folds, absence of teeth or fimbriae in the thoracic and caudal tracheal pores, and by the absence of comb of teeth in vasiform orifice.

Genus ***Kanakarajiella*** David & Sundararaj, 1993 Stat. Rev.

Type species: *Dialeurodes vulgaris* Singh, 1931. *Mem. Rep. Dept. Agric. India, Ent. Ser.*, 12(1): 33-34; by original designation.

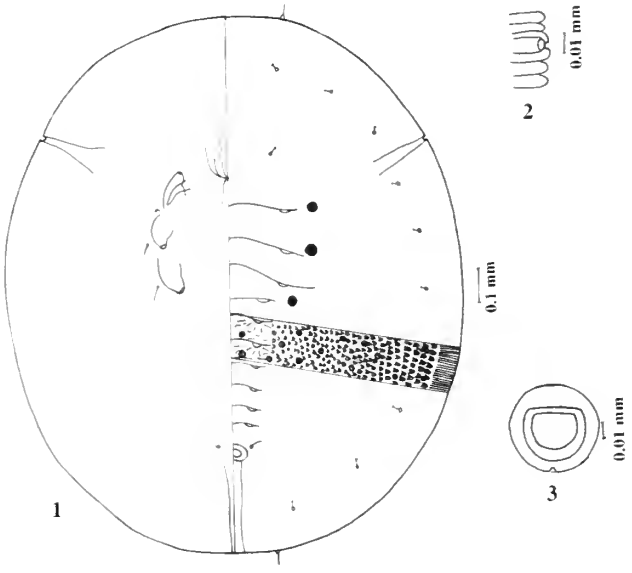
Diagnosis: Puparium white to light brown; elliptical to oval; margin smooth or crenulate; submargin not separated from dorsal disc; subdorsum/submargin with row of setae; pores well-defined without teeth or fimbriae; folds indicated without stipples; furrows distinct; longitudinal moulting suture reaching margin and transverse moulting suture reaching submargin. Vasiform orifice subcordate to circular, without comb of teeth; operculum large filling orifice, obscuring lingula.

Remarks: This genus differs from that of *Dialeurodes* Cockerell by the absence of stipples or granules on the thoracic and the caudal tracheal folds, absence of teeth or fimbriae in the thoracic and caudal tracheal pores and by the absence of comb of teeth in vasiform orifice.

1. *Kanakarajiella rotunda* sp. nov. (Figs 1-3)

Description

Puparium: White, without secretion of wax;



Figs 1-3: *Kanakarajiella rotunda* sp. nov.
1. Puparium, 2. Margin at thoracic tracheal pore region, 3. Vasiform orifice

subcircular, broadest at transverse moulting suture, 1.90-1.96 mm long, 1.64-1.66 mm wide. Margin regularly crenulate, 15-17 crenulations in 0.1 mm; thoracic tracheal pores distinct without inner teeth and caudal tracheal pore indicated by a slight depression. Anterior marginal setae 16 µm and posterior marginal setae 20 µm long.

Dorsum: Submargin striated. Subdorsum with dense microtubercles of varying size and shape, geminate pores disposed throughout dorsum. Median area with small broken transverse ridges. Pockets well-developed on all segmental sutures, lateral depressions on all segments. Longitudinal moulting suture reaching margin, transverse moulting suture reaching submedian. Three pairs of submedian tubercles – two pairs on cephalothorax (one pair each on pro- and mesothorax) and one pair on I abdominal segment. Thoracic and caudal tracheal furrows distinct, without ornamentation or sculpturing or stipples. Pores and porettes not discernible.

Chaetotaxy: Three pairs of setae – cephalic setae 5 µm long, eighth abdominal setae cephalolaterad of vasiform orifice, 10 µm long and caudal setae 8 µm long. First abdominal setae absent. A row of ten pairs of capitate setae – five pairs each on cephalothorax and abdomen, each 5 µm long.

Vasiform orifice: Subcircular, wider than long, 46 µm long, 50 µm wide; operculum subcordate, 24-26 µm long, 40-42 µm wide, filling orifice and obscuring lingula.

Venter: A pair of ventral abdominal setae 20 µm long, 60 µm apart. Thoracic and caudal tracheal folds distinct without stipples. Antennae reaching base of prothoracic legs. A pair of setae at the base of meso- and metathoracic legs, 10 µm long.

Host: *Syzygium* sp.

Material Examined: Holotype: One puparium, on slide from *Syzygium* sp., Coll. R. Pushpa, 24.v.2007, deposited in the collections of National Forest Insect Collection, Forest Research Institute, Dehradun, India (NFIC-FRI # 21871).

Paratypes: 2 puparia, data as for holotype, one each deposited in National Pusa Collection, Division of Entomology, Indian Agricultural Research Institute, New Delhi, India (IARI), and in Institute of Wood Science & Technology, Bangalore, India (IWST).

Type locality: INDIA: Tamil Nadu: Kumarapuram.

Remarks: The puparia were found in groups on the undersurface of leaves. This species resembles *Kanakarajiella vulgaris* (Singh) in having striated margin, distinct pores without inner teeth and thoracic and caudal tracheal folds without stipples, but differs from it in the puparium shape, having three pairs of submedian tubercles, ten pairs of subdorsal capitate setae and by the absence of the first abdominal setae and median tubercles on abdominal segments.

Etymology: The species name alludes to the circular body shape of the species.

2. *Kanakarajiella turpiniae* Meganathan & David Stat. Rev.

Kanakarajiella turpiniae Meganathan and David, 1994. *FIPPAT Entomology Series,* 5: 40.

Dialeurodes turpiniae: Martin and Mound, 2007. *Zootaxa*, 1492: 31.

Material Examined: Holotype: puparium, INDIA: Kerala: Valiyamullumala (Silent Valley), on *Turpinia malabarica*, 2.ii.1991, Meganathan.

Host: *Turpinia malabarica* (Meganathan and David, 1994).

Distribution: INDIA: Kerala: Valiyamullumala (Meganathan and David 1994).

Remarks: This species is rather distinct from the other species of *Kanakarajiella* by the absence of submarginal/ subdorsal setae and tubercles on dorsum and caudal furrow with sculptures.

3. *Kanakarajiella vulgaris* (Singh) Stat. Rev.

Dialeurodes vulgaris Singh, 1931. *Mem. Rep. Dept. Agric. India, Ent. Ser.*, 12: 33-34. Martin and Mound, 2007. *Zootaxa*, 1492: 31.

Kanakarajiella vulgaris (Singh) David and Sundararaj, 1993. *J. ent. Res.*, 17: 233.

Material Examined: INDIA: Kerala: Kottayam, 9 puparia, on *Solanum seaforthianum*, 12.vii.2006, R. Pushpa; Karadipara (Nelliyampathy), 1 puparium, on *Euonymus indicus*, 23.x.2006, R. Sundararaj; Tamil Nadu: Kumarapuram, 1 puparium, on *Phyllanthus reticulatus*, 24.v.2007, R. Pushpa; Mondaikadu, 2 puparia on *Randia malabarica*, 5.viii.1987, R. Sundararaj.

Hosts: *Jasminum sambac*, *Syzygium cumini* (Singh 1931); *Bidens pilosa*, *Erythrina lithosperms*, *Syzygium jambos* (Venkataramaiah 1971); *Canthium dicoccum*, *Coffea arabica*, *C. excelsa*, *C. robusta*, *Coffea* sp., *Randia malabarica* (David and Sundararaj 1993); *Litsea floribunda*, *Mappia foetida* (Meganathan and David 1994); *Tabernaemontana heyneyana*, *Jasminum* sp., *Litsea* sp., (Dubey and Ko 2008); *Euonymus indicus*, *Phyllanthus reticulatus*, *Solanum seaforthianum* (new host records).

Distribution: INDIA: Bihar (Pusa) (Singh 1931); Karnataka: Chikmagalur; Kerala: Silent valley (Meganathan and David 1994); Tamil Nadu: Munchirai, Mondaikadu (David and Sundararaj 1993); Karnataka: Honnawar, Kumargiri; Kerala: Waynad Wildlife Sanctuary (Dubey 2003).

Remarks: The puparium of this species is characterised by the presence of about 10 pairs of pointed submarginal setae and abdominal segments with median tubercles and by the absence of submedian tubercles.

KEY TO THE INDIAN SPECIES OF *KANAKARAJIELLA*

1. Submarginal/subdorsal setae present; dorsum with tubercles; caudal furrow without sculptures 2
— Submarginal/subdorsal setae absent; dorsum without tubercles; caudal furrow with sculptures .... *turpiniae* Meganathan & David
2. Cephalothorax with two pairs and I abdominal segment with a pair of submedian tubercles; abdominal segments without median tubercles; subdorsum with ten pairs of capitate setae; first abdominal setae absent ..... *rotunda* sp. nov.
— Cephalothorax and I abdominal segment without submedian tubercles; abdominal segments with median tubercles; submargin with a row of about 10 pairs of pointed setae; first abdominal setae present .... *vulgaris* (Singh)

ACKNOWLEDGEMENTS

We are grateful to the Director and Group Coordinator (Research), IWST, Bengaluru, for the facilities provided. Thanks are due to Prof. B.V. David, President, Sun Agro Biotech Research Centre, Porur, Chennai, for loaning the type specimen of *K. turpiniae* and for his valuable comments on the manuscript.

REFERENCES

DAVID, B.V. & R. SUNDARARAJ (1993): Studies on Dialeurodini (Aleyrodidae: Homoptera) of India: *Kanakarajiella* gen. nov. *J. ent. Res. 17(4)*: 289-295.

DUBEY, A.K. (2003): Biosystematics of the aleyrodids (Aleyrodidae: Homoptera: Insecta) of south Western Ghats, India. Thesis submitted to the FRI University, Dehradun, India. 282 pp.

DUBEY, A.K. & C.C. KO (2008): Whitefly (Aleyrodidae) host plants list from India. *Oriental Ins. 42*: 49-102.

JENSEN, A. (1999): Cladistics of sampling of the worlds diversity of whiteflies of the genus *Dialeurodes* (Hemiptera: Aleyrodidae). *Annl. Ent. Soc. America 92(3)*: 359-369.

MARTIN, J.H & L.A. MOUND (2007): An annotated check list of the world's whiteflies (Insecta: Hemiptera: Aleyrodidae). *Zootaxa 1492*: 1-84.

MEGANATHAN, P. & B.V. DAVID (1994): Aleyrodidae fauna (Aleyrodidae: Homoptera) of Silent Valley, A tropical evergreen rain-forest, in Kerala, India. *FIPPAT Entomology Series, 5*: 1-66.

SINGH, K. (1931): A contribution towards our knowledge of the Aleyrodidae (whiteflies) of India. *Mem. Dept. Agric. India. Entomol. Ser. 12*: 1-98.

VENKATARAMAIAH, G.H. (1971): A note on *Dialeurodes vulgaris* on coffee. *J. Coffee Res. 1*: 13-14.

■ ■ ■

DESCRIPTION OF A NEW *HOMOPORUS* THOMSON (HYMENOPTERA: PTEROMALIDAE) FROM NORTH-EASTERN INDIA, WITH A KEY TO ORIENTAL SPECIES

T.C. Narendran[1] and F.R. Khan[2]

[1]Department of Zoology, University of Calicut, Kerala 673 635, India. Email: drtcnarendran@yahoo.com
[2]Department of Zoology, Aligarh Muslim Unversity, Aligarh 202 002, Uttar Pradesh, India. Email: insectqh11@gmail.com

Homoporus neodestructor sp. nov. is described from material collected from Meghalaya. A key to Oriental species of *Homoporus* is provided.

Key words: New species, *Homoporus*, Pteromalidae, Key, India

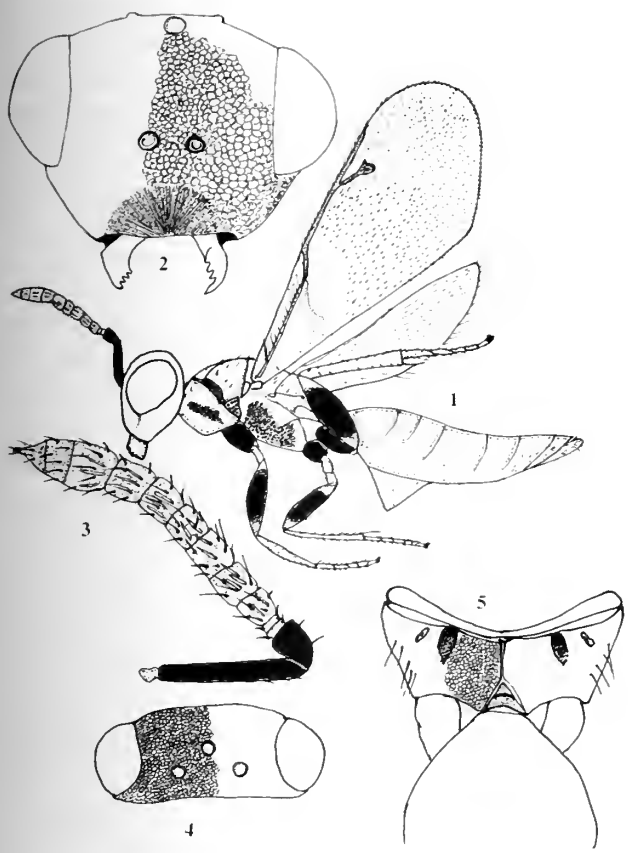
INTRODUCTION

Thomson (1878) erected the genus *Homoporus* based on the type species *Pteromalus fulviventris* Walker (Graham 1969). The species of *Homoporus* are distributed in the Oriental, Australian, Afrotropical, Palaearctic, Nearctic and Neotropical regions (Graham 1969; Bouček 1988; Xiao *et al.* 2004; Sureshan and Narendran 2000, 2001; Noyes 2003). Noyes (2003) listed 63 known species in the world and Narendran and Kumar (2009) added another species from India. In this paper, one more species new to science is described from India. In the Oriental region eight species are known among which four are from India (including the new species described here under). The holotype and paratype of the new species described in this paper are retained in the Department of Zoology, University of Calicut (DZCU), but eventually will be deposited respectively in the National Pusa Collection of Division of Entomology, Indian Agricultural Research Institute, New Delhi, India, (NPC) and the Insect Collections, Department of Zoology, Aligarh Muslim University, Aligarh (ZDAMU).

Abbreviations used: F1 to F6= Funicular segments 1 to 6; MV= Marginal vein; OOL= Ocellocular line; PMV= Postmarginal vein; POL= Postocellar line; SMV= Submarginal vein; STV= Stigmal vein; T1= Gasteral tergite 1.

Key to species of *Homoporus* of Oriental Region

1. First anellus longer than broad 2
— First anellus broader than long or not longer than broad.. 3
2. Lower clypeal margin distinctly notched in the middle; F3 to F6 quadrate; POL 1.6x OOL; MV 1.6x STV; forewing with brown infuscation near STV ..... **H. japonicus* Ashmead
— Anterior lower clypeal margin broadly truncate, without sharp tooth; each funicular segment longer than broad; POL 1-1.11x OOL; MV 2.3x STV; forewing without infuscation; gaster brown, slightly yellow centrally ..... **H. sinensis* Xiao *et al.*
3. Both mandibles quadridentate 4
— At least one mandible tridentate 8
4. Gaster black with green or blue refringence or gaster black with reddish or rusty colour at base 5
— Gaster yellow (sometimes with brown areas on sides) 7
5. Gaster at least 2x as long as broad; F6 as long as wide; MV 2x or a little more than 2x-STV; pronotum in front of collar not descending vertically with respect to plane of mesoscutum; pronotal neck at least partly visible in dorsal view 6
— Gaster shorter than 1.8x its width; F6 1.5x longer than wide; MV shorter than 2x STV; pronotum in front of collar descending vertically with respect to plane of mesoscutum; pronotal neck not visible in dorsal view (pronotal collar not margined) ..... * *destructor* (Say) (Extralimital)
6. Pronotal collar not margined; scape 3x as long as pedicel; F1 shorter than pedicel, as long as its width; clava (excluding spicule) 2.5x as long as F6 ..... *neodestructor* sp. nov.
— Pronotal collar margined medially; scape longer than 4-5x as long as pedicel; F1 as long as pedicel, distinctly longer than wide (5:3); clava 2x as long as F6 ..... **subniger* Walker (in part)
7. Fifth tarsal segment especially of mid and hind legs swollen; scape reaching beyond level of vertex; funicular segments distinctly longer than wide; MV 3x STV ..... *maharashtriensis* Narendran & Kumar
— Fifth tarsal segment not swollen; scape not reaching anterior ocellus, hence not at all reaching level of vertex; funicular segments gradually widening towards tip; MV 2.1x as long as STV ..... *acuminatus* Sureshan & Narendran
8. Gaster pale brownish-yellow with 2 dark lines dorso-laterally on either side, tips also dark brown; legs with last tarsal segments swollen (prominent on mid and hind legs); clypeus anteriorly with deep notch in middle; scape reaching beyond



Figs 1-5: *Homoporus neodestructor* sp. nov.
Female: 1. Body profile; 2. Head anterior view; 3. Antenna; 4. Head dorsal view; 5. Propodeum

anterior ocellus ..... *gladiatus* Sureshan & Narendran

— Gaster black with metallic green or blue refringence; other characters partly or completely different 9

9. Pronotum highly inclined vertically in front of collar; pronotal collar not margined; forewing with more or less a dark spot below base of MV ..... **luniger* (Nees)

— Pronotum not declining vertically; collar margined; forewing without dark spot or infuscation ..... (in part) ..... **subniger* (Walker)

* Names with an asterisk indicate no material of the species was examined and the differential features provided are taken from previous descriptions.

***Homoporus neodestructor* sp. nov.** (Figs 1-5)

Holotype: Female: Length 3 mm. Dark metallic green except the following: antenna pale yellow with pedicel and scape black with slight metallic green refringence; mandibles brown; eye brown, with anterior marginal area pale; ocelli pale reflecting yellow; tegulae pale yellow; all coxae concolorous with mesosoma; femora black with bases and apices pale yellow; trochanters, tibiae and tarsi pale yellow; pretarsi black; wings hyaline, veins pale brownish yellow.

Head: engraved-reticulate with sparse short white pubescence; clypeus finely striate- reticulate; striae not reaching gena; anterior margin of clypeus straight; head width in dorsal view 1.21x width of mesoscutum, 2.73x its length; width in front view 1.5x its height; vertex raised reticulate; temple length shorter than half length of eye; POL 1.6x OOL; malar sulcus faintly indicated, distance between eye and base of mandible 0.4x eye height in profile; eye separated by 1.6x eye height in front view; in dorsal view eye separated by a distance 3x POL; both mandibles with 4 teeth each. Antennae inserted below middle of face, a little above level of ventral margin of eyes; scape not quite reaching anterior ocellus; length 0.74x eye height in profile; pedicel plus flagellum 0.7x head width; funicular segments gradually widening towards tip; tip acuminate with a sharp terminal stylus or specula; relative L: W of antennal segments: scape= 45: 6; pedicel= 15: 10; F1= 10: 10; F2= 11: 11; F3= 12: 11; F4= 11: 11; F5= 11: 11; F6= 12: 12; clava= 32: 15.

Mesosoma: slightly arched in profile, with very sparse white pubescence; pronotum with raised reticulation, not margined not descending vertically in front of collar with respect to the plane of mesoscutum; pronotal neck visible; lateral panel of pronotum sunken; mesoscutum raised reticulate, 2.17x as wide as long; scutellum medially 1.1x as long as mesoscutum, similar sculptured as mesoscutum. Propodeum medially 0.4x as long as scutellum, raised reticulate, with two deep fovea with a pit on either side; nucha relatively small, a little raised and transverse between fork of median carina; spiracle elongately oval; callus with thin long pubescence, not dense; mesepisternum and lower mesepimeron densely reticulate; upper mesepimeron smooth and shiny; prepectus and lateral panel of pronotum densely reticulate. Forewing 2.5x as long as broad, with basal part almost bare; parastigmal vein indicated; CC with a row of ventral setae; upper side of CC without pubescence; speculum open behind (with 1 or 2 setae almost behind); relative length of SMV= 35; MV= 25; PMV= 20; STV= 12.

Metasoma: Ovate, mostly smooth, dorsally collapsing; gaster sessile, 1.5x length of mesosoma, a little longer than head plus mesosoma combined; hind margin of T1 straight not medially produced).

Male: Unknown.

Host: Unknown.

Variation: Length varies from 2.53-3.0 mm; black colour of femora reduced in paratype and body colour more bluish than greenish in paratype.

Material Examined: Holotype: Female, INDIA: Meghalaya, Shillong, Ladmawphlong 23.x.2008, F.R. Khan

(DZCU). Paratype: Female, Meghalaya, Jowai, Thaldskin, 22.x.2008, F.R. Khan (DZCU).

Etymology: The species is named after *Homoprus destructor* (Say) with which it resembles.

Remarks: This new species comes near *Homoporus destructor* (Say) (Say 1817) in general appearance but differs from it in having: 1) Gaster 2.2x as long as broad (in *H. destructor* 1.4- 1.6x as long as broad); 2) F6 as long as wide (in *H. destructor* F6 almost 1.5x longer than wide according to Dzhanokmen, 1987); 3) MV 2x or a little more than 2x STV (in *H. destructor* MV distinctly shorter than 2x STV) and 4) Pronotum in front of collar not descending vertically (in *H. destructor* pronotum in front of collar descending vertically).

This new species also resembles *Homoporus subniger* (Walker) (Walker 1835) very closely but differs from it in having: 1) scape 3x as long as pedicel (scape longer than 4-5x length of pedicel); 2) F1 shorter than pedicel (in *H. subniger* F1 as long as pedicel), 3) clava 2.5x as long as F6 (in *H. subniger* clava 2x as long as F6) and 4) Pronotal collar not margined (in *H. subniger* pronotal collar margined medially).

ACKNOWLEDGEMENTS

One of us (TCN) is grateful to Prof. N. Ramani, Head of the Department, Department of Zoology, University of Calicut, for permitting me to work in the Department. He is grateful to Dr. M. Nasser of the same Department for all support and encouragement. TCN thanks Prof. M. Hayat, Department of Zoology, Aligarh Muslim University, Aligarh, for the loan of specimens.

REFERENCES

Bouček, Z. (1988): Australacian Chalcidoidea (Hymenoptera) C.A.B International, Wallingford, U.K. Pp. 1-831.

Graham, M.W.R. de V. (1969): The Pteromalidae of NorthWestern Europe (Hymenopera: Chalcidoidea). *Bulletin of the British Museum (Natural History) (Entomology) Supplement 16*: 908 pp. 686 figs.

Narendran, T.C. & P.G. Kumar (2009): On three new species of Pteromalidae (Hymenoptera: Chalcidoidea) from Maharashtra, India. *Journal of Experimental Zoology 12(1)*: 29-34.

Noyes, J.S. (2003): (accessed 2010). Universal Chalcidoidea data base. http:/www.nhm.uk/jdsml/research-curation/research projects/chalcidoids/

Say, T. (1817): Some account of the insect known by the name of the hessian fly and a parasitic insect that feeds on it. *Journal of the Academy of Natural Sciences of Philadelphia1*: 45-48.

Sureshan, P.M. & T.C. Narendran (2000): Pteromalidae (Chalcidoidea: Hymenoptera) from India with the description of a new species *Entomon 25(2)*: 117-128.

Sureshan, P.M. & T.C. Narendran (2001): Another Indian species of *Homoporus* Thompson (Hymenoptera: Chalcidoidea: Pteromalidae) *Zoos' Print Journal 16(1)*: 391- 394.

Walker, F. (1835): Monographia Chalciditum. *Entomological Magazine 2(5)*: 476- 502; *3(1)*: 94- 97.

Xiao, H., Y.Z. Zhang, D.W. Huang & A. Polaszek (2004): A revision of *Homoporus* (Hymenoptera: Pteromalidae) of China. *Raffles Bulletin 52(1)*: 59- 65.

■ ■ ■

MISCELLANEOUS NOTES

1. FURTHER NOTE ON SOME BEHAVIOURAL ASPECTS OF THE NORTHERN PIG-TAILED MACAQUE *MACACA NEMESTRINA LEONINA*

ANWARUDDIN CHOUDHURY[1]

[1]The Rhino Foundation for Nature in NE India, C/o The Assam Co. Ltd., Bamunimaidam, Guwahati 781 021, Assam, India.
Email: badru1@sify.com

A detailed work on the ecology and behaviour of the northern Pig-tailed Macaque *Macaca nemestrina leonina* Linnaeus 1766, was published recently (Choudhury 2008). Additional recent information on the behavioural aspects of this relatively poorly documented primate is found in Choudhury (2009, 2010). Useful information on *leonina*, although relatively scanty, is found in Pocock (1931, 1939, 1941), McCann (1933), Fooden (1975), Choudhury (1988, 1989, 1993, 1997, 2003), and Feeroz *et al.* (1994). Groves (2001) had proposed full specific treatment for *leonina*. In this note, observations on some other aspects of behaviour observed during field works between February 1986 and May 2006, and which were not analysed before, have been presented.

The observations were carried out in Bherjan-Borajan-Podumoni Wildlife Sanctuary (27°25'-32' N; 95°19'-23' E) in Tinsukia district of eastern Assam, and Garampani and Nambor Wildlife Sanctuaries (26°23' N; 93°52' E) in Karbi Anglong district of central Assam. Bherjan-Borajan-Podumoni Wildlife Sanctuary is located on flat terrain (110-130 m above msl) and has three disjunct blocks covered by partially degraded tropical wet evergreen or rainforest and deciduous plantations. Garampani and Nambor Wildlife Sanctuaries are located on low undulating terrain (170-280 m above msl) and are covered by partially degraded tropical wet semi-evergreen rainforest.

General: 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 hours of observation in Bherjan, the macaques were observed for only 120 min on the ground, that too the lone males (only once a female with infant, and two immatures). The group may not come to the ground at all on many days while 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. During the season of crop raid, especially after the harvest of paddy is over (in January), the macaques of Borajan were observed to spend 38% of their diurnal time on the ground. In Nambor and Garampani, where canopy cover was almost closed, the macaques normally came down to cross over the National Highway that passes through the forest and feed on sugarcane left-over by wild elephants (Choudhury 1993, 2010). In Garampani, as much as 20% of their diurnal time was spent on the ground in February and March 1992.

Crop raiding reports are rare, however, in smaller pockets such as Borajan macaques raid paddy fields (usually after the harvest is over) and also in *jhum* (*jhum*=slash and burn shifting cultivation) pockets inside forests in Garo and Jaintia Hills of Meghalaya, to supplement their diet.

The macaques occupy the top storey (12 to 35 m in *Bombax*, *Dipterocarpus*, etc.) for roosting, basking and feeding. The understorey, especially the middle layer (2-10 m in *Bauhinia, Lagerstroemia, Albizzia*, bamboo, etc.) is used for feeding, resting and travelling. The lower branches of trees and lower shrubs were used for feeding. Activities on the forest floor included crossing of clearings, a little feeding but may be prolonged also in case of crop raiding, occasional drinking and play.

As a rule, the Pig-tailed Macaque is not very shy, however, in areas where it is hunted for food, it was extremely so (e.g., Nagaland) (Choudhury 2008).

Roosting: For roosting, in Bherjan and Podumoni forests, they preferred the higher branches of tall trees (>20 m; down to 16 m in partially degraded forest). The macaques arrive to roost fairly early (not just before dusk), 30-45 min before dusk, singly or in twos and threes, and take up their final roosting positions around sunset. While roosting, the macaques held the branches tightly, and remained in their positions throughout the night. They did not sleep in a tight cluster, but loosely dispersed in adjacent trees. The maximum distance observed between two extreme individuals of a roosting pig-tailed macaque group was about 100 m in Bherjan and Podumoni forests.

Vocalisation, communication and facial expressions: A variety of barks and calls are uttered by Pig-tailed macaques. The most frequent was medium to low-pitched *pno-pno* or *po-po*. This was uttered by almost all the individuals, one

after another or simultaneously when travelling from one location to another along trees, and sometimes during foraging and when any human being was seen nearby. During locomotion on the ground; however, they were more or less silent. The alpha male's alarm call was a harsh bark *hrr-hrr, argh* when the foraging members dispersed too far or when the female in estrous went out of sight. It also growls. The subadult and female alarm calls were *wheek, wheek*.

Quarrels and mock fights with grunts, especially among the sub-adults and juveniles, were not uncommon. Usually the adult male interfere uttering louder grunts to bring back silence. Overall, pig-tailed macaques are not silent animals and their presence can be easily detected due to a large group size and various vocalizations, and the sound of branch movements and twig-breaking when they travel.

The males also uttered *khek-khek* or *ghek-ghek* or *agh-agh* or *kheh-kheh* after dismounting from a copulation bout. The females either remain silent or make a low scream. Older females usually remain silent.

Pig-tailed macaques are very shy where they are hunted and utter a very distinctive *hoa, hooa, ho-a,* or *hua, hua* or *arr-huah, huah* and vanish immediately. Females and immatures made various 'squeals', 'screech', and 'screams'. Apart from vocalisations, pig-tailed macaques communicate by means of gestures (facial expressions), including look-threat, look away, grin, posture during locomotion, mounting gesture, presenting, freezing, touching with limbs, and possible tail expression.

Despite so many vocalizations, sometimes the groups could maintain effective silence such that their presence cannot be detected, especially when they were resting (not always as the young ones move about), or after fleeing owing to disturbance caused by humans. Immature males, adult females and juveniles grimaced with teeth visible when this researcher went within 3-5 m.

Sun basking: Such behaviour is mainly observed during cool winter months. They exposed their ventrum and sides of body to the sun in a sitting posture on tree branches at 20+ m height. The duration of sun basking observed ranged from 14 to 35 min. In summer, there may not be any sun basking on some days. On summer mornings when sun basking was observed, the duration ranged from less than a minute to seven minutes. During basking the most common behaviour was sitting still, self-manipulation, grooming and play between the young ones.

Fall: Accidental falls were also often observed. On August 04, 1992, an alpha male fell from more than 20 m height when the branch he was sitting on gave away. A few seconds after the fall, he uttered '*aargh*' and then vanished along the ground. On other occasions, a macaque jumped down 18-20 m while fleeing in Upper Dihing (west block) Reserved Forest, and two immatures fell from 20 m in Bherjan forests.

During rain: During drizzle, the adults mostly remained indifferent; however, on heavy rain, adults were seen sitting on branches with thick foliage, but the immature were observed playing and jumping from branch to branch.

This is probably the first time that these behavioural aspects of northern pig-tailed macaques have been published. The elusiveness of the macaque and poor visibility had its sway by wasting invaluable time in the field. Earlier observers who had studied form *nemestrina* also have similar comments (Bernstein 1967; Caldecott 1986). Although a dweller of dense forest, wherever degradation took place the macaque could adapt itself to the changed environment (e.g., Podumoni forests).

ACKNOWLEDGEMENTS

I thank Nur Husain and Dilip for accompanying me in the field.

REFERENCES

Bernstein, I.S. (1967): A field study of the pigtail monkey. *Primates 8*: 217-228.

Caldecott, J.O. (1986): An ecological and behavioural study of the pig-tailed macaque. *In*: Szalay, F.S. (Ed.): Contributions to primatology, Vol. 21. Basel (Switzerland): Karger. 259 pp.

Choudhury, A.U. (1988): Priority ratings for conservation of Indian primates. *Oryx 22*: 89-94.

Choudhury, A.U. (1989): Primates of Assam: their distribution, habitat and status. Ph.D. thesis, Gauhati University, Guwahati. 300 pp. + maps.

Choudhury, A.U. (1993): A naturalist in Karbi Anglong. Gibbon Books, Guwahati.

Choudhury, A.U. (1997): Checklist of the mammals of Assam. 2nd edn. Gibbon Books & ASTEC, Guwahati.

Choudhury, A.U. (2003): The pig-tailed macaque *Macaca nemestrina* in India – status and conservation. *Primate Conservation 19*: 91-94.

Choudhury, A.U. (2008): Ecology and behaviour of the pig-tailed macaque *Macaca nemestrina leonina* in some forests of Assam in north-east India. *J. Bombay Nat. Hist. Soc. 105(3)*: 279-291.

Choudhury, A.U. (2009): Interaction of the Pig-tailed macaque *Macaca nemestrina leonina* with other primates in some forests of Assam in north-east India. *J. Bombay Nat. Hist.Soc. 106(2)*: 202-203.

Choudhury, A.U. (2010): Notes on behaviour of Pig-tailed Macaque *Macaca nemestrina leonina* towards Sparrow-Hawk, Crows, Drongo and Elephants. *Zoo's Print 25(7)*: 23-25.

Feeroz, M., M. Islam & M. Kabir (1994): Food and feeding behaviour of hoolock gibbon (*Hylobates hoolock*), capped langur (*Presbytis pileata*), and pig-tailed macaque (*Macaca nemestrina*) of

Lawachara. *Bangladesh J. Zool. 22(2)*: 123-132.

Fooden, J. (1975): Taxonomy and evolution of liontail and pigtail macaques (Primates: Cercopithecidae). *Fieldiana Zoology 67*: 1-169.

Groves, C.P. (2001): Primate taxonomy. Smithsonian Inst. Press. Washington DC. 350 pp.

McCann, C. (1933): Notes on some Indian macaques. *J. Bombay Nat. Hist. Soc. 36*: 796-810.

Pocock, R.I. (1931): The pig-tailed macaques (*Macaca nemestrina*). *J. Bombay Nat. Hist. Soc. 35*: 297-311.

Pocock, R.I. (1939): The fauna of British India including Ceylon and Burma: Mammalia Primates and Carnivora. 2nd edition. Taylor & Francis, London. 503 pp.

Pocock, R.I. (1941): The Fauna of British India including Ceylon and Burma: Mammalia II. Primates and Carnivora. Taylor & Francis, London. 503 pp.

2. EFFECT OF AILA STORM ON FLYING FOX *PTEROPUS GIGANTEUS GIGANTEUS* (BRUNNICH)

S. Mallick[1,2] and S.K. Raut[1,3]

[1]Ecology and Ethology Laboratory, Department of Zoology, University of Calcutta, 35, B.C. Road, Kolkata 700 019, West Bengal, India.
[2]Email: sus.zooh@gmail.com
[3]Email: srimantakraut@gmail.com

During the course of studies on the bio-ecology of Flying Fox *Pteropus giganteus giganteus* (Brunnich) at Joteghanashyam area of Paschim Medinipur district of West Bengal, India, we took the opportunity to note the impact of Aila storm on a bat population occurring in the area. Our study programme was stimulated by a news broadcast on the radio and television announcing the approaching Aila storm. The senior author (SM) reached the site – a Silk Flower tree (*Albizia lebbeck*) – which was inhabited about 800 *P.g. giganteus* individuals, at 08:00 hrs on May 25, 2009. The Silk Flower tree was 42 m tall with a canopy of 12 m diameter with well-developed branching system. The tree was situated on a hill inside a village. The weather was cloudy and it began drizzling at around 09:35 hrs. SM continued observing the bats from the ground. The ground below the tree canopy was clean. Aila appeared suddenly at 10:46 hrs. The wind speed was very high (110 km/hr, as per local Meteorological Station); unable to stand under the Silk Flower tree SM took shelter in a nearby house. The wind speed remained at about 110 km/hr for the first 10 minutes. Thereafter, it decreased gradually and by 11:56 hrs the weather condition permitted SM to step out and visit the bat colony.

SM noticed a big and three small branches of the Silk Flower tree and 47 dead bats lying on the ground. Almost all the bats had blood oozing from the mouth. Forty-four bats were collected by the locals for feasting, while three were carried away by a mongoose (*Herpestes* sp.) into its burrow. The bats hanging from the tree had a blank look; in fact none of them left the tree to forage that night. However, the next evening (on May 26) they left the tree to forage.

In this case, 47 bats could not survive the severity of Aila storm. But it is not clear whether the speed of the wind or an attempt to seek a safe shelter dislodged them from the tree. Whatever the reason it is likely that once dislodged from the branch they failed to sustain themselves in the air because of the high speed of the wind, and therefore, fell to the ground. Thus, it is apparent that such natural calamities not only kill individuals but also create panic in the surviving individuals of *P.g. giganteus* for atleast 24 hours.

3. FIRST RECORD OF LESSER FALSE VAMPIRE BAT (*MEGADERMA SPASMA* LINNAEUS, 1758) IN GIR NATIONAL PARK & SANCTUARY

Md. Shamshad Alam[1]

[1]Department of Wildlife Sciences, Aligarh Muslim University, Aligarh, Uttar Pradesh, India.
Email: msalam01@gmail.com

On May 10, 2008, during my research on Striped Hyena *Hyaena hyaena* in Gir National Park and Sanctuary, I and my field assistant were in the Chodawadi range of the Park. We were approaching Dungarphadi a permanent water body at Ardak river for searching active dens and other evidence of Striped Hyena. There was no road or trail to Dungarphadi; it was a savannah type forest. After some time we started walking along a dry stream. After a few hundred metres walk, I located a sandy den (21° 08' 02.5" N; 70° 51' 08.7" E) and entered it cautiously. The den was an abandoned Indian

Crested Porcupine *Hystrix indica* den. While I was observing the den, a bat suddenly flew out, and settled on a tree nearby. I photographed the bat so that I could identify it later.

I compared photographs of the bat with the ones recorded from Gir and also with descriptions from Bates and Harrison (1997), Menon (2003) and Prater (2005). According to the Gir Management Plan, only two species of bats have been reported from Gir (Singh and Kamboj 1996), namely Flying Fox *Pteropus giganteus* and Short-nosed Fruit Bat *Cynopterus sphinx*. To confirm the identity of the bat I sent the photographs to Dr. Paul Bates, a bat specialist, Dr. Asad R. Rahmani (Director, BNHS), and Dr. Sandeep Kumar (Deputy Conservator of Forests, Wildlife Division, Sasan-Gir). The bat was identified as a Lesser False Vampire Bat *Megaderma spasma*. This is the first documentation of the Lesser False Vampire Bat *Megaderma spasma* from the Gir National Park and Sanctuary, Gujarat.

False vampire bats are tailless bats belonging to an ancient and carnivorous family Megadermatidae, which include five species in four genera (Bates and Harrison 1997; Macdonald 1999). There are two species of false vampire bats found in India: Greater False Vampire Bat *Megaderma lyra* and Lesser False Vampire Bat *Megaderma spasma*. These bats have long oval ears that have a distinct smaller "inner ear" or tragus. The easier way to differentiate them is by the shape of their noseleaf. Lesser False Vampire Bat has short, broad and heart-shaped noseleaf base, while Greater False Vampire Bat has a much elongated noseleaf (Bates and Harrison 1997).

Lesser False Vampire Bat *Megaderma spasma* is known from India, Sri Lanka, Myanmar, South-East Asia to Java, Philippines and Molucca Islands (Bates and Harrison 1997). In India, it is distributed in Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, West Bengal, Assam, Mizoram and Andaman Islands (Bates and Harrison 1997; Menon 2003).

ACKNOWLEDGEMENTS

I thank Dr. Jamal A. Khan for giving me an opportunity to work in Gir National Park and Sanctuary. I thank the Ministry of Environment and Forests (Govt. of India) for funding the Gir Hyena Ecology Project. I thank Gujarat Forest Department and Department of Wildlife Sciences, Aligarh, Muslim University, Aligarh, for providing logistic support.

REFERENCES

Bates, P.J.J. & D.L. Harrison (1997): Bats of Indian Subcontinent. Harrison Zoological Museum Publications. 258 pp.

Macdonald, D. (1999): The Encyclopaedia of Mammals. Greenwich Editions, London.

Menon, V. (2003): A Field Guide to Indian Mammals. Published by Dorling Kindersley (India) Pvt. Limited with association with Penguin Book (India) Pvt. Limited. 200 pp.

Prater, S.H. (2005): The Book of Indian Animals. Bombay Natural History Society, Oxford University Press. 324 pp.

Singh, H.S. & R.D. Kamboj (1996): Biodiversity Conservation Plan for Gir. A Management Plan for Gir Sanctuary & National Park. Forest Department, Gujarat State. 242 pp.

4. RECENT RECORDS OF GAUR *BOS GAURUS* SMITH IN BANGLADESH

Anwaruddin Choudhury[1]

[1]The Rhino Foundation for Nature in NE India, C/o The Assam Co. Ltd., Bamunimaidam, Guwahati 781 021, Assam, India. Email: badru1@sify.com, acbadru56@gmail.com

The range of Gaur *Bos gaurus* Smith 1827 extends from southern India to Vietnam (Ellerman and Morrison-Scott 1951; Choudhury 2002). It used to be common in the northern, north-eastern and south-eastern Bangladesh (Khan 1985; Asmat 2001; Choudhury 2002; Khan 2008). In the north and north-east, the Gaur used to occur along the foot of Garo, Khasi Hills and Jaintia Hills in undivided Mymensingh and Sylhet districts. In the south-east, they used to occur in undivided Chittagong Hill Tracts and Chittagong districts. Khan (1985) surmised that there is possibly no resident population in Bangladesh. He recorded a case in 1980 where a Gaur strayed from Garo Hills, Meghalaya, to Durgapur of undivided Mymensingh (now in Netrakona district) was killed and its meat taken by villagers. Khan (1985) and Asmat (2001) also stated that the last gaurs in herds were probably eliminated during the war of liberation in 1971.

I here report of some recent occurrence in Comilla and Feni (part of erstwhile undivided Noakhali district) districts, which were otherwise unrecorded cases and no publication of that country such as Khan (2008) also mentioned of these. These records were obtained during field visits in the fringe villages of Trishna Wildlife Sanctuary in Tripura, north-east India, in January 2008.

In 2004, a Gaur from Trishna Wildlife Sanctuary strayed

to Feni area of Bangladesh through Siddhinagar. What happened to it subsequently is not known. Feni is in erstwhile undivided Noakhali district (now Feni district).

In March-April 2007, three Gaurs, a bull and two cows, (one was pregnant) strayed from Trishna Wildlife Sanctuary through Garjania to 'Suorbazar' area of Bangladesh. Their fate also went unrecorded.

In the first week of November 2007, a bull from Trishna Wildlife Sanctuary strayed into Kuderpathar through Rajnagar area and was killed for meat.

In areas near India-Bangladesh border, Trishna Wildlife Sanctuary in Tripura and Dampa Tiger Reserve in Mizoram are the closest having Gaur populations. Balpakram National Park in Meghalaya, an important Gaur habitat, is a little distance away but straying of Gaur is possible owing to their habit of doing so (Choudhury 2002). In Khasi and Jaintia Hills sectors of Meghalaya, the Gaur is either extinct or stray individuals survive with lesser chances of straying into that country. In southern Assam (Karimganj district) and northern and western Tripura also the Gaur has vanished from forest areas nearer to the border. However, there could still be some stray movement between forests near Gumti Wildlife Sanctuary of Tripura and Mizoram areas with the forests in Chittagong Hill Tracts.

Khan (2008) included Gaur in the list of lost species but mentioned of possible vagrant animals in north-east (undivided Sylhet area) and south-east (Chittagong Hill Tracts) but did not mention of any recent specific cases and also not the areas mentioned in this note, which are actually in eastern Bangladesh.

Such frequent straying from Trishna Wildlife Sanctuary had ensured Bangladesh's name in the range countries of the Gaur. However, such straying is going to be stopped completely owing to border fencing. While such fencing has proved to be harmful for Asian Elephants *Elephas maximus* at different sectors (Choudhury 2007), for the gaurs of Trishna Wildlife Sanctuary it is going to be a boon as it will stop straying into Bangladesh as well as getting killed as there is no habitat in that sector across the border and the animals land up in densely inhabited villages only to get killed and eaten. With complete halt of movement from Trishna Wildlife Sanctuary, the only movement will remain in Dampa sector, Mizoram-Chittagong Hill Tracts, but fencing is also going to be erected here very soon. After closing of the Dampa border with Chittagong Hill Tracts the gaur can be listed as extinct in Bangladesh!

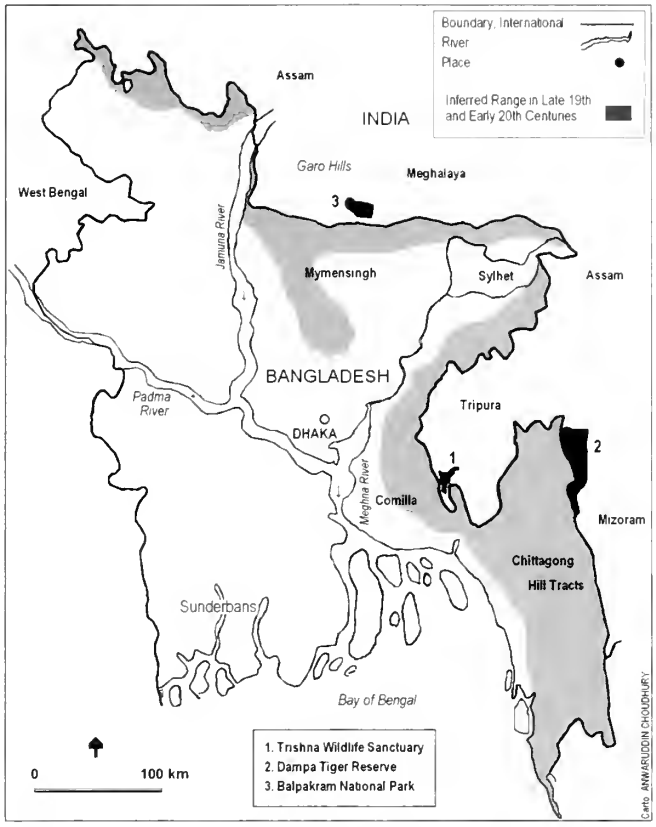


Fig. 1: Map of Bangladesh showing some of the areas/places mentioned in the text

ACKNOWLEDGEMENTS

I thank Kamal Banik and other members of Dishari NGO, and Forest officials and staff. Special thanks to Gauranga Chandra Debbarman and Gaursadan Jamatia, both Head Forest Guards, for corroborating these reports, which are also known to many of the fringe villagers.

REFERENCES

Asmat, G.S.M. (2001): *Bagladesher bilupto bannyaprani* [in Bengali]. Bangla Academy, Dhaka, Bangladesh. 184 pp.

Choudhury, A.U. (2002): Distribution and conservation of the Gaur *Bos gaurus* in the Indian Subcontinent. *Mammal Review 32(3)*: 199-226.

Choudhury, A.U. (2007): Impact of border fence along India – Bangladesh border on elephant movement. *Gajah 26*: 27-30.

Ellerman, J.R. & T.C.S. Morrison-Scott (1951): Checklist of Palaearctic and Indian Mammals, 1758 to 1946 (2nd edn, 1966). British Museum (Natural History), London.

Khan, M.A.R. (1985): Mammals of Bangladesh. N. Reza, Dhaka, Bangladesh. 92 pp.

Khan, M.M.H. (2008): Protected areas of Bangladesh – a guide to wildlife. Nishorgo Programme, Forest Department, Dhaka, Bangladesh.

5. A CONSERVATION PLEA FOR SAVING WILDLIFE IN THE LANDSCAPE BOUND BY GOLA, LADHIYA AND SHARADA RIVERS, NORTH INDIA

A.J.T.Johnsingh[1], Bivash Pandav[2] and Dhananjai Mohan[3]

[1]Nature Conservation Foundation, Mysore and WWF-India. Email: ajt.johnsingh@gmail.com
[2]Tiger and other Asian Big Cats, WWF International C/o - WWF Nepal, P.O. Box # 7660, Baluwatar, Kathmandu, Nepal. Email: bivash.pandav@wwfnepal.org
[3]Wildlife Institute of India, Chandrabani, PO Box 18, Dehradun 248 001, Uttarakhand, India. Email: dmohan@wii.gov.in

One of the scenic, neglected but promising landscapes for large mammals in India is in the eastern part of Uttarakhand. This landscape spreading over an area of nearly 1,200 sq. km includes the entire Haldwani Forest Division (FD) comprising of Nandhour, Danda, North Jaulasal, Chhakata and Sharada forest ranges; the Dogari and Boom forest ranges of Champawat FD and Kishanpur, Ransali, Jaulasal south and Kilpura ranges of Terai East FD (Fig. 1). Abutting ranges of Champawat FD (Bhingrada and Champawat) and Bharon range of Nainital FD, just north of Ladhiya and Gola rivers, are not included in this conservation planning though they are contiguous to the landscape. Those who have trekked here would concur with us that the mountainous parts of this landscape (Haldwani and Champawat FDs) are the most beautiful locales in the entire outer Himalayan range. Corbett (1944, 1954) has written about this hilly region in his accounts on Chowgarh tigers, Talla-Des, Chuka and Thak man-eaters. We had the pleasure of walking 130 km across this landscape: 60 km from Manch to Thuligad via Chuka and Thak in December 2005 and 70 km from Dalkania (Chowgarh tigers were shot here) to Chorgalia and Kalonia in January 2006. This landscape was once part of a much wider continuous landscape that existed all along the foot-hills of Himalaya (Toovey 1987). Isolation of this landscape was as a result of uncontrolled boulder mining in Gola river, townships, encroachments and other developments in the terai part of the landscape.

Based on these walks, plus the earlier Terai tiger surveys carried out by the Wildlife Institute of India in this landscape (Johnsingh *et al.* 2004), and the information we gathered from the forest staff during our treks, we conclude that the status of three endangered species – Golden Mahseer *Tor putitora*, Elephant *Elephas maximus* and Tiger *Panthera tigris* – is extremely critical here. During our 130 km trek, although we saw eight leopard *P. pardus* and six sloth bear *Melursus ursinus* tracks, we did not see a single tiger sign.

During the Terai tiger survey, covering the entire area of all the three divisions (*c.* 1,800 sq. km) we had walked 147 km along river beds, covering almost all potential tiger forest ranges, looking for tiger, leopard and prey signs. The number of different tiger pug marks seen was 34 and leopard 49, which gives an encounter rate of 0.23 tiger pug marks/km and 0.33 leopard pug marks/km, respectively. In comparison, 18.8 km walk in the four river beds in the southern part of Corbett Tiger Reserve (TR) yielded 21 tiger pug marks (1.1 pug marks/km) and two leopard pug marks (0.01/km; Johnsingh *et al.* 2004).

Poaching of ungulate prey by the Nepalese and the people of this landscape, as well as outsiders, particularly by the *Rai Sikhs* (who come from the *terai*, the fertile landscape south of the foot-hills, and hereafter called the Terai Poachers), is the major reason for the rarity of tiger in this landscape of enormous potential. While poaching by the local people and the Terai Poachers still continues, the illegal activities by the Nepalese have been contained to a great extent since 2003, after the deployment of Special Security Bureau forces along Sharada river with the specific purpose of curtailing incursions by the Maoists from Nepal. Related to tiger conservation, poaching by the Terai Poachers is extremely detrimental as they selectively kill Sambar *Cervus unicolor*, the most vital prey for tiger in the Asian forests, by using dogs and spears. Terai Poachers also indulge in other unlawful activities such as brewing and selling liquor in the forests, and occasionally waylaying villagers who transit through the forests carrying provisions. It is also reported that the Terai Poachers are responsible for the killing of most of the elephant tuskers in the area. Exploits of the Terai Poachers are largely for adventure and not driven by poverty. Presently, the status of the 40 or so elephants mostly confined to the south-eastern part of this landscape is extremely critical and it is one of the most precariously endangered sub-populations in the country. Other problems seen in this landscape are the widespread presence of cattle camps, use of destructive fishing methods (dynamites, gill nets and bleaching powder) in the Sharada, Nandhour and Ladhiya rivers, smuggling of timber and fire wood cutting along the southern portion of the landscape.

Yet the potential for the conservation of tiger and mahseer is extremely high, as the landscape has nearly

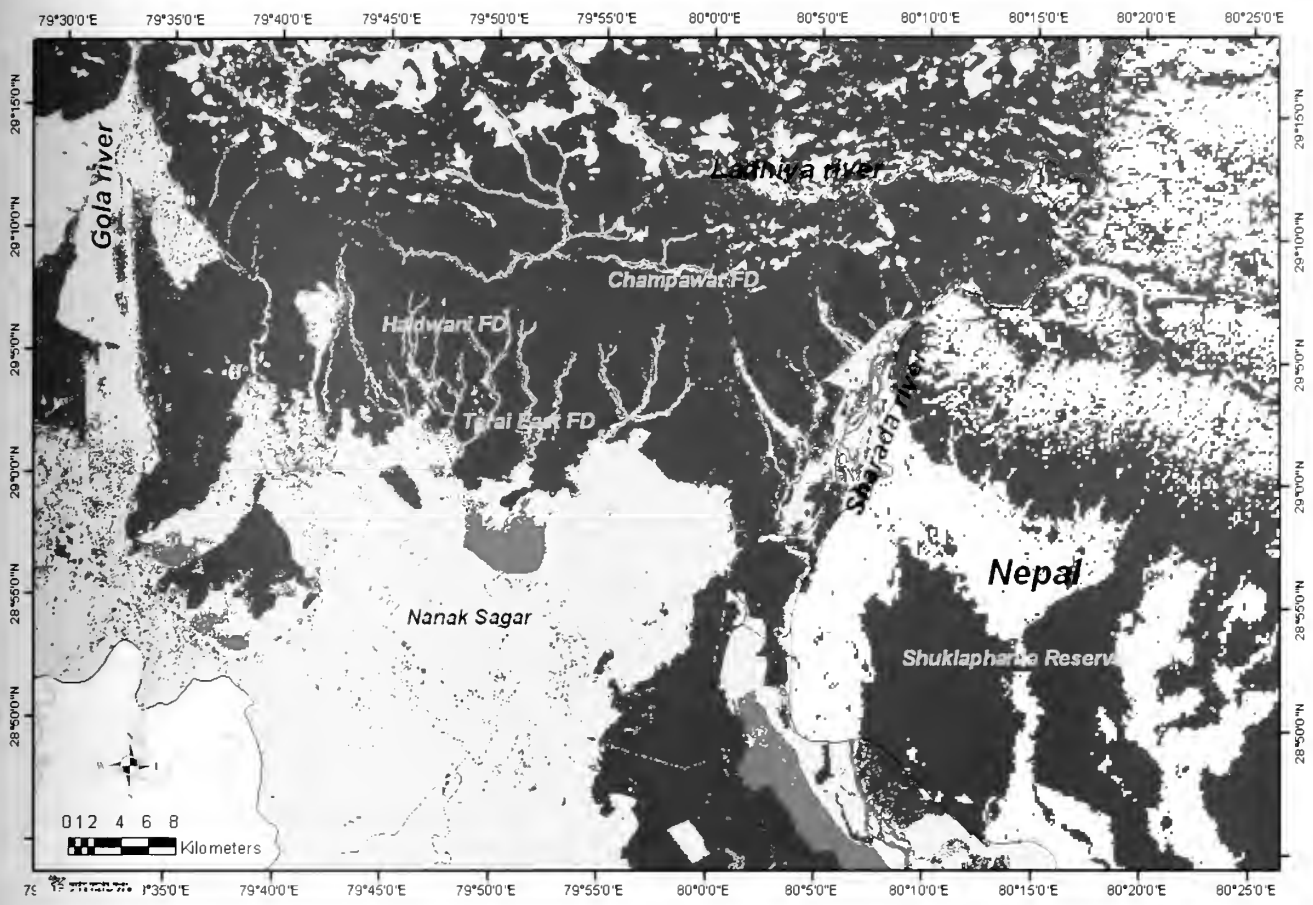


Fig. 1: The landscape bound by Gola, Ladhiya and Sharada rivers

1,000 sq. km intact Sambar-Tiger habitat. The Nandhour river flows for 30 km through a valley with no permanent human settlements, the final 20 km of Ladhiya between Chalti and its confluence with Sharada is sparsely populated and Sharada, beyond Chuka, flows for 20 km with only one cattle camp on the Indian side (opposite of the cattle camp on the Nepal side there is Parigaon village of 300-500 families). The area (Chakata range of Haldwani FD) has a weak connectivity with Ramnagar FD (Fatehpur range) and Nainital FD (Ranibagh range) which are connected with Corbett TR on the west. Sadly, the connectivity with Corbett TR across Terai Central, Ramnagar and Terai West FDs, which was seriously threatened by boulder mining in the past, seems to be totally broken now as a result of new developments such as the construction of Indian Oil Corporation Depo, Railway Sleeper Factory and allotment of 50 ha land to Indo-Tibetan Border Police for their campus development. There is still connectivity with the forests in Nepal across Sharada, and it appears that the continuity along the foot-hills beyond Sharada exists for about 20 km as Brahmadev corridor till the eastern part of Shuklaphanta Wildlife Reserve (Fig. 1). Surveys and immediate conservation initiatives to protect the forests here are urgently needed. The conservation measures suggested for the landscape would also immensely benefit the elephants pocketed in this landscape, particularly the tuskers would be able to live longer and contribute to breeding. Thus, this landscape has immense value in securing the future of tiger and associated species in the *terai- bhabar* landscape which in India and Nepal sprawls over an area of *c.* 40,000 sq. km. We present this report to urge the stakeholders to start working towards the following objectives:

- Establish *c.* 1,000 sq. km Nandhour-Ladhiya Conservation Reserve, which would encompass the Danda, Nandhour and Jaulasal (north) ranges of Haldwani FD, Dogari and Boom ranges of Champawat FD, Jaulasal (south) and Kilpura ranges of Terai East FD and other potential adjacent forest blocks (Fig. 2).

- Notify *c.* 400 sq. km as Nandhour Valley National Park including areas of Danda, Nandhour and Jaulasal (north), ranges of Haldwani FD as the core of the Conservation Reserve (which may be elevated to the level of a National Park or a Wildlife Sanctuary). Danda has human habitations only along its western and northern boundary,

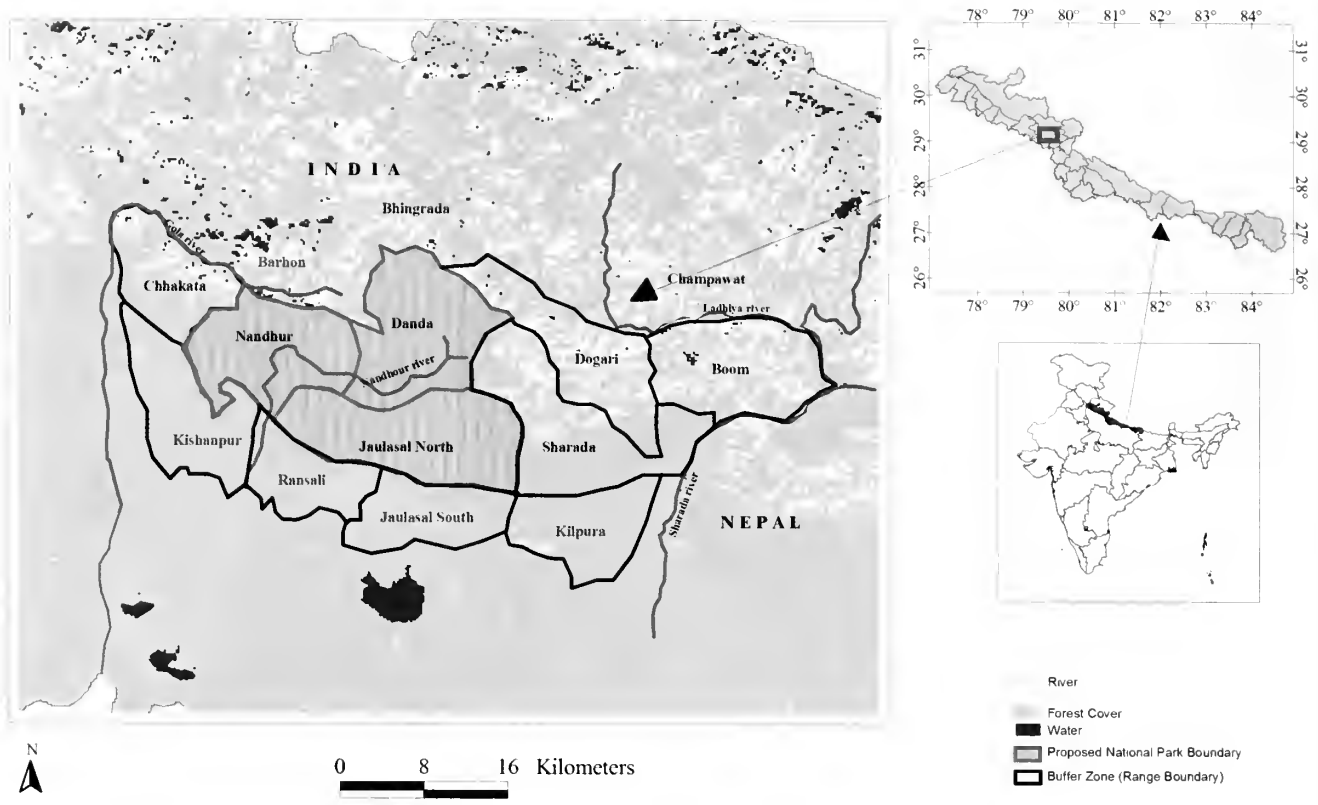


Fig. 2: Suggested Nandhour- Ladhiya Conservation Reserve with a core

and Nandhour only in the south. It is reported that Jaulasal does not have permanent settlements (Fig. 2).

■ Facilitate the only family living in Thak to settle down in Chuka and vacate the cattle camp on the bank of Sharada so that minimum 50 sq. km of Boom range becomes free of human habitation. This area marked by the Purnagiri temple in the south, Chuka in the north, Sharada river in the east and Kotkendri in the west, can become a satellite mini-core of the suggested Park/WLS. Endangered Serow *Capricornis sumatraensis* is reported to occur here.

■ Station a 50-person strong anti-poaching force of forest and police personnel along the southern boundary of the suggested Conservation Reserve, to patrol the forests, kill the dogs used in poaching, arrest the poachers and liquidate the liquor trade within the jungle. This protection force may have to continue for several years.

■ Initiate a dialogue with the elders of the villages all along the southern boundary, from where the Terai Poachers are reported to come, so that the men from the villages would stop their illegal activities inside the forests. We should also recruit, motivate and train 12-15 Terai Poachers from these villages as part of the anti-poaching force. They can also be trained as ecotourism guides to take adventure tourists to trek in this landscape. The villagers have a stake in protecting this landscape as water for their prosperous agriculture comes only from these mountains.

Spread the message of conservation in all the villages within and along the boundary of the Conservation Reserve (this should include villages in the immediate vicinity of Ladhiya on its north bank) about the need to give up poaching, and give sufficient financial incentives to grow fuel wood and fodder species on their lands so that pressures on the forests will be minimal. May be 500-1,000 m width of reserve forest all around the village, depending upon the size of the village, can be set aside for growing firewood and fodder.

■ Conduct a socio-economic survey of all the villages in this landscape at the earliest, so that appropriate conservation programmes for every village could be initiated following a participatory approach.

■ Conduct another absence/presence/abundance survey of tiger, leopard and wild ungulate signs in January-February, as done by Wildlife Institute of India between October 2002 and June 2003 (Johnsingh *et al.* 2004), and initiate a study to assess the population, range and habitat use of elephants in the landscape.

■ While allowing people to catch fish for their use with line and hook, nooses (a widely used method in

Uttarakand) and cast nets, ban destructive methods of fishing in Nandhour, Ladhiya and Sharada rivers to enable Mahseer to stage a come back.

■ Secure the support of Government of India, which has the responsibility to save the tiger through its National Tiger Conservation Authority, to establish Conservation Reserve and the National Park, which eventually, with some reintroduction, can support 30-50 tigers. As seen from the studies in the western part of Uttarakhand, in a similar habitat, the potential of this habitat to support high densities of wild ungulate prey is enormous (Harihar *et al.* 2008).

■ Long term plan for this promising landscape should include re-establishment of viable connectivity with Corbett TR and Suklaphanta Reserve.

ACKNOWLEDGEMENTS

Mr. P.R. Sinha, Director, Wildlife Institute of India, Nature Conservation Foundation, Mysore, Mr. Ravi Singh, Secretary General & CEO, WWF-India, Mr. Param Jit Singh, Conservator of Forests, Uttarakhand, Mr. Ashok Mehar, Divisional Forest Officer, Nainital FD, Mr. Kapil Lal, Divisional Forest Officer, Haldwani FD and Mr. Rajmani Pandey, Divisional Forest Officer, Champawat FD and Ravikiran Govekar, Maharashtra Forest Department facilitated the survey. Drs. S.P. Goyal and Nima Manjrekar read through the manuscript. Dr. K. Ramesh, Mr. Panna Lal, and Mr. P.K. Tomar, Wildlife Institute of India, prepared the figures. We thank them all.

REFERENCES

Corbett, J. (1944): Man-Eaters of Kumaon. Oxford University Press, London.

Corbett, J. (1954): The Temple Tiger and More Man-Eaters of Kumaon. Oxford Universities Press, London

Harihar, A., B. Pandav & S.P. Goyal (2008): Responses of tiger (*Panthera tigris*) and their prey to removal of anthropogenic influences in Rajaji National Park, India. *European Journal of Wildlife Research 55*: 97-105.

Johnsingh, A.J.T., K. Ramesh, Q. Qureshi, A. David, S.P. Goyal, G.S. Rawat, K. Rajapandian & S. Prasad (2004): Conservation status of tiger and associated species in the Terai Arc Landscape, India. Wildlife Institute of India, Dehradun. Pp. viii +110.

Toovey, J. (ed.) (1987): Tigers of the Raj. Pages from the Shikar Diaries – 1894 to 1949 of Colonel Burton, Sportsman and Conservationist, Alan Sutton.

6. LARGE-TAILED NIGHTJAR *CAPRIMULGUS MACRURUS* IN PHULWARI-KI-NAAL WILDLIFE SANCTUARY, UDAIPUR DISTRICT, RAJASTHAN

Harkirat Singh Sangha[1] and Dhirendra Devarshi[2]

[1]B-27, Gautam Marg, Hanuman Nagar, Jaipur 302 021, Rajasthan, India. Email: harkirat.sangha@gmail.com
[2]C-8, Prithviraj Road, Jaipur 302 001, Rajasthan, India.

While we were birding in Asawara area of Mamer in Phulwari-ki-Naal Wildlife Sanctuary, Udaipur district, Rajasthan on March 29, 2004, a Large-tailed Nightjar *Caprimulgus macrurus* started calling *chaun... chaunk...chaunk...* at 18:44 hrs soon after sunset. Being familiar with the distinct knocking and resonant call of the species we had no difficulty in identifying the species.

Soon after we heard another bird calling some distance away from the first one; the birds stopped calling when we tried to find them. Possibly they were disturbed by the noise created by trampling of dry leaves lying on the ground. Later in the evening one bird was briefly heard at 20:30 hrs and another flying close to the forest rest house at Mamer.

With an average annual precipitation of *c.* 650 mm, Phulwari-ki-Naal harbours dry deciduous forest and some patches of moist deciduous biotopes. There is preponderance of stunted Teak *Tectona grandis* and Mahua *Madhuca indica* trees in some parts of the Sanctuary. When we visited the area the trees had shed their leaves and ground was covered with a thick carpet of dry leaves. The habitat at Asawara seemed suitable for the species to breed as the species is known to breed from March to June "among dry leaves, often in rather open conditions" (Rasmussen and Anderton 2005).

Although apparently resident or a local migrant in much of its range, it is "only a summer visitor in some areas such as the Punjab Salt range (Rattray 1899: 342)" (Ali and Ripley 1983; Holyoak 2001).

The movements and distribution of the species "on western side south of sub-Himalayan Punjab (N. Maharashtra etc.)" are uncertainly known (Ali and Ripley 1983). It is sedentary and partially migratory, perhaps subject to some local movements (Cleere 1998). The species is known to be a summer breeding visitor in dry subtropical deciduous forest, but is confined to the Murree Hills eastwards to Kahuta (Grimmett *et al.* 2008).

Although it is difficult to comment about the status of the species in Phulwari-ki-Naal, it is certainly a new record for the area. We are not aware of any other sighting in Rajasthan except at Bharatpur (Kazmierczak and van Perlo 2000). Two new records of the species are from the

neighbouring Gujarat state, not very far from Phulwari-ki-Naal. The species was recorded on March 03 and 17, 2000, from Ratanmahal Wildlife Sanctuary. However, no visual observations were made (Trivedi and Soni 2006). Another record is from Phot Mahadev, Kachchh, Gujarat where eight individuals were photographed (Mishra and Singh 2010).

REFERENCES

Ali, S. & S.D. Ripley (1983): Handbook of the Birds of India and Pakistan. Second edition. Vol. 4. Delhi. Oxford University Press.

Cleere, N. (1998): Nightjars – A guide to Nightjars and Related Birds. Mountfield East Sussex. Pica Press. Pp. 247-250.

Grimmett, R., T. Roberts & T. Inskipp (2008): Birds of Pakistan. London. Christopher Helm. Pp. 80.

Holyoak, D.T. (2001): Nightjars and their Allies The Caprimulgiformes. Oxford University Press, Oxford. Pp. 528-541.

Kazmierczak, K. & B. van Perlo (2000): A Field Guide to the Birds of Indian Subcontinent. Pp. 152.

Mishra, V.V. & R. Singh (2010): Large-tailed Nightjar *Caprimulgus macrurus* sightings in Kachchh, Gujarat, India. *Indian Birds 5(5)*: 148.

Rasmussen, P.C. & J.C. Anderton (2005): Birds of South Asia. The Ripley Guide. Vol. 2. Washington D.C. and Barcelona. Smithsonian Institution and Lynx Edicions.

Trivedi, P. & V.C. Soni (2006): Significant bird records and local extinctions in Purna and Ratanmahal Wildlife Sanctuaries, Gujarat, India. *Forktail 22*: 39-49.

7. ADDITIONAL DISTRIBUTION RECORDS OF ASSAM ROOFED TURTLE *PANGSHURA SYLHETENSIS* (JERDON 1870) FROM DIFFERENT LOCALITIES OF WESTERN ASSAM AND ARUNACHAL PRADESH, INDIA

Rakesh Soud[1] and Lohit gogoi[2]

[1]Department of HSS, Indian Institute of Technology Guwahati. Amingaon, North Guwahati 39, Assam, India.
Email: assam_rhino@rediffmail.com
[2]Western Arunachal Landscape Programme. Arunachal Pradesh Field Office, World Wide Fund for Nature–India. Dirang, West Kameng Distt 790 101, Arunachal Pradesh, India.

The Chelonian fauna of north-eastern states of India comprises of at least 21 species, belonging to 3 families. Much of the existing knowledge on the distribution of the group in the region is based on collections that are decades old, scattered in several museums. Literature concerning the region's turtles and tortoises is scanty (Das 1990). The present note describes some additional distributional record of the *Pangshura sylhetensis* from different localities of Western Assam and Arunachal Pradesh of the Indian territory.

Pangshura sylhetensis was previously recorded from Manas Tiger Reserve, and Kolathua village of Sivasagar district (Das 1990), Cachar districts of Assam and Cherrapunji (Khasi hills) and Garo hills of Meghalaya. It is also recorded from Sylhet district of Bangladesh (Moll 1987). Recently, it was recorded from Kaziranga National Park, Manas National Park, Nameri National Park, Narayanpur Tea Estate, Sivasagar district, Sonapur, Cachar district, Lakhimpur district, North Cachar districts of Assam (Sarma 2007). We had a direct sighting record of the species from the Samukha river near Ultapani forest village and also a secondary record confirmed by village fishermen from the Zamduwar area of Chirang-Ripu reserve forest (26° 40' N; 89° 53' E), Bodoland Territorial Council, Assam. This extends the distribution of the species up to 90 km west from Manas Tiger Reserve.

There is scanty distributional record of the species in the bordering areas of Assam. We also recorded the species from Tenga valley (27° 12' 25.81" N; 92° 30' 49.17" E) of West Kameng district of Arunachal Pradesh at an elevation of 1,205 m. This specimen was rescued from a local fisherman who caught it from a local hill stream. This record also extends the northern distribution of the species up to Tenga valley, at least 150 km from Manas National Park and 70 km from Nameri National Park. Probably, this is the highest elevation record of the species.

ACKNOWLEDGEMENTS

The authors are thankful to Conservation worker Mr. N.K. Dey and members of Ultapani Biodiversity Conservation Society and Green Forest Conservation for their kind hospitality during different field trips at Chirang-Ripu R.F. and WWF officials of WAL programme for their encouragement in Arunachal Pradesh part. We also thank Dr. Saibal Sengupta for his different advice and consultation regarding the species in different visits to his herpetological lab at Arya College, Guwahati.

REFERENCES

Das, I. (1990): Additional records for Chelonians from Northern India. *J. Bombay Nat. Hist. Soc. 87(1)*: 91-97.

Moll, E.O. (1987): Survey of the freshwater turtles of India. Part II. The genus *Kachuga*. *J. Bombay Nat. Hist. Soc. 84(1)*: 7-25.

Sarma, P.K. (2007): Habitat ecology, population status and distribution of *Kachuga sylhetensis* (Jerdon) in certain districts of Assam. (Ph.D. Thesis) Gauhati University. 137 pp.

8. A NOTE ON THE OCCURRENCE OF NON-STYGOBITIC FISHES IN A CAVE IN ANDHRA PRADESH, PENINSULAR INDIA

Y. Ranga Reddy[1,2] and S.V. Sharma[1,3]

[1]Department of Zoology, Acharya Nagarjuna University, Nagarjunanagar 522 510, Guntur district, Andhra Pradesh, India.
[2]Email: yrangareddy@yahoo.com
[3]Email: profsharma@rediffmail.com

What with its vast territory, ancient and varied geomorphology, hydrology, and climate, the Indian subterranean domain has given rise to numerous natural caves and cavities of varied shapes and sizes. A small tract such as the Tungabhadra River Valley in Andhra Pradesh alone has more than one hundred caves (Prasad 1996). Generally characterized by perpetual darkness, low energy input and remarkable constancy of temperature and humidity, caves are inhabited by highly diversified organisms, ranging from protozoans to mammals besides bacteria and fungi. The typical cave/groundwater dwellers have originated from their extinct/extant epigean ancestors of marine, freshwater or terrestrial habitats at different times and in different ways. Hence, the subterranean realm (stygon) has come to be regarded as a promising place to look for insights into biological adaptation and speciation (Rouch 1986). That the Indian caves harbour rich biodiversity can be gauged by the fact that a recent preliminary study of just a single collection from the sandy bottom of a cave (Kotumsar Cave) has led to the discovery of three new taxonomically and biogeographically significant stygobitic crustacean taxa, together with a new amphipod family (Ranga Reddy 2006; Messouli *et al.* 2007; Ranga Reddy and Defaye 2009). Nevertheless, groundwater biology as a whole has received scant attention in India (Ranga Reddy 2002, 2004).

Based on their degree of adaptation to groundwater life, the hypogean aquatic fauna are generally classified into three broad ecological groups: stygobites or stygobionts, stygophiles, and stygoxenes. Stygobites are obligatorily confined to caves or other subterranean passages and exhibit a suite of stygomorphic characters such as the loss of eyes and melanin pigment (regressive features), and elaboration of other sensory structures like the lateral organs in fishes and antennae in insects and crustaceans (progressive features) (Proudlove 2006). While stygophiles can live, feed and reproduce in both epigean and hypogean habitats and show some degree of stygomorphic/behavioural adaptations, stygoxenes cannot complete their life in hypogean habitats and are not much different from their epigean counterparts.

As for the Indian subterranean fish fauna, only five stygobitic fish species are known till date, comprising two clariid catfishes (*Horaglanis krishnai* Menon 1950 and *H. alikunhii* Babu & Nayar 2004) and three synbranchid eels (*Monopterus eapeni* Talwar 1991, *M. roseni* Bailey & Gans 1998, and *M. digressus* Gopi 2002), all from the State of Kerala. Hora (1924) recorded eight non-stygobitic fishes for the first time from an Indian cave (Siju Cave, Assam), which included five cyprinids, namely *Neolissochilus hexastichus* (McClelland 1839) (= *Barbus hexastichus*), *Barilius barna* (Hamilton 1822), *Barilius bendelisis* (Hamilton 1807), *Devario aequipinnatus* (McClelland 1839) (= *Danio aequipinnatus*) and *Psilorhynchus sucatio* (Hamilton 1822), an unidentified species of the balitorid genus *Nemacheilus*, an ambassid, *Chanda nama* (Hamilton 1822), and the walking snakehead, *Channa orientalis* Bloch & Schneider 1807 (*Ophiocephalus gachua* in source). Since then, only four non-stygobitic species are known from the Indian caves: three loaches, namely *Schistura sijuensis* (Menon 1987) from Siju cave, *Indoreonectes evezardi* (Day 1872) from Kotumsar cave, Chhatisgarh and *Schisturia papulifera* Kottelat, Harries & Proudlove 2007 from a cave of Synrang Pamiang system, Meghalaya, and a lone specimen of an unidentified schizothoracine fish from a cave near Udaipur, Rajasthan (Tehsin *et al.* 1988). On the other hand, the world tally of the described subterranean fish species, as of 2003, is 125 (Proudlove 2006).

This note is meant to report on a fortuitous collection of seven non-stygobitic fish species from Nelabilum cave (15° 00' 05" N; 78° 03' 20" E), which is located south-east of Ankireddipalle village in Kurnool district of Andhra Pradesh in peninsular India. According to Gebauer (2003), the cave is

a 'partly explored and partly mapped' natural cave and perennial spring in Precambrian (Algonkian) Narji limestone (Low. Kurnool). The natural subvertical fissure of the cave has been modified by man into a sort of a stepwell, giving access to groundwater. A 60 m long passage, including two flights of steps, leads to 'what looks like a penetrable sump' with clear water (depth 10 m). The existence of the cave is threatened by increasing industrial activity in the area by way of limestone quarrying for slabs and cement. As in the case of most Indian caves, practically nothing is known about the biology of the cave.

All the specimens reported herein were collected at the cave entrance on three dates by one of the authors (YRR) and/or his field assistants, using plankton net and/or baited hooks, and preserved in formalin. Counts and measurements follow Kottelat (2001) while nomenclature and ecology are based on Froese and Pauly (2009). Morphometric data are presented as percentages of standard length, with averages in parentheses. On October 3, 2005, water temperature of the cave was 27°C, air temperature 27°C and pH 6.5.

Specimens are deposited in the Department of Zoology, Acharya Nagarjuna University, Nagarjunanagar 522 510, pending transfer to the National Collections of Zoological Survey of India, Kolkata.

Puntius sarana (Hamilton 1822)

Material examined: 23 specimens, 49-160 mm SL; 3.x.2005.

D iii 8, P i 14, V i 7-8, A iii 5, L.l. 28-32. Head length 26.25-30.0 (28.38), body depth 26.66-33.12 (31.27), predorsal distance 42.85-53.33 (47.08), preventral distance 46.66-55.0 (51.92), preanal distance 60.00-71.86 (68.99), base of dorsal fin 15.62-18.33 (18.68), base of anal fin 22.00-26.66 (21.96), length of pectoral fin 18.33-20.62 (20.49), least height of caudal peduncle 13.33-15.60 (14.13), eye diameter 8.3-10.2 (9.2), snout length 9.37-11.2 (10.10), interorbital distance 10.2-11.8 (11.2).

Body oblong, compressed and deep; head with 2 pairs of barbels, rostral and maxillary, maxillary barbels longer, extending beyond hind margin of orbit; third unbranched ray of dorsal fin osseous, strong with minute serrations along posterior margin, basal region of dorsal and anal fins each covered with row of scales, auxiliary scale occurring at axle of ventral; dorsum uniformly olive, flanks silvery; in juveniles, 5-6 pigment bands present above lateral line and a dark vertical band covered by opercular membrane; an oval diffused dark spot on 26th to 28th lateral line scales. Body coloration, barbels, and eye diameter are as in the epigean forms.

This is a widely distributed Asiatic species. It is reportedly benthopelagic and potamodromous, occurring in freshwaters, but tolerant to brackish conditions.

Puntius ticto (Hamilton, 1822)

Material examined: 1 specimen, 29 mm SL. 3.x.2005.

D iii 8, P i 13, V i 6, A ii 5, L.l. 23. Head length 28.57, body depth 39.28, predorsal distance 53.57, preventral distance 57.14, preanal distance 67.85, base of dorsal 17.85, base of anal 14.28, length of pectoral 21.42, least height of caudal peduncle 17.85, eye diameter 8.5, snout length 10.6 and interorbital distance 10.7.

Body compressed, deep, barbels absent, lower jaw protruding beyond upper jaw, mouth upturned, third unbranched ray of dorsal with fine serrations along posterior border, a blotch on 3rd to 5th scales and a large distinct circular spot on the 17th to 19th lateral scales above anal. The present specimen agrees with its epigean counterparts in body coloration.

This species is known to inhabit still, shallow, marginal waters of rivers and tanks, subtropical in distribution and benthopelagic in habits, feeding on the organisms present on muddy bottom.

Rasbora daniconius (Hamilton, 1822)

Material examined: 5 specimens; 62-68 mm. SL. 3.x.2005.

D ii 7, P i 13-14, V i 9, A ii 5, L. l. 30-31. Head length 26.47 - 27.42 (26.94), body depth 16.12-7.64 (16.88), predorsal distance 51.47- 54.83 (53.15), preventral distance 45.16-48.52 (46.34), preanal distance 64.51-78.72 (68.28), base of dorsal 11.29-17.02 (13.73), base of anal 11.29-12.76 (11.52), length of pectoral 20.96-23.40 (21.23), least height of caudal peduncle 9.67-11.76 (10.71), eye diameter 6.4-7.3 (7.1), snout length 5.8-6.4 (6.1), interorbital distance 7.1-8.82 (7.66).

Body compressed, lower jaw projecting beyond upper jaw, symphysial knob on lower jaw, mouth small, upturned, caudal fin forked. Lateral line parallel to the ventral body contour, a grayish band occurring mid-laterally and extending from behind orbit to caudal fin. The narrow stripe generally seen above the base of anal fin in the epigean forms is not discernible in the present specimens.

This species is predominantly freshwater, inhabiting slow-flowing sandy streams and rivers. It is benthopelagic and potamodromous.

Garra gotyla stenorhynchus Jerdon, 1849

Material examined: 1 specimen; 47 mm SL. 3.x.2005.

D iii 5, P i 14, V i 14, A iii 5, L. l. 32. Head length 25.53, body depth 23.40, predorsal distance 48.93, preventral distance 57.44, preanal distance 78.72, base of dorsal 17.02, base of anal 12.76, length of pectoral 23.40, least height of caudal peduncle 12.76; eye diameter 8.5, snout length 10.6, interorbital distance 14.8.

Body subcylindrical, snout with a well-formed median proboscis and a transverse lobe at its tip, mouth arched, a mental adhesive disc associated with the lower jaw, 2 pairs of barbels, anterior ones longer, origin of dorsal fin nearer the snout, a black spot is present at the upper angle of the gill opening. In the preset specimen, an elliptical spot close to caudal fin is noticed, which has not hitherto been reported for this species.

A hillstream inhabitant, this species is endemic to peninsular India. It is benthopelagic.

Mystus cavasius (Hamilton 1822)

Material examined: 3 specimens, 88-102 mm SL. 30.x.2005.

D I 7, P I 8, V i 5, A iv 7-9. Head length 22.5, body depth 20.0, predorsal distance 35.0, preventral distance 48.75, preanal distance 66.25, base of adipose dorsal 40.0, base of anal 10.0, length of pectoral 15.0, least height of caudal peduncle 8.75, eye diameter 6.25-7.6 (7.5), snout length 8.6-8.9 (8.7), interorbital distance 7.2-7.9 (7.6).

Body elongate, occipital process narrow reaching the basal bone of rayed dorsal, median fontanelle long, extending to the base of occipital process, 4 pairs of barbels, maxillary barbels long, reaching base of caudal fin; rayed dorsal fin high and pointed, its spine weak, first dorsal ray long, base of adipose dorsal fin long, its origin closely behind rayed dorsal; pectoral spine strong with denticulations on inner margin, origin of ventral vertically below last ray of dorsal fin; a dark spot at the basal bone of rayed dorsal, a humeral spot and a band on upper flanks, belly white. The present specimens are not different from the epigean forms in body coloration and eye diameter.

This species is tropical, demersal, amphidromous, living in fresh- and brackish waters.

Mystus bleekeri (Day, 1877)

Material examined: one specimen, 95 mm SL. 30.x.2005.

D I 7, P I 9, V i 5, A iii 7. Head length 23.52, body depth 24.50, predorsal distance 32.35, preventral distance 45.09, preanal distance 64.70, base of adipose dorsal 36.27, base of anal 11.76, length of pectoral 16.66, least height of caudal peduncle 6.86, eye diameter 7.8, snout length 8.8, interorbital distance 8.2.

Body elongate, occipital process reaching basal bone of rayed dorsal, 4 pairs of barbels, maxillary pair extending up to anal fin, adipose dorsal long, originating closely behind rayed dorsal, ventral originating vertically below adipose dorsal, upper part of body grayish, grayish band occurring on either side of lateral line, lower band reaching ventral fin, a dark blotch behind opercle, rayed dorsal and caudal fins dark in colour. The present specimens accord well with the epigean forms in body coloration.

This is a demersal, potamodromous, widely distributed Asian species, inhabiting lakes, tanks, canals and rivers.

Channa orientalis Bloch & Schneider 1801

Material examined: 2 specimens, 110-125 mm SL. 9.iii.2008.

D 35, P 15, V 6, A 22, L.l. 45. Head length 28.12-32.32 (30.22), body depth 20.33-22.22 (21.27), predorsal distance 32.22-36.36 (34.28), prepectoral distance 28.81-32.32 (30.56), preanal distance 46.52-52.61 (49.51), base of dorsal fin 40.10-49.10 (45.60), base of anal 36.36-37.28 (36.82), length of pectoral fin 22.03-22.22 (22.12), length of ventral 10.31-12.52 (11.41), eye diameter 4.9-5.21 (5.11), snout length 7.89-8.23 (8.11), interorbital distance 8.11-8.20 (8.15).

Body elongate, eyes moderate, lower jaw longer than upper, with 12 caniniform teeth, 5 scales between orbit and preopercular angle, 12 predorsal scales, 45 lateral line scales, lateral line bending at 12th scale, pectoral fin reaching anal fin, ventral smaller than pectoral, caudal fin round in shape; body dark green dorsally, a row of dark oblique bands on the flanks above and below lateral line, a dark band extending anteriorly from opercle to snout and passing onto orbit, ventral body pale in colour, pectoral fin with vertical black bands, caudal fin with vertical stripes, dorsal and anal with narrow white outer margin, ocellus occurring on lower part of last 5 dorsal fin rays. Body coloration is same as in epigean forms.

This species is benthopelagic, potamodromous, inhabiting fresh- and brackish waters and widely distributed in Asia.

CONCLUSION

None of the species reported herein is as yet known from any cave habitat. All are benthopelagic and potamodromous except for *Mystus* spp., which are demersal. Particularly, the occurrence in the Nelabilum cave of

Garra gotyla stenorhynchus is puzzling, given its general preference for swift-flowing mountain streams. On the whole, all these species appear to be accidental stygoxenes in the cave.

It is noteworthy that all the five blind and/or depigmented fishes from India are known to occur only in Kerala State, where the lateritic soil formation with its network of crevicular hypogean habitats seems to favour the evolution of stygobitic fishes. Lateritic soils cover an area of 100,000 sq. km along the west coast of India in the States of Kerala, Karnataka, Maharashtra and Goa (Venkata Reddy 1997), besides the hilly areas of Orissa and Assam. Further faunistic surveys in these States are likely to bring to light several more significant finds of stygobitic fishes.

While precious little is know about the biodiversity of the Indian caves, caves themselves are now endangered, inter aila, by increasing industrial and agricultural activities (Biswas 2009). Hence, the governmental and non-governmental organisations need to play proactive role in preserving the fragile cave ecosystems and encourage research in this vital area of basic science.

ACKNOWLEDGEMENTS

One of us (YRR) is grateful to the Department of Science & Technology, Ministry of Science & Technology, Government of India, for funding support under a Major Research Project (SR/SO/AS/25/2007) and also to the authorities of Acharya Nagarjuna University for necessary facilities. Thanks are also due Mr. D. Ambedkar (Acharya Nagarjuna University) for assisting in the field, Dr. H.D. Gebauer (Germany) for providing information on the caves of Andhra Pradesh, Dr. A. Subrahmanyam (Hindu College, Guntur) for arranging local hospitality, and Dr. P.V. Nageswara Rao, Mr. Patibandla Venkata Subba Rao and Dr. Kodela Venkata Rao (Acharya Nagarjuna University) and Dr. K. Subhash Babu (Cochin University of Science & Technology, Cochin) for supplying the necessary literature.

REFERENCES

Babu, K.K.S. & C.K.G. Nayar (2004): A new species of the blind fish *Horaglanis* Menon (Siluroidea: Clariidae) from Parappukara (Trichur District) and a new report of *Horaglanis krishnai* Menon from Ettumanur (Kottayam District), Kerala. *J. Bombay Nat. Hist. Soc. 101*: 296-298.

Bailey, R.M. & C. Gans (1998): Two new synbranchid fishes, *Monopterus roseni* from peninsular India and *M. desilvai* from Sri Lanka. *Occasional Papers of the Museum of Zoology of the University of Michigan* No. 726: 1-18.

Biswas, J. (2009): The biodiversity Krem Mawkhyrdop of Meghalaya, India, on the verge of extinction. *Curr. Sci. 96*: 904-910.

Day, F. (1872): Monograph of Indian Cyprinidae, Part 2. *J. Asiat. Soc. Beng. 41*: 1-29, 171-198, and 318-327.

Froese, R. & D. Pauly (Eds.) (2009): FishBase World Wide Web electronic publication www.fishbase.org, version (02/2009).

Gebauer, L. (2003): South Asia cave registry. Gebauer, Schwäbisch Gmünd, Germany.

Gopi, K.C. (2002): A new synbranchid fish, *Monopterus digressus* from Kerala, peninsular India. *Rec. zool. Surv. India 100*: 137-143.

Hamilton-Buchanan, F. (1822): An account of the fishes found in the river Ganges and its branches. Edinburgh and London. vii + 405 pp. + 39 pls.

Hora, S.L. (1924): Fishes of the Siju Cave, Garo Hills, Assam. *Rec. Indian Mus. 26*: 27-31.

Kottelat, M. (2001): Fishes of Laos. Wildlife Heritage Trust, Cambodia. 198 pp.

Kottelat, M., D.R. Harries & G.S. Proudlove (2007): *Schistura papulifera*, a new species of cave loach from Meghalaya, India (Teleostei: Balitoridae). *Zootaxa 1393*: 35-44.

Messouli, M., J.R. Holsinger & Y. Ranga Reddy (2007): Kotumsaridae, a new family of subterranean amphipod crustaceans from India, with description of *Kotumsaria bastarensis*, new genus, new species. *Zootaxa 1589*: 33-46.

Menon, A.G.K. (1950): On a remarkable blind siluroid fish of the family Clariidae from Kerala, India. *Rec. Ind. Mus. 48*: 59-66.

Menon, A.G.K. (1987): *Noemacheilus sijuesis* sp. nov. The fauna of India and adjacent countries. Pisces, Zoological Survey of India. IV, Teleostei-Cobitidae, Part 1, Homolopteidea: 175.

Prasad, K.N. (1996): Pleistocene cave fauna from peninsular India. *J. Caves & Karst Stud. 58*: 30-34.

Proudlove, G.S. (2006): Subterranean fishes of the world. An account of the subterranean (hypogean) fishes described up to 2003 with a bibliography 1541-2004. International Society for Subterranean Biology, Moulis, xviii + 304 pp.

Ranga Reddy, Y. (2002): Why neglect groundwater biology? *Curr. Sci. 83*: 931-932.

Ranga Reddy, Y. (2004): Little known biodiversity of subterranean freshwater habitats in India, with special reference to crustacean fauna. *J. Bombay Nat. Hist. Soc. 101*: 186-189.

Ranga Reddy, Y. (2006): First Asian report of the genus *Chilibathynella* Noodt, 1963 (Bathynellacea, Syncarida), with the description and biogeographic significance of a new species from Kotumsar Cave, India. *Zootaxa 1370*: 23-37.

Ranga Reddy, Y. & D. Defaye (2009): Two new Parastenocarididae (Copepoda, Harpacticoida) from India: *Parastenocaris muvattupuzha* n. sp. from a river and *P. kotumsarensis* n. sp. from a cave. *Zootaxa 2077*: 31-55.

Rouch, R. (1986): Sur l'écologie des eaux souterraines dans le karst. *Stygologia 2*: 352-399.

Talwar, P.K. & A.G. Jhingran (1991): Inland fishes of India and adjacent countries. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 1185 pp.

Tehsin, R., V.S. Durve & M. Kulshreshtha (1988): Occurrence of a schizothoracine fish (snow trout) in a subterranean cave near Udaipur, Rajasthan. *J. Bombay Nat. Hist. Soc. 85*: 211- 212.

Venkata Reddy, D. (1997): Engineering Geology for Civil Engineers. Oxford IBH Publishing Co. Pvt. Ltd., New Delhi. 390 pp.

9. A NEW RECORD OF REEF FISH *ISTIGOBIUS DIADEMA* (STEINDACHNER 1876), FROM ANDAMAN ISLAND

KAMLA DEVI[1] AND V. MADHAN CHAKKARAVARTHY[2]

[1]Zoological Survey of India, National Coral Reef Research Institute (NCRI), Andaman & Nicobar Regional Centre, Haddo, Port Blair 744 102, Andaman & Nicobar Islands, India. Email: kddkamla@gmail.com
[2]Email: madhan.chak@gmail.com

Introduction

The Gobiidae is the largest family of marine fishes in the world because of their small size and bamboozling behaviour. Gobioid species reported from Andaman and Nicobar Islands have been a source of continuous interest since the time of Blyth (1846, 1863), Day (1875, 1889) and Hora (1934). As per the recent checklist of fishes by Rao (2009), 29 species of gobioid fishes are known to occur in Andaman and Nicobar Islands.

A field survey was conducted in January 2008 in the coral reef area of the west coast of Inglis Island (12° 08'-12° 09' N; 93° 07'-93° 08' E), South Andaman. Three specimens of Gobioid fishes were collected by using cast net. The morphometric measurements and meristematic counts of the species were calculated (Bohlke and Robins 1968). All counts and measurements were taken with dial calipers, and meristic counts were determined with the aid of a dissection microscope. The collected specimens are preserved in 4% formaldehyde and deposited in the National Zoological Collection (Reg. No. 4305) of Zoological Survey of India at Port Blair. A detailed scrutiny of fish specimens collected from coral reef ecosystem of Inglis Island, Ritchie's Archipelago, South Andaman, led to the diagnosis of a new record, *Istigobius diadema* (Steindachner 1876) (Family: Gobidae) (Fig. 1).

Systematic Account

Order : Perciformes
Family : Gobiidae
Genus : *Istigobius diadema* (Steindachner, 1876)
Type Locality : Indo-West Pacific

Description: Body moderately elongate, compressed posteriorly. Its depth from 1.8 to 2.0 cm and length 10.5 to 12.0 cm; head slightly depressed; snout and upper jaw was projecting beyond lower jaw; diameter of eye 0.4-0.5 cm; gill opening not extending anteriorly to a vertical through pre-opercular margin. Pelvic fins united medially its length ranging from 1.8 to 2.0 cm; Pectoral fin slightly longer than pelvic fin 2.1 to 2.2 cm; interdorsal space 2.0 to 2.2 cm; scales ctenoid excepting operculum, occipital region, breast and

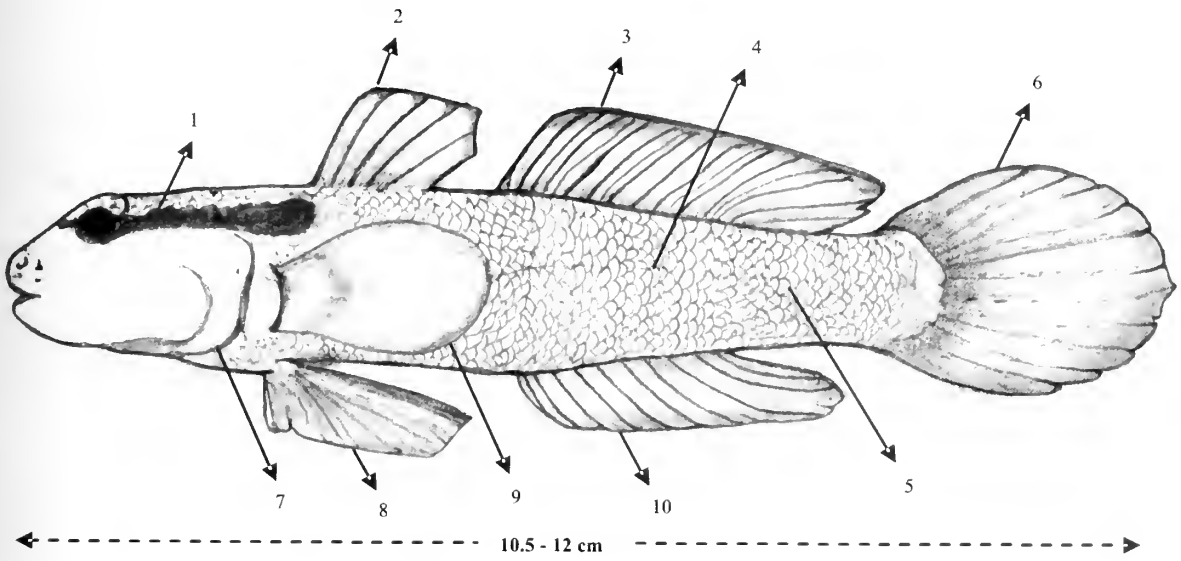


Fig. 1: Schematic diagram of *Istigobius diadema* (Steindachner, 1876)
1. Bold-black line extending from eye to pectoral-fin base; 2. 1st dorsal fin rays (VI); 3. 2st dorsal fin rays (I/10); 4. Transverse line scales (10 - 11); 5. Lateral line scales (31 - 34); 6. Caudal fin rays (19); 7. Operculum; 8. Pelvic fin rays (1/5) 9. Pectoral fin rays (18 - 19); 10. Anal fin rays (10)

pectoral fin base with cycloid scales, other part of head naked. Sensory canals and pores present on head; longitudinal pattern of sensory-papillae rows on cheek; a pair of short sensory papillae just behind chin. Head and body pale grayish brown, very bold dark line proceeding from posterior portion of eyes along sensory pore path to first dorsal origin and a dark stripe connecting both the eyes anteriorly.

Ecology: Found on coral rubble areas at the depth of 2 m.

Distribution: Eastern Indian Ocean and Indonesia

ACKNOWLEDGEMENTS

We thank the Director, Zoological Survey of India, Kolkata, for facilities and funds provided to carry the faunistic survey and Dr. C. Raghunathan, Officer-in-Charge, Zoological Survey of India, National Coral Reef Research Institute, Andaman and Nicobar Regional Centre, Port Blair for the facilities and encouragement to conduct this work. Thanks are also due to Chief Wildlife Warden, Port Blair and District Forest Officer, ACF and Range Officer, Havelock, for their permission and help in surveying this protected area. The valuable help and excellent co-operation extended by G. Ponnuswamy, Photographer, and A. Polycap, Collection Tender, are also gratefully acknowledged. We are grateful to Dr. O. Murdey, Programme Manager, Division of International Programme, National Science Foundation,Washington, D.C., who assisted by sharing his knowledge.

REFERENCES

Blyth, E. (1846): Notes on the fauna of Nicobar Islands. *J. Asiat. Soc. Ben*: 367-379.

Blyth, E. (1863): The Zoology of Andaman Islands. Appendix to Moutat's Adventure and Researches among the Andaman Island. Pp. 345-367.

Bohlke, J.E. & C.R Robins (1968): Western Atlantic seven-spined gobies, with descriptions of ten new species and a new genus, and comments on Pacific relatives. *Proceedings of the Academy of Natural Sciences of Philadelphia 120*: 45-174.

Day, F. (1875): The Fauna of British India including Ceylon & Burma, Taylor and Francis, London. Text and atlas in 4 parts. London xx+778 pp., 195 pls.

Day, F. (1889): The Fauna of British India including Ceylon and Burma, Fishes. I, 548, pp., II, 509 pp. Taylor and Francis, London.

Hora, S.L. (1934): The systematic position of Hamilton's species of gobioid fishes from the Ganges. *Rec. Indian Mus. 13(3)*: 205-329.

Rao, D.V. (2009): Checklist of fishes of Andaman and Nicobar Islands. *Environment & Ecology 27(1A)*: 334-353.

10. A REPORT ON THE MIGRATION OF THE BUTTERFLY *PHALANTA ALCIPPE* (NYMPHALIDAE) IN THE ANDAMAN & NICOBAR ISLANDS

Muhamed Jafer Palot[1]

[1]Western Ghat Regional Centre, Zoological Survey of India, Kozhikode 673 006, Kerala, India. Email: palot.zsi@gmail.com

The butterfly fauna of the Andaman & Nicobar Islands has not received much attention. Although more than 150 species of butterflies have been recorded in the Andaman groups of islands (Ferrar 1951; Khatri 1989; Soubadra Devy *et al.* 1994), nothing is known about their status, distribution and ecology. While conducting a study on the animal resource base available to the Jarawas of the Andaman Islands, on May 10, 2002, at around 10:20 hrs, I came across a swarm of tawny brown butterflies crossing the busy road of Port Blair in the south-north direction. I counted about 37 individuals per minute from a vantage point. The same swarm was observed near the Netaji Stadium, Port Blair, and near the Secretariat, all proceeding towards north. Later, I identified the species as the Small Leopard *Phalanta alcippe* Cramer.

Williams (1938) had listed 66 migrant species from India. He did not list the Small Leopard in his list, although he reported the Common Leopard *Phalanta phalantha* (Drury) as a common migratory species of India and Sri Lanka. Wynter-Blyth (1957) had also not included the Small Leopard among migratory species.

Apparently, the onset of the south-west monsoon in the southern Andamans could be the main reason for the initiation of this migratory behaviour, on May 11-12, 2002. Even during a drizzle, this species moved with ease in small aggregations comprising two or three individuals flying at a height of 1-2 m above the ground level.

The Small Leopard is a locally common butterfly mostly found in the forested tracts of the southern Andamans. During my stay in September-October 2001 and April-May 2002 the population of the Small Leopard butterfly in the Jarawa Reserve was fairly good and evenly distributed.

ACKNOWLEDGEMENTS

The author is grateful to the Director, Zoological Survey of India, Kolkata, for giving me an opportunity to study the fauna of the Andamans. I am also thankful to Dr. C. Radhakrishnan, Officer-in-Charge, ZSI, Kozhikode and Dr. T.K. Pal, Scientist-E and leader of the Expedition, for facilities and encouragement.

REFERENCES

FERRAR, M.L. (1951): On the butterflies of the Andaman and Nicobar Islands. *J. Bombay Nat Hist. Soc. 47(3)*: 470-491.

KHATRI, T.C. (1989): A revised list of butterflies (Rhopalocera: Lepidoptera) from Bay islands. *J. Andaman Sci. Assoc. 5(1)*: 57-61.

SOUBADRA DEVY, M., T. GANESH & P. DAVIDAR (1994): Butterfly distribution on the Andaman Islands. *J. Andaman Sci. Assoc. 10(1 & 2)*: 50-56.

WILLIAMS, C.B. (1938): The migration of Butterflies in India. *J. Bombay Nat. Hist.* Soc. *40*: 439-457.

WYNTER-BLYTH, M.A. (1957): Butterflies of the Indian Region. Bombay Natural History Society. Mumbai.

■ ■ ■

Printed by Bro. Leo at St. Francis Industrial Training Institute, Borivli, Mumbai 400 103 and published on May 06, 2011 by Dr. Ashok Kothari for Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk, Shaheed Bhagat Singh Road, Mumbai 400 001, Maharashtra, India.

INSTRUCTIONS TO AUTHORS

The *Journal* welcomes concise reports of original research in natural history, taxonomy and other aspects of zoology and botany of general interest.

SUBMISSION OF MANUSCRIPT

Hard copies of manuscripts (including illustrations) **in duplicate**, typewritten **in double space** on one side of the paper and a copy of the MS on a floppy diskette or CD using MS Word, should be submitted to the Editor, *Journal of the Bombay Natural History Society*, Hornbill House, Shaheed Bhagat Singh Road, Mumbai 400 023. Submission of a manuscript to the *Journal* implies that it has not been submitted for publication elsewhere.

Please do not send manuscripts by e-mail unless requested to do so. We do not download unsolicited material.

PREPARATION OF MANUSCRIPT

Main Papers and New Descriptions

Manuscripts of papers for the Main section and New Descriptions should be as concise as possible. Pages should be numbered consecutively, and the matter on Page 1 should be arranged in the following order: Title of the paper; Name(s) of Author(s), Department(s) and Institution(s); Footnote containing address of Author for correspondence with e-mail id, followed by the List of Abbreviations used in text. A short running title derived from the original title may also be given for main papers. Page 2 should contain the Abstract. The text may be arranged in the following order: Introduction; Material and Methods or Methodology; Results; Discussion; Acknowledgements; References. Abstract, Key Words, Tables and Captions for Figures should be typed separately.

Title: The title should be such as to be useful for indexing and information retrieval.

Abstract: The abstract, not exceeding 200 words, should indicate the scope and significant content of the paper, highlighting the principal findings and conclusions.

Introduction: The introductory part should bear no heading, should be brief and state precisely the objective of the study in relation to the present status of knowledge in the field. Review of literature should be restricted to the essential references.

Material and Methods or Methodology: The nomenclature, sources of materials and the procedures should be clearly stated. New methods should be described in detail, but if the methods are well known, a mere reference to them will do; any modifications made in the methods should be stated.

Results: Only data relevant to the objectives of the study and main conclusions emerging from the study should be included. The data should be arranged in a unified and coherent sequence for clarity and readability. The same data should not be presented in both tables and figures, and such data as can be easily and briefly stated in the text should not be depicted diagrammatically. Only such tables and figures as are necessary should be given.

Tests of statistical significance should be identified and references used should be cited. Statements about the statistical significance of the results must be borne out by the level of significance, preferably provided in the tables and legends. The use of the word "significant" should be restricted to "statistically significant".

Discussion: The discussion should provide an interpretation of the results of the study, without repeating information already presented under Results. It should relate the new findings to the known and include logical deductions. Where necessary, the Results and Discussion can be combined.

Illustrations: The number of illustrations should be kept to the minimum and numbered consecutively in Arabic numerals. Simple linear plots or linear double reciprocal plots that can be easily described in the text should be avoided. Extension of graphs beyond the last experimental point is permissible only while extrapolating data.

Line drawings should be either laser prints of computer generated illustrations or manually prepared in Indian ink on tracing paper, drawn to approximately twice the printed size. The drawings are usually reduced to the page width or column size, and **care should be taken that the size of letters, numerals, dots and symbols is relatively uniform and sufficiently large to permit this reduction.**

Photographs: Photographs for reproduction must be clear, with good contrast. Prints should be at least 9x12 cm and on glossy, glazed paper.

Tables: Each table should have an explanatory title and should be numbered in Arabic numerals. Units (metric) of measurement should be abbreviated and placed below the headings. Negative results should be indicated as Nil (0) and absence of a datum by a dash.

Acknowledgements: Acknowledgements should be brief and relevant.

References: Responsibility for the accuracy of references rests with the author(s). Abstracts of papers presented at scientific meetings may be cited. References to literature should be alphabetically arranged under author's name, with the abridged titles of journals or periodicals in italics and titles of books or papers in Roman type, thus:

Aluri, Raju J.S. & C. Subha Reddi (1995): Ecology of the pollination in two cat-mint species. *J. Bombay Nat. Hist. Soc. 91(1)*: 63-66.

Prater, S.H. (1971): The Book of Indian Animals. 3rd Edn. Bombay Natural History Society, Mumbai. pp. 35-48.

Species names should carry the Author's name and subspecies (trinomials) should only be used where identification has been authentically established by comparison of specimens actually collected.

For the standardised common and scientific names of the birds of the Indian subcontinent refer to *Buceros* Vol. 6, No. 1 (2001).

Miscellaneous Notes: The section accommodates incidental observations on flora and fauna of the Asian region, and need not follow strictly the above section headings. No abstract is required, but key words may be included and references must be cited as in the rest of the *Journal*.

Reprints: 25 reprints will be supplied free of charge to the authors of Main Papers and New Descriptions. Authors of Miscellaneous Notes will be sent one free copy each of the *Journal*.

The Editors reserve the right, other things being equal, to publish a member's contribution before that of a non-member. The Editors also reserve the right to publish invited papers on priority.

Registered with the Registrar of Newspapers under RN 5685/57 ISSN 0006-6982

CONTENTS

NEW DESCRIPTIONS

Printed by Bro. Leo at St. Francis Industrial Training Institute, Borivli, Mumbai 400 103 and published by Dr. Ashok Kothari for Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk, Shaheed Bhagat Singh Road, Mumbai 400 001.
website: www.bnhs.org; Email: bnhs@bom4.vsnl.net.in

JOURNAL
OF THE
BOMBAY NATURAL HISTORY SOCIETY

DECEMBER 2010 VOL. 107 (3)

BNHS INDIA CONSERVING NATURE SINCE 1883

JOURNAL OF THE BOMBAY NATURAL HISTORY SOCIETY

Hornbill House, Shaheed Bhagat Singh Marg, Mumbai 400 001.

VOLUME 107(3): DECEMBER 2010

CONTENTS

NEW DESCRIPTIONS

REVIEWS

MISCELLANEOUS NOTES

MAMMALS

AVES

Cover Photograph: Hard-ground Barasingha
Cervus duvaucelii branderi
By Anant Zanjale

ACKNOWLEDGEMENT

We are grateful to the Ministry of Science and Technology, Govt of India, for enhanced financial support for the publication of the Journal.

SUMMER DIET OF INDIAN GIANT FLYING SQUIRREL *PETAURISTA PHILIPPENSIS* (ELLIOT) IN SITAMATA WILDLIFE SANCTUARY, RAJASTHAN, INDIA

Chhaya Bhatnagar[1,3], Vijay Kumar Koli[1,4] and Satish Kumar Sharma[2]

[1]Aquatic Toxicology and Wildlife Research Laboratory, Department of Zoology, Mohanlal Sukhadia University, Udaipur 313 001, Rajasthan, India.
[2]Sajjangarh Wildlife Sanctuary, Udaipur 313 001, Rajasthan, India. Email: sksharma56@gmail.com
[3]Email: bhatnagarchhaya@yahoo.co.in
[4]Email: vijaykoli87@yahoo.in

Summer feeding habit of the Indian Giant Flying Squirrel *Petaurista philippensis* was studied from March 2009 to June 2009 in Sitamata Wildlife Sanctuary. These squirrels are arboreal and entirely depend on plant material. Of 2,157 feeding records, 13 plant species from 10 families were identified in their feeding behaviour. Used food items were piths (58.59%), twigs (16.87%), leaves (5.09%), bark (2.64%), flowers (5.23%), buds (4.82%), fruits (6.44%) and seeds (0.27%). Mahuwa *Madhuca longifolia* was a predominant species in their feeding. They are early rising and use their early active time in feeding after which their activity lowers during night.

Key words: *Petaurista philippensis*, arboreal, feeding behaviour, *Madhuca longifolia*

INTRODUCTION

Food is one of the most important resources for growth, reproduction and survival of animals. Consequently, animals that are generally herbivores, respond to spatial and temporal variability of food availability by selecting specific feeding habitats (McNaughton 1990; Wilmshurst *et al.* 1999; Ball *et al.* 2000) and diet (Hanley 1997; Dumont *et al.* 2002). Dietary variation occurs in response to plant phenology and changes in availability of resources (Poulsen *et al.* 2001). Impact of plant phenology on primary consumers has gained much attention in recent years (Van Schaik *et al.* 1993; White 1998; Curran and Leighton 2000).

Flying squirrels (Rodentia: Sciuridae: Petauristainae) are nocturnal gliding mammals, comprising of 12 genera and 43 species (Eisenberg 1981). Only one species of flying squirrel is found in Europe and north Asia, and two species in North America. Species richness peaks in the South-east Asian countries (Lee and Liao 1998; Nandini 2001). Eleven species are found in India, most of which are concentrated in the Himalayan, the North-east regions and the Western Ghats (Nandini 2001).

Petaurista philippensis has a wide distribution and occurs in most forests of peninsular India (Prater 1971; Agarwal and Chakraborty 1979; Wilson and Reeder 1993). Southern Rajasthan is a distinct patch for the occurrence of *P. philippensis*. Tehsin (1980) and Chundawat *et al.* (2002) reported the presence of Large Brown Flying Squirrel in Phulwari Wildlife Sanctuary in Udaipur district of Rajasthan. Sitamata Wildlife Sanctuary is also a prominent area of distribution of *P. philippensis* in southern Rajasthan.

In Rajasthan, climate ranges from arid to semiarid and the rainfall is very low and erratic. During summer, the sun shines directly upon Tropic of Cancer, which increases the temperature (32°C to 40°C) in southern Rajasthan; the subtropical forest replaces the tropical deciduous forest, and water and food availability becomes low. Summer, therefore, is a very critical time for *Petaurista philippensis* for survival. This study was carried out to understand how *P. philippensis* copes with unfavourable situations and was confined to its food availability, food preference and diet during summer.

STUDY AREA

The study was carried out in the Sitamata Wildlife Sanctuary (Fig. 1), which is situated between 24° 04'-24° 23' N and 74° 25'-74° 40' E. The Sanctuary covers an area of 422.95 sq. km. It is situated in the south-eastern region of Rajasthan where three very ancient mountain ranges of India meet forming a teak forest. The configuration of land is hilly and rugged with altitude varying from 280 to 600 m. The general slope of the land is from North-West to South-East. Forest with subtropical feature is characterized by distinct winter, summer and rainy seasons. Average rainfall is 756 mm and the temperature ranges between 6°C in winter and 45°C in summer. The Sanctuary harbours nearly 50 species of mammals, 275 species of birds, 40 species of reptiles, 9 species of amphibians, 30 species of fishes and more than 800 species of plants (Kartikeya 2005).

MATERIAL AND METHODS

The present study was carried out during summer between March and June 2009. Four flying squirrel sites,

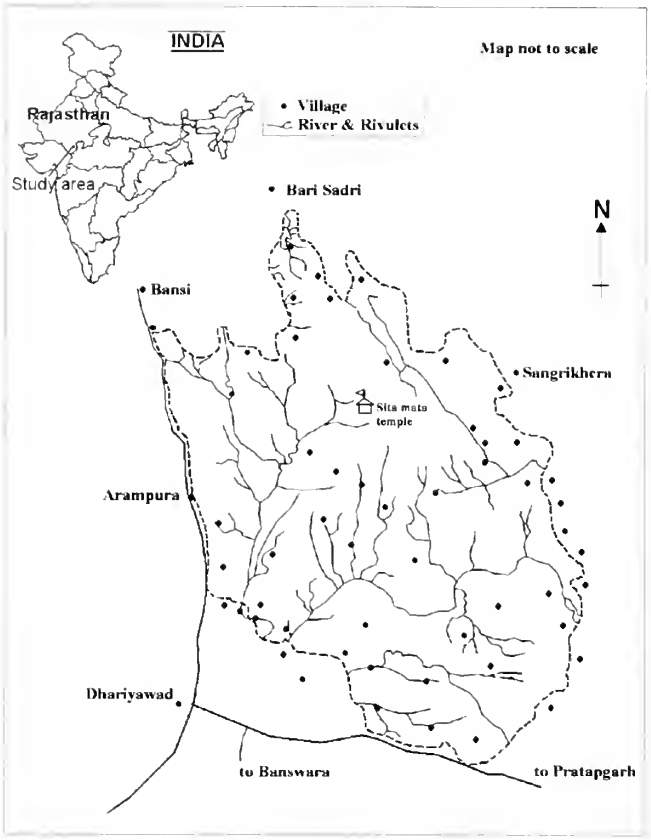


Fig. 1: Map of Sitamata Wildlife Sanctuary (Study area)

which they inhabited permanently, were identified and marked (Table 1). Identification of sites where squirrels were present was done using two procedures. Initially the area was thoroughly explored to locate the squirrel inhabited trees and sites. These were later confirmed by the forest personnel and by exploring the area at regular time intervals. The sites were visited fortnightly with a minimum of five days stay in the field during each visit in fifteen days and eight nights in one month. Being nocturnal and arboreal, the flying squirrel is hard to locate during night. They were detected by eyeshine and calls, and occasionally by their movement on or between trees. Every night around dusk, vigilant move was carried along a trail, which meandered through the study area. Binocular and spotlight (NS-8300DX) with a Swiss handle and stand were used to observe the flying squirrel.

Behaviour of individual flying squirrel was recorded using Focal Animal Sampling Method (Altmann 1974). In this method occurrence of specified actions (feeding) of an individual were recorded during each sample period. A record was made of the length of each period and for each focal individual. The amount of time during the sample was actually in view. Once chosen, a focal individual was followed to whatever extent possible during each of the sample periods. The data was recorded at five second intervals from the time the squirrel started feeding.

Phenological data were also collected monthly during the study period. The data was taken to assess the association between abundance of plant parts and composition of the diet of the flying squirrel. Phenology of plant species was categorized into two phases: vegetative phase and reproductive phase. Vegetative phase was further sub-categorized into piths, twigs, leaves and bark, while reproductive phase was sub-categorized into buds, flowers, fruits and seeds.

RESULTS

A total of 2,153 feeding records were collected during 304 hrs of field observation with a mean (± SE) of 538 ±97.94 records/month (Range = 0-467). The flying squirrel consumed 8 plant parts from 13 species belonging to 10 families (Table 2). Most feeding records were from Sapotaceae (33.14%), Combretaceae (33.14%), Anacardiaceae (8.71%), Moraceae (7.27%), Ebenaceae (7.09%), whereas other families contributed a smaller amount. Three families, namely Moraceae, Combretaceae and Anacardiaceae include two species each, while other families had one species each.

Six species of trees including *Mangifera indica*, *Mitragyna parviflora*, *Alvizia odoratissima*, *Cordia myxa*, *Tectona grandis* and *Sarcopetalum tomentosa* contributed < 5% (range 0.27-3.29%) and 2 species of trees including *Madhuca longifolia* and *Terminalia bellirica* contributed >20% (range 510-715 of the 2,157 feeding records). Remaining species contributed between 5 to 10% of feeding records. *Madhuca longifolia* was a predominant species for

Table 1: Location of Flying squirrel sites in Sitamata Wildlife Sanctuary

S. No.	Site	Location	Nesting tree
1	Arampura naka 1	24°13' 19" N, 74°25' 54" E	*Madhuca longifolia*
2	Arampura naka 2	24°13' 21" N, 74°25' 53" E	*Madhuca longifolia*
3	Lambi samel	24°13' 07" N, 74°25' 36" E	*Madhuca longifolia*
4	Kunda nala	24°13' 39" N, 74°25' 55" E	*Terminalia bellirica*

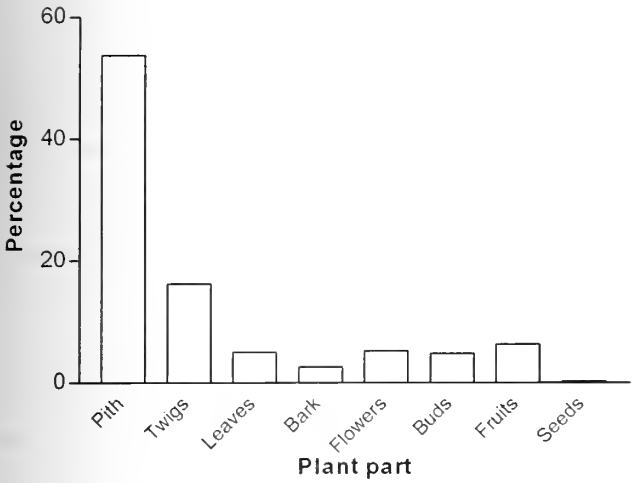


Fig. 2: Percentage observation of plant parts in the diet of the Flying squirrel during summer season

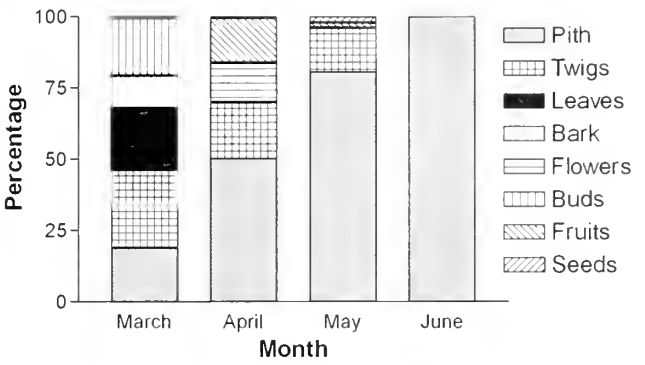


Fig. 3: Monthly diet composition of the flying squirrel

feeding and it contributed 33.14% of feeding records and *Tectona grandis* contributed only 0.27% and ranked 13 in the list. Both *Madhuca longifolia* and *Terminalia bellirica* species contributed more than half of the feeding records.

Eight food items were consumed by the flying squirrel during the study period. Pith was most frequently (58.59%) consumed, followed by twigs (16.87%), fruits (6.44%), flowers (5.23%), leaves (5.09%),buds (4.82%), bark (2.64%) and seeds (0.27%) (Fig. 2). Pith was obtained from 10 plant species, twigs from 7 plant species, leaves and fruits from 2 plant species, bark, flowers and buds were obtained from only *Madhuca longifolia*. Seeds were least preferred and obtained from *Tectona grandis* (Table 2).

Table 2: Plant species and part consumed by *Petaurista philippensis* at Sitamata Wildlife Sanctuary (Rajasthan) during summer in 2009

S.No.	Family	Species	Part	Phenophase*	% Feeding time	Rank
1	Ebenaceae	*Diospyros melanoxylon*	Twig	imm	7.09	5
			Pith	-		
2	Sapotaceae	*Madhuca longifolia*	Bark	imm	33.14	1
			Buds	-		
			Pith	-		
			Fruit	r, sr, ur		
			Flower	m, imm		
			Twig	imm		
3	Combretaceae	*Terminalia tomentosa*	Leaf	imm	9.50	3
			Pith	-		
		Terminalia bellirica	Twig	imm	23.64	2
			Leaf	imm		
			Pith	-		
4	Anacardiaceae	*Lannea coromandelica*	Pith	-	5.42	6
		Mangifera indica	Pith	-	3.29	8
5	Moraceae	*Ficus religiosa*	Twig	imm	7.27	4
			Pith	-		
		Ficus bengalensis	Pith	-	5.33	7
6	Rubiaceae	*Mitragyna parviflora*	Twig	imm	2.41	9
			Pith	-		
7	Fabaceae	*Alvizia odoratissima*	Twig	imm	0.92	11
8	Boraginaceae	*Cordia myxa*	Fruit	m	0.69	12
9	Lamiaceae	*Tectona grandis*	Seed	m	0.27	13
10	Menispermaceae	*Sarcopetalum tomentosa*	Twig	imm	1.20	10
			Pith	-		

*Codes for phenological phase of plant parts consumed.
imm = immature; m = mature; ur = unripe; sr = partly ripe; r = ripe

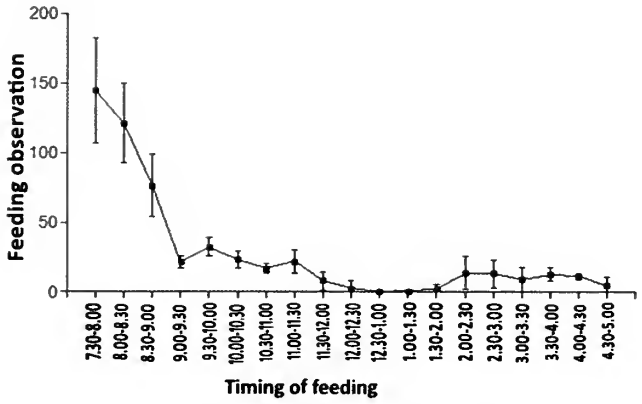


Fig. 4: Feeding time of the Flying squirrel during their active period (7.30 pm-5.00 am)

It was also observed that in March only 5 food parts were used in 508 feeding records. The most preferred feeding plant part was twigs, which comprised 27.95% of the monthly feeding records. This was followed by leaves (21.65%), buds (20.47%) and pith (18.70%) (Fig. 3, Table 3). In April, 4 food items were used in 817 feeding records and the percentage of pith increased and reached 50.30% which was followed by twigs (19.95%), fruits (15.91%) and flowers (13.83%). Use of pith further increased in May reaching 80.60% with 361 feeding records. Except pith other food parts were twigs (15.78%), fruits (1.93%) and seeds (1.66%). In June, the only feeding part was pith which comprised 100% of the monthly feeding records.

The feeding time of the flying squirrel is shown in Fig. 4. The most active time of feeding was when flying squirrels emerged from their holes. After emerging, they started feeding. Feeding became less around 00:30 hrs. Between 00:30 hrs and 02:00 hrs, the feeding activity ceased. Feeding resumed after 02:00 hrs, but the frequency was low. Thus, the peak time of feeding was 19:30 to 21:30 hrs while 24:00 to 02:00 hrs was resting time.

DISCUSSION

The flying squirrel fed primarily on pith in summer besides twigs, leaves, bark, flowers, buds, fruits and seeds. Other studies on the diet of the flying squirrel also show that they are largelyfolivorous (Lee *et al.* 1986; Kawamichi 1997; Kuo and Lee 2003; Nandini and Parthasarathy 2008). The flying squirrel is a selective forager and only 13 plant species and 8 plant parts were consumed in their summer diet. Besides they consumed the part only from a few plant species in each month. Some species of plants were used more whereas others were used sporadically emphasizing its preference. Kuo and Lee (2003) showed that the flying squirrel consumed at least 79 species-specific parts of plants belonging to 30 families, and Nandini and Parthasarathy (2008) reported that 25 different plant parts of 10 tree species were recorded in the feeding of the flying squirrel. Japanese Giant Flying Squirrels *P. leucogenys* were also found to be highly selective feeders (Ando *et al.* 1985; Kawamichi 1997). Janzen (1978) and Kuo and Lee (2003) stated that, relative to terrestrial animals, arboreal species are unable to store large amounts of fat, which would restrict their movements and increase the risk of falling. Furthermore, because arboreal folivores rely on relatively poor quality food, they may be constrained by their ability to convert energy (Eisenberg 1978; Kuo and Lee 2003).

In this study, the flying squirrel preferred to feed on pith, as it comprised 58.59% of its diet. Pith is the central part of stem or twig which is rich in water content and nutrition. This content fulfils the requirement of water for flying squirrel in summer. Immature leaves were used during March. Coley (1983) showed that young and mature leaves of pioneer species contain fewer digestion reducers such as cellulose, tannins, and lignin and are relatively palatable to herbivores.

Table 3: Data on different plant parts consumed each month and their monthly percentages

Plant part	March		April		May		June	
	No. of observations	%	No. of observations	%	No. of observations	%	No. of observations	%
Pith	95	18.70	411	50.30	291	80.60	467	100
Twigs	142	27.95	163	19.95	57	15.78	-	-
Leaves	110	21.65	-	-	-	-	-	-
Bark	57	11.22	-	-	-	-	-	-
Flowers	-	-	113	13.83	-	-	-	-
Buds	104	20.47	-		-	-	-	-
Fruits	-	-	130	15.91	7	1.93	-	-
Seeds	-	-	-	-	6	1.66	-	-
Total	508	-	817	-	361	-	467	-

Nandini and Parthasarathy (2008) revealed that fruit was most usable plant part for the flying squirrel, in the Western Ghats, which constituted 48.42% of all plant parts. The difference in feeding parts of plants may be because, the habitat of the flying squirrel in the Western Ghats has more humid area and the squirrel does not require to conserve water. In the present study, water conservation by the animal is much required as the forest is of dry deciduous type. Thus, the flying squirrel consumed a wide variety of plant parts. The diet of the flying squirrel changed in relation to plant phenology. This habit is related to availability of food and composition of forest. For example, reproductive phase of *Madhuca longifolia* is fixed in annual time period, so, flying squirrel used their phase parts (bud, flower and fruit) in March and April; bark was used in March. Thin bark is often removed to the depth of the cambium, but thicker bark may not be (MacKinnon 1978). Some seeds or fruits are produced relatively early in summer, which may contribute to the food available for young squirrels (Thompson and Thompson 1980). Giant flying squirrels also shifted to other food items, even when a previously known food item was still available. This was usually because a newly available food item was more preferable; in particular, a rapid shift from mature leaves to swelling buds (in March), and a successive change from one species of oak to another in search of new leaves or acorns due to their slightly different periods of leaf out and seed production (Kawamichi 1997). No significant relationship was found between availability of parts of plants and feeding frequency, implying that Indian Giant Flying squirrels did not select food on the basis of total availability. Similar observations were reported by Kuo and Lee (2003). During the present study, no occasion was witnessed when the flying squirrel fed on food of animal origin. Similar observations were also noted by Kawamichi (1997), Nandini and Parthasarathy (2008) and Kuo and Lee (2003).

According to Nandini (2001), flying squirrels begin feeding around 18:30 hrs, while in this case both feeding and calling began around 19:00 hrs. Feeding dropped around 22:00 hrs. At 22:00 hrs most individuals were noticed either calling or sitting. The present study also showed that most active feeding time was from 19:30 to 21:30 hrs that reduced till 24:00 hrs, while after 02:00 hrs some feeding was observed.

Thus, from the present study it can be inferred that Mahuwa *Madhuca longifolia* is the most preferred plant with respect to feeding and pith is the preferred plant part.

REFERENCES

Agarwal, V.C. & S. Chakraborty (1979): Catalogue of Mammals in ZSI, Rodentia Part I. Sciuridae. In the records of ZSI *74(4)*: 333-481.

Altmann, J. (1974): Observational study of behaviour sampling method. *Behaviour 49*: 227-265.

Ando, M., S. Shiraishi & T.A. Uchida (1985): Food habits of the Japanese Giant Flying Squirrel, *Petaurista leucogenys*. *Journal of the Faculty of Agriculture 29*: 189-202.

Ball, J.P., K. Danell & P. Sunesson (2000): Response of a herbivore community to increased food quality and quantity: an experiment with nitrogen fertilizer in a boreal forest. *Journal of Applied Ecology 37*: 247-255.

Chundawat, P.S., S.K. Sharma & H.S. Solanki (2002): Occurrence of the Large Brown Flying Squirrel (*Petaurista petaurista philippensis*) in Phulwari Wildlife Sanctuary, Rajasthan. *Zoos' Print Journal 17(11)*: 941.

Coley, P.D. (1983): Herbivory and defensive characteristics of tree species in a lowland tropical forest. *Ecological Monographs 53*: 209-233.

Curran, L.M. & M. Leighton (2000): Vertebrate responses to spatiotemporal variation in seed reproduction of mast-fruiting Dipterocarpaceae. *Ecological Monographs 70*: 101-128.

Dumont, B., P. Carrère & P. D'hour (2002): Foraging in patchy grasslands: diet selection by sheep and cattle is affected by the abundance and spatial distribution of preferred species. *Animal Research 51*: 367-381.

Eisenberg, J.F. (1978): The evolution of arboreal herbivores in the class Mammalia. Pp. 135-152. *In*: Montgomery, G.G. (Ed.): The Ecology of Arboreal Folivores. Smithsonian Institution Press. Washington D.C.

Eisenberg, J.F. (1981): The Mammalian Radiations: an analysis of trends in evolution, adaptation, and behaviour. The University of Chicago Press, Chicago. Pp. 610.

Hanley, T.A. (1997): A nutritional view of understanding and complexity in the problem of diet selection by deer (Cervidae). *Oikos 79*: 209-218.

Janzen, D.H. (1978): Complications in interpreting the chemical defenses of trees against tropical arboreal plant-eating vertebrates. Pp. 73-84. *In*: Montgomery, G.G. (Ed.): The Ecology of Arboreal Folivores. Smithsonian Institution Press. Washington, D.C.

Kartikeya, K. (2005): Biodiversity Extinction and Conservation. Aavishkar Publishers, Distributers, Jaipur (Raj.).

Kawamichi, T. (1997): Seasonal changes in the diet of Japanese flying squirrels in relation to reproduction. *Journal of Mammalogy 78*: 204-212.

Kuo, C.C. & L.L. Lee (2003): Food availability and food habits of Indian giant flying squirrels (*Petaurista philippensis*) in Taiwan. *Journal of Mammalogy 84*: 1330-1340.

Lee, P.F. & C. Liao (1998): Species richness and research trends of flying squirrel. *J. Taiwan Museum 51(2)*: 1-20.

Lee, P.F., D.R. Progulske & Y.S. Lin (1986): Ecological studies on two sympatric *Petaurista* species in Taiwan. *Bulletin of the Institute of Zoology, Academia Sinica 25*: 113-124.

Mackinnon, K.S. (1978): Stratification and feeding differences among Malayan squirrel. *Malay. Nat. J. 30*: 593-608.

Mcnaughton, S.J. (1990): Mineral nutrition and seasonal movements of African migratory ungulates. *Nature 345*: 613-615.

Nandini, R. (2001): Status and distribution of the Small Travancore Flying Squirrel (*Petinomys fuscocapillus fuscocapillus*) and the

Large Brown Flying Squirrel (*Petaurista philippensis*) in the Western Ghats. Technical report submitted to the Sálim Ali Centre for Ornithology and Natural History, Coimbatore.

NANDINI, R. & N. PARTHASARATHY (2008): Food habits of the Indian Giant Flying Squirrel (*Petaurista philippensis*) in a rain forest fragment, Western Ghats. *Journal of Mammology 89(6)*: 1550-1556.

POULSEN, J.R., C.J. CLARK & T.B. SMITH (2001): Seasonal variation in the feeding ecology of the Gray-cheeked Mangabey (*Lophocebus albigena*) in Cameroon. *American Journal of Primatology 54*: 91-105.

PRATER, S.H. (1971): The Book of Indian Animals. Third ed. Bombay Natural History Society and Oxford University Press. 324 pp.

TEHSIN, R.H. (1980): Occurrence of the Large Brown Flying Squirrel and Mouse Deer near Udaipur, Rajasthan. *J. Bombay Nat. Hist. Soc. 77(3)*: 498.

THOMPSON, D.C. & P.S. THOMPSON (1980): Food habits and caching behavior of urban grey squirrels. *Canadian Journal of Zoology 58*: 701-710.

VAN SCHAIK, C.P., J.W. TERBORGH & S.J. WRIGHT (1993): The phenology of tropical forests: adaptive significance and consequences for primary consumers. *Annual Review of Ecology and Systematics 24*: 353-377.

WHITE, F.J. (1998): The importance of seasonality in primatology. *International Journal of Primatology 19*: 925-927.

WILMSHURST, J.F., J.M. FRYXELL, B.P. FARM, A.R.E. SINCLAIR & C.P. HENSCHEL (1999): Spatial distribution of Serengeti wildebeest in relation to resources. *Canadian Journal of Zoology 77*: 1223-1232.

WILSON, D.E. & A.E. REEDER (1993): Mammal Species of the World: a Taxonomic Reference. Pp. 1206. Second Ed. Smithsonian Institution Press, Washington D.C.

■ ■ ■

CONFLICT IDENTIFICATION AND PRIORITIZATION IN PROPOSED TSANGYANG GYATSO BIOSPHERE RESERVE, EASTERN HIMALAYA, INDIA

Shivaji Chaudhry[1,3], Gopi Govindhan Veeraswami[2], Kripaljyoti Mazumdar[1,4] and Prasanna Kumar Samal[1,5]

[1]G.B. Pant Institute of Himalayan Environment and Development, North East Unit, Vivek Vihar, Itanagar 791 113, Arunachal Pradesh, India.
[2]Wildlife Institute of India, Chandrabani, Dehradun 248 001, Uttarakhand, India. Email: gopigv@wii.gov.in
[3]Email: shivaji.chaudhry@gmail.com
[4]Email: kripaljyoti@gmail.com
[5]Email: prasannasamal@rediffmail.com

Along with the Greater Himalaya, in the eastern Himalayan region there has been increased efforts to bring more areas under the Protected Area Network. Protected areas including conservation areas in Arunachal Pradesh are mostly located in the low and mid-elevation forest areas. To address the need of having a protected area in the higher altitudes of the State, of late a biosphere reserve has been proposed in the western Arunachal Pradesh. This paper aims to document the existing human-wildlife conflict and prioritize the conflicts, in an effort to promote conservation in the Tsangyang Gyatso Biosphere Reserve. The paper also attempts to understand the complexity of land transfer and regulations of community, particularly pasture lands in the Biosphere reserve. This study was carried out between September 2007 and July 2008 in the proposed biosphere reserve. A total of 13 species were recorded to be in direct conflict with humans, and based on the conflict intensity mapping nine were screened as high to moderate conflicting species. Conflict intensity as per the local perceptions was recorded high for 38% species and 31% species showed moderate intensity of conflict with humans. As per the local perception, causes for human-wildlife conflict in order of importance were: increased population, non-timber forest products (NTFP) collection, road construction and increased predators. Local people perceived four major factors, namely compensatory schemes, reducing prey hunt, reducing pressure on forest and increasing vigil to safeguard crops and livestock to mitigate the existing conflicts.

INTRODUCTION

During the 5th World Park Congress organized by the IUCN, human-wildlife conflict (HWC) was identified to be a key challenge facing Protected Area management and conservation (IUCN 2003). A major source of conflict between park authorities and local communities in the Subcontinent revolves around livestock and crop damage within Protected Areas (PAs) of their buffer zone (Kharel 1997; Mishra 1997; Hussain 2003). Today, the PAs are a pervasive land use covering 14.36% of earth's surface (www.tradingeconomics.com/world/terrestrial-protected-areas-percent-of-total-surface-area-wb-data.html). There are indications that the PAs will continue to grow as individual countries have made ambitious commitments to establish new PAs; however the relative rate of growth of PAs is not significantly different between countries with different number of unprotected species (Pyke 2007). Most of the areas under PAs network, historically productive in terms of their economic value (Scott *et al.* 2001), have decentralised land management regimes and multifaceted land protection measures that hinder the optimal use of the land resource (Theobald and Hobbs 2002). Many international NGOs have strongly advocated the use of setting map-based geographical priorities while not affecting the established social and economic drivers in the region (Olson and Dinerstein 1998; Myers *et al.* 1999). Inspite of all these efforts there seems to be lack of political will to formulate a conservation policy, which is clearly evident from existing gaps between the conservation policies and conservation practice in general (Chhatre and Saberwal 2005). Prioritization of areas for biodiversity representation is essential for conservation planning, particularly in megadiverse countries where high deforestation threatens biodiversity (Sanchez-Cordero *et al.* 2005). In general, two methods of prioritization have been used, (i) sets of place based on expert advice (Dinerstein *et al.* 2000) and (ii) using algorithmic data containing the vital conservation information (Margules *et al.* 1998). We hereby discuss the former in the western part of Arunachal Pradesh, which forms a major part of the biological hotspot – Eastern Himalaya (Myers *et al.* 1999).

Approximately 10% of the world's population lives in mountain areas and livestock is the major source of their economy (Pun and Mares 2000; Mishra *et al.* 2006). India has a high human population and boasts of having the largest cattle population in the world (449 million; WRI 1996). Habitat loss in the Himalayan region is a serious concern as the region supports very fragile ecosystems. There have been attempts to link the fauna with its habitat or native flora globally (Siemann *et al.* 1998; Knops *et al.* 1999). It is estimated that the Himalayan region has lost 70% of its native habitat (Anonymous 2006). Therefore, in most of the Indian Himalayan region biodiversity conservation measures are usually taken care of by declaring PAs (Bagchi *et al.* 2004).

Loss of human life due to wildlife is often immediately discussed, but the loss of crops or livestock which are means to subsistence seldom get attention of administrators (Rao *et al.* 2002). More than often loss of subsistence causes much displeasure to locals in the conservation priority areas (Parry and Campbell 1992; Newmark *et al.* 1993; Maikhuri and Rao 1998). In Manas National Park human-elephant conflict is on the rise, the intensity of conflict was higher in fields and nearby parks; elephant bulls were reported to be more violent than the females (Nath *et al.* 2009). A seasonal study of the crop raiding patterns of elephant in Zimbabwe suggest that the point at which the quality of wild grasses declines to the quality of crop species correspond to the movement of bull elephant out of PAs and into fields (Osborn 2004). In Garo hills, India, the analysis of elephant movement using participatory monitoring suggested that elephant visits to fields peaked at the time of harvest of crop (Datta-Roy *et al.* 2009).

Crop raiding by primates are reported throughout the globe, especially in the tropical and subtropical regions. In Indonesia, *Macaca fascicularis* and *Presbytis thomasi* are most destructive primates in the region (Marchal and Hill 2009). Crop raiding by *Semnopithecus entellus* in and around Aravalli region of India is very high as these primate species can feed upon 184 types of food items and incur crop losses worth $1,800-2,400 annually (Chhangani and Mohnot 2004). Squirrels like *Funambulus palmarum* in addition to their natural diet also take significant portion of cardamom in the Western Ghats of India (Chakravarthy *et al.* 2008).

Livestock depredation by wild animals is also the cause of resentment among traditional herders and pastoral people. Livestock depredation is increasingly becoming a contentious issue in the Himalayan region (Jackson and Wangchuk 2004). In Nepalese Himalaya, conflict with rural communities due to livestock predation by large carnivores like the Snow Leopard, Leopard, Wolf and Wild Dog has risen sharply in recent years (Jackson 1996). Therefore, the present paper attempts to understand the man-animal conflict and possible mitigatory measures to foster a pro-people biosphere reserve management.

The state of Arunachal Pradesh has been of great interest to biologists with recent discoveries of primate species — Arunachal Macaque *Macaca munzala* (Sinha *et al.* 2005), a new species to science, and range extension of the Tibetan Macaque *Macaca thibetana* (Kumar *et al.* 2005) in India; a new bird species to science — Bugun Liocichla *Liocichla bugunorum* has recently being described (Athreya 2006). Three other large mammals previously unknown from India: two species of deer – Leaf Deer *Muntiacus putaoensis* (Datta *et al.* 2003), and the Black Barking Deer *Muntiacus crinifrons* – and the Chinese Goral *Nemorhaedus caudatus*, a primitive mountain goat (Mishra *et al.* 2006), have also been discovered in Arunachal Pradesh recently. There have been confirmed sightings of Black Musk Deer *Moschus fuscus* (Kumar and Nair 2007) and of fishes like *Amblyceps arunachalensis*, *Psilorhynchoides arunachalensis*, *Erethistoides senkhiensis* (Nath and Dey 1989; Nebeshwar *et al.* 2007; Tamang *et al.* 2008) and probably many more that await description. To conserve this biodiversity, the state and the central government have initiated steps by bringing this area under the existing national/state PA network by proposing it for a biosphere reserve status. The region harbours significant altitudinal variation (100-7,090 m above msl), which creates myriads of habitat for different types of flora and fauna (Chaudhry *et al.* 2006). Arunachal Pradesh is located at the junction of Palearctic and Indo-Malayan realms, which enriches its biodiversity (Mani 1974). The state is known to have 50% angiosperms and avifauna of India (Rao and Hajra 1986; Singh 1994; Chowdhury 1998; Procter *et al.* 1998).

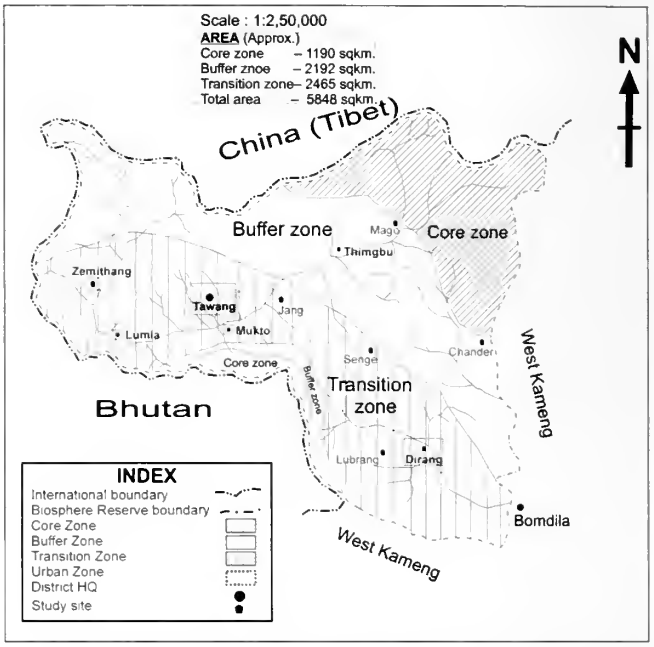


Fig. 1: The proposed Tsangyang Gyatso biosphere reserve showing study sites

STUDY AREA

The survey was carried out in the Tsangyang Gyatso Biosphere Reserve (Fig. 1) in Western Arunachal Pradesh from September 2007 to July 2008. Tawang district spans over 2,172 sq. km with a human population density (16 per sq. km) marginally exceeding the average for Arunachal (13 per sq. km). The region is drained by the Tawang Chu, Nyamjang Chu (both of which meet and drain into Bhutan)

and their tributaries, and comprises five administrative circles (Tawang, Mukto, Thingbu, Lumla, and Zemithang). The Buddhist *Monpa* tribe is the predominant community inhabiting Tawang. There is a considerable presence of the Indian Army in the district, given that it shares international boundaries with Bhutan and China. The larger (7,422 sq. km) West Kameng district has a lower human density (10 per sq. km), with the people belonging to 5 tribes: *Monpa*, *Sherdukpen*, *Khowa*, *Aka*, and *Miji*. The region is drained by the Kameng or Bhareli and its tributaries (eventually joining the Brahmaputra), and is divided into six administrative circles (Bomdila, Dirang, Kalaktang, Bhalukpong, Nafra, and Thrizino).

METHODOLOGY

The study was carried out in the Western Arunachal Pradesh in the districts of the West Kameng and Tawang, eastern range of the Himalaya. The study villages were selected based on reports of human-animal conflicts. An informal questionnaire was used to assess the response of the villagers (Table 1). A total of 149 individuals were interviewed comprising 109 males and 40 females. The secondary information regarding the study area was also collected from six villages. The targeted people belonged to different groups, such as the village headman, school teachers, servicemen, farmers and hunters.

Survey was conducted in the Chander, Lubrang and Senge villages under Dirang circle of West Kameng district and Jang, Mago of Thingbu circle and Zemithang of Zemithang circle, Tawang district. This study was carried out between September 2007 and July 2008 in the proposed biosphere reserve (BR). An informal discussion, with the help of visual identification aid, was used to enlist number of species in the proposed biosphere reserve, which were confirmed by either sighting them or by trophies in possession of villagers. The identification of mammals was carried out with locals using the book A FIELD GUIDE TO INDIAN MAMMALS by Vivek Menon (2003) and photographic plates developed by us. IUCN Red Data book was referred to ascertain the threat status of the species enlisted in the survey.

Table 1: Questionnaire used in the study of conflict mitigation

1. How many different species you see in your locality?
2. Could you identify them with these colour plates?
3. Do some of them raid your crops?
4. Do some of them predate on your livestock?
5. What time do they attack your crops/livestock (day/night)?
6. What is the extent of the damage (high/moderate/low)?
7. Do you kill them in grudge when they damage the crop (yes/no)?
8. What are the causes due to which their attacks have become frequent?
9. What do you think could be done to reduce the damage or stop killing wild animals?

RESULTS

Vegetation types

The vegetation type in the two study districts – West Kameng and Tawang – can be classified into the following five types (Dutta Choudhury 1996; Anonymous 2003) — Tropical evergreen, Subtropical evergreen, Temperate forest, Sub-alpine fir vegetation and Alpine vegetation (Table 2). The total forest cover of the two districts reports about 5,809.91 sq. km area, which accounts for 60.5% coverage as compared to the total area of both the districts, with 56.6% for Tawang district and 61.7 % in case of West Kameng district (Table 2) respectively. The tropical evergreen forests are found along the foothills of southern West Kameng district up to an altitudinal range of 900 m. Out of the two districts, tropical evergreen forests are found only in the West Kameng district covering an area of 494.5 sq. km. The subtropical evergreen forest or mixed forest covers an area of 1,714.85 sq. km of both the districts and are found at an altitudinal range of 900-1,800 m, largely in the Kalaktang and Rupa valley area of West Kameng district. The temperate forests are confined to elevation ranging from 1,800 to 3,500 m and are found mainly in Bomdila, Dirang (West Kameng district), Senge, Jang and Tawang valley (Tawang district) covering an area of 3,031.3 sq. km. The sub-alpine fir vegetation covers an area of 465.8 sq. km in both the districts and are found in Lower Sela area, hill slopes above Tawang valley, Mago area and Jung valley (of Tawang district) at an altitudinal range of 3,500 to 4,500 m. Alpine vegetation dominated by herbaceous species like *Rheum*, *Arenaria*, *Saussurea*, etc. along with *Rhododendron* spp. are

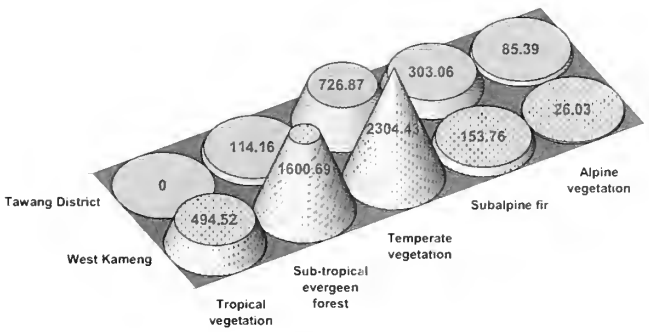


Fig. 2: Vegetation and forest types of the studied districts

found within an altitudinal range of 4,500 to 5,500 m. Covering an area of 111.4 sq. km in both the districts, alpine vegetations are found only in the hill slopes around Bumla, Pangchen, Chuna and Tawang (Tawang district). Fig. 2 shows the relative areas covered by these five types of vegetation.

Demographic profile

The total population of the Tawang district is 38,924 and that of West Kameng is 74,599. There are five major tribes in the West Kameng district while Tawang district has only one. *Aka*, *Miji* and *Bugun* are the three tribes, who are predominantly shifting cultivators, while *Sherdukpen* and Monpas are purely settled cultivators. The *Aka*, *Miji* and *Bugun* live at low elevations (200-2,200 m) in the tropical to subtropical zones, while the *Monpas* and *Sherdukpen* live in temperate to alpine zones. Agriculture, horticulture, NTFP collection and livestock rearing are the major source of income for the local people. *Monpas* living in the higher reaches, beyond 3,000 m, practice transhumance type of pastoralism with barter links, with the people at the lower elevation (Chaudhry *et al.* 2006; Dollo *et al.* 2006). In recent times, there has been increased thrust for developmental activities like installment of brewery, pine extraction unit and hydel projects at the lower reaches, while at the higher elevations road construction, army settlements, pasture expansion are cause of habitat destruction (pers. obs.).

Altogether 6 villages were selected for the study in the 2 districts of the state. Senge was the largest having 152 houses followed by Jang 119, while the lowest was Chander having only 20 houses. Similar trends were recorded in terms of population with Senge having 35%, Jang 27.4%, Zemithang 14.5%, Mago 13.1%, Lubrang 5.3% and Chander 4.6%. Mago and Chander were pure pastoral villages. Jang had maximum of the agricultural workforce 58%, Senge 37.9%, Zemithang 3.7% and Lubrang had the lowest with 0.4%. Most of the people worked in the primary sector (mainly labour work). Senge had the largest chunk with 73% of workers followed by Jang 13.6%, Zemithang 3.8%, Mago 6.8%, Lubrang 0.6% and Chander 2.1%. Non-workers chiefly comprising of kids and elderly also accounted for a significant number, while workers are those who had worked for the major part of the reference period (i.e., 6 months or more). Average land holding was found at the higher elevation villages, which may be attributed to lack of infrastructure like road, the trends reversed in areas having road connectivity like Zemithang, Senge and Jang (Table 3).

Six villages were identified in the reconnaissance survey as the flashpoints of man-animal conflict. These villages broadly fall in three ecological zones, i.e., subtropical, temperate, sub-alpine and alpine zones covering two districts of the state. Vegetation is subtropical broad-leaved forest in Zemithang, broad-leaved temperate forest in Chander, sub-alpine coniferous forest in Senge and alpine pasture in Mago. In Jang, the vegetation is temperate broad-leaved mixed forest while Lubrang is a pastoral village with grasses like *Poa alpina*, *Juncus thomsonii* etc and surrounded by temperate broad-leaved forest. A total of 12 animal species, including domestic dog, were identified to be in direct conflict with human interests in these sites, which can be conveniently divided into two categories: livestock depredators and crop raiders. Jang, Zemithang and Chander had 3 conflicting species followed by 2 each in the remaining villages (Table 4).

Faunal diversity

According to our initial study and literature review there are 40 species of mammals belonging to 34 genera in the proposed biosphere reserve; altogether 18 families belonging to 8 orders. 22 (55%) species of the animals were recorded in the low risk category (LR), 5 (12.5%) species were recorded in the endangered list (EN), 7 (17.5%) were found to be in

Table 2: Vegetation types with dominant species in the study area (in sq. km)

Vegetation Type	Tawang (area in sq. km.)	West Kameng (area in sq. km.)	Dominant species
Alpine vegetation	85.39	26.03	*Rheum australe*, *Berginia purpurascens*, *Rhododendron lepidotum* etc.
Sub-alpine fir	303.06	153.76	*Abies densa*, *Rhododendron barbatum*, *Berberis aristata*, *Anemone rivularis* etc.
Temperate vegetation	726.87	2,304.43	*Rhododendron arboreum*, *Magnolia campbelli*, *Quercus grifithii*, *Pinus wallichiana* etc.
Subtropical evergeen forest	114.16	1,600.69	*Ficus palmata*, *Castanopsis tribuloides*, *Callicarpa arborea*, etc.
Tropical vegetation	0	494.52	*Altingia excelsa*, *Ailanthus grandis*, *Sterculia villosa*, *Duabanga grandiflora* etc.
Total Forest Cover	1,229.48 (56.6%)	4,579.43 (61.7%)	

the vulnerable list (VU), 3 (7.5%) in the least concerned (LC), 1(2.5%) species was near threatened, 2 (5%) species were, however, not found in the IUCN listings. As far as mammalian families are concerned, there were 18 families, Bovidae and Felidae were the largest comprising 15% representation each, followed by Scuiridae having 12.5%, Cercopithecidae and Mustelidae 10% each, Muridae and Cervidae had 5% each, while rest of the families had 5% each of the species representation. Carnivora 35% was largest order, followed by Atriodactyla 25%, Rodentia 20%, Primate 12.5%, Lagomorpha, Perissodactyla and Pholidata contributed 2.5% each. Hence, from the enumeration it can be concluded that carnivore diversity was maximum followed by herbivore, and therefore livestock depredation would be a concern in the immediate future. As per the villagers, the numbers of Tiger *Panthera tigris* and Kiang *Equus kiang* are very low and often their sightings are seasonal.

Conflicting species

There were altogether 13 animal species which were in direct conflict with humans. Out of which two Greater Bandicoot Rat *Bandicota indica* and Domestic Dog *Canis familiaris* live in close association with humans, while the other 11 species were found in the wild. Crop raiders and livestock depredators had equal share of representation, i.e., 54%. Himalayan Black Bear *Ursus thibetanus* had the unique distinction of having the ability to raid crops and kill livestock. Conflict intensity as per the local perception was recorded high for 38% species, while 31% species show moderate intensity of conflict with humans and therefore need proper attention before they become a threat. Rest 31% showed low intensity of conflict, which may be partly attributed to their behavioural patterns and partly due to availability of alternate feeding materials. Snow Leopard *Uncia uncia*, Wild Dog *Cuon alpinus* were blamed for maximum livestock depredation and were subject to retaliatory persecution. However, according to the villagers, their sightings have gradually diminished in recent times. Wild Boar *Sus scrofa* and Arunachal Macaque *Macaca munzala* have been cause of grave concern for their crop raiding behaviour (Table 5).

Based on the conflict intensity mapping, nine potential species were screened as high to moderate conflicting species out of total thirteen. Omnivores lead the tally with 44% representation, primates (33%) constituted the herbivore group, while carnivores had 22% representation. 56% showed diurnal activity while remaining 44% were nocturnal. All the herbivores had affinity towards feeding young leaves while Malayan Porcupine *Hystrix brachyura subcristata* was reported to be feeding more on bulbs and tubers, it may be noted that the species is also known to cause debarking of trees and their subsequent death. Domestic Dog *Canis familiaris* is a known human ally since time immemorial and only recently it has been on the list due to its predating activity, especially on young calves. The other omnivores were found to be feeding much on the fruits, grains, berries and on small mammals. Pure carnivores like Snow Leopard *Uncia uncia* and Wild Dog *Cuon alpinus*, however, were dependent on gorals, deer and small animals (Table 5).

Factors inducing conflicts and prioritization of conflicts

Five causes for conflict, namely deforestation, road construction, NTFP collection, increased number of livestock predators and increased population for man-animal conflict were identified, in all the six study sites. According to the villagers, deforestation was reported to be the major cause of human-animal conflict, causing 18% of the incidents. The village-wise break-up of the deforestation as a cause of conflict was highest in Senge 29%, Chander 22%, Lubrang 18%, Mago, Jang 11% and least in Zemithang 7%.

Table 3: Occupational structure and demographic profile of study sites

Village	No. of Houses (No.)	Total Population (No.)	Agriculture and plantation (No.)	Main Workers (No.)	Livestock and forestry sector (No.)	Other services (No.)	Average house holding (No.)
Mago	57	301	0	126	53	34	5
Jang	119	486	158	252	0	3	4
Zemithang	63	231	10	71	0	84	4
Senge	152	1,795	103	1,353	95	1,231	12
Lubrang	23	162	1	12	0	35	7
Chander	20	87	0	39	26	35	4
Total	434	3,062	272	1,853	174	1,422	6

(Source: Census 2001, Govt. of India)

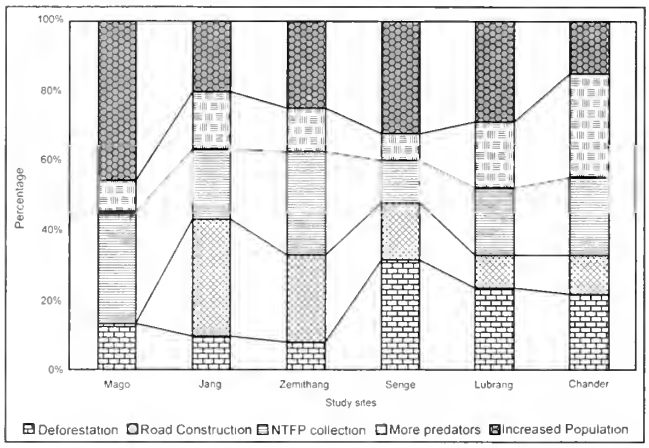


Fig. 3: Percentage of people (Y-axis) in study area (X-axis) citing cause of conflict

17% of the people in the study area thought that road construction has led to increased conflict. The break-up showed that Jang 40% had highest incidence of man-animal conflict following road construction followed by Zemithang 24%, Senge 16%, Chander 12% and Lubrang 8%. 22% of the people had identified indiscriminate NTFP collection as a cause of this conflict; the village wise break-up showed that Mago and Zemithang 21%, Jang and Chander 18%, Lubrang 12% and last Senge 9% shared similar views on NTFP collection as a cause of conflict. On an average, 16% of the people believed that conflicts are more prevalent nowadays due to increase in the number of crop raiders and livestock depredators, which according to them is true in case of Primates and Dholes. Village-wise break-up of increased predators as a cause of conflict shows that 33% of people from Chander, 21% Jang, 17% Lubrang, 12% Zemithang and 8% each, Mago and Senge supported this view. The major cause according to the respondents was increased population (27%). Mago had highest number of people having this view (25%) followed by 20% in Senge (which has an army built up in the area), Jang, Zemithang and Lubrang 15% each and lastly Chander (10%) (Fig. 3).

Therefore, according to people's perception causes for human-wildlife conflict in order of importance were increased population > NTFP collection > road construction > increased predators. All these factors are related to each other as well as with economics. Subsequent ban on timber logging by Supreme Court in 1996 has resulted in greater reliance on NTFPs, and livestock and animal husbandry. Road construction and development impetus in the area increased after the 1962 Sino-Indian Conflict, resulting in habitat loss of wild animals. These factors have resulted in increased man-animal conflict. The analysis was further extended to identify adequate measures to reduce the man-animal conflict in the biosphere reserve. Four factors were enlisted by the local people as compensatory schemes, reducing prey hunt, reducing pressure on forest and increasing vigil to safeguard crops and livestock. Compensatory schemes were demanded by the local people and this constituted an overall of 32% demand in the region, Chander had highest 20%, Mago and Zemithang 19% each, Jang 17%, Senge 15% and Lubrang 10%. Most of the compensation demanding villages are pastoral village and have limited access to roads. The

Table 4: Study areas under maximum incidences of human-wildlife conflict

Study villages	Geographical Gradient & Elevation (m above msl)	Dominant vegetation	Conflicting species
Mago	27°41' 11.4" N, 92°12' 10.6" E 3,600 m	*Poa alpine*, *Aletris pauciflora*, *Juncus thomsonii*	Snow Leopard *Uncia uncia*, Wild Dog *Cuon alpinus*
Jang	27° 34' 54.1" N, 91° 58' 54.2" E 2,400 m	*Quercus grifithii*, *Lyonia ovalifolia*, *Pinus wallichiana*	Domestic Dog *Canis familiaris*, Arunachal Macaque *Macaca munzala*,
Zemithang	27° 42' 40.4" N, 91° 43' 49.7" E 2,300 m	*Quercus grifithii*, *Rhododendron arboreum*	Rhesus Macaque *Macaca mulatta* Arunachal Macaque *Macaca munzala*, Malayan Porcupine *Hystrix brachyura subcristata* Wild Boar *Sus scrofa*
Senge	2,900 m	*Rhododendron grande*, *Tsuga dumosa*, *Arundinaria maling*	Domestic Dog *Canis familiaris*, Rhesus Macaque *Macaca mulatta*
Lubrang	27° 21' 57" N, 92° 10' 44.3" E 2,800 m	*Rhododendron arboreum*, *Acer pectinatum*, *Lyonia ovalifolia*	Wild Dog *Cuon alpinus*, Yellow-throated Marten *Martes flavigula*
Chander	27° 23' 5.5" N, 92° 20' 30.4" E 2,950 m	*Betula alnoides*, *Acer oblongum*, *Rhododendron grande*	Wild Dog *Cuon alpinus*, Yellow-throated Marten *Martes lavigula*, Himalayan Black Bear *Ursus thibetanus*

other three villages that have road connectivity had less demand for compensation (10-17%). Reducing the hunting of prey such as deer, small mammals and birds to balance the prey-predator relation was agreed upon by 20% people. Jang and Zemithang had 20% each followed by Chander and Zemithang 17% each and lastly by remaining two villages 13% each. 27.5% people agreed to increase the vigil to reduce the crop and livestock loss to the wild animals, Jang had the highest with 24%, Lubrang 19% , Senge 17%, 15% each from Mago and Chander, followed by 10% of people in Zemithang. Similar views were shared about reducing pressure on the forest with 20% people from Chander, Lubrang, Senge and Jang. 17% people in Zemithang, 13% in Lubrang and least with Mago 10% (Table 6).

DISCUSSION AND CONCLUSION

It seems from the foregoing result that human-animal conflict in the proposed biosphere reserve is a serious issue. In the state, most of the studies related to mammals were restricted to taxonomical descriptions, but as a matter of fact their role in human-animal conflict has not been taken up adequately (Mishra *et al.* 2006). This arises primarily due to two counts, one there is lack of acclimatization with the people and second, the people distrust government agents either for taxes or for land acquisition. Apart from these two, the recent religious ban on the hunting of animals inside forest by the Tawang monastery can also be accounted for the reluctance of the people to respond (pers. comm.). There are three direct stakeholders in the state department, i.e., agriculture, horticulture and forest departments, but none are keeping data on human-animal conflicts (pers. obs.). Most of the land is under forest cover and hence it is the dominant land use and in recent times it has been put to pressure owing to developmental activities (Dollo *et al.* 2006). The region has most of the forest under the category of unclassed state forest which are strictly under community control, and therefore they are governed by the customary laws of the community (Singh and Sundriyal 2006).

Community lands governed by traditional institutions are broadly divided into two groups – land tenureship and ownership. However, in recent times the traditional systems are under transition and are gradually taken up by the Panchayati Raj Institutions (PRI) having village headman (Gaonburha) who may have greater political mileage along with a handful of his subordinates which at times creates inequitable pattern of resource utilization affecting sustainability in long run (Chaudhry *et al.* 2006). As evident from Table 6 four factors are driving the man-animal conflict in the region (i) population (ii) loss of vegetation (iii) NTFP

Table 5: List of the animal species reported to have conflicts with humans

Species	Conflict			
	Livestock depredation	Activity time	Crop raiding	Conflict intensity
Rhesus Macaque *Macaca mulatta*	–	Diurnal	√	++
Capped Langur *Trachypithecus pileatus*	–	Diurnal, Crepuscular	√	+
Marbled Cat *Felis marmota*	√	Nocturnal	–	+
Snow Leopard *Uncia uncia*	√	Diurnal, Crepuscular	–	+++
Wild Dog *Cuon alpinus*	√	Diurnal, Nocturnal (Hunting)	–	+++
Malayan Porcupine *Hystrix brachyura subcristata*	–	Nocturnal	√	+++
Greater Bandicoot Rat *Bandicota indica*	–	Nocturnal	√	+
Arunachal Macaque *Macaca munzala*	–	Diurnal	√	+++
Wild Boar *Sus scrofa*	–	Nocturnal	√	+++
Yellow-throated Marten *Martes flavigula*	√	Diurnal, Nocturnal	–	++
Leopard *Panthera pardus*	√	Nocturnal	–	+
Domestic Dog *Canis familiaris*	√	Diurnal	–	++
Himalayan Black Bear *Ursus thibetanus*	√	Diurnal, Nocturnal	√	++

Key: – = absence of conflict; √ = presence of conflict; + = low conflict intensity; ++ = Moderate conflict intensity; +++ = High conflict intensity

Table 6: Remedial conservation measures as suggested by the villagers for reducing the conflicts

Villages	Compensation	No hunting of prey	Increasing vigil	Reducing pressure on forest
Mago (n=22)	9	4	6	3
Jang (n=30)	8	6	10	6
Zemithang (n=24)	9	6	4	5
Senge (n=25)	7	5	7	6
Lubrang (n=21)	5	4	8	4
Chander (n=27)	10	5	6	6

Figures in parenthesis indicate number of persons interviewed

collection and (iv) less vigil, all these factors are related to one another when the main need becomes quick money (Saha *et al.* 2006).

The government lacks data and outreach to the far flung areas and therefore there is lack of support for the rural and pastoral highlanders. Our data show that the respondents support compensatory schemes for crops or livestock lost to wildlife (Table 4). Most of forest related operations (timber, fuel, NTFPs, hunting) with the rising population were responsible for rise in the recent conflicts (Fig. 2). This is especially true when developmental thrust received a shot in arm after 1962 Sino-Indian conflict (Saha *et al.* 2006). There were number of roads constructed and rapid expansion of army settlements and urbanization process. Other developmental activities like horticulture areas expansion, pasture expansion have already aggravated forest status and hence the present day man-animal conflict has raised to alarming proportions. Therefore, the need of the hour is to document the best practices in the traditional institutions for resource utilization, management and conservation, the region is known for its Buddhism related values and traditional modes of conflict resolution and compensation hold good for the future. An ideal situation will be to complement the traditional knowledge with that of formal conservation science.

ACKNOWLEDGEMENTS

We acknowledge the grants received from the Ministry of Environment and Forests, Government of India. We also acknowledge the research facility provided by the Director, G.B. Pant Institute of Himalayan Environment and Development. We thank Mr. Mihin Dollo for the study area map. We would like to thank the Director, Wildlife Institute of India for his support. Thanks are also due to the help rendered by Mr. Tsering Dargey of Mon Pastoral and Development Society and also the friendly *Monpa* people.

REFERENCES

Anonymous (2003): Natural Resource Atlas of Arunachal Pradesh, State Remote Sensing Application Centre, Arunachal Pradesh.

Anonymous (2006): Preliminary Identification of IPAs for medicinal plants in Himalayas. Count. Reprt. India, Pragya. Pp. 1-55.

Athreya, V. (2006): Is relocation is viable management option for unwanted animals? The case of Leopard in India. *Cons. and Soci.*: 419-423.

Bagchi, S., C. Mishra & Y.V. Bhatnagar (2004): Conflicts between traditional pastoralism and conservation of Himalayan Ibex (*Capra sibirica*) in the Trans-Himalayan Mountains. *Anim. Conserv.* 7: 121-127.

Chakravarty, A.K., N.E. Thyagaraj, L.V. Kumar & A.C. Girish (2008): Crop raiding and management of *Funambulus palmarum* in cardamom (*Elettaria cardamomum*) plantation of Western Ghats of Karnataka, South India. *Current Science 95(7)*: 907-911.

Chaudhry, S., M. Dollo, R.C. Sundriyal (2006): Livestock linked rural economy: of West Kameng and Tawang districts, Arunachal Pradesh. Pp. 343-356. *In*: Ramakrishnan, P.S., K.G. Sexena & K.S. Rao (Eds): Shifting agriculture and sustainable development in North East India. UNESCO-MAB Series, Oxford and IBH Publishing Co. Pvt. Ltd.

Chhangani, A.K. & S.M. Mohnot (2004): Crop raid by Hanuman langur *Semnopithecus entellus* in and around Aravallis, (India) and its management. *Primate report 69*: 35-47.

Chhatre, A. & V. Saberwal (2005): Political incentives for biodiversity conservation. *Cons. Biol. 19(2)*: 310-317.

Chowdhury, H.J. (1998): Orchids of Arunachal Pradesh. Bishen Singh Mahendra Pal Singh, Dehradun, India.

Datta, A., J. Pansa, M.D. Madhusudan & C. Mishra (2003): Discovery of the leaf deer *Muntiacus putaoensis* in Arunachal Pradesh: An addition to the large mammals of India *Curr. Sci. 84(3)*: 454-458.

Datta-Roy, A., N. Ved & C. Williams (2009): Participatory elephant monitoring in South Garo Hills: efficacy and utility in a human-animal conflict scenario. *Tropical Ecology 50(1)*: 163-171.

Dinerstein, E., G. Powell, D. Olson, E. Wikramanayake, R. Abell, C. Loucks, E. Underwood, T. Allnutt, W. Wettenggel, T. Ricketts, H. Strand, S. O'Connor & N. Burgess (2000): A workbook for conducting biological assessments and developing biodiversity visions for eco-region based conservation. Part I: Terrestrial ecoregions. Conservation Science Program, WWF-USA, Washington, DC. Pp. 1-249.

Dollo, M., S. Chaudhry, R.C. Sundriyal (2006): Traditional farming and land tenure systems in West Kameng disctict, Arunachal

Pradesh. *In*: Ramakrishnan, P.S., K.G. Sexena & K.S. Rao (Eds): Shifting agriculture and sustainable development in North East India. UNESCO-MAB Series. Oxford and IBH Publishing Co. Pvt. Ltd. Pp. 293-315.

Dutta Choudhury, S. (1996): Arunachal Pradesh District Gazetteers: East Kameng, West Kameng and Tawang Districts. Sate editors (Gazetteers), Gazetteers Department. Government of Arunachal Pradesh. Pp. 11-15.

Hussain, S. (2003): The status of the snow leopard in Pakistan and its conflict with local farmer livelihood. *Oryx 37(1)*: 26-33.

IUCN (2003): World parks congress press release. Retrieved September 17, 2003, from the IUCN website www.iucn.org.

Jackson, R.M. (1996): Reducing livestock depredation losses in the Nepalese Himalaya. Pp. 241-247. *In*: Timm, R.M. & A.C. Crabb (Eds): Proceedings of 17th Vertebrate Conference.

Jackson, R.M. & R. Wangchuk (2004): A community-based approach to mitigating livestock depredation by snow leopards. Taylor and Francis *9*: 307-315.

Kharel, F.R. (1997): Agricultural crop and livestock depredation by wildlife in Langtang National Park, Nepal. *Mountain Research and Development 17(2)*: 127-134.

Knops, J.M.H., D. Tilman, N.M. Haddad, C. Naeem, E. Mitchell, J. Haarstad, M. Ritchie, K. Howe, P. Reich, E. Siemann & J. Groth (1999): Effects of plant species richness on invasion dynamics, disease outbreaks, insect abundances and diversity. *Ecology letters 2*: 286-293.

Kumar, R.S. & M.V. Nair (2007): Dark Wraith of the High Himalaya: Black Musk Deer. *Hornbill*, April-June: 17-19.

Kumar, R.S., C. Mishra & A. Sinha (2005): Discovery of Tibetan Macaque *Macaca thibetana* in Arunachal Pradesh, India. *Current Science 88(9)*: 1387-1388.

Maikhuri, R.K. & K.S. Rao (1998): A ban on common sense. *Down to Earth 6(17)*: 32-36.

Mani, M.S. (1974): Ecology and Biogeography in India. Dr. W. Junk, B.V. Publishers, The Hague. *24*: 698-724.

Marchal, V. & C. Hill (2009) Primate crop-raiding: A study of local perceptions in four villages in North Sumatra, Indonesia. *Primate Conservation 24*: 107-116.

Margules, C.R., A.O. Nicholls & R.L. Pressey (1998): Selecting networks of reserves to maximize biological diversity. *Biological Conservation 43*:63-76.

Menon, V. (2003): A Field Guide to Indian Mammals. Penguin Books India. 200 pp.

Mishra, C. (1997): Livestock depredation by large carnivores in the Indian Trans Himalaya: Conflict perceptions and conservation prospects. *Environmental Conservation 24(4)*: 338-343.

Mishra, C., M.D. Madhusudan & A. Datta (2006): Mammals of the high altitudes of western Arunachal Pradesh, eastern Himalaya: an assessment of threats and conservation needs. *Oryx 41*: 1-7.

Myers, N., R.A. Mittermeier, C.A. Mittermeier, G.A.B. da Fonseca & J. Kent (1999): Biodiversity hotspots for conservation priorities. *Nature 403*: 853-858.

Nath, P. & S.C. Dey (1989): Two new fish species of the genus *Amblyceps* Blyth from Arunachal Pradesh, India. *Journal of the Assam Science Society 32*: 1-6.

Nath, N.K., B.P. Lahkar, N. Brahma, S. Dey, J.P. Das, P.K. Sarma & B.K. Talukdar (2009): An assessment of human-elephant conflict in Manas National Park, Assam, India. *Journal of Threatened Taxa 1(6)*: 309-316.

Nebeshwar, K., K. Bagra & D.N. Das (2007): A new species of cyprinoid genus *Psilorhynchoides* Yazdani *et al.* (Cypriniformes: Psilorhynchidae) from Arunachal Pradesh, India. *Zoos' Print Journal 22(3)*: 2632-2636.

Newmark, W.D., N.L. Leonard, H.I. Sariko & D.G.M. Gamassa (1993): Conservation attitudes of local people living adjacent to five protected areas in Tanzania. *Biological Conservation 63*: 177-183.

Olson, D.M. & E. Dinerstein (1998): The global 200: a representation approach to conserving Earth's most biologically valuable ecoregions. *Conservation Biology 12*: 502-503.

Osborn, F.V. (2004): Seasonal variation of feeding patterns and food selection by crop-raiding elephants in Zimbabwe. *African Journal of Ecology 42*: 322-327.

Parry, D. & B. Campbell (1992): Attitudes of rural communities to animal wildlife and its utilization in Chobe Enclave and Mababe Depression, Botswana. *Environmental Conservation 19*: 245-252.

Procter, K.H., K. Haridasan & G.W. Smith (1998): How far does lowland tropical rainforest go? *Global Ecology Biogeography Letters 7*: 141-146.

Pun, H.L. & V. Mares (2000): The sustainable development of mountain regions: a paradigm shift and new considerations. *In*: Tulachan, P.M., M.A.M. Saleem, J. Maki-Hokken & T. Pratap (Eds): Contribution of livestock to mountain livelihoods: research and development issues: 35-42. International Centre for Integrated Mountain Development.

Pyke, C.R. (2007): The implications of global priorities for biodiversity and ecosystem services associated with protected areas. *Ecology and Society 12(1)*: 4.

Rao, K.S., R.K. Maikhuri, S. Nautiyal & K.G. Saxena (2002): Crop damage and livestock depredation by wildlife: A case study from Nanda Devi Biophere Reserve, India. *Journal of Environment Management 66*: 312-32.

Rao, R.R. & P.K. Hajra (1986): Floristic diversity of the eastern Himalaya - in a conservation perspective. *Proceedings of Indian Academy of Sciences (Animal Science/Plant Science) Supplement*: 103-125.

Saha, D., K.I. Singh & R.C. Sundriyal (2006): Non-timber forest products linked rural livelihood in west Kameng district, Arunachal Pradesh. Shifting agriculture and sustainable development in North East India. Oxford and IBH Publishing Co. Pvt. Ltd. Pp. 357-370.

Sanchez-Cordero, V., V. Cirelli, M. Munguia & S. Sarkar (2005): Place prioritization for biodiversity representation using species ecological niche modelling. *Biodiversity Informatics 2*: 11-23.

Scott, J.M., F.D. Davis, R.G. McGhie, R.G. Wright, B. Csuti, P. Morgan & R.L. Pressey (2001): Representation for natural vegetation in protected areas: capturing the geographic range. *Biodiversity and Conservation 10*: 1297-1301.

Siemann, E., D. Tilman, J. Haarstad & M. Ritchie (1998): Experimental tests of the dependence of arthropod diversity on plant diversity. *American Naturalist 152*: 738-750.

Singh, P. (1994): Recent bird records from Arunachal Pradesh. *Forktail 10*: 65-104.

Singh, K.I. & R.C. Sundriyal (2006): Involving local communities in forest management in west Kameng district, Arunachal Pradesh. Shifting agriculture and sustainable development in North East India. Oxford and IBH Publishing Co. Pvt. Ltd. Pp. 317-342.

Sinha, A., A. Datta, M.D. Madhusudan & C. Mishra (2005): *Macaca munzala*: A new species from Western Arunachal Pradesh, North-eastern India. *International Journal of Primatology 26(4)*: 977-989.

Tamang, L., S. Chaudhry & D. Choudhury (2008): *Erethistoides senkhiensis*, a new catfish (Teleostei: Erethistidae) from India. *Ichthyological Exploration of Freshwaters 19(2)*: 185-191.

Theobald, D.M. & N.T. Hobbs (2002): A framework for evaluating land use planning alternatives: protecting biodiversity on private land. *Conservation Ecology 6(1)*: 5. www.tradingeconomics.com/world/terrestrial-protected-areas-percent-of-total-surface-area-wb-data.html.

AN ASSESSMENT OF NUTRITIVE VALUE, RARITY AND CONSERVATION OF *MONSONIA HELIOTROPIOIDES* (CAV.) BOISS. — A THREATENED PLANT OF NORTH-WEST RAJASTHAN, INDIA

R.K. Gehlot[1,3] and Vinod Kumari[1,2]

[1]Department of Botany, Laboratory of Conservation Biology, Government Dungar College, Bikaner 334 001, Rajasthan, India.
[2]Address for Correspondence: L-15 Green Park Colony, Near Sophia School, Bikaner 334 001, Rajasthan, India.
Email: kumari.vinod13@gmail.com
[3]Email: ramkarangehlot@gmail.com

Monsonia heliotropioides (Mayur Shikha) is a rare herbaceous fodder plant of north-west Rajasthan whose population has been continuously decreasing. It was observed only from a few localities having calcarious cankar land with a very scanty population. Protection of habitat may be an effective control measure for the conservation of this species. From the leaves 23.77% crude proteins, 58.79% carbohydrates, 5.36% crude fat and only 5.89% crude fibres were estimated. All plant parts had an appreciable amount of minerals. Tannins were present in all the parts with a maximum concentration in leaves, whereas alkaloids and saponins were not detected. Seed germination was observed only under mechanical scarification. Besides poor germination percentage other reason observed for rarity, were specific habitat and its disappearance, easy grazing of whole umbellate inflorescence consequently low seed production and dispersal mechanism of fruit.

Key words: *Monsonia heliotropioides*, threatened plant, nutritive value, rarity, germination, habitat, conservation

INTRODUCTION

Existence of a plant species may be necessary for maintenance and balance of the ecosystem. So, throughout the globe, conservation of biodiversity is one of the most urgent needs. The primary tool for biodiversity conservation is derived from the analysis of basic taxonomic and phytogeographic data, which defines the centres of endemism and species diversity (Kiran Raj 2010). North-west Rajasthan forms an important part of the Great Indian Desert. In the recent past, many areas of this region were subjected to considerable ecological changes, which has modified the pattern and abundance of many species, consequently a number of plant species have become threatened. Only a few attempts have been made to study the plants of this region (Sahni 1970; Pandey *et al.* 1983; Harsh and Tiwari 1998).

The threatened status of a plant species can be assessed from its population distribution, regeneration capacity and present trends of exploitation pressure on such species (Lucas and Synge 1978; Jain and Sastry 1980; Nayar and Sastry 1987, 1988, 1990; Ali 2010). *Monsonia heliotropioides* (Cav.) Boiss. is an annual herb with woody root stock and radical leaves; it belongs to the Family Geraniaceae (Bhandari 1990). A rare plant of north-west Rajasthan, it is reported from a very few localities, having calcarious canker land. It is a good fodder plant and also used as a valuable remedy in acute and chronic dysentery, especially of use in ulceration of the lower part of the intestine (Leyel 1981). Desert plants are generally rich in nutritive contents, especially proteins (Mathur and Karwasra 1967; Purohit 1987; Singh and Singh 2011). Efforts for conserving plants can be improved if the species selected are thoroughly investigated for their use, since multiple uses of any plant can motivate people for its conservation. Therefore, during the present investigation besides studying the causes of rarity and conservation measures, the fodder value of plant was also assessed.

MATERIAL AND METHODS

Field trips were regularly made to different localities in the study area to study the distribution, habitat, phenology since 1998 and information was also sought from locals regarding utility, low population, rarity and present trends of exploitation pressure on the species. Various aspects of threat were studied on the basis of criterion given by Perring and Farwell (1977).

For the estimation of nutritive content, methods of AOAC (1990) were used. Mineral content was estimated by the Atomic Absorption Spectrophotometer (AAS) method. The qualitative estimation of alkaloids, saponins and tannins were made by the method of Amar Singham *et al.* (1964) and Arthur and Chan (1962).

Seed germination study was performed in earthen pots filled with soil collected from the habitat the plant grew, under controlled conditions and various treatments.

RESULTS AND DISCUSSION

Monsonia heliotropioides is regarded as a good fodder plant for cattle in the area due to palatability and nutritive

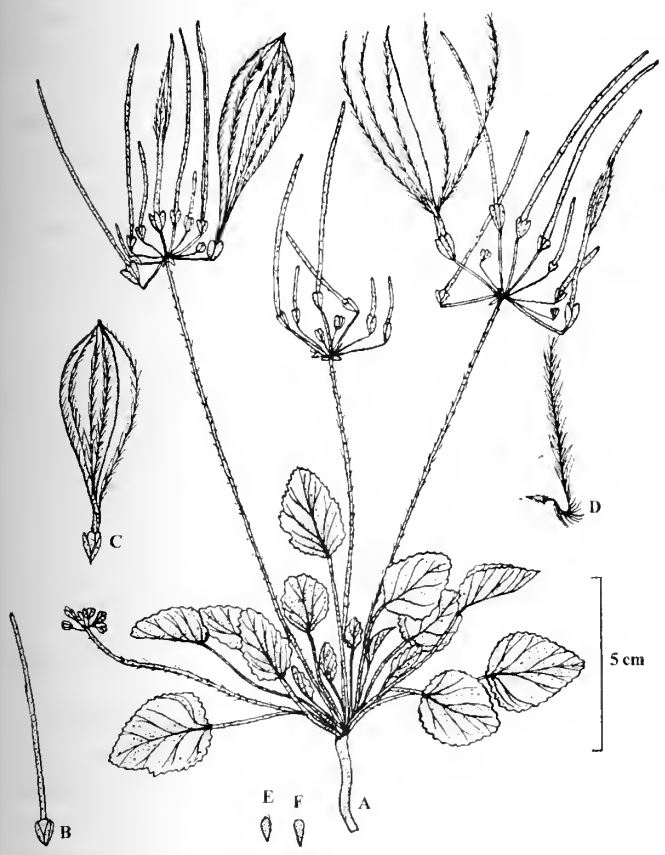


Fig. 1: *Monsonia heliotropioides* (Cav.) Boiss
A: Habit; B: Fruit, C. Dehiscing fruit; D: Mericarp with bristle;
E: sepal; F. Petal

value. The distributional range of this species was found to be very restricted with scanty population. The main causes of depletion of this species observed during the study were shrinkage of grazing lands, uncontrolled grazing and destruction of habitat by locals for collecting calcarious cankers used mainly for construction purpose. *Prosopis juliflora*, which regenerates faster and grows aggressively, is seriously threatening the survival of indigenous species in north-west Rajasthan (Singh and Singh 2011). Britto *et al.* (2002) observed that habitat degradation was the main cause of threat for *Ceropegia* sp. and suggested that they have genetically depleted and are scarcely available.

M. heliotropioides in its vegetative stage has prostrate radical leaves. During the reproductive period it bears inflorescence on long erect peduncle; the length of peduncle is about twice during fruit formation. The fruits are easily grazed as they are long beaked and umbellate, like the crown of a peacock (hence the local name Mayur Shikha). The fruit dehisces into small mericarps with long hairy bristles, which enables it to disperse widely by wind through long distances and habitats where the conditions may not be suitable for its seed germination and consequently growth, as a result of which a large number of seeds are destroyed. This is the main reason for its rare occurrence and small population.

Analysis of the plant parts showed that *Monsonia heliotropioides* contains high crude proteins, which are maximum in leaves (23.77%) and minimum in roots (9.58%) (Table 1). Adequate amount of nitrogen supply help to maintain normal metabolism under water and heat stress, one of the major factor for all plants in arid regions (Hellmuth 1968). Crude fibres were higher in root and fruit than leaves. The high percentage of crude fibres in fruits may be due to the presence of long beak in fruits and bristles in mericarps. Total ash content was comparatively very low in fruits. Total carbohydrate was estimated to be lower in leaves (58.79%) than roots (76.5%) and fruits (79.4%). All the plant parts showed a good amount of mineral nutrients, especially phosphorus, manganese and zinc. High fodder value of this plant is clearly evident from the present biochemical analysis particularly of high proteins and mineral contents. High concentration of mineral elements in medicinal plants act not only as curative, but also as preventive agents for many diseases (Pandey *et al.* 2006). Qualitative test for alkaloids, tannins and saponins revealed that tannins were present in all the parts with comparatively dense precipitation in leaf extract. Tannins have astringent properties, which hastens the healing of wounds and inflamed mucous membrane (Okwu and Okwu 2004). High amount of tannins in leaves reported

Table 1: Nutritive content in different parts of *Monsonia heliotropioides* (on % dry matter basis)

Nutritive contents	Roots	Leaves	Fruits
Crude Protein	9.58 ±0.92	23.77 ±1.60	11.16 ±1.02
Crude Fat	0.83 ±0.52	5.36 ±0.21	3.21 ±0.28
Crude Fibre	23.85 ±1.48	5.89 ±0.59	22.50 ±1.13
Ash	13.09 ±1.36	12.08 ±0.25	6.23 ±0.46
Nitrogen Free Extract	52.65 ±2.06	52.90 ±2.23	56.90 ±1.99
Organic Matter	86.91 ±2.18	87.92 ±1.74	94.21 ±1.29
Total Carbohydrate	76.50 ±1.93	58.79 ±1.18	79.40 ±1.45
Calcium	0.77 ±0.12	1.01 ±0.14	1.15 ±0.16
Phosphorus	1.27 ±0.18	0.95 ±0.15	1.69 ±0.58
Magnesium*	101 ±0.82	128 ±1.77	111 ±1.38
Copper*	2.7 ±0.18	3.1 ±0.20	2.1 ±0.44
Iron*	42.7 ±2.22	48.7 ±0.77	34.2 ±0.69
Zinc*	3.8 ±0.21	2.4 ±0.20	3.2 ±0.16
Manganese*	3.4 ±0.28	4.4 ±0.42	6.7 ±0.40

values are mean ±S.D. of five samples
* mg/100 gdw

in present study justify its medicinal value in dysentery and ulceration of intestine. Alkaloids and saponins were not observed. These substances play an important role in ecology and physiology of adaptations, but may sometimes cause negative effect on grazing animals in case of higher concentration. High concentration of saponins in fodder plants may cause foaming in intestinal tract of grazing animals, which lead to bloating in cattle.

Germination of seeds was observed only under the treatment of mechanical scarification, which was very poor (30%). There was no effect of acid scarification, Indole Acetic acid and Gibbrellic acid on germination of seeds. Seed germination was epigeal although the seed coat remains inside the soil due to the attachment at the lower part of hypocotyl. It has been concluded that hard seed coat is impermeable for water and gases, and requires partial decomposition before germination.

Protection of habitat, control on grazing, introduction in area of similar habitat and ecological condition and maintenance of its seeds in seed banks, replacing them with fresh collection every year, as seeds gradually lose viability under storage, may be important conservation measures for this species.

ACKNOWLEDGEMENT

The second author thanks UGC for financial support for this work.

REFERENCES

AOAC (1990): Method of Chemical Analysis. Association of Official Agricultural Chemists. Virginia, USA.

Ali, M.A. (2010): Ethno-medicinal use of a threatened cucurbit from Bihar. *Curr. Sci. 99(9)*: 1164.

Amar Singham, R.D., N.G. Bisset, A.M. Millard & M.C. Woods (1964): A phytochemical survey of Malaya, part III alkaloids and saponins. *Econ. Bot. 18(3)*: 270-280.

Arthur, H.R. & R.P.K. Chan (1962): A survey of Hong Kong plants testing for alkaloids, essential oil and saponins. *China Trop. Sci. 4*: 147-158.

Bhandari, M.M. (1990): Flora of the Indian Desert. MPS. Repros, Jodhpur. 435 pp.

Britto, S.J., E. Natarjan & D.I. Arockiasamy (2002): *In vitro* flowering and shoot multiplication from nodal explants of *Ceropegia bulbosa* Roxb. var. *bulbosa*. *Taiwania 48(2)*: 106-111.

Harsh, L.N. & J.C. Tiwari (1998): Biodiversity of vegetational complex in arid regions of India. *In*: Bawa, R. & P.K. Khosla (Eds): Biodiversity of forest species. Bishen Singh Mahender Pal Singh, Dehradun.

Hellmuth, E.O. (1968): Eco-physiological studies on plants in arid and semi-arid region in western Australia I. Autecology of *Rhagodia baccata* (Labill). Moq. *J. Ecol.* 56: 319-344.

Jain, S.K. & A.R.K. Sastry (1980): Threatened Plants of India – A State of Art Report. B.S.I., Hawrah. pp. 48.

Kiran Raj, M.S. (2010): Global biodiversity crisis and priorities in Indian plant systematics. *Curr. Sci. 99(11)*: 1491.

Leyel, C.F. (1981): A Modern Herbal. Dower Publication, Inc. New York. 902 pp.

Lucas, G.L. & H. Synge (1978): The IUCN Plant Red Data Book. Morges, Switzerland. 540 pp.

Mathur, C.S. & R.S. Karwasra (1967): Some nutritional aspects of Chamghas (*Corchorus anticharis* Reeusch.). *The Ind. Vet. J. 44*: 525-527.

Nayar, M.P. & A.R.K. Sastry (1987): Red Data Book of Indian Plants. Vol. I. Botanical Survey of India, Calcutta.

Nayar, M.P. & A.R.K. Sastry (1988): Red Data Book of Indian Plants. Vol. II. Botanical Survey of India, Calcutta.

Nayar, M.P. & A.R.K. Sastry (1990): Red Data Book of Indian Plants. Vol. III. Botanical Survey of India, Calcutta.

Okwu, D.E. & M.E. Okwu (2004): Chemical Composition of *Spondias mombin* Linn. plant parts. *J. Sustain. Agric. Environ.* Pp. 140-147.

Pandey, R.P., B.V. Shetty & S.K. Melhotra (1983): A preliminary census of rare and threatened plants of Rajasthan. Pp. 55-62. *In*: Jain, S.K. & R.R. Rao (Eds): An Assessment of Threatened Plants of India. Botanical Survey of India, Hawrah.

Pandey, H.K., S. Vir & S.C. Das (2006): Macro and Micro elements in some important Himalayan herbs, used for the cure of various diseases. *J. Med. Arom. Pt. Sci. 28*: 27-30.

Perring, F.H. & L. Farwell (1977): British Red Data Book I. Vascular Plants. Society for the Promotion of Nature Conservation, London.

Purohit, G.R. (1987): Nutritive value of some plants of arid zone of Rajasthan. Abst. All Ind. Sem. on Ad. in Bot. Res. in India during the last ten years, Bikaner. Pp. 83-84.

Sahni, K.C. (1970): Protection of Rare and Endangered Plants in the Indian Flora. *IUCN Pub. New Ser. 18*: 95-102.

Singh, D. & R.K. Singh (2011): Kair (*Capparis decidua*): A potential ethno-botanical weather predictor and livelihood security shrub of the arid zone of Rajasthan and Gujarat. *Ind. J. Trad. Knowdg. 10(1)*: 146-155.

■ ■ ■

PORCELLANID CRABS FROM GOA, EASTERN ARABIAN SEA (CRUSTACEA: DECAPODA: PORCELLANIDAE)

Alexandra Hiller[1,3], Sadanand Harkantra[2] and Bernd Werding[3]

[1]Smithsonian Tropical Research Institute, Apartado 843-03092, Panama, Republic of Panama. Email: HillerA@si.edu
[2]Biological Oceanography Division, National Institute of Oceanography (Council of Scientific and Industrial Research, New Delhi), Dona-Paula 403 004, Goa, India. Email: cabira@rediffmail.com
[3]Department of Animal Ecology, Justus-Liebig-University, Heinrich-Buff-Ring 26-32, D-35392 Giessen, Germany. Email: Bernd.Werding@uni-giessen.de

We report here 10 species of Porcellanidae sampled along the coast of Goa, India, each of which is described and figured. *Polyonyx splendidus* is registered for the first time outside the type region, and *Petrolisthes coccineus* is registered for the first time for the Arabian Sea. Accordingly, the porcellanid fauna of the western coast of the Indian subcontinent now consists of 16 species, including two endemics, *Polyonyx liendersoni* and *P. splendidus*. For the Indian Ocean, 9 species are here reported as endemic. We provide a key for the identification of all species so far reported for the western coast of the Indian subcontinent.

Key words: Crustacea, Anomura, Porcellanidae, Goa, Arabian Sea, taxonomy, biogeography

INTRODUCTION

The Porcellanid fauna of the coast of Goa remains unknown despite earlier studies conducted at different locations of the East Arabian Sea, e.g. Ratnagiri (Sankolli 1963a,b, 1966), along the west coast of India and coast of Pakistan (Tirmizi *et al.* 1982, 1989). Towards the goal of studying the occurrence, habitat and distribution of the species on the coast of Goa, we conducted fieldwork in the rocky region of Bogmolo in the vicinity of Marmugoa harbour, including St. George Island, and of Anjuna for ten days in December 2006.

MATERIAL AND METHODS

Crabs were collected during low tide by snorkelling and scuba diving up to 12 m depth, and preserved in 75% ethanol. Collected specimens were brought to the National Institute of Oceanography (NIO), Biological Oceanography Division, Dona-Paula, Goa, for identification. For each species we included: (1) the taxonomic history including a list of synonyms, (2) number and sex of specimens collected, (3) habitat characteristics and distribution, and (4) a scientific drawing of habitus (using a camera lucida). This information is followed by a taxonomic key to the species of the western coast of the Indian subcontinent.

RESULTS

Systematic account

***Ancylocheles gravelei* (Sankolli, 1963)** (Fig. 1)

Paclyclieles sp.: Gravely, 1927: 140, pl.20, fig.9.

Porcellana gravelei: Sankolli, 1963a: 280, fig.1; Sankolli, 1966: 304, fig.5; Haig, 1965: 108; Haig, 1972: 447

Ancylocheles gravelei: Haig, 1978: 777; Haig, 1981: 275; Tirmizi, *et al.*, 1982: 4 (key), fig.11; Tirmizi *et al.*, 1989: 35, fig.22; Morgan, 1990: 28

Material examined: 4♂, 5♀, Bogmolo Beach, St. George Island, under rocks, mid-tide, 0.5 m.

Description: Carapace about as long as broad, subquadrate. Dorsal surface smooth, laterally slightly rugose, anterior regions well-marked. No epibranchial spine. Front broad, sinuously transversal or evenly rounded. Orbits moderately deep, inner orbital angle produced into rounded edge, outer orbital angle produced into small tooth.

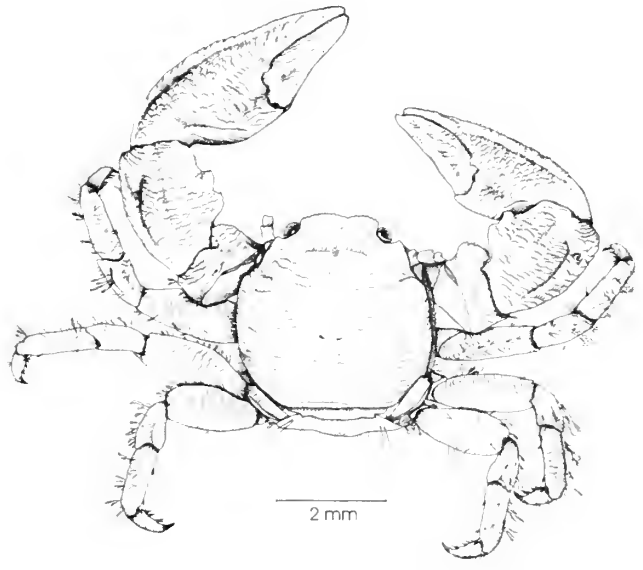


Fig. 1: *Ancylocheles gravelei* (Sankolli, 1963), male, Goa, Bogmolo, St. George Island

Eyes moderately large. Movable segments of antennae granulous without larger projections.

Chelipeds subequal; merus with a large, denticulate lobe at antero-proximal edge, carpus about 1½ times as long as broad, anterior margin with two large teeth on proximal half; dorsal surface granular with two longitudinal crests, outer border strongly convex; palm granular with a broad longitudinal ridge, extending onto pollex, outer border convex or distally nearly straight.

Walking legs slender, moderately granular with scattered, simple setae, dactylus with four movable spinules on inner border.

Habitat: The species is abundant in the lower intertidal area, and inhabits interstices of stones and rubble overgrown by sponges and other fouling organisms.

Distribution: *A. gravelei* shows a disjunctive distribution in the Indian Ocean, and is known from Pakistan, the western Indian coast and West Australia.

***Enosteoides ornatus* (Stimpson, 1858)** (Fig. 2)

Porcellana ornata: Stimpson, 1858: 242; Stimpson, 1907: 188; Gordon, 1931: 526, 529, fig.1; Miyake, 1943: 118, figs.42, 43; Sankolli, 1966: 302, fig.4; Kim & Choe, 1968: 1, pl.1, fig.1, fig.1; Morton & Morton, 1983: 272, 274, 299, figs.12.9: 4, 12.20: 3

Porcellana corallicola: Haswell, 1882: 759; Johnson, 1970: 32, figs.3q, r

Petrolisthes corallicola: Miers, 1884: 271, pl.29, fig.c

Enosteoides ornatus: Haig, 1978: 709; Haig, 1981: 271; Markham, 1982: 329; Tirmizi *et al.*, 1982: 4; Tirmizi *et al.*, 1989: 37, fig.23; Haig, 1992: 305, fig.2; Yang & Sun, 1992: 209, fig.15; Yang & Naiyanetr, 1997: 9, fig.5; Hsieh *et al.*, 1998: 335, figs.32b, 33; Komai, 2000: 361

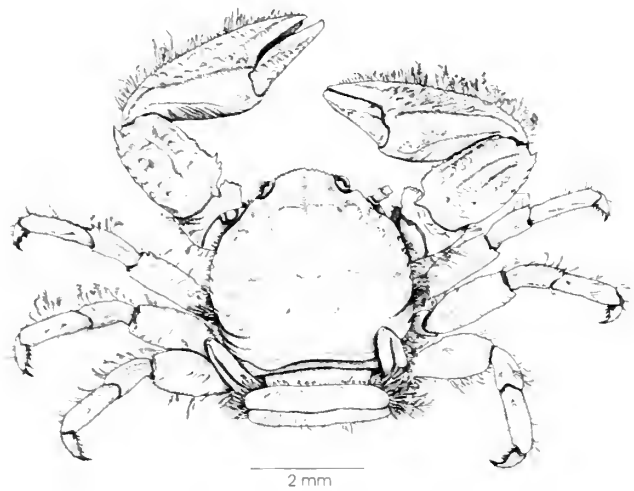


Fig. 2: *Enosteoides ornatus* (Stimpson, 1858), female, Bogmolo, St. George Island, Goa

Material examined: 1♂, 2♀, Anjuna Beach, 1.0-1.5 m, under rocks; 8♂, 10♀, Bogmolo Beach, St. George Island, 5 m, under rocks.

Description: Carapace as long as broad, ovate, epibranchial edges slightly pronounced, rounded. Dorsal surface uneven, granular; regions well-defined. Front projecting beyond eyes, triangular in dorsal view, denticulate. Orbits moderately deep, outer orbital angle weakly pronounced. Side walls covered with long, plumose setation. Eyes small. First and second movable segments of antenna short, granulate, third one simple.

Chelipeds robust, subequal in size; merus with prominent, denticulate lobe at antero-proximal edge; carpus about 2 times as long as broad, anterior border denticulate, proximally forming irregular sharp tooth; dorsal surface with three longitudinal crests, outer margin with a row of sharp teeth, the distal one forming a spine-tipped prominent edge; surface of palms with longitudinal crest, outer margin spinulated, with a fringe of long feathered setae.

Walking legs slender, covered with scattered, long, feathered setae; carpus of leg 1 with antero-distal spine; dactylus with five movable spines.

Habitat: Haig (1981) reported the species from the intertidal area under stones, and on coral heads to 54 m depth. We found the species sporadically on the coast of Goa from the lower intertidal to 8 m depth.

Distribution: The species is known from Pakistan and the western Indian coast, eastward through the Bay of Bengal, and from West Australia. In the western Pacific, the species has been reported from the Gulf of Thailand through the South China Sea, Taiwan Strait and southern Japan, and from eastern Australia.

***Pachycheles natalensis* (Krauss, 1843)** (Fig. 3)

Porcellana natalensis: Krauss, 1843: 58, pl.4, figs.1, 1a-c; Stimpson 1858: 228

Pisosoma natalensis: Paul'son, 1875: 88, pl.11, fig.5; (English translation, 1961: 94, pl.11, fig.5)

Pachycheles sculptus: Ortmann, 1894: 29; Nobili, 1906a: 136; Nobili, 1906b: 67

Pachycheles natalensis: Stimpson, 1907: 186; Riddell, 1911: 263; Balss, 1915: 8; Ramadan, 1936: 25; Barnard, 1950: 472, figs. 87a-f; Barnard, 1955: 4; Haig, 1964: 371; Haig, 1966a: 286 (key), 289; Haig, 1966b: 43; Haig, 1966c: 53; Sankolli, 1966: 300, fig.3; Lewinsohn, 1969: 150, fig.33; Lewinsohn, 1979: 50; Tirmizi *et al.*, 1982: 2 (key), fig.1, pl.1; Tirmizi *et al.*, 1989: 4, figs.1, 2; Werding & Hiller, 2007: 4, fig.3

Pisosoma sculpta: Gravely, 1927: 124, pl.20, fig.8

Material examined: 3♂, 4♀, Anjuna Beach, 1.0-1.5 m,

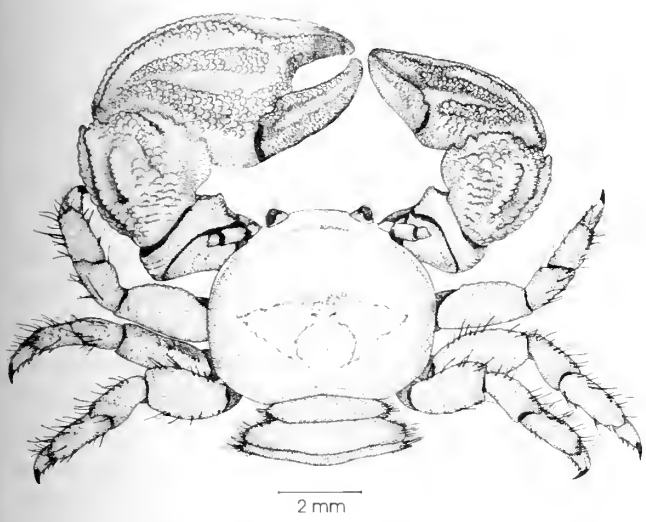


Fig. 3: *Pachycheles natalensis* (Krauss, 1843), male, Red Sea, Egypt (from Werding & Hiller, 2007)

mid-low tide, under rocks; 6♂, 6♀, Bogmolo Beach, low tide, under rocks.

Description: Carapace generally somewhat broader than long, subovate, convex. Dorsal surface smooth, regions poorly defined. Front inclined, rounded from above or moderately trilobate. Orbits well-defined, outer orbital angle forming a blunt tooth. Lateral walls formed by anterior trapezoid plate covering two thirds of wall, another large, subquadrate plate covering posterior area.

Eyes medium-sized. First movable segment of antenna with conical tubercle; second and third somewhat granulated; flagellum 1½ as long as carapace, sparsely setose.

Chelipeds large, robust, different in size, surface of carpus and manus nearly smooth or covered with large granules arranged in three longitudinal crests in carpus, and forming two similar crests along outer margin of chela; carpus about as long as broad or barely longer, anterior border with three or four teeth decreasing in size distally; outer margin of palm convex, fingers gaping in major cheliped, usually with tuft of setae in gape of larger chela, meeting for entire length in minor cheliped. Walking legs stubby, moderately granulated and with scattered, simple setae; dactylus with three movable spines.

Telson five-plated; males with a pair of pleopods.

Habitat: The species was found regularly in the deeper intertidal zone inhabiting interstices of stones and rubble held together by sponges.

Distribution: *P. natalensis* is restricted to the western Indian Ocean, including the Red Sea, along the coast of the Arabian Sea. On the African coast it is distributed southward to Mozambique including Madagascar.

***Petrolisthes boscii* (Audouin, 1826)** (Fig. 4)

Porcellana boscii: Audouin, 1826: 89; Heller, 1861a: 24; Heller, 1861b: 256

Petrolisthes boscii: Stimpson, 1858: 227; Paul'son, 1875: 87, 88; Henderson, 1893: 427; Ortmann, 1897: 284; McCulloch, 1913: 353, fig.53; Balss, 1913: 29, pl.1, fig.4; Balss, 1915: 7; Gravely, 1927: 140; Hale, 1929: 68; Ramadan, 1936: 24; Miyake, 1937: 211, fig. 1, pl.12, fig.2; Miyake, 1943: 90, figs.23, 24; Vatova, 1943: 15; Haig, 1964: 360; Haig, 1965: 99; Sankolli, 1966: 296, fig.1; Haig, 1966c: 51; Sarojini & Nagabhushanam, 1968: 153, pl.1, fig.3; Lewinsohn, 1969: 132, figs.27a-e; Johnson, 1970: 13; Nakasone & Miyake, 1971: 8; Mustaquim, 1972: 154, fig.2; Ahmed & Mustaquim, 1974: 174; Hogarth, 1988: 1101; Tirmizi *et al.*, 1982: 2, fig.3; Tirmizi *et al.*, 1989: 10, figs.5a-h; Haig, 1992: 312, figs.8a-c; Yang & Sun, 1992: 197, figs.2a-c, 3a-e; Yang & Naiyanetr, 1997: 5; Komai, 2000: 364; Werding & Hiller, 2007: 7, 8, fig.5

Petrolisthes amakusensis: Miyake & Nakasone, 1943: 173, figs.1-3

Petrolisthes rugosus: Miers, 1884: 270

Porcellana (*Petrolisthes*) *boscii*: de Man, 1888: 217

Material examined: 12♂, 15♀, Bogmolo Beach, under rocks, low-tide; 1♂, 1♀, Bogmolo Beach, St. George Island, 5 m, under rocks; 2♂, 2♀, Anjuna Beach (North), under rocks, 1.0-1.5 m, low tide.

Description: Carapace slightly longer than broad, inversely cordate, evenly rounded along branchial margins; surface with inconspicuous, interrupted transverse, plications; one epibranchial spine present. Front sinuously triangular with longitudinal depression; orbitae shallow, without supraocular spine, postorbital angle rectangular, without tooth. Eyes

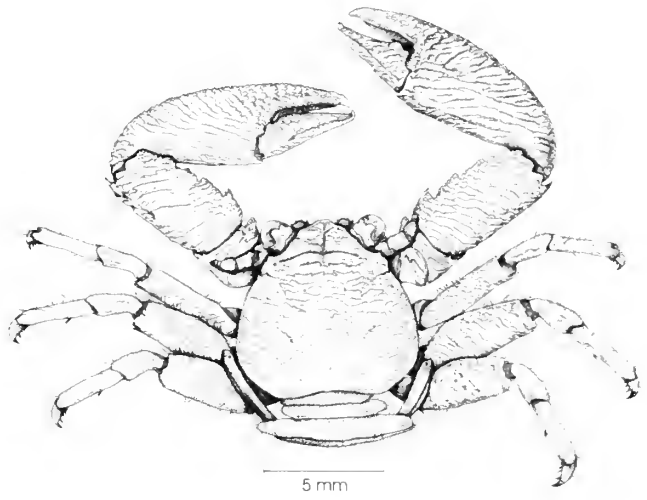


Fig. 4: *Petrolisthes boscii* (Audouin, 1826), male, Bogmolo, St. George Island, Goa

moderately large. Basal segments of antennulae with some transverse rugae, anterior margin with teeth. First movable segment of antennae with serrated, spine-tipped lamellar lobe; second and third segments slightly rugose.

Chelipeds subequal, surface with piliferous striations, merus rugose with serrated lobe on anterior margin; carpus two times as long as broad, armed on anterior margin with two or three broad, serrated teeth proximally, the first one spine-tipped; posterior margin slightly convex, armed distally with a strong spine, followed by two smaller ones. Chelae broad, with transverse striations, outer margin evenly rounded, spineless.

Walking legs rugose; all segments with irregularly wide-set, feathered and simple setae; Merus spineless with an exception of a small posterodistal spine on legs 1 and 2, carpus spineless; propodus with terminal triplet of movable spines on ventral border and an additional one at mid level; dactylus large with three movable spinules on inner border.

Habitat: Lewinsohn (1969) reported *P. boscii* from shallow water to 18.3 m depth, from rocks, boulders and corals. We found it among boulders in the deeper intertidal and the subtidal, where it appears to be the most abundant porcellanid species.

Distribution: West Indian Ocean, including the Red Sea, and along the coast of the Arabian Sea through the Bay of Bengal. In the Pacific from the Gulf of Thailand, Indonesia and Japan. Also in tropical Australia.

***Petrolisthes coccineus* (Richardson *et al.*, 1839)** (Fig. 5)

Porcellana coccinea: Richardson *et al.*, 1839: 87, pl.26, figs.1, 2; Dana, 1852-53: 423

Petrolisthes coccineus: Laurie, 1926: 14; Miyake, 1943: 59, figs.3, 4; Haig, 1966b: 46, (key); Kensley, 1970: 114, fig.8; Haig, 1983: 280; Haig, 1992: 313, fig.9; Hsieh *et al.*, 1998: 303, fig.16; Yang & Sun, 1990: 3, pl.3

Petrolisthes barbatus: de Man, 1893: 296, pl.7, figs.4, 4a; Ortmann, 1894: 28; Ward, 1942: 63

Petrolisthes pubescens: Balss, 1913: 30, pl.1 fig.2

Petrolisthes nipponensis: Miyake, 1937: 213, fig.22, pl.12 fig.1

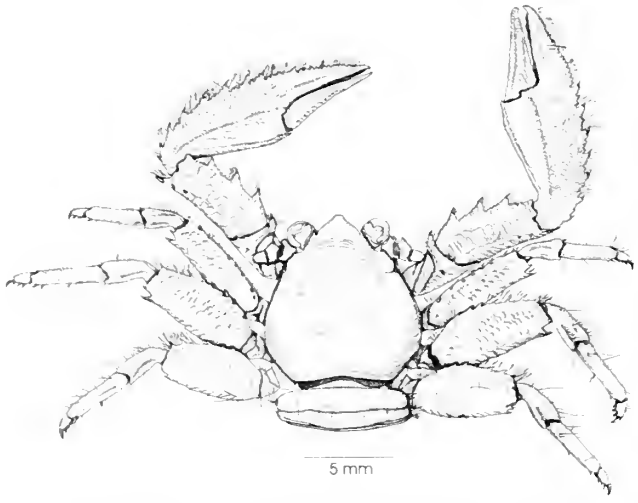


Fig. 5: *Petrolisthes coccineus* (Richardson *et al.*, 1839), male, Bogmolo, St. George Island, Goa

Material examined: 3♂, 2 juv. Bogmolo Beach, under rocks, low tide.

Description: Carapace slightly longer than broad, evenly rounded along branchial margins, inversely cordate. Surface with faint, transverse plications on cardiac region and along posterior lateral margins; one epibranchial spine present. Front narrow, sinuously triangular with longitudinal depression; orbitae shallow, supraocular spine strong, postorbital angle blunt. Eyes large. Basal segment of antennulae with some transverse rugae, anterior margin with teeth. First movable segment of antennae with serrated, spine-tipped, lamellar lobe; second produced forwardly, forming a serrated, edged tooth; third segment slightly rugose.

Chelipeds subequal, merus rugose with spine-tipped projection on anterior margin; distal border with a pair of spines, a third one upon surface; carpus about two-and-a-half times as long as broad; surface with two rows of scale-like, flattened granules, one forming a shallow longitudinal crest along midline, the second along posterior margin; anterior margin with three serrated spine-tipped teeth; posterior margin slightly concave, distal edge armed with a pair of strong spines, followed by two weaker ones. Chelae flat, surface with a row of granules forming a longitudinal ridge; area towards outer margin with scattered granules and scattered, feathered setae. Outer border with a row of strong, spine-tipped teeth.

Walking legs rugose, with scattered, simple, feathered setae; anterior margin of merus with a row of strong spines; a pair of large posterodistal spines on merus of legs 1 and 2, a smaller one on leg 3; carpus of leg 1 with anterodistal spine; propodus with terminal triplet of movable spines on ventral border, with one or two, additional ones; dactylus large with three movable spinules on inner border.

Habitat: Haig (1983) reported the species from shallow water to 1.2 m in the Seychelles. According to Miyake (1943), the species occurs between tide marks under rocks. We found few specimens in two locations under large boulders.

Distribution: *P. coccineus* shows an extremely large distributional range from the coast of Mozambique through scattered locations in the Indian Ocean, and the western Pacific to the Easter Island. Its occurrence on small and distant oceanic islands is remarkable. In the Indian Ocean, it is reported from the Seychelles, Chagos Archipelago and Nicobar

Islands; in the Pacific from Ogasawara, the Mariana Islands, Hawaii, the Tuamotu Archipelago and Easter Island. Additionally, it has been reported from Indonesia and Taiwan. The finding from India is the first record from continental Asia.

***Petrolisthes lamarckii* (Leach, 1820)** (Fig. 6)

Pisidia lamarckii: Leach, 1820: 54

Petrolisthes lamarckii: Stimpson, 1858: 227; Miers, 1884: 557; Stimpson, 1907, pl.22 fig.2; Ortmann, 1894: 26; Borradaile, 1898: 464; Miyake, 1942: 342, figs.7, 8; Miyake, 1943: 98, fig.29; Barnard, 1950: 477 figs.89 a-d; Haig, 1964: 362; Haig, 1966b: 47; Mustaquim, 1972: 154, fig.3; Haig, 1979: 124; Haig, 1983: 283; Kropp, 1983: 100; Yang, 1983: 3, pl.4; Tirmizi *et al.*, 1982: 10, fig.4; Hogarth, 1988: 1101; Tirmizi *et al.*, 1989: 12, figs.7, 8; Haig, 1992: 315, fig.11; Hsieh *et al.*, 1998: 326, fig.28

Petrolisthes lamarcki: Doflein & Balss, 1913: 162

Petrolisthes lamarcki: Laurie, 1926: 140; Taylor, 1968: 170

Porcellana dentate: H. Milne Edwards, 1837: 252

Porcellana pulchripes: White, 1847: 129

Porcellana speciosa: Dana, 1852-53: 417; Dana, 1855: pl.26, fig.8; Balss, 1913: 30 *Petrolisthes dentatus*: Rathbun, 1910: 314

Porcellana bellis: Heller, 1865: 76.

Material examined: 4♂, 3♀ Anjuna Beach, intertidal; 2♀, Anjuna Beach, intertidal; 14♂, 20♀, Bogmolo Beach, under rocks, intertidal 1 m.

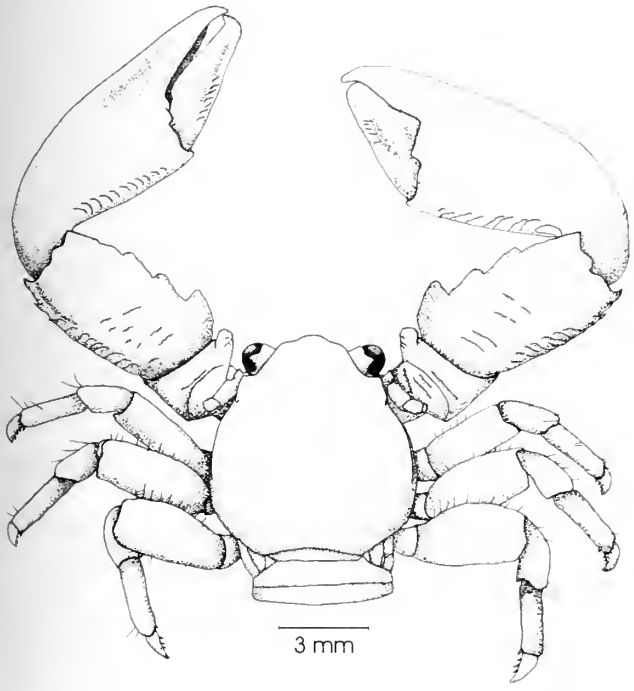


Fig. 6: *Petrolisthes lamarckii* (Leach, 1820, male, Indian Ocean, Kenya (from Werding & Hiller, 2007)

Description: Carapace about as long as broad, ovate, weakly convex front to back and transversely, lateral margins evenly rounded. Dorsal surface slightly rugose, regions moderately marked. A single epibranchial spine present, sometimes obsolescent, especially in larger specimens. Front moderately broad, sinuously triangular, with a longitudinal depression. Orbits shallow, no supraocular spine, outer orbital angle not produced. Lateral walls complete, with some longitudinal ridges.

Eyes moderately large. First movable segment of antennae with serrated, lamellar lobe; second with large tubercle, third nearly smooth.

Chelipeds subequal, robust, surface rugose or granulate; merus rugose with serrated lobe on anterior margin; carpus two times as long as broad, covered with granules, anterior margin armed with three low, wide-set teeth, decreasing in size distally, posterior margin armed with a row of large, flattened granules, the distal two produced into spines; palm broad, covered with scattered granules, outer margin moderately convex.

Walking legs rugose, anterior margin fringed with feathered setae; anterior margin of merus spineless; a posterodistal spine on merus of legs 1 and 2; dactylus with three movable spinules on inner border.

Habitat: *P. lamarckii* occurs in the uppermost level of the intertidal, frequently under large, steady boulders.

Distribution: The species shows a large distributional range in the Indo-West Pacific, and has been recently reported from the Red Sea, with two females found by Werding and Hiller (2007) in an old collection by C.B. Klunzinger in 1877. While the specimens of Klunzinger were from El Quseir, we recently found several individuals near Dahab in the Gulf of Aquaba (Werding and Hahn, unpublished). However, a reliable distributional picture of the species cannot be confirmed before the *P. lamarckii* – complex is critically reviewed (see discussion below).

Discussion: When Kropp (1983) reviewed the *P. lamarckii* complex he created *P. borradailei* to receive specimens morphologically close to *P. lamarckii*, but distinguishable by the absence of epibranchial spines. This author described the presence of a "distinctive line of irregularly spaced, pale orange dots" in all *P. borradailei* specimens. We observed such an arrangement of orange dots in numerous specimens from the Red Sea (unpublished data), all showing well-formed epibranchial spines, thus clearly belonging to *P. lamarckii*. On the other hand, some specimens from Goa exhibit a row of irregular whitish or pale yellow dots, and in several individuals the epibranchial spines are

poorly defined or lacking. Thus, the presence or absence of epibranchial spines seems to be a variable character among populations or even within a local population. Consequently, the differences between *P. borradailei* and *P. lamarckii* are not clear and *P. borradailei* might be a junior synonym of *P. lamarckii*.

***Pisidia dehaanii* (Krauss, 1843)** (Fig. 7)

Porcellana dehaanii: Krauss, 1843: 59, pl.4 figs.2, 2a-c; Barnard, 1947: 378; Barnard, 1950: 467, figs.88 e-h; McNae & Kalk, 1958: 83, 126; Kensley, 1969: 153; Kensley, 1970: 105

Pisidia dehaanii: Haig, 1960: 209; Sankolli, 1965: 3; Sankolli, 1966: 305, fig.6; Haig, 1966c: 48; Sarojini & Nagabhushanan, 1968: 161, pl.II, fig.6; Mustaquim, 1972: 153, fig.1; Haig, 1978: 707; Lewinsohn, 1979: 52; Haig, 1981: 276; Tirmizi & Yaqoob, 1982: 15, fig.9, 27, pl.9; Hogarth, 1988: 1102; Tirmizi & Yaqoob, 1989: 27, figs.17, 18

Material examined: 1♂, 2♀ (ov.), Bogmolo Beach, under rocks, 0.5-1.0 m, low tide.

Description: Carapace about as long as broad, ovate. Dorsal surface rough, regions well-marked, with a pair of tufts formed by feathered setae on protogastric ridges, epibranchial edges pronounced, rounded, no epibranchial spine; two spines on branchial margin. Front with three prominent, rounded lobes, separated by deep clefts, median lobe considerably longer than lateral ones. Orbits shallow, outer orbital angle acuminate. Basal segment of antennulae with forwardly-directed, spine-tipped lobes; first and second movable segments of antennae finely granular, bearing one or two small spines, flagellum about 1½ times as long as carapace.

Chelipeds different in size; merus with anterodistal, flattened trapezoid lobe; carpus about 2 times as long as broad, slightly rugose, anterior and posterior margin convex, dorsal surface with a shallow, longitudinal crest, larger chela broad, slightly rugose, outer margin convex; smaller cheliped similar with slightly concave outer margin.

Walking legs moderately long, slender, slightly rugose, with scattered setae; dactylus with three movable spinules on inner border.

Habitat: Haig (1981) referred to the ecology of the species as "intertidally among rocks and weeds". On the coast of Goa we only found scattered small specimens in interstices of stones and rubble agglomerated by sponges in the lower intertidal.

Distribution: *Pisidia dehaanii* is an endemic to the Indian Ocean, and was reported from the South African coast as far south as 32° S, northward from the Persian Gulf, and from both coasts of India.

***Pisidia gordoni* (Johnson, 1970)** (Fig. 8)

Porcellana (allied to *serratifrons*): Miers, 1884: 277

Porcellana serratifrons: Henderson, 1888: 110 (part); Grant & McCulloch, 1906: 39, 40; Nobili, 1906b: 75; Sankarankutty, 1963: 278, fig.3; McNeill, 1968: 34

Porcellana spinulifrons: Gordon, 1931: 530, figs.4C, 5

Pisidia cf *spinulifrons*: Haig, 1965: 105, 106

Pisidia spinulifrons: Sankolli, 1966: 307, fig.7

Porcellana (*Pisidia*) *gordoni*: Johnson, 1970: 29, fig.3

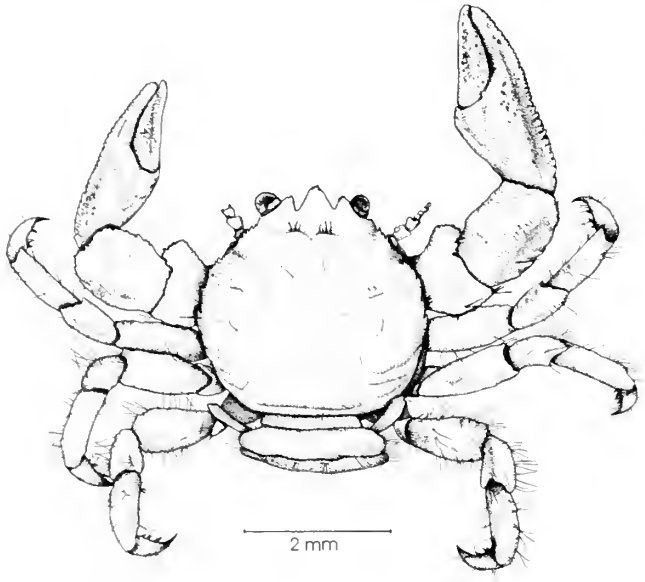


Fig. 7: *Pisidia dehaanii* (Kraus, 1843), male
Bogmolo, St. George Island, Goa

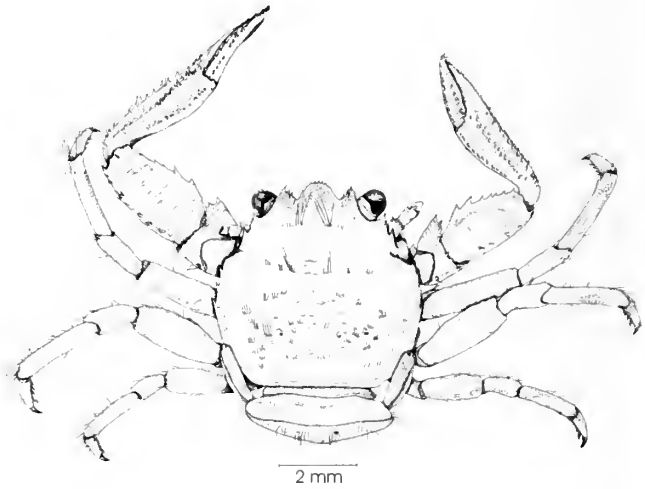


Fig. 8: *Pisidia gordoni* (Johnson, 1970), male
Bogmolo, St. George Island, Goa

Pisidia gordoni: Haig, 1973: 283; Haig, 1978: 707; Haig, 1981: 277; Tirmizi *et al.*, 1989: 34, fig.21; Morgan, 1990: 32; Yang & Sun, 1990: 4, figs.5, 6; Haig, 1992: 318, fig.14; Komai, 2000: 366; Siddiqui & Kazmi, 2003: 88

Material examined: 6♂, 8♀, Bogmolo Beach, St. George Island, under rocks, 5 m, mid-low tide.

Description: Carapace slightly longer than broad, subovate. Dorsal surface rough, regions well-marked; epibranchial edges rounded, fringed with some smaller spinules; no prominent epibranchial spine. Front with three lobes, median lobe considerably broader than lateral ones, lateral lobes spine-tipped. Eyes large, orbits well-defined, outer orbital angle produced into a sharp spine, followed by another one of the same size. First and second movable segments of antennae finely granular, flagellum about 2 times as long as carapace.

Chelipeds slender, different in size, merus with spiny anterodistal projection, carpus more than two times as long as broad, slightly rugose, anterior margin convex, with irregular acute tooth; chelae with three longitudinal crest with rows of acute tubercles, except in larger cheliped of large animals.

Walking legs long and slender, slightly rugose, with scattered setae; dactylus with four movable spinules on inner border.

Habitat: Small specimens were found scattered in the lower intertidal, and large adults occurred regularly under stones in depths between 6-10 m. Haig (1966c) reported it at 50 m depth.

Distribution: The species is an endemic to the Indian Ocean and has been reported from Delagoa Bay, Mozambique, Madagascar and Pakistan. The findings from Goa are the first record from the Indian coast and represent a considerable range extension.

***Polyonyx hendersoni* Southwell, 1909** (Fig. 9)

Polyonyx hendersoni: Southwell, 1909: 117, figs.6-9; Gravely, 1927: 141, pl.20 fig.11; Johnson, 1958: 98, 112; Haig, 1964: 380; Sankolli, 1966: 309, fig. 8; Tirmizi *et al.*, 1982: 3, fig.8, pl.VIII; Tirmizi *et al.*, 1989: 25, figs.15, 16

Material examined: 3♂, 2♀, Bogmolo Beach, 0.5-1.0 m, low tide, inside white sponge; 1♂, 1♀, Bogmolo Beach, St. George Island, 6 m, inside white sponge.

Description: Carapace rounded, nearly as broad as long, longitudinally convex. Dorsal surface smooth, except for some fine plications on branchial regions; epibranchial angles not produced, regions not defined. Front broad inclined, nearly straight from above. Orbits shallow, outer orbital angles insignificant. Lateral walls complete.

Eyes small, barely visible from above. First movable

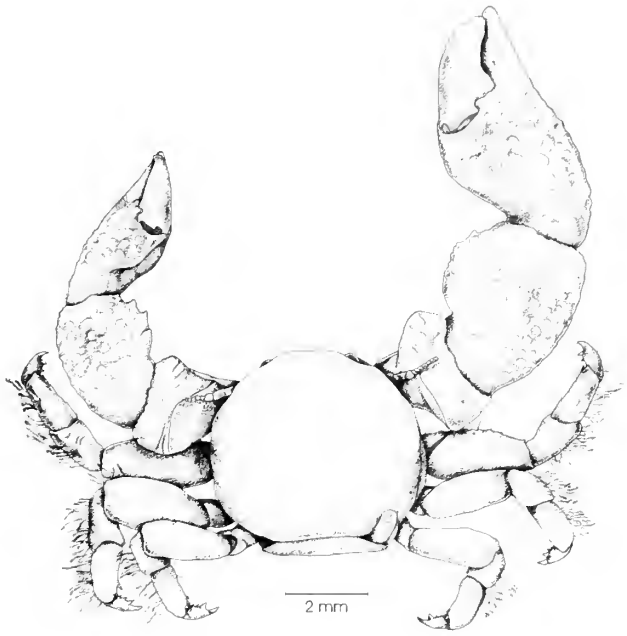


Fig. 9: *Polyonyx hendersoni* Southwell, 1909, male Bogmolo, St. George Island, Goa

segment of antenna subcylindric, short, second more than twice as long as broad, smooth, third smooth; flagellum 1½ times as long as carapace. Basal segment of antennules without prominence.

Chelipeds large, robust, different in size, irregularly covered with rounded, large granules; merus granulated, with some transverse ridges, anterodistal edge produced into large, rounded lobe; carpus 1½ times as long as broad, anterior border produced with three to five irregular tooth; fingers of manus of larger cheliped in large specimens gaping, fingers bent upwards, meeting for entire length in minor cheliped. Outer border of larger chela concave.

Walking legs smooth with long feathered setae on carpus, propodus and dactylus; dactylus with three strong, fixed spines.

Habitat: *P. hendersoni* seems to inhabit exclusively the water ducts of Demospongiae, inside which we found the species, from the intertidal to a depth of 6 m.

Distribution: The species has been reported from Pakistan, the western Indian coast to the south tip, eastward to the Gulf of Mannar, and from Sri Lanka.

Remarks: *Polyonyx hendersoni* belongs to a morphological group within the genus that is different from the *P. sinensis* - group (Johnson 1958), with species generally found within tubes of polychaete worms. Johnson (1958) stated that *P. hendersoni* did not seem to be closely related to any other species. He ascribed this species to the *P. biunguiculatus* group, highlighting that "its nearest affinities are apparently to *P. obesulus*". However, he

mentioned some differences between *P. hendersoni* and other species of *P. binngniculatus* group, emphasizing on the different form of the meral lobe of the chelipeds, the armature of the chelipeds, the setation of the smaller cheliped, and the different form of the dactyli of the walking legs. *P. hendersoni* forms a clade together with *P. splendidus* Sankolli (see below), which also inhabits sponges.

***Polyonyx splendidus* Sankolli, 1963** (Fig. 10)

Polyonyx splendidus: Sankolli, 1963b: 79, figs.1a-i; Sankolli, 1966: 311, fig. 9

Material examined: 1♂, Bogmolo Beach, 0 m, low tide, in yellow sponge.

Description: Carapace rounded, nearly as broad as long, longitudinally convex. Dorsal surface with some granulation and plications more accentuated in branchial regions; epibranchial angles faintly produced, regions moderately marked. Front broad, somewhat produced beyond eyes, inclined, nearly straight from above or weakly trilobate. Orbits distinct, outer orbital angles insignificant. Lateral walls complete.

Eyes moderately large, visible from above. First movable segment of antenna subcylindric, short, second twice as long as broad, smooth, third smooth; flagellum 1½ times as long as carapace. Basal segment of antennules without protuberance.

Chelipeds large, robust, different in size, covered with scale-like granules, partly arranged in longitudinal ridges on carpus of larger chela; merus granulated, with some transverse ridges, anterodistal edge produced into a large, rounded lobe, spine tipped in some cases; carpus 1½ to 2 times as long as broad, anterior border produced, with two or three spine-tipped teeth; fingers of manus in both chelipeds meeting in entire length, fingers bent upwards; outer border of larger chela straight or slightly concave; outer border and parts of upper surface of carpus and manus covered with dense, feathered setation.

Walking legs slender, smooth, with long-feathered setae on carpus, propodus and dactylus; dactylus with three strong, fixed spines.

Habitat: This species has been found by Sankolli (1966) in similar conditions as *P. hendersoni*, and was found by us inside a sponge. Despite intensive efforts to sample this species along the coast in the regions of Anjuna and Bogmolo, we found only one specimen in the duct of a sponge.

Distribution: The species is known only from the original description by Sankolli (1963b) and a later mention by the same author (Sankolli 1966). The former findings are from the coast near Ratnagiri (Maharashtra State), and the present finding extends its distribution southward to Bogmolo Beach, Goa.

Remarks: As mentioned above, *P. hendersoni* and *P. splendidus* seem to form a distinct clade within *Polyonyx*, which probably deserve their own generic status. The present findings of the two species living in sponges confirms our view that the body form and the form of the dactyli of the walking legs constitute adaptations to living in the water ducts of sponges (see discussion in Werding and Hiller 2004). The distribution of the two species seems to be restricted to the Indian subcontinent.

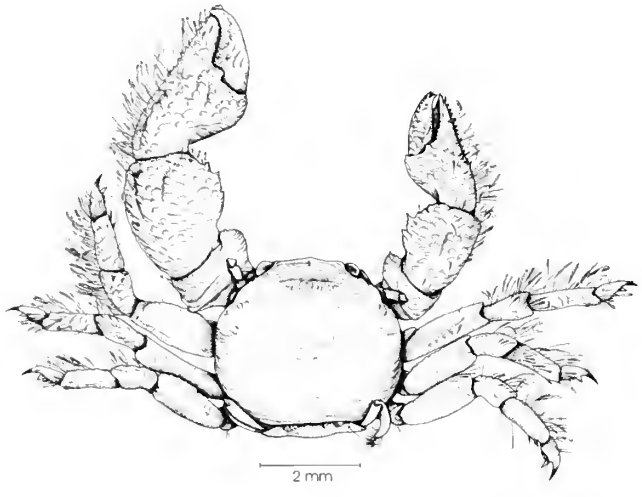


Fig. 10: *Polyonyx splendidus* Sankolli, 1963, male St. George Island, Goa,

KEY TO THE SPECIES OF THE WESTERN COAST OF THE INDIAN SUBCONTINENT

1 Chelipeds markedly different in size (heterochaely) 2
— Chelipeds (sub) equal (isochaely) 8
2 Front tridentate, lateral margins of carapace with spinules posterior to epibranchial angle 3
— Front rounded, lateral margins of carapace spineless 4
3 Median frontal lobe narrow, chelipeds stout, without acute spines on merus and carpus ..... *Pisidia dehaanii*
— Median frontal lobe broad, chelipeds slender, with acute spines on anterodistal edge of merus and anterior margin of carpus *Pisidia gordoni*
4 Side walls of carapace divided in two parts 5
— Side walls of carapace entire 6
5 Carapace and chelipeds bare of setae ..... *Pachycheles natalensis*
— Carapace with dense setation on frontal region, chelipeds densely setose ..... *Pachycheles tomentosus*
6 Carapace subquadrate, broader than long, anterior margin of

carpus of chelipeds entirely convex ..... *Polyonyx loimicola*

— Carapace subquadrate to subovate, as long as broad, carpus of chelipeds denticulated on anterior margin 7

7 Both chelipeds covered with dense, feathered setation, anterior margin of carpus of chelipeds with 2-3 spine-tipped tooth ..... *Polyonyx splendidus*

— Chelipeds at most with short setation, anterior margin of carpus of chelipeds with blunt tooth .. *Polyonyx hendersoni*

8 Carpus of chelipeds with longitudinal crests on upper surface separated by deep grooves 9

— Carpus of chelipeds without longitudinal crests and grooves (but sometimes with granules arranged in longitudinal rows) 10

9 Lateral borders of carapace with a series of sharp spines ... . *Enosteoides ornatus*

— Lateral borders of carapace without spines .... *Ancylocheles gravelei*

10 Surface of carapace and extremities with irregular, rounded granules, front trilobate, carpus of chelipeds with a blunt tooth on antero-proximal edge ..... *Petrolisthes ornatus*

— Surface of carapace and chelipeds smooth to rough or with piliferous striations, front sinuously triangular 11

11 Manus of chelipeds with a longitudinal crest, walking legs with a row of spines on anterior margin of merus .... *Petrolisthes coccineus*

— Manus of chelipeds evenly rounded, walking legs without spines on anterior margin of merus 12

12 Carapace and chelipeds with piliferous striations on upper surface ..... *Petrolisthes boscii*

— Carapace and chelipeds without piliferous striations on upper surface 13

13 Carapace with epibranchial spines ... *Petrolisthes lamarckii*

— Carapace without epibranchial spines 14

14 Chelipeds massive, with three to four shallow tooth on anterior margin of carpus ..... *Petrolisthes rufescens*

— Chelipeds slender, with one proximal tooth on anterior margin of carpus, a second one present on half distance .... *Petrolisthes leptocheles*

DISCUSSION

The porcellanid fauna of the western coast of the Indian subcontinent currently consists of 16 species (Table 1), 10 of which were sampled in the present study. A total of 9 species are endemic to the Indian Ocean, and 2 species, *Polyonyx hendersoni* and *P. splendidus*, seem to be endemic to the eastern Arabian Sea. Of special interest is an assemblage of 4 Indian Ocean endemics present on the coast of Pakistan, *Pachycheles tomentosus*, *Petrolisthes leptocheles*, *Petrolisthes ornatus* and *Petrolisthes rufescens* (the latter two also present on the coast of Kutch), which marks a faunistic break and the

Table 1: Porcellanid species reported from the western coast of the Indian subcontinent in the present study

Species	SAMP	NSAMP	EAS-END	IO-END	IWP
Ancylocheles gravelei (Sankolli 1963)	x			x	
Enosteoides ornatus (Stimpson 1858)	x			x	
Pachycheles natalensis (Krauss, 1843)	x			x	
Petrolisthes boscii (Audouin 1826)	x				x
Petrolisthes coccineus (Richardson *et al.*, 1839)	x				x
Petrolisthes lamarckii (Leach 1820)	x			x	x
Pisidia dehaanii (Krauss 1820)	x				
Pisidia gordoni (Johnson 1970)	x				x
Polyonyx hendersoni Southwell, 1909	x		x		
Polyonyx splendidus Sankolli, 1963	x		x		
Pachycheles tomentosus Henderson, 1893		x		x	
Petrolisthes leptocheles (Heller 1861)		x		x	
Petrolisthes ornatus Paul'son 1875		x		x	
Petrolisthes rufescens (Heller 1861)		x		x	
Pisidia delagoae (Barnard 1955)		x		x	
Polyonyx loimicola Sankolli 1965		x			x

EAS: East Arabian Sea, IO: Indian Ocean, IWP: Indo-West Pacific.
END: Endemic species, SAMP: species sampled, NSAMP: not sampled

eastern-most limit of these species. This break could be explained by the water quality of the upper water layer, which is strongly influenced by the monsoon rains on the south coast of Mumbai. Changes in salinity resulting from strong rainfall can particularly affect intertidal species with low tolerance to low salinities.

ACKNOWLEDGEMENTS

We thank Dr. Satish Shetye, Director, NIO, Goa, (CSIR, New Delhi), for his cooperation. This study is a part of the NIO Ballast Water Management Programme of Directorate of General of Shipping, Ministry of Shipping, New Delhi. This is NIO contribution No. 4922.

REFERENCES

Ahmed, M. & J. Mustaquim (1974): Population structure of four species of porcellanid crabs (Decapoda, Anomura) occuring on the coast of Karachi. *Marine Biology 26*: 173-182.

Audouin, V. (1826): Explication sommaire des planches de Crustacés de l'Egypte et de la Syrie, publiées par Jules-Cesar Savigny, member de l'Institu; Offrant un exposé des caracters naturels des generes avec la distinction des especes. Desription de l'Egypte, ou recueil des observation et des recherches que ont ete faites en Égypte pendant l'Expedition de l'armée francaise. *Histoire Naturelle 1(4)*: 77-98.

Balss, H. (1913): Ostasiatische Decapoden. I. Die Galatheiden und Paguriden. *Königlich-Bayrische Akademie der Wissenschaften. Abhandlungen der Mathematisch-naturwissenschaftlichen Klasse,* Supplement *2*: 1-85.

Balss, H. (1915): Anomuren, Dromiaceen und Oxystomen. Die Decapoden des Roten Meeres II. Expeditionen S.M. Schiff "Pola" in das Rote Meer, nördliche und südliche Hälfte. Zoologische Ergebnisse XXXI. *Denkschriften / Akademie der Wissenschaften in Wien, Mathematisch-Naturwissenschaftliche Klasse* 92: 1-20, fig. 1-9.

Barnard, K.H. (1947): Descriptions of new species of South African Decapod Crustacea, with notes on synonymy and new records. *Annals and Magazine of Natural History (11)13*: 361-392.

Barnard, K.H. (1950): Descriptive catalogue of South African decapod Crustacea (crabs and shrimps). *Annals of the South African Museum 38*: 471-481.

Barnard, K.H. (1955): Additions to the fauna-list of South African Crustacea and Pycnogonida. *Annals of the South African Museum 43(1)*: 1-107.

Borradaile, L.A. (1898): On some crustaceans from the South Pacific. Part II. Macrura Anomura. *Proceedings of the Zoological Society of London 3*: 457-468.

Dana, J.D. (1852-53): Crustacea. United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842, under the command of Charles Wilkes, *U.S.N. 13*: viii + 1-685 (1852), 686-1618 (1853). C. Sherman, Philadelphia.

Dana, J.D. (1855): Crustacea. United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842, under the command of Charles Wilkes, *U.S.N. Ibid 14*: 1-27, Philadelphia.

Doflein, F. & H. Balss (1913): Die Galatheiden der Deutschen Tiefsee-Expedition. *Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition auf dem Dampfer "Valdivia" 1898-1899, 20,* 125-184.

Gordon, I. (1931): Brachyura from the coasts of China. *Journal of the Linnean Society of London, Zoology 37*: 525-558.

Grant, F.E. & A.R. McCulloch (1906): On a collection of crustaceans from the Port Curtis district, Queensland. *Proceedings of the Linnean Society of NSW 31*: 2-53.

Gravely, F.H. (1927): Orders Decapoda (except Paguridea) and Stomatopoda. *In*: The littoral fauna of Krusadai Island in the Gulf of Manaar. *Bulletin, Madras Government Museum 1(1)*: 135-155.

Haig, J. (1960): The Porcellanidae (Crustacea Anomura) of the eastern Pacific. Allan Hancock Pacific Expeditions, 24, 440 pp.

Haig, J. (1964): Papers from Dr. Th. Mortensen Pacific expedition 1914-1916. 81. Porcellanid crabs from the Indo-West Pacific, Part 1. *Videnskabelige Meddelelser fra Dansk Naturhistorik Foren 126*: 355-386.

Haig, J. (1965): The Porcellanidae (Crustacea, Anomura) of Western Australia with descriptions of four new Australian species. *Journal of the Royal Society of Western Australia 48(4)*: 97-118.

Haig, J. (1966a): A review of the Indo-West Pacific species of genus *Pachycheles* (Porcellanidae, Anomura). *Proceeding Symposium of Crustacea, India 1*: 285-294.

Haig, J. (1966b): Sur une collection de crustaces porcellanes (Anomura: Porcellanidae) de Madagascar et des Comores. *Cahiers Orstom Océanographie 3(4)*: 39-50.

Haig, J. (1966c): The Porcellanidae (Crustacea Anomura) of the Iranian Gulf and Gulf of Oman. *Videnskabelige Meddedeleser fra Dansk Naturhistorisk Forening 129*: 49-65.

Haig, J. (1972): The anomuran crabs of Western Australia: Their distribution in the Indian Ocean and adjacent Seas. *Journal of the Marine Biological Association India 14(2)*: 443-451.

Haig, J. (1973): Galatheidea (Crustacea, Decapoda, Anomura) collected by the F.I.S. Endeavour. *Records of the Australian Museum 28*: 269-289.

Haig, J. (1978): Contribution toward a revision of the procellanid genus *Porcellana* (Crustacea: Decapoda: Anomura). *Proceedings of the Biological Society of Washington 91(3)*: 706-714.

Haig, J. (1979): Expédition Rumphius II (1975) Crustacés parasites, commensaux, ets. (Th. Monod et R. Werene, éd.) V. Porcellanidae (Crustacea, Decapoda, Anomura). *Bulletin du Muséum national d'Histoire naturelle, Paris*, 4 Serie, 1, Section 1(1): 119-136.

Haig, J. (1981): Porcellanid crabs from the Indo-West Pacific, Part II. *Steenstrupia 7(12)*: 269-291.

Haig, J. (1983): Porcellanidae (Decapoda, Anomura) from the Seychelles, Western Indian Ocean. *Crustaceana 45(3)*: 279-289.

Haig, J. (1992): Hong Kong's Porcellanid Crabs. *In*: Morton, B. (Ed.): The marine flora and fauna of Hong Kong and southern China III. Proceedings of the Fourth International Marine Biological Workshop: The marine flora and fauna of Hong Kong and Southern China; Hong Kong, 11-29 April 1989. Hong Kong University Press. Pp. 303-327.

Hale, H.M. (1929): Crustacea. Notes on the Fauna of Dirk Hartog Island, Western Australia. No. 4. *Transactions of the Royal Society, South Australia 53*: 67-70.

Haswell, W.A. (1882): Description of some new species of Australian Decapoda. *Proceedings of the Linnean Society of New South Wales 6*: 750-763.

Heller, C. (1861a): Synopsis der im rothen Meere vorkommenden Crustaceen. *Verhandlungen der Zoologisch-botanischen Gesellschaft in Wien 11*: 3-32.

HELLER, C. (1861b): Beiträge zur Crustaceen-Fauna des rothen Meeres. Zweiter Theil. *Sitzungsberichte der Akademie der Wissenschaften zu Wien*, Mathematisch-naturwissenschaftliche Klasse *44*: 241-295.

HELLER, C. (1865): Crustaceen. *In*: *Reise der oesterreichischen Fregatte "Novarra" um die Erde, in den Jahren 1857, 1858, 1859, unter den Befehlen des Commodore B. von Wullerstorf-Ubair*. Zoologischer Theil, 2(3), Vienna. 280 pp.

HENDERSON, M.B. (1893): A contribution to Indian carcinology. Part X. *Transactions of the Linnean Society London 2(5)*: 325-431.

HENDERSON, J.R. (1888): Report on the Anomura collected by H.M.S. Challenger during the Years 1873-76. *Rep. Zool. Challenger Expedition*, 27: xi + 221.

HOGARTH, P.J. (1988): Anomuran Crustacea (Paguridae, Porcellanidae, and Hippidae) from Oman, principally from Dhofar province, southern Oman. *Journal of Natural History 22*: 1095-1110.

HSIEH, B.F., T.Y. CHAN & H.P. YU (1998): On the Porcellanid Crabs (Crustacea: Decapoda: Porcellanidae) of Taiwan. *Annual of Taiwan Museum 40*: 276-360.

JOHNSON, D.S. (1958): The Indo-West Pacific species of the genus *Polyonyx* (Crustacea, Decapoda, Porcellanidae). *The Annals of Zoology, Academy of Zoology II (8)*: 95-118.

JOHNSON, D.S. (1970): The Galatheidea (Crustacea: Decapoda) of Singapore and adjacent Waters. *Bulletin of the national Museum Singapore 35(1)*: 1-43.

KENSLEY, B. (1969): Decapod Crustacea from the south-west Indian Ocean. *Annals of the South African Museum 52*: 149-181.

KENSLEY, B. (1970): A small collection of decapod crustacea from Mocambique. *Annals of the South African Museum 57*: 103-122.

KIM, H.S. & B.L. CHOE (1968): Addition of three anomuran species to the fauna of Korea. *Reports from the Institute of Marine Biology, Seoul National University 2*: 1-9.

KOMAI, T. (2000): A checklist of Thalassinidae and Anomura (Crustacea: Decapoda) from The South China Sea. *The Raffles Bulletin of Zoology*. Suppl. *8*: 343-376.

KRAUSS, F. (1843): *Die südafrikanischen Crustaceen. Eine Zusammenstellung aller bekannten Malacostraca, Bermerkungen über deren Lebensweise und geographische Verbreitung, nebst Beschreibung und Abbildung mehrerer neuer Arten*. E. Schweizerbart, Stuttgart. 68 pp.

KROPP, R.K. (1983): Three new species of Porcellanidae (Crustacea: Anomura) from the Mariana Islands and a discussion of Borradaile's *Petrolisthes lamarckii* complex. *Micronesia 19(1-2)*: 91-106.

LAURIE, R.D. (1926): No. VI. - Anomura collected by Mr. J. Stanley Gardiner in the Western Indian Ocean in H.M.S. "SealarK". *Transactions of the Linnean Society London (Zool.) 19*: 121-167.

LEACH, W.E. (1820): Galatéadées. *Dictionaire des Sciences Naturelles 18*: 49-56.

LEWINSOHN, C. (1969): Die Anomuren des Roten Meeres (Crustacea Decapoda: Paguridae, Galatheidea, Hippidea). *Zoologische Verhandelingen 104*: 1-210.

LEWINSOHN, C. (1979): Researches on the coast of Somalia. The shore and the Dune of Sar Uanle. 23. Porcellanidae (Crustacea Decapoda Anomura). *Italian Journal of Zoology*, Supplemento *XII*: 39-57.

MAN, J.G. DE (1888): Bericht über die von Herrn Dr. Brock im indischen Archipel gesammelten Decapoden und Stomatopoden. *Archiv für Naturgeschichte Berline 53(1)*: 215-600.

MAN, J.G. DE (1893): Report on the podophthalmous Crustacea, collected in the year 1891 by Dr. H. Ten Kate in some Islands of the Malay Archipelago. *Notes Leyden Museum 15*: 284-311.

MACNAE, W. & M. KALK (1958): A natural history of Inhaca Island, Mocambique. Witwatersrand University Press, Johannesburg, 163 pp.

MARKHAM, J.C. (1982): Bopyrid isopods parasitic on decapod crustaceans in Hong Kong and southern China. Pp. 325-391. *In*: Morton, B. & C.K. Tseng (Eds): The marine flora and fauna of Hong Kong and southern China. *Proceedings of the First International Marine Biological Workshop*: The marine flora and fauna of Hong Kong and Southern China; Hong Kong, April 18 - May 10, 1980. Hong Kong University Press.

MCCULLOCH, A.R. (1913): Studies in Australian Crustacea. No. 3. *Records of the Australian Museum 9*: 321-353.

MCNEILL, F.A. (1968): Great Barrier Reef Expedition 1928-29. Crustacea, Decapoda & Stomatopoda. Trustees of the British Museum (Natural History), London. *Scientific Reports 7(1)*: 1-98.

MIERS, E.J. (1884): Collections from Melanesia. Crustacea. *In*: Report on the Zoological Collections made in the Indo-Pacific Ocean during the voyage of H.M.S. 'Alert' 1881-2, British Museum London. Pp. 178-322.

MILNE EDWARDS, H. (1837): *Histoire naturelle des Crustacés, comprenant l'anatomie, la physiologie et la classification de ces animaux*, 2, Paris. 531 pp.

MIYAKE, S. (1937): Porcellanids from Tanabe Bay. *Annotationes Zoologicae Japonensis, 16(3)*: 210-216.

MIYAKE, S. (1942): Studies on the decapod crustaceans of Micronesia. III. Porcellanidae. *Palao Tropical Biological Station Studies* II *(3)*: 329-379.

MIYAKE, S. (1943): Studies on the crab-shaped anomura of Nippon and adjacent waters. *Journal of the Department of Agriculture, Kyusyu Imperial University 7(3)*: 49-158.

MIYAKE, S. (1961): Three new species of the Anomura from Japan (Crustacea, Decapoda). *Journal of the Department of Agriculture, Kyusyu Imperial University 11(3)*: 237-247.

MIYAKE, S. & Y. NAKASONE (1943): On two species of the genus Petrolisthes (Anomura, Porcellanidae) from Japan. *Journal of the Faculty of Agriculture, Kyushu University 14(1)*: 173-182.

MORGAN, G.J. (1990): A collection of Thalassinidea, Anomura and Brachyura (Crustacea: Decapoda) from the Kimberley region of northwestern Australia. *Zoologische Verhandelingen*, 265, 1-90.

MORTON, B. & J. MORTON (1983): The seashore ecology of Hong Kong. *Hong Kong University Press*. 350 pp.

MUSTAQUIM, J. (1972): Species of porcellanid crabs from Karachi. *Pakistan Journal of Zoology 4(2)*: 153-159.

NAKASONE, Y. & S. MIYAKE (1971): Porcellanid crabs (Anomura: Porcellanidae) from New Caledonia and the Fiji Islands. *Biological Magazine Okinawa 8*: 1-13.

NOBILI, G. (1906a): Faune carcinologique de la Mer Rouge. Décapodes et Stomatopodes. *Annales des Sciences Naturelles (Zoologie) (9)4*: 1-347.

NOBILI, G. (1906b): Mission J. Bonnier et Ch. Pérez. (Golfe Persique, 1901). Crustacés décapodes et Stomatopodes. *Bulletin Scientifique de la France et de la Belgique 40*: 13-159.

ORTMANN, A.E. (1894): Zoologische Forschungsreisen in Australien und dem Malayischen Archipel ausgeführt in den Jahren 1891-1893 von Dr. Richard Semon. Fünfter Band: Systematik und Thiergeographie. I. Lieferung. Crustaceen. *Denkschriften der medizinisch-naturwissenschaftlichen* Gesellschaft *zu* Jena *8*: 3-80.

ORTMANN, A.E. (1897): Carcinologische Studien. *Zoologische Jahrbücher, Abt. für Systematik, Geographie und Biologie der Thiere 10*: 273-297.

RICHARDSON, J., N.A. VIGORS, G.T. LAY, E.T. BENNETT, R. OWEN, J.E. GRAY, W. BURKLAND & G.B. SOWERBY (1839): The zoology of Captain Beechey's voyage; compiled from the collections and notes made by Captain Beechey, the officers and naturalist of the expedition, during a voyage to the Pacific and Behring's

Straits performed on His Majesty's Ship Blossom under the command of Captain F.W. Beechey, R.N., F.R.S., in the years 1825, 26, 27 and 28.: i-xii, 1-180.

PAUL'SON, O. (1875): *Isledovaniya rakoobraznykh krasnago morya s zametkami otnositel'no rakoobraznykh drugikh morei*, xiv + 144 pp. (1961, English translation, 164 pp.).

RAMADAN, M.M. (1936): Report on a collection of Stomatopoda and Decapoda from Ghardaqa, Red Sea. *Bulletin of the Faculty of Science, Egyptian (Fouad I) University 6*: 1-43.

RATHBUN, M.J. (1910): Decapod crustaceans collected in Dutch East India and elsewhere by Mr. Thomas Barbour in 1906-1907. *Bulletin of the Museum of Comparative Zoology 52*: 305-317.

RIDDELL, W. (1911): The Anomura. Reports on the Marine Biology of the Sudanese Red Sea, from collections made by Cyril Crossland. XVII. *Journal of the Linnean Society London, (Zool.) 31*: 260-264.

SANKARANKUTTY, C. (1963): On three species of porcellanida (Crustacea, Anomura) from the Gulf of Mannar. *Journal of the Marine Biological Association India 5(2)*: 273-279.

SANKOLLI, K.N. (1963a): On a new species of porcellanid crab (Decapoda, Anomura) from India. *Journal of the Marine Biological Association India 5(2)*: 280-283.

SANKOLLI, K.N. (1963b): On a new species of porcellanid crab (Decapoda, Anomura) from India. *Journal of the Zoological Society of India 15(1)*: 79-84.

SANKOLLI, K.N. (1965): On the Porcellanidae (Crustacea, Anomura) of Ratnagiri. *Symposium on Crustacea, Marine Biol. Ass. India.* Abstracts of Papers: 3

SANKOLLI, K.N. (1966): On the Porcellanidae (Crustacea, Anomura) of Ratnagiri along the west coast of India. *Proceedings of the Symposium of Crustacea, Cochin 1*: 295-313.

SAROJINI, R. & R. NAGABHUSHANAM (1968): Notes on porcellanid crabs (Crustacea, Anomura) from Waltair Coast. *Journal of the Zoological Society India 20(1&2)*: 149-163.

SIDDIQUI, F.A. & Q.B. KAZMI (2003): A checklist of marine anomurans (Crustacea: Decapoda) of Pakistan, northern Arabian Sea. *Memoirs of Museum Victoria 60(1)*: 87-89.

SOUTHWELL, T. (1909): Report on the Anomura collected by Mr. James Hornell at Okhamandal in Kattiawar in 1905-06. Pp. 105-123. *In*: Hornell, J. (Ed.): *Report to the Government of Baroda on the marine ecology of Okhamandal in Kattiawar.* Part 1. London.

STIMPSON, W. (1858): Prodromus descriptionis animalium evertebratorum, quae in Expeditione ad Oceanum Pacificum Septentrionalem, a Republica Federata miss, Cadwaladaro Ringgold et Johanne Rodgers Ducibus, observavit et descripsit. Pars VII. Crustacea Anomuoura. *Proceedings of the Academy of Natural Sciences Philadelphia 10*: 225-252.

STIMPSON, W. (1907): Report on the Crustacea (Brachyura and Anomura) collected by the North Pacific exploring expedition, 1853-1856. *Smithsonian Miscellaneous Collections 49(3)*: 5-240.

TAYLOR, J.D. (1968): Coral reef and associated invertebrate communities (mainly molluscan) around Mahé, Seychelles. *Philosophical Transactions of the Royal Society of London (B) 254*: 129-206.

TIRMIZI, N.M., M. YAQOOB & F.A. SIDDIQUI (1982): An illustrated key to the identification of anomurans (Porcellanidae, Albuneidae and Hippidae) of the northern Arabian Sea. *Centre of Excellence, Marine Biology, University of Karachi, Pakistan 2*: 1-29.

TIRMIZI, N.M., M. YAQOOB & F.A. SIDDIQUI (1989): Marine fauna of Pakistan: 3 Porcellanid crabs (Crustacea, Anomura). *Centre of Excellence, Marine Biology, University of Karachi, Pakistan 6*: 1-46.

VATOVA, A. (1943): I Decapodi della Somalia. *Thalassia 6(2)*: 1-37.

WARD, M. (1942): Notes on the Crustacea of the Desjardins Museum, Mauritius Institute with descriptions of new genera and species. *Mauritius Institute Bulletin 2(2)*: 49-109.

WERDING, B. & A. HILLER (2004): Description of a new species of *Petrolisthes* from the western Pacific (Decapoda, Anomura, Porcellanidae). *Crustaceana 77*: 257-264.

WERDING, B. & A. HILLER (2007): The Porcellanidae (Crustacea: Decapoda: Anomura) of the Red Sea with description of a new species of *Petrolisthes*. *Zootaxa 1460*: 1-24.

WHITE, A. (1847): List of the specimens of Crustacea in the collection of the British Museum, London: 1-143.

YANG, S.L. (1983): Preliminary report on the Porcellanidae (Crustacea, Anomura) of Xisha Island, Guangdong Province, China. *Memoirs of Beijing Natural History Museum 24*: 1-9.

YANG, S.L. & Z.X. SUN (1990): On the porcellanid crabs from the coast of Fujian Province, China. *Bejing Natural History Museum 45*:1-15.

YANG, S.L. & Z.X. SUN (1992): On the porcellanid crabs (Anomura: Porcellanidae) of Guanxi Province, China. *Transactions of the Chinese Crustacean Society 3*: 196-213.

YANG, S.L. & P. NAIYANETR (1997): Thailand's Porcellanid Crabs (Crustacea: Decapoda: Anomura). *Memoirs of Bejing Natural History Museum 56*: 1-13.

■ ■ ■

FLORA OF SANDY COAST OF GANJAM DISTRICT, ORISSA, INDIA

D. Sahu[1,2] and M.K. Misra[1,3]

[1]Ecology & Floristic Laboratory, Post Graduate Department of Botany, Berhampur University, Bhanja Bihar 760 007, Orissa, India.
[2]Email: dbsahu2007@rediffmail.com
[3]Email: malayakmisra@rediffmail.com

This paper deals with the systematic account of plants from the sandy coast of Ganjam district of Orissa, and reports 175 species of angiosperms under 134 genera belonging to 61 families. The specimens were deposited in the Herbarium of the P.G. Department of Botany, Berhampur University, Berhampur (BOTB). Poaceae was the dominant family followed by Euphorbiaceae, Cyperaceae, Fabaceae and Asteraceae. Families were arranged according to the modified Bentham and Hooker's system of classification. The native species are represented by 155 species (89%), whereas the exotic species are represented by 20 species (11%), of which 16 species (9% of the total) are naturalized in the area. *Ceropegia candelabrum* – a species hitherto reported from inland is now reported from the coastal area. *Bulbostylis subspinescens* and *Micrococca mercurialis* are reported after 85 years of their first collection from the coast.

Key words: strand flora, angiosperms, native and exotic species, Ganjam district, Orissa, sandy coast

INTRODUCTION

Orissa has a coastline of 481 km and is rich in strand flora and forests. Coastal Orissa harbours littoral and tidal forests (Champion and Seth 1968). However, these forests have been degraded to a large extent due to various biotic interferences. Ganjam, one of the six coastal districts of Orissa, bordering Andhra Pradesh on the south, is represented by sandy coasts and devoid of tidal forests. The strand flora of Ganjam coast has not been studied in detail even though some sporadic reports on it are available (Rao 1971; Brahmam and Saxena 1980; Subudhi *et al.* 2002). The FLORA OF THE PRESIDENCY OF MADRAS (Gamble 1915-1936) refers to the plants of the district, but Haines (1921-1925) and Mooney (1950) did not include the plants of the district in their floras. Brahmam and Saxena (1980) mentioned some sand dune plants of Ganjam coast in their Ganjam flora. The present paper covers the sandy coastal flora of Ganjam district in Orissa.

MATERIAL AND METHODS

Ganjam district lies between 18° 58' to 20° 17' N and 84° 06' to 85° 11' E. The coast of Ganjam is bounded by Srikakulam district of Andhra Pradesh on the south and Puri district of Orissa on the north; the coast line runs over 64 km long along the Bay of Bengal (Fig. 1). The Chilika lake, the largest brackish water lagoon of Asia is located on the extreme north-east of the district. Rushikulya, the biggest river of Ganjam, discharges its waters into the Bay of Bengal and the estuarine zone is famous for the annual visit of thousands of Olive Ridley *Lepidochelys olivacea* turtles to the shore for nesting. The district experiences a climate when near the sea with an active south-west monsoon and the average annual rainfall at Gopalpur is 1,296 mm. Relative humidity is high (64-86%) throughout the year.

Ganjam coast is famous for the Kewda *Pandanus fascicularis* used in perfume industry. There are about 120 distillation units (*bhatties*) in the coastal area that extract kewda essence from the male flowers (Sahu and Misra 2007). Moreover, Indian Rare Earth (IRE) Limited and Gopalpur port are situated in the Ganjam coast.

An extensive floristic survey of the sandy coast of Ganjam district was conducted during 2007-2009. The plants were collected from different localities along the coast during different seasons. Specimens collected were dried and preserved with saturated mercuric chloride solution in ethyl alcohol (Jain and Rao 1977). The specimens were identified with the help of the local floras (Haines 1921-1925; Gamble 1915-1936; Saxena and Brahmam 1994-1996) and the voucher specimens were deposited in the Herbarium of the Department of Botany, Berhampur University (BOTB), Orissa, India. The field number cited after the scientific names of the plants are of M.K. Misra, D. Sahu and R.C. Sahoo. The specimens collected are arranged in a tabular form indicating the family, flowering period and growth form. The families are arranged according to modified Bentham and Hooker's system (1862-1883) of classification and under each family the species are arranged alphabetically.

RESULTS

The present study reports a total number of 175 species of angiosperms from the sandy coast of Ganjam district, Orissa

Table 1: Plant species found in the strand flora of Ganjam district, Orissa, India

Family	Name of the taxa	Flowering period	Growth form
Annonaceae	*Annona squamosa* L.; 573	Mar.-May	T
	Polyalthia suberosa (Roxb.) Thw.; 475	Apr.-May	T
Menispermaceae	*Tinospora cordifolia* (Willd.) Hook.f. & Thoms.; 587	Aug.-Dec.	L
Capparaceae	*Cleome viscosa* L.; 578	May-Oct.	H
Violaceae	*Hybanthus enneaspermus* (L.) F.v.Muell.; 533	Throughout year	H
Caryophyllaceae	*Polycarpaea corymbosa* (L.) Lam.; 546	Nov.-Feb.	H
Portulacaceae	*Portulaca quadrifida* L.; 1508	Most part of year	H
Malvaceae	*Abutilon indicum* (L.) Sweet subsp. *indicum*; 597	Jul.-Apr.	S
	Sida acuta Burm.f.; 515	Sep.-May	H
	Sida cordata (Burm.f.) Borssum; 1534	Jul.-Dec.	H
	Sida cordifolia L.; 70	Aug.-Dec.	H
Sterculiaceae	*Waltheria indica* L. var. *indica*; 509	Aug.-Jan.	H
Tiliaceae	*Grewia tilifolia* Vahl; 1516	Apr.-Jun.	T
	Triumfetta rhomboidea Jacq.; 1075	Jul.-Jan.	H
Zygophyllaceae	*Tribulus terrestris* L.; 1011	Throughout year	H
Oxalidaceae	*Oxalis corniculata* L.; 173	Throughout year	H
Rutaceae	*Toddalia asiatica* (L.) Lam.; 600	Aug.-Apr.	S
Meliaceae	*Azadirachta indica* A.Juss.; 572	Feb.-May	T
Celastraceae	*Cassine glauca* (Rottb.) Kuntze; 271	Sep.-Dec.	T
Rhamnaceae	*Ziziphus mauritiana* Lam.; 594	Aug.-Oct.	T
	Ziziphus oenoplia (L.) Mill.; 1515	Jun.-Sep.	S
Vitaceae	*Cissus quadrangula* L.; 53	Apr.-Jan.	S
	Cissus vitiginea L.; 376	Jul.-Oct.	L
Sapindaceae	*Cardiospermum halicacabum* L.; 113	Apr.-Nov.	H
Anacardiaceae	*Anacardium occidentale* L.; 1025	Feb.-Apr.	T
	Lannea coromandelica (Houtt.) Merr.; 177	Mar.-Apr.	T
Caesalpiniaceae	*Caesalpinia bonduc* (L.) Roxb.; 125	Aug.-Oct.	L
	Cassia occidentalis L.; 542	Aug.-Nov.	S
	Cassia tora L.; 62	Sep.-Nov.	H
	Tamarindus indica L.; 98	Apr.-Jun.	T
Fabaceae	*Abrus precatorius* L.; 218	Aug.-Sept.	S
	Alysicarpus vaginalis (L.) DC.; 13	Sep.-Jan.	H
	Atylosia scarabaeoides (L.) Benth.; 279	Aug.-Jan.	H
	Crotalaria umbellata Wight ex Wight & Arn.; 498	Oct.-Dec.	H
	Crotalaria pallida Ait.; 1062	Jul.-Apr.	H
	Desmodium biarticulatum (L.) F.v. Muell.; 513	Aug.-Nov.	H
	Desmodium triflorum (L.) DC.; 251	Most part of year	H
	Tephrosia purpurea (L.) Pers. var. *maritima* Haines; 34	Most part of year	H
	Tephrosia villosa (L.) Pers.; 310	Jul.-Apr.	H
	Vigna trilobata (L.) Verdc.; 585	Sep.-Feb.	H
	Zornia diphylla (L.) Pers.; 1034	Aug.-Oct.	H
Mimosaceae	*Acacia auriculiformis* A.Cunn. ex Benth.; 122	Throughout year	T
Myrtaceae	*Syzygium cumini* (L.) Skeels; 570	Mar.-Apr.	T
Lythraceae	*Ammannia baccifera* L.; 270	Sep.-Nov.	H
Onagraceae	*Ludwigia perennis* L.; 577	Oct.-Nov.	H
Passifloraceae	*Passiflora foetida* L.; 1536	Aug.-Nov.	H
Cucurbitaceae	*Coccinia grandis* (L.) Voigt; 06	Most part of year	H
Cactaceae	*Opuntia stricta* (Haw.) Haw.; 200	Jun.-Sep.	S
Molluginaceae	*Glinus lotoides* L.; 1537	Feb.-May	H
	Glinus oppositifolius (L.) A.DC.; 326	Mar.-Oct.	H
	Mollugo pentaphylla L.; 12	Throughout year	H
Apiaceae	*Centella asiatica* (L.) Urban; 599	Most part of year	H
Rubiaceae	*Hedyotis graminifolia* L. f. subsp. *arenaria* (Haines) Deb & Dutta; 1047	Aug.-Nov.	H
	Hedyotis herbacea L.; 508	Aug.-Jan.	H

Table 1: Plant species found in the strand flora of Ganjam district, Orissa, India (*contd.*)

Family	Name of the taxa	Flowering period	Growth form
	Hedyotis puberula (G.Don) Arn.; 74	Sep.-Mar.	H
	Hydrophylax maritima L. f.; 1066	Feb.-Nov.	H
	Morinda pubescens Sm.; 1501	Apr.-Jul.	T
	Pavetta crassicaulis Bremek.; 539	Jun.-Aug.	S
	Spermacoce articularis L. f.; 521	Jul.-Oct.	H
	Spermacoce hispida L.; 1018	Jul.-Dec.	H
Asteraceae	*Chromolaena odorata* (L.) R. King & H.Robins.; 528	Oct.-Dec.	S
	Eclipta prostrata (L.) L.; 112	Aug.-Apr.	H
	Emilia sonchifolia (L.) DC.; 131	Aug.-Apr.	H
	Grangea maderaspatana (L.) Poir.; 107	Jan.-Apr.	H
	Launaea sarmentosa (Willd.) Schult-Bip. ex Kuntze; 04	Mar.-Nov.	H
	Mikania micrantha Kunth; 590	Jan.-Mar.	L
	Parthenium hysterophorus L.; 102	Oct.-Apr.	H
	Tridax procumbens L.; 1058	Throughout year	H
	Vernonia cinerea (L.) Less.; 1053	Most part of year	H
Primulaceae	*Anagallis arvensis* L.; 304	Jun.-Mar.	H
Sapotaceae	*Manilkara zapota* (L.) P.Royen; 541	Apr.-Jul.	T
Salvadoraceae	*Azima tetracantha* Lam.; 305	Mar.-May	S
Apocynaceae	*Carissa carandas* L.; 591	Mar.-Apr.	S
	Catharanthus roseus (L.) G. Don; 536	Throughout year	H
	Holarrhena pubescens (Buch.-Ham.) Wall.ex G.Don; 118	May-Jul.	T
	Ichnocarpus frutescens (L.) R.Br.; 105	Sep.-Dec.	L
Asclepiadaceae	*Calotropis gigantea* R.Br.; 239	Dec.-Jul.	S
	Ceropegia candelabrum L; 1519	Aug.-Oct.	L
	Hemidesmus indicus (L.) R.Br.; 564	Aug.-Oct.	L
	Pergularia daemia (Forssk.) Chiov.; 59	Aug.-Dec.	L
	Tylophora indica (Burm.f.) Merr.; 1026	Aug.-Oct.	L
Boraginaceae	*Heliotropium indicum* L.; 154	Most part of year	H
Convolvulaceae	*Evolvulus alsinoides* (L.) L.; 209	Jul.-Feb.	H
	Evolvulus nummularius (L.) L.; 1056	Jul.-Nov.	H
	Ipomoea campanulata L.; 158	Nov.-Feb.	L
	Ipomoea pes-caprae (L.) R.Br.; 09	Most part of year	L
	Merremia tridentata (L.) Hall. f. subsp. *tridentata*; 151	Feb.-Nov.	H
Solanaceae	*Physalis minima* L.; 1502	Aug.-Jan.	H
	Solanum trilobatum L.; 88	Throughout year	L
	Solanum viarum Dunal; 1006	Most part of year	H
	Solanum virginianum L.; 1005	Throughout year	H
Scrophulariaceae	*Lindernia anagallis* (Burm. f.) Pennell; 324	May-Dec.	H
	Lindernia caespitosa (Bl.) Panig.; 93	Aug.-Dec.	H
	Lindernia ciliata (Colsm.) Pennell; 99	Sep.-Nov.	H
Pedaliaceae	*Pedalium murex* L.; 03	Aug.-Nov.	H
Acanthaceae	*Asystasia gangetica* (L.) T. Anders.; 374	Oct.-Dec.	H
Verbenaceae	*Clerodendrum inerme* (L.) Gaertn.; 484	Most part of year	S
	Lantana camara L. var. *aculeata* (L.) Mold.; 545	Throughout year	S
	Phyla nodiflora (L.) Greene; 596	Most part of year	H
Lamiaceae	*Geniosporum tenuiflorum* (L.) Merr.; 391	Jun.-Oct.	H
	Hyptis suaveolens (L.) Poit.; 56	Sep.-Jan.	H
	Leucas lanata Benth.; 463	Oct.-Dec.	H
	Ocimum basilicum L.; 54	Sep.-Jan.	H
Nyctaginaceae	*Boerhavia diffusa* L.; 10	Most part of year	H
Amaranthaceae	*Achyranthes aspera* L.; 275	Oct.-Feb.	H
	Aerva lanata (L.) Juss. ex Sch.; 103	Aug.-Jan.	H
	Allmania nodiflora (L.) R.Br. ex Wight; 34	Jul-Dec.	H
	Alternanthera sessilis (L.) R.Br. ex DC.; 84	Jul.-Jan.	H
	Amaranthus viridis L.; 1003	Throughout year	H

Table 1: Plant species found in the strand flora of Ganjam district, Orissa, India (*contd.*)

Family	Name of the taxa	Flowering period	Growth form
Chenopodiaceae	*Suaeda maritima* (L.) Dumort; 393	Apr.-Dec.	H
Polygonaceae	*Antigonon leptopus* Hook. & Arn.; 24	Throughout year	L
Aristolochiaceae	*Aristolochia indica* L.; 17	Jul.-Oct.	L
Lauraceae	*Cassytha filiformis* L.; 08	Oct.-Nov.	H
Euphorbiaceae	*Acalypha indica* L.; 47	Jul.-Dec.	H
	Breynia vitis-idaea (Burm.f.) Fischer; 41	Mar.-Feb.	S
	Croton bonplandianus Baill.; 64	Throughout year	H
	Euphorbia hirta L.; 276	Throughout year	H
	Euphorbia rosea Retz.; 1015	Feb.-Oct.	H
	Euphorbia tirucalli L.; 520	Jul.-Oct.	S
	Jatropha curcas L.; 83	May-Oct.	S
	Jatropha gossypifolia L.; 79	Jul.-Oct.	S
	Micrococca mercurialis (L.) Benth.; 35	Aug.-Sep.	H
	Phyllanthus fraternus Webster; 501	Apr.-Jan.	H
	Phyllanthus reticulatus Poir.; 512	Most part of year	S
	Phyllanthus rotundifolius Klein ex Willd.; 1016	May-Oct.	H
	Phyllanthus urinaria L.; 370	Jul.-Oct.	H
	Phyllanthus virgatus Forst. f.; 336	Jul.-Feb.	H
	Ricinus communis L.; 181	Most part of year	S
	Sebastiania chamaelea (L.) Mull.-Arg.; 581	Most part of year	H
Moraceae	*Ficus benghalensis* L. var. *benghalensis*; 72	Apr.-Jun.	T
	Ficus religiosa L.; 80	Jul.-Oct.	T
	Streblus asper Lour.; 372	Mar.-Apr.	T
Casuarinaceae	*Casuarina equisetifolia* L.; 1031	Apr.-May	T
Agavaceae	*Agave americana* L.; 534	Apr.-May	S
Liliaceae	*Asparagus racemosus* Willd.; 1527	Sep.-Oct.	H
	Gloriosa superba L.; 51	Sep.-Nov.	H
Commelinaceae	*Commelina benghalensis* L.; 196	Jul.-Jan.	H
Arecaceae	*Borassus flabellifer* L.; 15	Mar.-May	T
	Cocos nucifera L.; 46	Throughout year	T
	Phoenix sylvestris (L.) Roxb.; 332	May-Oct.	T
Pandanaceae	*Pandanus fascicularis* Lam.; 116	Jul.-Sep.	S
Typhaceae	*Typha angustata* Bory & Chaub.; 1067	Most part of year	H
Cyperaceae	*Bulbostylis barbata* (Rottb.) C.B.Cl.; 124	Jul.-Nov.	G
	Bulbostylis subspinescens C.B.Cl.; 465	Jul.-Dec.	G
	Cyperus arenarius Retz.; 20	Jul.-May	G
	Cyperus compressus L.; 40	Jul.-Dec.	G
	Cyperus iria L.; 43	Aug.-Jan.	G
	Cyperus paniceus (Rottb.) Boeck.; 390	Jul.-Aug.	G
	Cyperus polystachyos Rottb.; 29	Feb.-Oct.	G
	Cyperus rotundus L. subsp. *rotundus*; 50	Jul.-Dec.	G
	Cyperus stoloniferus Retz.; 52	Oct.-Feb.	G
	Cyperus triceps Endl.; 55	May.-Dec.	G
	Eleocharis atropurpurea (Retz.) Presl.; 58	Aug.-Dec.	G
	Fimbristylis acuminata Vahl; 583	Jul.-Nov.	G
	Fimbristylis aestivalis (Retz.) Vahl; 548	Apr.-May	G
	Fimbristylis ferruginea (L.) Vahl; 592	Apr.-Oct.	G
	Fimbristylis ovata (Burm.f.) Kern; 575	Jun.-Dec.	G
Poaceae	*Aristida setacea* Retz.; 164	Aug.-Feb.	G
	Arundo donax L.; 1007	Oct.-Dec.	G
	Bambusa arundinacea (Retz.) Willd.; 266	?	T
	Bothriochloa bladhii (Retz.)S.T. Blake; 273	Aug.-Feb.	G
	Brachiaria distachya (L.) Stapf; 19	Sep.-Dec.	G
	Chloris barbata Sw.; 119	Sep.-Jan.	G
	Cynodon dactylon (L.) Pers.; 91	Most part of year	G

Table 1: Plant species found in the strand flora of Ganjam district, Orissa, India (*contd.*)

Family	Name of the taxa	Flowering period	Growth form
	Dactyloctenium aegyptium (L.) P. Beauv.; 42	Sep.-Mar.	G
	Digitaria ciliaris (Retz.) Koeler; 27	Jun.-Apr.	G
	Digitaria longiflora (Retz.) Pers.; 156	Jul.-Dec.	G
	Eragrostis ciliaris (L.) R.Br.; 162	Most part of year	G
	Eragrostis coarctata Stapf; 38	Sep.-Apr.	G
	Eragrostis japonica (Thunb.) Trin; 148	Oct.-Jan.	G
	Eragrostis tremula (Lam.) Hochst. ex Steud.; 23	Jul.-Dec.	G
	Oplismenus burmannii (Retz.) P. Beauv.; 215	Oct.-Nov.	G
	Perotis indica (L.) Kuntze; 1514	Aug.-Nov.	G
	Spinifex littoreus (Burm.f.) Merr.; 1080	Sep.-Feb.	G
	Sporobolus indicus (L.) R.Br. var. *diander* (Retz.) Jovet & Guedes; 26	Jun.-Feb.	G

G-Grass, H-Herb, L- Liana, S-Shrub, T-Tree, ?-Not observed

(Table 1). These taxa belong to 134 genera distributed among 61 Angiosperm families. The monocots constitute 24% of the total species (Table 2).

The 10 dominant families of the coastal flora were represented by 96 species (55% of the total species). The most dominant family was Poaceae (18 species) followed by Euphorbiaceae (16 species), Cyperaceae (15 species), Fabaceae (11 species), Asteraceae (9 species) and Rubiaceae (8 species).

The floristic components are classified into five growth forms (i) grasses and sedges, (ii) herbs, (iii) shrubs, (iv) woody climbers (lianas) and (v) trees. The highest number of species (49%) was grouped under herbs; grasses and sedge were represented by 18% of the species. Trees and shrubs were represented by 13% and 12% of species, respectively. The woody climbers constituted 8% of species.

The part of the beach that lies between the ordinary low and high tide is included under foreshore. All the species observed in this region are native. The foreshore consists of stabilized and unstabilized sand dunes. The heights of the stabilized sand dunes ranged between 10 to 15 m and harbour *Cyperus arenarius*, *Spinifex littoreus*, *Ipomoea pes-caprae* and *Launaea sarmentosa*. The unstabilized sand dunes are mostly covered with dense patches of *Hydrophylax maritima*, *Sesuvium portulacastrum* and *Digitaria longiflora*.

Table 2: Floristic analysis of strand flora of Ganjam district, Orissa, India

Taxa	Monocotyledons	Dicotyledons	Total
Families	8 (13%)	53 (87%)	61 (100%)
Genera	27 (20%)	107 (80%)	134 (100%)
Species	42 (24%)	133 (76%)	175 (100%)

The foreshore ranges from 0.5 to 1.0 km from the water line along the coast. The width of the backshore ranges between 0.5 and 1.0 km from foreshore towards interior. Backshore flora consists of a mixture of native, naturalized, exotic and some cultivated native species. Exotic species such as *Anacardium occidentale*, *Casuarina equisetifolia* and *Cocos nucifera* are planted in the backshore area. *Pandanus fascicularis* is also often cultivated in the area. *Annona squamosa*, *Cleome viscosa*, *Cassia tora*, *Opuntia stricta*, *Chromolaena odorata*, *Parthenium hysterophorus*, *Lantana camara* var. *aculeata*, *Hyptis suaveolens*, *Croton bonplandianus*, *Jatropha gossypifolia*, *Jatropha curcas* are some of the examples of naturalized alien species that invaded the coast.

DISCUSSION

Rao (1971) has divided internal distribution pattern of the Indian maritime strand flora into three types – one type includes those plants showing complete fidelity to inner strand, the second type encompasses plants of mid/outer strand under the maritime influence, and the third type consists of plants from strand to inland extension. Out of the first type only the sand strand flora is observed in the district and rock strand is absent. The interesting elements of this strand flora are *Cyperus arenarius*, *Ipomoea pes-caprae*, *Hydrophylax maritima*, *Sesuvium portulacastrum* and *Spinifex littoreus* (Table 1).

Rao (1971) while reporting strand flora of India cited 75 species of angiosperms for Orissa coast. Most of these species mentioned by Rao are from the northern part of Orissa and 21 species reported in the paper have also been included in Rao's list of 75 species. The taxa reported by Subudhi *et*

al. (2002) for Orissa coast does not cover Ganjam coast.

Ceropegia candelabrum, a climber reported many years ago from the interior part of the state (Khurda and Dhani area of Khurda district) by Haines and Mooney, is now recorded from the vicinity of *Casuarina equisetifolia* plantations of the sandy coast of Ganjam district.

Bulbostylis subspinescens and *Micrococca mercurialis* were reported from Puri and Konark sandy coast by Haines (1921-1925) and are new records for Ganjam sandy coast. These species have been considered as threatened taxa by Saxena and Brahmam (1994-1996), but on the coast of Ganjam these species are common.

The coastal flora is an admixture of native as well as exotic species. Out of the total 175 species, 155 species (89%) are native including 3 (2%) species which are planted. The exotic species in the area are represented by 20 species (11%) of which 16 species (9% of the total) have already been naturalized in the area (Table 1).

Although the exotic species are very few in number, they have invaded the coastal areas to an extent that they have now become a threat to the growth of native species. *Antigonon leptopus*, *Chromolaena odorata*, *Hyptis suaveolens* and *Parthenium hysterophorus* are the most notorious invasive aliens. The loss of native flora in the coast may be due to habitation and privatization of common property resources of the coastal villages (Sahoo and Misra 1994) and industrialization. The industries such as Indian Rare Earth Limited, hatcheries, Gopalpur port and such other activities in the Ganjam coast pose a threat for the very survival of strand flora.

The aged beefwood (*Casuarina equisetifolia*) plantations in the coast provides a congenial environment for the growth of many species such as *Aristolochia indica*, *Asystasia gangetica*, *Ceropegia candelabrum*, *Coccinia grandis*, *Emilia sonchifolia*, *Hybanthus enneaspermus*, *Micrococca mercurialis*, *Pergularia daemia*, *Sida cordifolia*, *Solanum trilobatum* and *Tylophora indica*. *Azadirachta indica*, *Lannea coromandelica* and *Morinda pubescens* are also common within the beefwood plantation and seeds of these species are usually dispersed by birds.

The plant resources of the coast of Ganjam district are

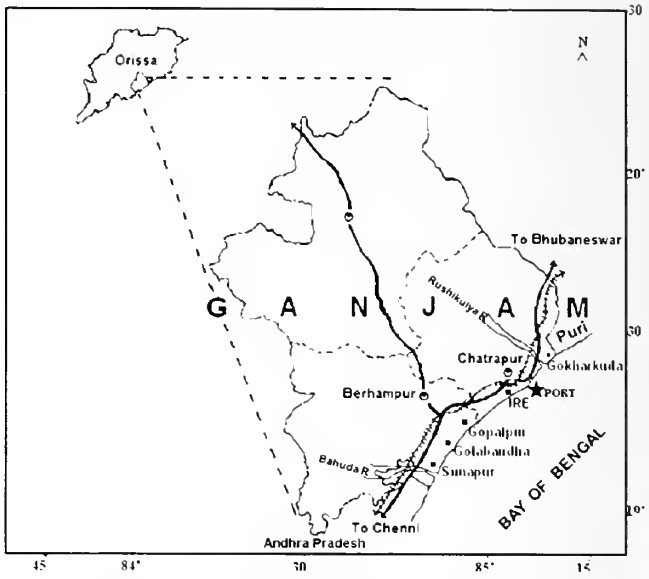


Fig.1: Map showing the coastal Ganjam district, Orissa, India

ecologically and economically very important. Different components of Screw pine *Pandanus fascicularis*, a semi-natural plant, are used by the local people (Panda *et al.* 2000-2001) for various purposes. The male flowers of the kewda plant yield perfume (kewda scent, kewda oil and kewda water), worth millions of rupees (Sahu 2004; Sahu and Misra 2007). Coconut *Cocos nucifera* and Cashew nut *Anacardium occidentale* are important economic resources of the area. The creeping stem of *Cyperus arenarius*, a native species on the sands, is utilized to prepare traditional rope. Stem, leaf and branches of many of the species, such *as Calotropis gigantea, Cassia occidentalis, Chromolaena odorata, Lantana camara* var. *aculeata*, and Screw pine *Pandanus fascicularis* and Palmyra palm *Borassus flabelifer* are used as fuel.

ACKNOWLEDGEMENTS

We thank the Ministry of Earth Sciences, Government of India for financial assistance and the Head, P.G. Department of Botany, Berhampur University, Berhampur for laboratory facilities.

REFERENCES

Bentham, G & J.D. Hooker (1862-1883): Genera Plantarum. 3 vols, London.

Brahmam, M. & H.O. Saxena (1980): Flora of Ganjam, Orissa (India). *J. Econ. Tax. Bot. 1*: 119-125.

Champion, H.G. & S.K. Seth (1968): Revised Survey of Forest Types of India. Publication Division, Government of India, New Delhi.

Gamble, J.S. (1915-1936): Flora of Madras Presidency. London. Reprinted 1967, Calcutta. 1389 pp.

Haines, H.H. (1921-1925): The Botany of Bihar and Orissa. London. Reprinted 1961, Botanical Survey of India, Calcutta. 1372 pp.

Jain, S.K. & R.R. Rao (1977): A Hand Book of Field and Herbarium Methods. Today and Tomorrow's Printers & Publishers, New Delhi. Pp. 157.

Mooney, H. (1950): Supplement to the Botany of Bihar and Orissa. International Book Distributors and Publishers, Reprinted 1986, Dehradun. Pp. 294.

Panda, K.K., S. Mahapatra, L.N. Das, M.K. Misra & B.B. Panda (2000-

2001): Optimal utilization of kewda, *Pandanus fascicularis* to ameliorate economy and ecology of coastal India. *J. Medicinal & Aromatic Plant Science. 22 & 23*: 679-682.

Rao, T.A. (1971): Distributional resume of the maritime strand flora of India. *Bull. Bot. Surv. India. 13*: 192-202.

Sahoo, H.P. & M.K. Misra (1994): Village ecocomplex functioning with common property resources: a case study on coastal Orissa. *Env. Cons. 21*: 57-61.

Sahu, D. (2004): Ecology, energetic and economics of kewda (*Pandanus fascicularis* Lam.) industries in Ganjam district, Orissa. M. Phil. Thesis, Berhampur University. Pp. 67.

Sahu, D. & M.K. Misra (2007): Ecology and traditional technology of screw pine perfume industry in coastal Orissa. *Indian J. Traditional Knowledge 6(2)*: 253-261.

Saxena, H.O. & M. Brahmam (1994-96): The Flora of Orissa. Vols. 4. Regional Research Laboratory and Orissa Forest Development Corporation Ltd., Bhubaneswar, Orissa. 2918 pp.

Subudhi, H.N., B.P. Choudhury & B.C. Achary (2002): Systematic enumeration of plants from Orissa coast. *J. Eon. Tax. Bot. 26(1)*: 185-192.

■ ■ ■

NEW DESCRIPTIONS

TWO NEW CYPRINID FISHES UNDER THE GENUS *GARRA* (HAMILTON) FROM KERALA, SOUTHERN INDIA

B. Madhusoodana Kurup[1,3] and K.V. Radhakrishnan[1,2]

[1]Kerala University of Fisheries and Ocean Studies, Kochi 682 506, Kerala, India.
[2]Key Laboratory of Ecology and Environment Science in Guangdong Higher Education, Guangdong Provincial Key Laboratory for Healthy and Safe Aquaculture, College of Life Science, South China Normal University, Guangzhou 510 631, China.
Email: krishnaradh76@gmail.com
[3]Email: madhukurup@hotmail.com

Two new Cyprinid fishes under the genus *Garra* (Hamilton) have been described from river Periyar, Kerala. The morphometric and meristic characters of the two species varied from the species hitherto described. *Garra emarginata* sp. nov. is named after its emarginated caudal fin, while *Garra mlapparaensis* sp. nov. is named after its type locality. A key to the species under the genus *Garra*, reported so far from Kerala, is also provided.

Key words: *Garra emarginata* sp. nov., Pooyamkutty, *Garra mlapparaensis* sp. nov., Mlappara, Periyar river

INTRODUCTION

The genus *Garra* (Hamilton) is represented by 24 species in the Indian subcontinent (Jayaram 1999), of which 19 are distributed in India. Rema Devi and Indra (1984) described *Garra menoni* from Silent Valley, Kerala, India. *Garra kalakadensis* was subsequently described by Rema Devi (1992) from Kalakkad Wildlife Sanctuary, Tamil Nadu. Shaji *et al.* (1996) described *Garra surendranathani* from Chalakkudy, Periyar, Pamba and Achenkovil rivers of Kerala. Recently, *Garra periyareusis* was described by Gopi (2001) from the Periyar lake. The other species known from Kerala, so far, include *Garra gotyla stenorhynchus*, *G. mullya*, *G. lunghi* and *G. mcclellandi* (Jayaram 1999). Barring *Garra menoni*, the other species were described from the streams of the Periyar river system (Arun *et al.* 1996; Zacharias *et al.* 1996). Recently, Radhakrishnan and Kurup (2007) reported *Garra ceylonensis* from Periyar river, which is the first record of this species from Indian waters. Thus, the total number of species recorded under genus *Garra* in Kerala is raised to eight While investigating the fish fauna of Periyar river as a part of the NAT-ICAR Project on Germplasm Inventory, Evaluation and Gene Banking of freshwater fishes, we came across specimens of two species with morphomeristics and coloration different from those of hitherto known species. These two species are reported as new additions to science.

MATERIAL AND METHODS

The specimens were collected with a cast net of 12 mm mesh size from two locations along Periyar river – Pooyamkutty and Mlappara. Morphometric measurements were recorded using a dial calliper, with an accuracy of 0.1 mm. Data are presented as percentages, with the range followed by the mean in parentheses. Meristic counts follow Talwar and Jhingran (1991).

Garra emarginata sp. nov. (Fig. 1)

Diagnosis: An elongate, slender species with an emarginated caudal fin, eyes small, interorbital region flattened, dorsal fin with 8 branched rays, lateral line complete with 35 scales, body with minute black spots arranged in series on either side of lateral line, distance between vent and anal fin 2.7-3.4 times that between anterior origin of anal and ventral fins.

Description: Based on 4 specimens collected from Pooyamkutty, Periyar river, ranging from 77.2 - 89.54 mm SL.

D.II, 8; P.I, 13; V.I, 7; A.I, 5; C.19.

Body elongate and slender. Depth of body 15.86-18.39% (17.19%) in SL, length of head 21.85-24.07% di 3.40%) of SL, Mental disc well-developed, length of 5 lsc 70.35-74.19% (72.27%) in width of disc and the latter

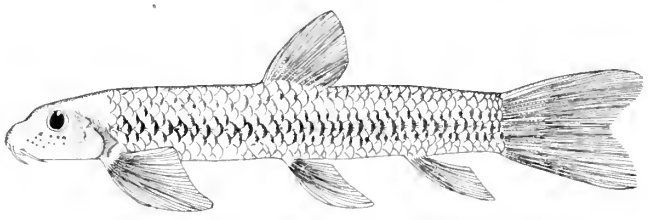


Fig. 1: Lateral view of *Garra emarginata* sp. nov.

51.38-65.12% (58.35%) in the width of head. Snout round and smooth. Two pairs of barbels; rostral barbels equal to or slightly greater than eye forming 102-112.69% (108.23%) of the eye diameter. Eyes small, not visible from ventral side of the head, diameter 17.08-18.83% (19.75%) of head length, 36.0-44.85% (38.28%) in the interorbital distance. Interorbital region flattened and 46.89-52.41% (49.2%) in the length of the head. Abdomen slightly rounded. Distance of the vent from anal fin origin 29.77-32.22% (30.33%) in the distance between anterior origins of ventral fin and anal fin. Caudal peduncle 10.91-12.48% in SL (11.25%), 44.44 -50.92% in HL and least depth 89.38-99.63% (92.46%) its own length.

Squamation: Thirty-five scales along the lateral line, 4.5 from the origin of dorsal to lateral line, 2.5 between the lateral line and pelvic fin origin, predorsal scales 11-12, preventral scales 13, preanal scales 26, circumpeduncular scales 12.

Fins: Dorsal fin inserted closer to snout than to caudal. It is shorter than head length, base 62.44-86.48% (75.63%) of the height. Pectorals larger than head and forms 106.88-130.13% (119.53%) in head length. Ventral fins almost equal or slightly larger than head and forms 89.37-106.02% (100.29%) in head length and 79.45-92.68% (86.25%) in pectoral fin length. Distance between pectoral and ventral fins 33.19-35.54% (34.46%) in SL. Distance between ventral and anal fins 26.62-32.16% (29.16%) in SL. Preanal distance 80.91%-87.4% (83.61%) in SL and predorsal distance 48.22-51.68% (49.08%) in SL. Preventral distance 52.06-55.39% (52.69) in SL and prepectoral distance 18.42-21.88% (20.42%) in SL. Caudal emarginate.

Holotype: Deposited at ZSI (WGRS) CLT. No. V/F 13033,115.26 mm TL, Pooyamkutty, Periyar river, 23.v.2003, Coll. Dr. K.V. Radhakrishnan.

Paratypes: 3exs. 107.4 mm, 102.3 mm and 97.5 mm TL, Pooyamkutty, Periyar river, 23.v.2003, Coll. Dr. K.V. Radhakrishnan. (Deposited at School of Industrial Fisheries Museum, Cochin University of Science and Technology, Regn No.1, 62a, 62b, 63c)

Coloration: In life, the ground colour is greyish green with the ventral side pale white. Minute dark spots arranged on either side of the lateral line in a series. Fins generally pale, orange red, dorsal rays have blackish tips. In formalin, the ground colour turns brown.

Distribution: INDIA: Kerala, Pooyamkutty on Periyar river.

Etymology: Named after the emarginated nature of the caudal fin that differentiates the species from other related species.

Remarks: The species, *Garra emarginata*, is different from its closely related species *G. hughi*, *G. surendranathani* and *G. periyarensis* in many respects. Unlike *Garra hughi*, the new species has prominent scales on the predorsal, breast and belly regions and presence of lesser number of lateral line scales. The species differs from *Garra periyarensis* in absence of a deep cut and knob-like protuberance in the snout and presence of scales on the breast and belly region. *Garra emarginata* lacks the characteristic black blotches of *Garra surendranathani*. It differs from *Garra mullya* in having more lateral line scales, broad and round head and snout, more flattened and wide interorbital region and smaller eyes when compared to head length. The new species can be differentiated easily from *Garra menoni* in the presence of more lateral line scales, presence of scales in the breast and belly regions, wide interorbital distance and in colour pattern, namely the new species possess minute dark spots arranged on either sides of the lateral line in a series. The emarginated nature of caudal fin differentiates the species under the Genus *Garra* inhabiting the Western Ghats region, however this character is shared with *G. manipurensis* recorded from Manipur. Nevertheless, *G. emarginata* can be differentiated from *G. manipurensis* by the morphometric characters such as presence of scales on the chest region, width of mental disc in relation to width of head and difference in lateral line scale counts, shape of head, colour pattern.

Garra mlapparaensis sp. nov. (Fig. 2)

Diagnosis: A species of *Garra* having an elongated and slender body, with dorsal fin having 7 branched rays, lateral line complete with 36 scales, scales on the lateral sides have blackish posterior ends, distance between vent and anal fin 3.15 times that of the distance between anterior origin of anal and ventral fins.

Description: Based on a single specimen 94.58 mm SL, collected from Mlappara, Periyar Tiger Reserve in Periyar river.

D.I-II, 7; P.I, 12; V.I, 7; A.I, 5; C.19.

Body elongate and slender, depth of body 18.64% in SL, length of the head 22.08% of SL, mental disc well developed, width of the disc 73.22% in the width of head. Snout rounded with fine tubercles. Barbels two pairs; rostral barbels slightly greater than diameter of eye and forming

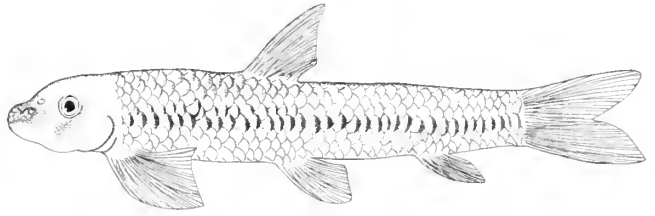


Fig. 2: Lateral view of *Garra mlapparaensis* sp. nov.

106.21% of the eye. Eyes moderate and not visible from ventral side of the head, diameter 21.20% of head length, 43.86% in the interorbital width. Interorbital distance 48.34% in the length of the head. Abdomen slightly rounded. Distance of the vent from anal fin origin 31.70% in that between anterior origin of ventral fin to anal fin. Caudal peduncle length 14.92 % in SL, 65.34% in head length and its least depth 77.49 % in its own length.

Squamation: 35 scales along the lateral line, 4.5 from the origin of dorsal to lateral line, 3.5 between lateral line and pelvic fin origin, predorsal scales12, preventral scales 13 and preanal scales 24, circumpeduncular scales 12.

Fins: Dorsal fin inserted closer to snout than to caudal, longer than head length, base 26.45 % of height. Pectorals almost equal to head length and form 98.70% in the latter. Pelvic fins smaller than head and form 89.26% in head length and 90.44% in pectoral fin length. Distance between pectoral and ventral fins 31.58% in SL. Distance between ventral and anal fins 24.40% in SL. Preanal distance 77.55% in SL and predorsal distance 45.39% in SL. Preventral distance 50.72% in SL and prepectoral distance forms 19.34% in SL. Caudal forked.

Coloration: In life, the ground colour is greenish-brown with the ventral side pale white. The posterior edges of the scales on the lateral sides are blackish. Fins generally orange red and the dorsal rays have blackish tips. In formalin, the ground colour turns brown.

Holotype: Deposited in ZSI (WGRS) CLT. No. V/F 13032 94.58 mm TL, Mlappara, Periyar, 18.ii.2002.

Paratypes: None.

Distribution: INDIA: Kerala, Mlappara, upstream of Periyar river.

Etymology: Named after the locality from where the specimen was collected.

Remarks: *Garra mlapparaensis* is closely related to *Garra lughi* in the number of lateral line scales, wide and well developed sucking disc, however, it differs from the latter in the presence of larger eyes and also in the position of insertion of dorsal fin, which is closer to the snout than to the caudal fin; the dorsal fin is equidistant from the snout and caudal fin in *Garra lughi*. It can be differentiated from *Garra periyarensis* in the absence of a deep cut at the snout, presence of scales on the breast and belly regions and placement of the vent, which is almost midway between the anterior origins of anal fin and ventral fins in the latter.

KEY TO SPECIES OF GENUS *GARRA* IN KERALA

1. Head with a single proboscis ..... *Garra gotyla stenorhynchus*
— Proboscis absent 2
2. Lateral line scales 34 or fewer, scales uniformly present on body 3
— Lateral line scales 35 or more, scales uniformly present on body or absent on ventral side 4
3. Interorbital distance more than 2 times in head length ..... *Garra ceylonensis*
— Interorbital distance less than or about two times in head length ..... *Garra mullya*
4. Snout with a deep transverse groove, vent placed almost midway between origins of anal fin and ventral fin 5
— No transverse groove present; if present, not deep. Vent not placed midway between origins of anal fin and ventral fins 6
5. Breast and belly scale less ..... *Garra periyarensis*
— Scales present uniformly on body ..... *Garra mcclellandi*
6. Lateral line scales 35-38, scales absent on a part of the body 7
— Scales present almost uniformly along the body 8
7. Lateral line scales 35-36, head less depressed, eyes 4.2-4.6 times in head length, depth of caudal peduncle form 1-1.2 times in its length and scales absent on breast and belly .... *Garra menoni*
— Lateral line scales 36-38, head more depressed, eyes 5.8-6 times in head length, caudal peduncle less deep, forming 1.2-1.4 times in its length, scales usually absent on mid-dorsal region ..... *Garra hughi*
8. Body brownish-green, scales on the lateral sides have dark posterior edges ..... *Garra mlapparaensis* sp. nov.
— Body with back blotches or minute spots arranged in a series 9
9. Body with black blotches and dots, head with minute tubercles, eyes larger, caudal forked ..... *Garra surendranathani*
— Body with minute dark dots arranged on either sides of the lateral line, eyes small, caudal emarginated ..... *Garra emarginata* sp. nov.

ACKNOWLEDGEMENTS

We sincerely thank the Officer-in-charge, Zoological Survey of India, and scientists for help to identify the new species. Special thanks are due to Dr. K. Rema Devi for her sincere effort in separating the two new species from our collection of fishes. The financial support given by the NAT-ICAR Project for the present study is thankfully acknowledged. We also thank Prof. (Dr.) Ramakrishnan Korakandy, Director, School of Industrial Fisheries, Cochin University of Science and Technology, Kerala, India for facilities for carrying out this study. The assistance of M.D. Mahesan during the survey is acknowledged.

REFERENCES

ARUN, L.K., C.P. SHAJI & P.S. EASA (1996): Record of new fishes from Periyar Tiger Reserve. *J. Bombay Nat. Hist. Soc. 93(1)*: 103-104.

GOPI, K.C. (2001): *Garra periyarensis*, a new cyprinid fish from Periyar Tiger Reserve, Kerala, India. *J. Bombay Nat. Hist. Soc. 98(1)*: 80-83.

JAYARAM, K.C. (1999): The Freshwater Fishes of the Indian Region. Narendra Publishing House, New Delhi.

RADHAKRISHNAN, K.V. & B.M. KURUP (2007): On the record of *Garra ceylonensis*, Bleeker 1863, a Sri Lankan cyprinid fish from India. *J. Bombay Nat. Hist. Soc. 104(3)*: 357-358.

REMA DEVI, K. & T.J. INDRA (1984): *Garra menoni*, a new Cyprinid fish from Kerala, South India. *Bull. Zool. Surv. India. 5(2&3)*: 121-122.

REMA DEVI, K. (1992): *Garra kalakadensis*, a new Cyprinid fish from Kalakkad Wildlife Sanctuary. *Rec. Zool. Surv. India. 91(2)*: 239-245.

SHAJI, C.P., L.K. ARUN & P.S. EASA (1996): *Garra surendranathani* – A new cyprinid fish from the Southern Western Ghats. *J. Bombay Nat. Hist. Soc. 93(3)*: 572-575.

TALWAR, P.K. & A.G. JHINGRAN (1991): Inland fishes of India and adjacent countries. Oxford and IBH Publishing Co., New Delhi.

ZACHARIAS, V.J., A.K. BHARDWAJ & P.C. JACOB (1996): Fish fauna of Periyar Tiger Reserve. *J. Bombay Nat. Hist. Soc. 93*: 39-43.

■ ■ ■

FISHES OF THE GENUS *HOMALOPTERA* VAN HASSELT, 1823 IN KERALA, WITH DESCRIPTION OF A NEW SPECIES *HOMALOPTERA SILASI*

B. Madhusoodana Kurup[1,3] and K.V. Radhakrishnan[1,2]

[1]Kerala University of Fisheries and Ocean Studies, Kochi 682 506, Kerala, India.
[2]Key Laboratory of Ecology and Environment Science in Guangdong Higher Education, Guangdong Provincial Key Laboratory for Healthy and Safe Aquaculture, College of Life Science, South China Normal University, Guangzhou 510 631, China.
Email: krishnaradh76@gmail.com
[3]Email: madhukurup@hotmail.com

A new Homalopterid fish, *Homaloptera silasi* is described based on five specimens collected from Kattamadithode, a small stream connecting with Periyar river in Periyar Tiger Reserve at Chokkanpetty. The morphomeristic characters of the species were found varied when compared to all other known species of the Genus *Homaloptera* and is described here as a new species.

Key words: *Homaloptera silasi* sp. nov., Kattamadithode, Periyar Tiger Reserve, Chokkanpetty, Periyar river, Kerala

Homalopterine loaches inhabit fast flowing water of hill streams, and are characterized by a flattened head and body, horizontally oriented, enlarged, paired fins bearing adhesive pads covered with unculi on the ventral surface, that helps them to live in mountain streams and rivulets (Kottelat 1989). The genus *Homaloptera* van Hasselt is represented by four species in the Indian subcontinent, namely *Homaloptera bilineata* Blyth, *H. modesta* (Vinciguerra), *H. rupicola* (Prashad & Mukerji), which are distributed in Burma (=Myanmar), and *Homaloptera montana* Herre, found in Silent Valley and New Amarambalam area of Western Ghats (Menon 1987). Indra and Rema Devi (1981) described a new species, *Homaloptera pillaii* from Silent Valley, while Shaji and Easa (1995) described *Homaloptera menoni* from Siruvani area of Bhavani river. Arunkumar (1999) described a new species from Manipur, *Homaloptera manipurensis*. Recently, Arunachalam *et al.* (2002) added a new species, *Homaloptera santhamparaiensis* from the Panniyar tributary of Periyar river at Santhamparai. The present discovery of a new species of the genus *Homaloptera* is from Kattamadithode, a small stream joining Periyar river at Chokkanpetty area of Periyar Tiger Reserve.

MATERIAL AND METHODS

Morphometric measurements were recorded with a dial calliper to the nearest millimetre and expressed as percent of standard length. Meristics were counted following Talwar and Jhingran (1991).

Homaloptera silasi sp. nov. (Fig. 1)

Holotype: Deposited in ZSI, Calicut, no. ZSI/WGRS/CLT/V/F 13118, 67.92 mm TL, Chokkanpetty, Periyar Tiger Reserve, 12.ii.2004, Coll. Dr. K.V. Radhakrishnan.

Paratypes: 2 exs. Deposited in ZSI, Calicut, no. ZSI/WGRS/CLT/V/F 13118a & b, 49.70 mm, 51.26 mm TL, Chokkanpetty, Periyar Tiger Reserve, 12.ii.2004, Coll. Dr. K.V. Radhakrishnan.

Diagnosis: An elongate fish with a sub-cylindrical body. Head depressed, eyes small, narrowly elongated snout, dorsal fin inserted close to the base of caudal fin than the tip of snout, small pectoral fins, height less than length of head and not reaching pelvic fins, pelvic fins small, not reaching vent or anal fin. 89 to 93 lateral line scales, caudal peduncle short and stout, and its least depth less than two times its length.

Description: Based on 5 specimens collected from Kattamadithode, Chokkanpetty, Periyar Tiger Reserve, ranging from 40.18 to 67.92 mm SL (Mean value in parentheses).

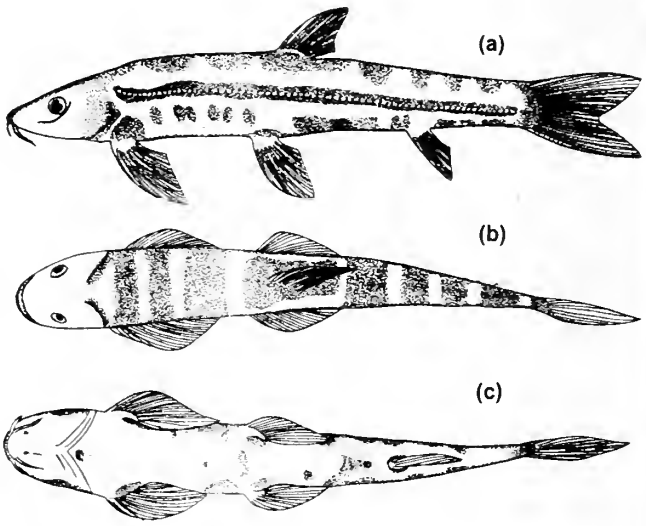


Fig. 1: *Homaloptera silasi* sp. nov.
(a) lateral, (b) dorsal, (c) ventral view

Table 1: Comparison of *Homaloptera silasi* sp.nov. with closely related species

Character	*H. silasi*	*H. pillaii*	*H. montana*	*H. menoni*	*H. manipurensis*	*H. santhamparaiensis*
Lateral line scales	89-93	83-93	70-72	59-62	42-43	88-95
Insertion of Dorsal fin	Close to the caudal base than to the snout	Equidistant between the snout and caudal fin	Equidistant between the snout and caudal fin	Close to the snout than the caudal fin	Close to the caudal base than to the snout	Close to the caudal base than to the snout
Colour pattern on body and fins	Irregular brown blotches or bands on back, a dark brown lateral streak, fins dusky, caudal base has a dark band	Body light to dark brown mottled with numerous black spots. Fins are dusky brown	Ten dark short bars on back, an ill-defined band below lateral line, caudal fin with black blotch at tips	Irregular blotches on the back. The dorsal, ventral and anal fins have two rows of spots	Six black and broad bands from occiput to the base of caudal fin, rows of varying number of black bands on the fins	Body uniform dark brown, Belly pale white. Dorsal marked with 8-9 dark indistinct brown blotches. Fins dusky white, rays dark brown
No. of rays on pectoral	5/9	7-9/11-13	4/8	5/9	5/10	4/10
% Length of pectoral fin in head length	86.81%	89.2%-104.9%	98.2%	92.14%	88.62%	66.8%-84.6%
% of body depth in standard length	15.46%	14.33%	13.70%	13.94%	12.25%	15%-19%
% of Eye diameter in head length	8.26%	15.02%	22.22%	30.33%	15.38%	13.3%-20%
% of height of caudal peduncle in its length	63.48%	73.18%	72.14%	30%	57.14%	62.5%-83.3%
Shape of caudal fin	Slightly emarginate	Emarginate	Truncate	Slightly emarginate	Forked	Emarginate

D.I, 8; P.V, 9; V.II, 8; A.I, 6; C.19; L.l. 89-93.

Body: Body sub-cylindrical and covered with scales except on the ventral surface. Body depth 14.31-17.62% (15.46%) in SL. Maximum width of the body 83.74-102.06% (92.05%) in maximum depth of the body. Depth of the body 49.02-71.93% (54.44%) in HL. Lateral line complete with 89-93 scales. Scales small imbricate, covering the whole body except head and ventral profile.

Head: Head depressed, snout elongated and broadly pointed. Length 49.80-58.26% (54.56%) in SL, width 67.01-72.51% (69.86%) in HL. Eyes small and placed in the middle of the head, not visible from ventral surface of head, is 7.76-9.84% (8.26%) of HL and 22.62-60.61% (41.70%) of interorbital distance. Snout 38.27-47.36% (42.85%) of HL and 92.44-105.90% (99.78%) of post orbital distance. Interorbital distance 34.32-41.31% (37.73%) of HL.

Fins: Dorsal fin situated just behind the origin of pelvic fin and its origin closer to the base of caudal fin than to the snout tip. Predorsal length 49.80-58.26% (54.56%) in SL and 108-114% (112.22%) in post dorsal length. The length of dorsal fin 70.84-84.21% (77.82%) in HL, and 18.05-20.63% (19.14%) in SL. Pectoral fins not reaching pelvics, its length

19.58-22.16% (21.37%) in SL and 106.71-118.97% (111.75%) in height of dorsal fin. It forms 80.03-92.55% (86.81%) in HL. Pelvic fins short and not reaching the vent or anal fin. Length of ventral fins 77.14-85.57% (81.25%) in the length of pectoral fin and 64.40-79.19% (70.55%) of head length. Anal fins shorter than pectoral and pelvic fins and 42.54-68.63% (56.29%) in head length and 11.70-16.47% (13.87%) in standard length. Vent situated close to the origin of anal fin. The distance from vent to anal fin 12.14-17.90% (15.17%) in the distance between the origin of pelvic fin and anal fin. Caudal peduncle short and stout and its length 13.72-17.53% (15.56%) in standard length and 58.70-71.54% (63.12%) in head length. Its least height 54.58-70.63% (63.48%) in its length.

Coloration: Ground colour pale yellowish-green, dorsal with irregular brown blotches. Area below the lateral line and a small region on the ventral surface has blackish brown patches. Head is mottled with irregular brown blotches, which sometimes coalesce to form a uniform brown patch. A dark longitudinal stripe passes from behind the opercle to the caudal peduncle. Fins are generally dusky with blackish patches. Bases of the paired and unpaired fins are marked by darkish brown spot or band, which in the case of caudal fin have a well-defined deep brown to black transverse band at caudal base.

Distribution: INDIA: Kerala, Chokkanpetty in Periyar Tiger Reserve.

Etymology: Named after Dr. E.G. Silas, a renowned fishery scientist who has made outstanding contributions to the taxonomy of freshwater fishes of Western Ghats.

Other material examined: *Homaloptera pillaii* ZSI/SRS F462, Holotype, 69 mm, Silent Valley, river Kunthi, Kerala; ZSI/SRS F 463, Paratypes, 2 examples, 49-57 mm SL, Sayvala, New Amarambalam, Kerala; *H. santhamparaiensis*: ZSI/SRS F 5322, Holotype, 6.1 mm SL, Santhamparai, Panniyar stream of Periyar, Kerala; ZSI/SRS 5323, Paratype, 45 mm SL, Santhamparai, Panniyar stream of Periyar, Kerala.

Remarks: The new species, *Homaloptera silasi*, can be differentiated from other closely related species such as *H. montana*, *H. pillaii*, *H. menoni* and *H. manipurensis* by an array of characters such as position of insertion of dorsal fin, small eyes, small pectoral and pelvic fins and characteristic colour pattern. The new species show some similarity with *H. santhamparaiensis* in the lateral line scale counts and also in the smaller eyes, but disagrees in the shape of head and snout and pectoral fin counts. The new species described is compared with the closely related species and the results are summarized in Table 1.

KEY TO THE SPECIES OF *HOMALOPTERA* VAN HASSELT REPORTED FROM KERALA

1. Origin of dorsal fin equidistant or nearer snout than caudal 2
— Origin of dorsal fin towards the caudal than the snout tip 3
2. Origin of dorsal fin close to snout ..... *H. menoni*
— Origin of dorsal fin equidistant between snout and caudal fin 4
3. Body with a distinct dark lateral band along lateral line, unbranched pectoral fin rays 5 ..... *H. silasi* sp. nov.
— Body without any lateral bands along lateral line, unbranched pectoral fin rays 4 ..... *H. santhamparaiensis*
4. Lateral line scales 70-72 ..... *H. montana*
— Lateral line scales 83-93 ..... *H. pillaii*

ACKNOWLEDGEMENTS

We thank the Officer-in-charge, ZSI, and Drs K. Rema Devi and T.J. Indra for help in identifying the new species. The financial support given by the NAT-ICAR Project for the present study is thankfully acknowledged. We also thank Prof. (Dr.) Ramakrishnan Korakandy, Director, School of Industrial Fisheries, Cochin University of Science and Technology, Kerala, India for providing necessary facilities for carrying out this study.

REFERENCES

ARUNACHALAM, M., J.A. JOHNSON & K. REMA DEVI (2002): *Homaloptera santhamparaiensis*, a new species of Balitorid fish (Teleostei: Balitoridae) from a Western Ghat stream of Kerala, India. *Acta Zool. Taiwan. 13(1)*: 31-37.

ARUNKUMAR, L. (1999): *Homaloptera manipurensis*, a new Homalopterid fish from Manipur, India. Uttar Pradesh. *J. Zool. 19(3)*: 201-205.

INDRA, T.J. & K. REMA DEVI (1981): A new species of the genus *Homaloptera* from Silent valley, Kerala, South India. *Bull. zool. Surv. India 4(1)*: 67-71

KOTTELAT, M. (1989): Zoogeography of the fishes from the IndoChinese Island waters with an annotated checklist. *Bull. zool. Mus. Amsterdam 12(1)*: 1-56.

MENON, A.G.K. (1987): The fauna of India and adjacent countries. *Rec. Zool. Surv. India.* 259 pp.

SHAJI, C.P. & P.S. EASA (1995): *Homaloptera menoni* – A new Homalopterid (Pisces: Homalopteridae) from Kerala. *J. Bombay Nat. Hist. Soc. 92(3)*: 395-397

TALWAR, P.K. & A.G. JHINGRAN (1991): Inland Fishes of India and Adjacent Countries. Oxford and IBH Publishing Co., New Delhi.

■ ■ ■

TOR REMADEVII, A NEW SPECIES OF *TOR* (GRAY) FROM CHINNAR WILDLIFE SANCTUARY, PAMBAR RIVER, KERALA, SOUTHERN INDIA

B. Madhusoodana Kurup[1,3] and K.V. Radhakrishnan[1,2]

[1]Kerala University of Fisheries and Ocean Studies, Kochi 682 506, Kerala, India.
[2]Key Laboratory of Ecology and Environment Science in Guangdong Higher Education, Guangdong Provincial Key Laboratory for Healthy and Safe Aquaculture, College of Life Science, South China Normal University, Guangzhou 510 631, China.
Email: krishnaradh76@gmail.com
[3]Email: madhukurup@hotmail.com

A new cyprinid fish is described under the genus *Tor* based on 19 specimens collected from Chambakkad and Koottar regions of river Pambar in Chinnar Wildlife Sanctuary. Morphometric and meristic characters of the new species varied from the species hitherto described.

Key words: *Tor remadevii*, Chinnar river, Chinnar WLS, Pambar river

INTRODUCTION

Genus *Tor* (Gray 1834), well-known as Mahseer, is widely distributed in the freshwaters of Asia, Africa and Indo-Australian Archipelago (Tilak and Sharma 1982). The *Tor* species so far reported from Indian region include *Tor khudree* (Sykes), *T. mosal* (Hamilton-Buchanan), *T. mussullah* (Sykes), *T. neilli* (Day), *T. putitora* (Hamilton-Buchanan) and *T. progenius* (McClelland). Mahseer shows different pattern of distribution from the Himalaya to Peninsular region in the Indian subcontinent (Jayaram 1999). *T. kulkarnii* described by Menon (1992) from Deolali hills of Maharashtra is not included as a valid species of the Indian region (Jayaram 1999). Among the various species, *Tor khudree*, *T. mussullah and T. tor* are hitherto known from southern India (Kulkarni and Ogale 1979; Kulkarni 1980; Sen and Jayaram 1994; Menon 1999; Ajithkumar *et al.* 2000; Kurup *et al.* 2001; Shaji and Easa 2001). *Tor khudree malabaricus* (Kulkarni 1980) reported from Malabar, Kerala, was subsequently treated as a synonym of *T. khudree* by Menon (1999). During the survey of NAT-ICAR project on Germplasm Inventory Evaluation and Genebanking of Freshwater Fishes of Kerala, we came across 19 specimens of a *Tor* species from the river Pambar, whose morphometric and meristic characters totally varied from the species hitherto described under this genus, and therefore erected as a new species.

MATERIAL AND METHODS

Nineteen specimens were collected using cast net, having 5 mm and 8 mm mesh sizes and gill nets having 32 and 78 mm mesh sizes from the Chambakkad and Koottar localities of river Pambar in Chinnar Wildlife Sanctuary, Kerala. Morphometric measurements were recorded using a dial reading calliper with an accuracy of 0.1 mm. Morphometry of the new species are presented as percentages, with the range followed by the mean in parentheses. Meristic counts were done following Talwar and Jhingran (1991). Taxonomy of Mahseer fishes under the Genus *Tor* by Menon (1992) was also consulted.

Tor remadevii sp. nov. (Fig.1)

Holotype: Deposited in ZSI (WGRS) CLT. No. V/F 13119a, 331.82 mm TL, Chambakkad, Pambar river, Chinnar Wildlife Sanctuary, 18.v.2004, Coll. Dr. K.V. Radhakrishnan.

Paratype: 2 exs. Deposited in ZSI (WGRS) CLT. No. V/F 13119b, 160.84 mm and 113.64 mm TL, Chambakkad, Pambar river, Chinnar Wildlife Sanctuary, 18.v.2004, Coll. Dr. K.V. Radhakrishnan (16 remaining paratypes ranging from 114.23 mm to 228.16 mm TL are kept at the museum of School of Industrial Fisheries, Cochin University of Science and Technology., Reg. No. SIF/Mus/F/212A to SIF/Mus/F/212B).

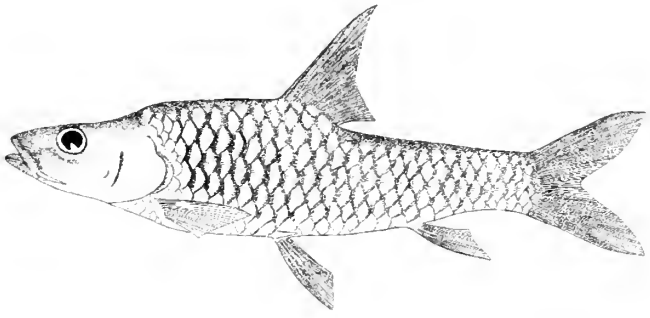


Fig. 1: Lateral view of *Tor remadevii* sp. nov.

Diagnosis: An elongate species with the dorsal fin equal to depth of the body and with a strong osseous spine, head straight, snout pointed and with a terminal or slightly upturned mouth, lips fleshy and the mentum small (fleshy in younger specimens), head length more than body depth, a deep hump at the occipit, lateral line scales 27-29. Body colour greenish to metallic silvery along back and fins reddish with blackish patches.

Description: Based on 19 specimens ranging in size from 113.64 mm to 331.82 mm TL.

D.IV, 10; P.I, 15; V.I, 8; A.I, 5; C.19; L.l. 27-29.

Body: Body elongate. Head length 31.48-33.68% (32.45%) in SL. Depth of the body 84.43-90.10% (83.55%) in head length and 25.60-28.37% (27.09%) in SL. Width of head 39.19-44.89% (41.02%) in head length. Snout elongated and its length 30.45-48.17% (34.33%) in head length and 9.29-16.09% (11.15%) in SL. Eyes lie at the posterior half and superiorly, its diameter is 13.21-23.55% (18.49%) in head length. Dorsal profile has a moderate to prominent hump after the head region, before the insertion of dorsal fin. Two pairs of barbels are present, maxillary more elongated than rostral barbels.

Fins: Origin of dorsal lies opposite to that of pelvics and midway between tip of snout and base of caudal fin. Dorsal spine osseous, strong and smooth, equal to depth of body, forming 96.28-101.24% (99.02%) in the latter, 27.91-30.87% (29.60%) in SL and 88.12-96.04% (91.22%) in head length. Pectoral fins form 60.13-74.73% (67.10%) in height of dorsal fin. Ventral fins are 91.18-99.34% (92.51%) in height of pectoral fins. Caudal fin is deeply forked. Caudal length form 25.87-29.49% (27.54%) in SL. The length of caudal peduncle is 14.42-17.23% (15.60%) in head length. The least depth of caudal peduncle is 68.29-88.67% (74.46%) in its length.

Squamation: 27-29 scales along the lateral line, 4.5 from the origin of dorsal to lateral line, 2.5-3 between the lateral line and pelvic fin origin, predorsal scales 9-11, preventral scales 8 and preanal scales 17-18. Scales between pectoral and ventral fins 8, pelvic and anal fins 9-10. Circumpeduncular scales 14-16.

Coloration: Dorsal side of the body is greenish to metallic black with the sides silvery, ventral side is white. Head is silvery white, while the eyes are dark bluish. Fins are eventually reddish with blackish patches. Body uniformly silvery in colour in younger specimens, belly white and fins red orange.

Distribution: INDIA: Kerala, Chinnar Wildlife Sanctuary, Chambakkad and Koottar localities of river Pambar.

Etymology: Named after the renowned freshwater fish taxonomist, Dr. K. Rema Devi, Scientist, Zoological Survey of India, Chennai.

KEY TO THE SPECIES OF *TOR* REPORTED FROM THE INDIAN REGION

1. Length of head considerably greater than body depth 2
— Length of head shorter or more or less equal to body depth 4
2. Dorsal fin inserted midway between tip of snout and caudal fin base, dorsal spine length equal to body depth below it 3
— Dorsal fin inserted nearer tip of snout than caudal base, dorsal spine length shorter than body depth below it ... *Tor khudree*
3. A characteristic hump over occiput, head and snout straight, mouth slightly upturned, body bluish dark with fins red orange *Tor remadevii* sp. nov.
— No hump over occiput, Head and snout normal, mouth slightly subterminal, colour silvery with the fins yellowish ..... *Tor putitora*
4. Body deep, 4.5 rows of scales between base of dorsal fin and lateral line, a distinct hump over occiput ..... *Tor mussullah*
— 3 to 3.5 rows of scales between dorsal fin base and lateral line. No such hump over occiput 5
5. Dorsal spine weak, articulated ..... *Tor neilli*
— Dorsal spine strong 6
6. Lips hypertrophied. A fan-shaped rounded structure behind upper lip present ..... *Tor progenius*
— No such fan-shaped structure behind upper lip 7
7. Pre-dorsal scales 6. Dorsal fin inserted midway between tip of snout and caudal fin base. Ventral profile more arched than dorsal (N. India) ..... *Tor tor*
— Pre-dorsal scales 8. Dorsal fin inserted nearer tip of snout than caudal fin base. Dorsal profile more arched than ventral ..... *Tor mosal*

Other material examined: *Tor putitora*: NBFGR, 1 ex. 186 mm TL.

Remarks: The new species shows remarkable variation from *Tor khudree* and *Tor mussullah*, which are reported from Western Ghats due to the presence of a strong and osseous spine in the dorsal fin and the length of the head, which is more than body depth, a most valid identification character widely used for differentiating various species coming under the genus *Tor*. Also, the dorsal fin is high with its length more or less equal to body depth, a character which differentiates it from that of *Tor tor*. The species, however, shows close similarity with the Himalayan Yellow Fin Mahseer, *Tor putitora* in possessing an elongated head and strong dorsal fin, in contrast, it strongly

Table 1: Comparison of morpho-meristic characters of the new species with the closely related species under the genus, *Tor* in India

Characters	*T. remadevii*	*T. khudree*	*T. mussullah*	*T. putitora*	*T. progenius*	*T. tor*	*T. mosal*
HL in SL HL in BD BD in SL	2.9-3.2 0.8-0.9 3.5-3.9	3.1-3.8 0.9-1.0 3.2-3.8	3.9-4.0 1.3-1.5 3.0-3.1	3.0-3.6 0.72-0.89 3.4-3.8	3.5-3.8 0.9-1.2 3.5-3.8	3.5-4.0 1.0-1.3 3.0-3.7	3.5-4.0 0.9-1.0 3.3-4.0
Insertion of dorsal fin	Midway between snout and caudal base	Nearer to the tip of snout than caudal fin	Nearer to the tip of snout than caudal fin	Midway between snout and caudal base	Equidistant or slightly towards the snout	Equidistant or slightly towards the snout	Equidistant or slightly towards the snout
Scale rows between pelvic fin and lateral line	2.5-3.0	2.5	3.5	2.5	2.5	2.5	2.5
Dorsal profile	With a characteristic hump over occiput	Slightly arched	A hump over occiput	Arched, without a	Moderately arched, characteristic hump	Greatly arched without any hump	Slightly arched
Placement of mouth	Terminal or slightly upturned	Subterminal	Subterminal	Subterminal	Subterminal	Subterminal	Subterminal
Placement of eyes	Anteriorly in the head, not visible from below head	Anteriorly in the head, visible from below head	Anteriorly in the head, visible from below head	Anteriorly in the head, not visible from below head	Anteriorly in the head, visible from below head	Anteriorly in the head, visible from below head	Posteriorly in the head, visible from below head
Eye diameter in HL	5.4	2.7-4.7	5.8-6.0	2.8-5.3	3.0-4.7	3.2-4.1	3.3-4.2
Lateral line scales	27-29	25-27	26-27	25-28	24-27	22-27	23-26
Least height of caudal peduncle in its length	1.13-1.5	1.4-1.5	1.5	1.4-1.8	1.4-1.8	1.4-1.5	1.4-1.6
Last unbranched dorsal fin ray	Strong and osseous. Longer than BD	Weak. Shorter than BD	Strong and smooth. Shorter or equal to BD	Dorsal bony, smooth. Shorter or equal to BD	Shorter than or equal to BD	Strong and smooth. Shorter than BD	Strong and smooth. Shorter than BD
Coloration	Dorsal side greenish to metallic black with sides silvery and on ventral side white	Sides above lateral line creamy yellowish-white and silvery bluish-grey below	Dark with bronzy reflections. Fin rays of caudal and dorsal reddish-grey	Back reddish to sap green. Body below lateral line light orange fading to silvery white. The pectoral, pelvic and caudal fins peacock-green	Specimens preserved in spirit have body above lateral line greyish becoming darker towards the dorsal side. Ventral side of body silvery	Dorsal side greyish green, lateral sides pinkish with greenish-golden above and light olive green below. Dorsal fin reddish and pelvics, pectoral and anal fins deep orange	Anteriorly olive yellowish and posteriorly burnt amber in colour. Dorsal fin light reddish-orange and pectoral and pelvic fins yellowish-orange

SL = Standard Length; BD = Body Depth, HL = Head Length

differs from the latter due to the presence of a characteristic hump at the occiput, presence of straight head and snout, and possession of a terminal or slightly upturned mouth in the new species. Conversely in *Tor putitora*, the mouth is subterminal in position and the head profile is also bending downwards. The new species also differ from *Tor mosal* and *Tor kulkarni* (Menon 1992) in a number of characters such as head length in relation to body length, body depth and height of dorsal fin in relation to body depth, and eye diameter and snout length in relation to head length.

ACKNOWLEDGEMENTS

The financial support given by the NAT-ICAR Project for the present study is thankfully acknowledged. Thanks are also due to scientists of ZSI (WGRS) Kozhikkode for help in identifying the new species. We also thank Prof. (Dr.) Ramakrishnan Korakandy, Director, School of Industrial Fisheries, Cochin University of Science and Technology, Kerala, India for providing necessary facilities for carrying out this study. The assistance of M.D. Mahesan and C.P. Sunil Kumar during the field survey is also acknowledged.

REFERENCES

Ajithkumar, C.R., C.R. Biju & K. Raju Thomas (2000): Ecology of hill streams of Western Ghats with special reference to fish community. BNHS Final Report, Bombay Natural History Society. 312 pp.

Gray, J.E. (1834): The Illustrations of Indian Zoology, chiefly selected from the collection of General Hardwick. 96 pp.

Jayaram, K.C. (1999): The Freshwater Fishes of the Indian Region. Narendra Publishing House, New Delhi. 551+xvii.

Kulkarni, C.V. & S.N. Ogale (1979): The present status of Mahseer (Fish) and artificial propagation of *Tor kiudree* (Sykes). *J. Bombay Nat. Hist. Soc. 75(3)*: 651-660.

Kulkarni, C.V. (1980): Eggs and early development of *Tor mahseer* Fish. *J. Bombay Nat. Hist. Soc. 77(1)*: 70-75.

Kurup, B.M., T.G. Manojkumar & K.V. Radhakrishnan (2001): Germplasm Inventory, Evaluation and Gene banking of freshwater fishes. NAT-ICAR Research Report. Cochin University of Science and Technology, Cochin, Kerala. 364 pp.

Menon, A.G.K. (1992): Taxonomy of Mahseer fishes of the Genus *Tor* Gray with description of a new species from Deccan. *J. Bombay Nat. Hist. Soc. 89(2)*: 211-228.

Menon, A.G.K. (1999): Checklist of freshwater fishes of India. *Rec. zool. Surv. India, Occ. Paper No. 175*: 366.

Sen, T.K. & K.C. Jayaram (1994): The Mahseer Fishes of India – A Review. *Rec. Zool. surv. India, Occ. Paper No. 39*: 38.

Shaji, C.P. & P.S. Easa (2001): Freshwater Fishes of the Western Ghats. KFRI-NBFGR Publication. 108 pp.

Talwar, P.K. & A.G. Jhingran (1991): Inland Fishes of India and Adjacent Countries. Oxford & IBH Publishing Co. Ltd., New Delhi. 1158+xix.

Tilak, R. & V. Sharma (1982): Game Fishes of India and Angling. International Book Distributors, Dehradun. 304 pp.

■ ■ ■

CHANNA MELANOSTIGMA, A NEW SPECIES OF FRESHWATER SNAKEHEAD FROM NORTH-EAST INDIA (TELEOSTEI: CHANNIDAE)

KHANGJRAKPAM GEETAKUMARI[1,2] AND WAIKHOM VISHWANATH[1,3]

[1]Department of Life Sciences, Manipur University, Canchipur, Imphal 795 003, Manipur, India.
[2]Email: geetameme@gmail.com
[3]Email: wvnath@gmail.com

Channa melanostigma, a new channid fish species is described from north-east India. The species is distinguished from all its congeners by a combination of the following characters: 14-15 black zig-zag transverse bars at irregular intervals on caudal fin (when stretched), the interspaces being 2/3rd of the bars; dorsal fin inserted after 3-4 scales vertically above the pectoral fin origin, ½7-½8 scales below the lateral line, 5 cheek scales, 27-28 circumpeduncular scales, 50-51 vertebrae, 7 branchial tooth plates, 36-37 branched dorsal fin rays and last dorsal fin inserted in between 41 and 43 vertebrae.

Key words: Channid fish, new species, Arunachal Pradesh

INTRODUCTION

Freshwater snake-headed fishes of the Family Channidae is represented by 31 species, of which 28 are of Asian genus *Channa* Scopoli and three of African genus *Parachanna* Li *et al.* (2005). All species in this genus have cavities in the head which act as a primitive lung enabling them to live for long time out of water (Shaw and Shebbeare 1937).

North-east India having many derelict swamps is rich in channid fauna. Hamilton (1822) described *Ophiocephalus barca* from Brahmaputra river, Assam; *O. gachua* from ponds and ditches of Bengal and *O. marulius* from Gangetic provinces, India. McClelland (1845) described *O. amphibeus* from the vicinity of Chel river, North Bengal. Playfair (1867), Vierke (1991) and Musikasinthorn (2000) respectively described *O. stewartii*, *Channa bleheri* and *C. aurantimaculata* from Assam. Shaw and Shebbeare (1937) and Menon (1954), listed *O. striatus* and *O. punctatus* respectively from North Bengal and Manipur. All the above species are now in *Channa*. The works of Sen (1999), Nath and Dey (2000) and Sen (2006) on the fishes of Arunachal Pradesh did not include any additional species of *Channa*. Vishwanath and Geetakumari (2009) provided diagnostic characters of nine species of *Channa* from North-east India and studied their inter-relationships. Recently, Bagra *et al.* (2009) included an unidentified species, *Channa* sp. 1, in their checklist of fishes of Arunachal Pradesh, which was also collected from the type locality of the new species under description.

Collections from Lohit river (Brahmaputra basin), Arunachal Pradesh, in 2007, included an unnamed species of *Channa* which is herein described as *Channa melanostigma*, a new species.

MATERIAL AND METHODS

Measurements were made point to point with dial calipers to the nearest 0.1 mm. Counts and measurements were made on the left side of specimens under a PC-based binocular stereozoom microscope with transmitted light. Counts and measurements followed Musikasinthorn (1998). Clearing and staining of specimens for osteology followed Hollister (1934). Identification and nomenclature of bones and vertebral counts followed Greenwood (1976). As the gill rakers in the genus are modified to form toothplate, we use the term 'branchial toothplate count' instead of gill raker count following Greenwood (1976). The count was taken on the first gill arch starting from hypobranchial to epibranchial on the left side of the specimens. Measurements of head length and body parts are expressed as proportions of standard length (SL) while subunits of the head, as proportions of head length (HL). Material examined in this study is deposited in Manipur University Museum of Fishes (MUMF).

Channa melanostigma sp. nov. (Fig. 1)

Material examined: **Holotype**: MUMF-Per 39, 134.8 mm SL; India: Arunachal Pradesh: Lohit district, Lohit river, Brahmaputra drainage: Tezu, 27° 54′ 41″ N, 96° 10′ 23″ E; K. Nebeshwar Sharma, 29.iii.2007.

Paratypes: 7 specimens, MUMF-Per 40-46, 6, 82.1-143.0 mm SL; same data as for holotype, MUMF-Per 45 and 46 dissected, cleared and stained for osteology.

Diagnosis: *Channa melanostigma* is distinguished from its nearest congener *C. stewartii* in having distinct 14-15 black zigzag transverse bars at irregular intervals (when stretched), the interspaces being 2/3rd of the bars on the caudal fin (Fig. 2a) vs. no black zigzag bars in the caudal fin (Fig. 2b);

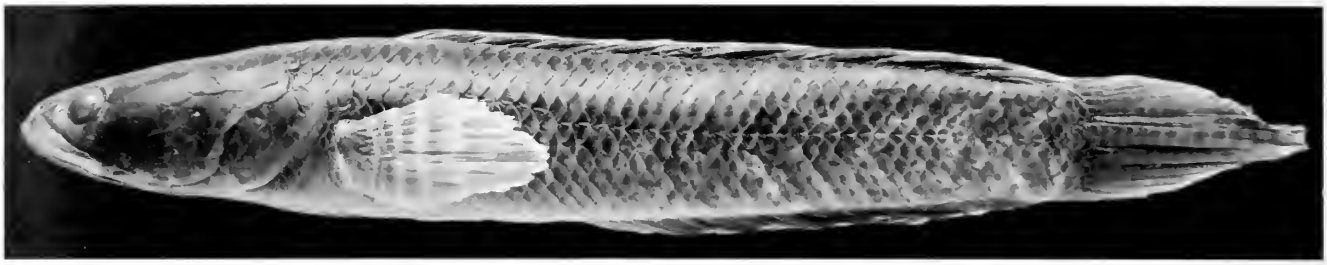


Fig. 1: Side view of *Channa melanostigma* sp. nov., paratype, MUMF-Per 40, 112.5 mm SL

dorsal fin origin after 3-4 scales vertically above the pectoral fin origin vs. vertically above the pectoral origin, vertebra 50-51 vs. 44, branchial toothplate count 7 vs. 3 and more number of scales below the lateral line ½7-½8 vs. ½5. It is also distinguished from *C. gachua* in having more number of vertebra (50-51 vs. 43), toothplate count (7 vs. 9), last dorsal fin ray inserted in between 41st and 43rd vertebrae (vs. 35th and 36th). In case of *C. gachua* the juveniles have a very distinct ocellus at the posterior end of the dorsal fin base but the ocellus is completely absent in case of the *C. melanostigma*. It differs from *C. aurantimaculata* in having less number of dorsal fin rays (36-37 vs. 45-47), last dorsal finray inserted between 41st and 43rd vertebrae (vs. 46th and 47th), cheek scales 5 vs. 10 and less number of circumpeduncular scales (28 vs. 34).

Description: Morphometric data are in Table 1. Dorsal fin 36-37 simple rays. Anal fin 24-25 simple rays, pectoral fin one simple and 14-15 branched rays, pelvic fin 5 simple rays, caudal fin 14 branched rays, predorsal scales 13-14, lateral line scales dropping one row following 15-17th anterior-most scales. Two large cycloid scales on each side of lower jaw, transverse scales ½3-½4/1/½7-½8, caudal fin with 14-15 black zigzag bars, black spots throughout the flank, 12-14 alternate black and whitish transverse bars on the body, cheek scales 5-6, circumpeduncular scales 27-28, scales below the lateral line ½7-½8, total vertebrae 50-51; last ray of dorsal fin in between 41-43 vertebrae, precaudal + caudal vertebrae = 44-45+6, toothplate count 7. Cephalic sensory pores single, without satellite openings. Body elongated, cross-section almost circular in anterior portion and somewhat compressed posteriorly. Body depth greatest at ventral fins origin. Body widest at pectoral fin origin. Dorsal and anal fin bases long (56.9-62.6% SL and 37.7-44.3% SL, respectively). Head depth 11.7-14.6% HL, head width 15.9-20.9% HL, body depth 14.4-15.3% SL, caudal peduncle depth 9.7-10.75% SL, pelvic fin length 7.4- 9.2% SL.

Outer margins of pectoral and caudal fins rounded. Dorsal fin origin after 3-4 scales vertically above the pectoral fin origin. Head elongated 26.9-31.3% SL, concave in lateral view. Snout narrow, dorsal profile of snout somewhat convex.

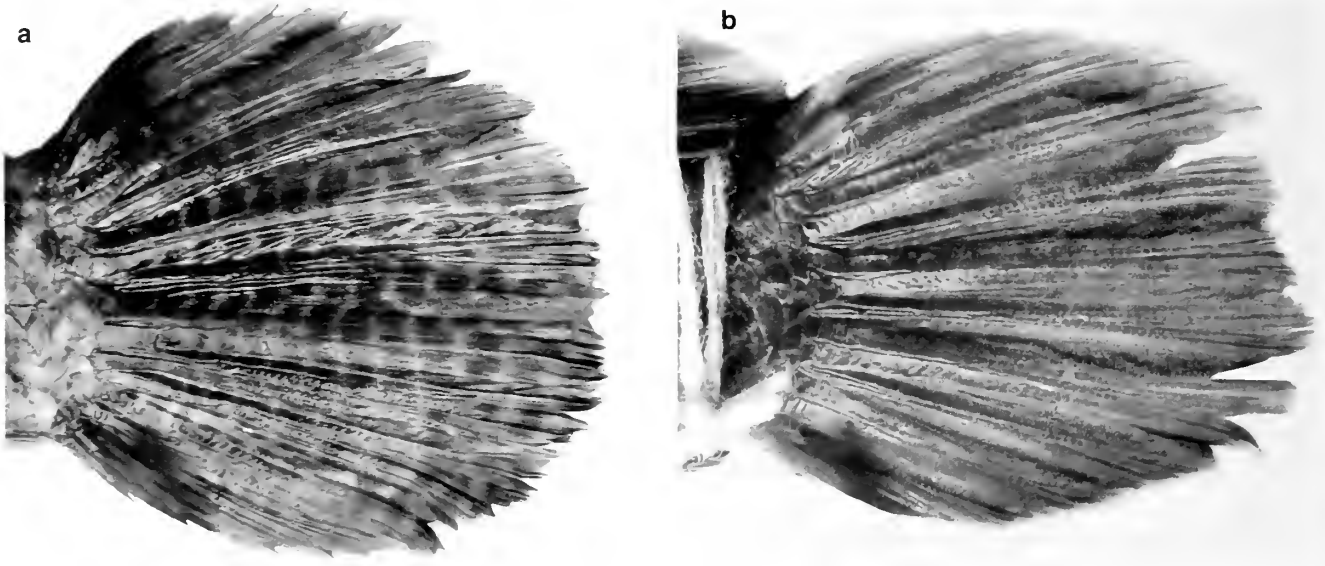


Fig. 2: Comparison of caudal fins: a. *Channa melanostigma* sp. nov. (paratype, MUMF-Per 40, 112.5 mm SL) stretched, b. *C. stewartii* (MUMF-Per 21, 109.7 mm SL)

Table 1: Biometric data of *Channa melanostigma* sp. nov. and *C. stewartii* except SL and HL in mm

	C. melanostigma sp. nov.				*C. stewartii*	
	Holotype MUMF- Per/39	Paratypes MUMF-Per/40-45 (n=6) (Lohit)			MUMF-Per/21, 22 (n=2)	Goswami *et al.* (2006) (n=6)
SL (mm)	134.8	82.1-143.0			109.7-155.2	148.0-157.0
% SL		mean	range	S.D.		
Head length	30.8	29.8	26.9-31.3	1.91	30.8-30.9	29.3-30.7
Head depth	14.4	13.6	11.7-14.6	1.38	15.0-16.4	14.0-14.7
Head width	19.9	18.8	15.9-20.9	1.96	20.1-21.4	19.0-19.8
Body depth	17.4	15.4	14.4-15.3	1.03	17.9-18.3	14.0-15.9
Body width	13.6	12.5	10.7-14.3	1.34	12.1-13.3	11.8-12.7
Caudal peduncle length	10.2	10.3	9.9-11.0	0.41	10.0-11.2	10.0-11.0
Caudal peduncle depth	10.8	10.2	9.7-10.7	0.51	10.8-11.2	10.3-11.2
Predorsal length	35.3	34.2	31.6-35.7	3.90	32.9-33.9	31.9-35.5
Preanal length	53.1	51.5	47.8-53.1	1.93	48.6-52.5	50.0-53.3
Prepectoral length	32.0	30.8	27.8-32.6	2.16	32.1-34.1	28.7-32.5
Prepelvic length	37.2	34.4	29.6-37.6	3.90	35.6-37.4	35.0-37.7
Dorsal fin base length	56.9	59.2	58.3-62.6	2.11	61.7-64.6	59.2-61.7
Anal fin base length	37.7	40.9	39.7-44.3	2.68	39.2-39.7	37.0-39.2
Pectoral fin length	18.3	18.3	17.1-20.0	1.04	19.4-19.8	17.8-19.8
Pelvic fin length	7.7	8.1	7.4-9.2	0.69	6.1-7.1	7.0-7.6
Head length (mm)	41.5	39.3	32.4-41.5	3.59	34-47.9	4.3-4.7
% HL						
Head depth	46.9	45.3	42.3-46.6	1.89	48.5-53.0	46.5-48.9
Head width	64.0	62.7	57.2-66.9	3.50	65.0-69.3	64.0-66.0
Snout length	19.5	21.8	21.8-23.1	1.37	21.5-21.8	No data
Eye diameter	14.5	14.9	14.3-15.6	0.61	13.9-15.6	14.6-16.0
Preorbital head depth	24.8	25.0	23.4-26.5	1.19	24.2-30.9	21.1-31.9
Postorbital head length	68.2	66.7	63.8-68.8	2.23	66.8-69.5	65.4-69.2
Postorbital head depth	34.7	32.5	29.6-34.9	2.29	24.2-30.9	No data
Interorbital width	34.9	33.3	31-35.3	1.97	32.9-38.4	30.4-35.6
Upper jaw length	40.5	42.5	40.1-48.7	3.52	41.1-45.9	30.9-37.4

Interorbital region almost flat. Orbit not reaching dorsal contour of head in lateral view. Mouth large, maxilla and premaxillary process extending to vertical level of the posterior end of the orbit.

Dentition: Many small conical teeth embedded in premaxilla, prevomer, and palatine, the prevomer being with 10 more additional large canine-like teeth. Dentary is also with many small teeth on outer region, plus 9 large canine-like teeth medially on each side (Fig. 3).

Colour: In alcohol, dorsal side of body brown or darkish brown, ventral side whitish, 12-14 alternate dark and whitish transverse bars on the sides. Black spots scattered throughout the body 4-5 rows of spots on dorsal fin, caudal fin with distinct 14-15 zigzag cross bars at irregular intervals where the interspace between two bars is 2/3rd of the zigzag bar. Pectoral fin with 5-6 black bars. Edges of dorsal and anal fins white.

Distribution: Presently known from Lohit river at Tezu, Lohit district, Arunachal Pradesh (Brahmaputra drainage), India (Fig. 4).

Etymology: Named after the melanophores present on each scale on flanks.

Discussion: *Channa melanostigma* is similar to *C. stewartii* in overall body appearance, head shape, i.e., generally rounded in lateral view and coloration, numerous small black spots scattered on body, narrow and pointed snout, lateral line scales 46-47, scale rows between preopercular angle and posterior border of orbit 4-6, predorsal scales 13, maxilla and premaxillary process extending to vertical level of the posterior end of the orbit, pectoral fin rays 14-15, caudal fin rays 13-14, and scales above the lateral line 3½. However, *C. melanostigma* is distinct particularly in having the caudal bars, more number of branchial toothplates, vertebra and scales below lateral line.

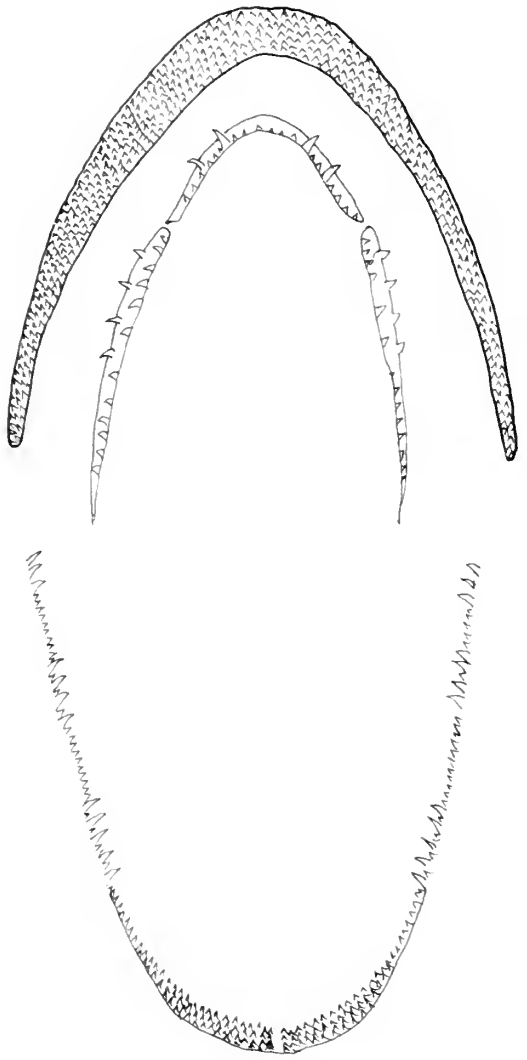


Fig. 3: Dentition of *Channa melanostigma* sp. nov. (MUMF-Per 46)

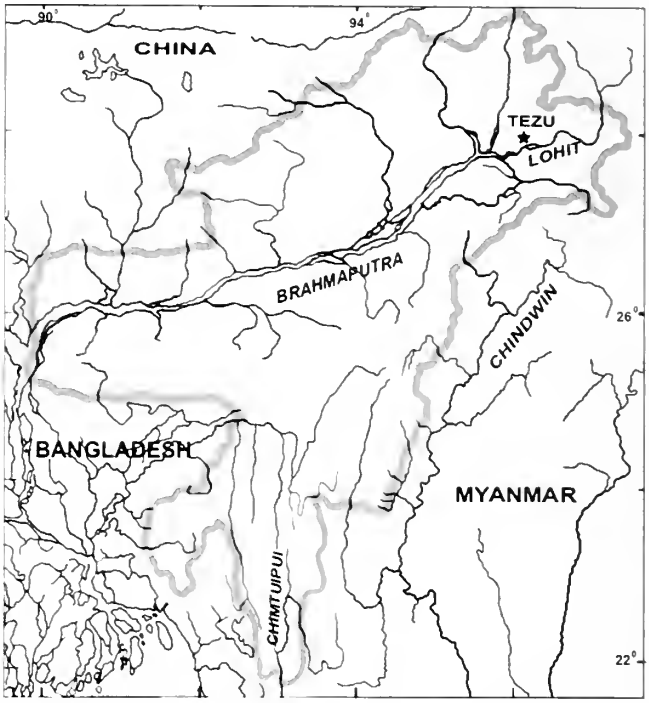


Fig. 4: Collection sites of *Channa melanostigma* sp. nov. from NE India

The new species is also similar to *C. gachua* in having white coloration at the edge of dorsal and anal fins, lateral line 46-47, and presence of 5-6 black bars on the pectoral fin. However, *C. melanostigma* is distinguished from both the species as in diagnosis above. But it is distinguished from the latter in its more number of vertebrae and more posteriorly inserted dorsal fin.

Channa melanostigma is distinguished from *C. aurantimaculata* in having less number of dorsal fin rays (36-37 vs. 45-47), last dorsal fin ray inserted between 41st and 43rd vertebrae (vs. 46th and 47th), cheek scales 5 vs. 10 and less number of circumpeduncular scales (28 vs. 34), from *C. punctatus* in having 50-51 vertebrae (vs. 35); from *C. amphibeus*, in its less numbers of lateral line pierced scales (46-47 vs. 80-81); from *C. barca*, in having continuous black bars in the pectoral fin (vs. dotted bars); from *C. bleheri* in having pelvic fin (vs. absence); from *C. harcourtbutleri* in having 10 scales below the lateral line (vs. ½7-½8) and from *C. marulius* and *C. striata* by the presence of two large cycloid scales on each side of the undersurface of lower jaw (vs. absence).

The new species is easily distinguished from *Channa nox* of China and *C. orientalis* of Sri Lanka in presence of pelvic fin (vs. absence); *C. panaw* of Myanmar in having 27-28 circumpeduncular scales (vs. 21-24); *C. ornatipinnis* of Myanmar in absence of three dorsal fin blotches (vs. presence); and *C. pulchra* of Myanmar in absence of one anterior dorsal fin blotch (vs. presence). The species is also distinguished from *C. argus* of China, *C. baramensis* of Malaysia; *C. bankanensis*, *C. lucius*, *C. cyanospilos*, *C. melanopterus*, *C. melasoma*, *C. micropeltes*, and *C. pleurophthalmus* of Indonesia by the presence of two large cycloid scales on each side of the undersurface of lower jaw (vs. absence).

Hora and Mukerji (1934) synonymised *Channa harcourtbutleri* with *C. gachua*. However, Ng *et al.* (1999) resurrected the species from synonymy and reported it to be endemic in Inle lake of Myanmar. Menon (1954) listed *C. harcourtbutleri* from Manipur without any collection data. This was probably a misidentification of *C. gachua*.

Vishwanath and Geetakumari (2009) recognized two groups of *Channa* in north-east India, namely 'gachua-group', with large cycloid scales on each side of the undersurface of lower jaw which included *C. amphibeus*, *C. aurantimaculata*,

C. barca, *C. bleheri*, *C. gachua*, *C. punctata*, *C. stewartii* and 'marulius-group' without the scales as in the above which included *C. striata* and *C. marulius*. The new species under description belong to the 'gachua-group' as its has large cycloid scales.

General inventory and phylogenetic study of the diverse species of *Channa* in north-east India and adjoining areas is awaited.

Comparative Material: *Channa amphibeus*: ZSI 11435, 1, neotype, 184.6mm SL; INDIA: Northern Bengal. *Channa aurantimaculata*: MUMF-Per 01, 2, 175-182.0 mm SL; INDIA: Arunachal Pradesh, Lohit district, Teju river. GUBM (Guwahati University Biodiversity Museum uncat., 1 ex, 345 mm SL; INDIA: Assam, Guijan. *Channa barca*: ZSI 1387, 1 ex, 260.7 mm SL; INDIA: Calcutta. GUBM uncat., 1 ex, 447.7 mm SL, INDIA: Assam, Guwahati, Marigoan Market; MUMF-Per 44 (2), 295-298 mm SL, INDIA: Assam, fringe area of Pobitora Wildlife Sanctuary, Morigaon. *Channa bleheri*: MUMF-Per 03, 2, 148.4-149.1 mm SL, INDIA: Arunachal Pradesh, Dikrong river, Doymukh; BMGU uncat., 1 ex, 121.0 mm SL, INDIA: Assam, Tinsukia district. *Channa gachua*: ZSI F 2705, 1 ex, 246.0 mm SL, BANGLADESH: Bulagunj, Sylhet; MUMF-Per/0004 (6), 112.8-112.9 mm SL, INDIA: Manipur, Nambul River, Singda. *Channa harcourtbutleri*: ZSI F 9439, 1 ex, 189.0 mm SL, MYANMAR: Inle Lake, S. Shan states. *Channa marulius*: MUMF uncat., 1 ex, 488.0 mm SL, INDIA: Manipur, Barak river, Vanchengphai, Tamenglong district; MUMF-Per 25, 7, 97.8-151.6 mm SL, Chindwin Basin, Moreh, India. *Channa punctata*: ZSIF 7688, 1 ex, 144.6 mm SL, INDIA: Bihar, Bhagmati River, Purnea, Champaran district; MUMF-Per 13, 6, 95.6-105.9 mm SL, INDIA: Manipur, Nambul River, Singda. *Channa stewartii*: ZSI 10024, 1, 170.0 mm SL, INDIA: Meghalaya, Shillong; MUMF-Per 21, 2, 109.7-155.2 mm SL, INDIA: Arunachal Pradesh, Deopani river, Rowing, Lower Devang Valley district; BMGU uncat., 1 ex, 260.0 mm SL, INDIA: Assam, Guijan. *Channa striata*: ZSI F 12922, 1 ex, 247.6 mm SL, INDIA: Andhra Pradesh, Cheyyeru river, near Razampeta; MUMF-Per 31, 8, 164.8-187.0 mm SL, INDIA: Manipur, streams near Imphal valley.

ACKNOWLEDGEMENTS

We are grateful to Prof. M.M. Goswami, Guwahati University, for donating *Channa barca* from his collection and also for permitting to examine his collections in GUBM. We thank Dr. K. Nebeshwar Sharma for collecting *Channa* specimens from Arunachal Pradesh. The first author is grateful to Manipur University for the award of UGC research scholarship. The second author is grateful to the Ministry of Environment & Forests, Government of India for financial assistance (Project No. 14/11/2006-ERS/RE).

REFERENCES

BAGRA, K., K. KADU, K.N. SHARMA, B.A. LASKAR, U.K. SARKAR & D.N. DAS (2009): Ichthyological survey and review of the checklist of fish fauna of Arunachal Pradesh, India. *Checklist 5(2)*: 330-350.

GREENWOOD, P.H. (1976): A review of the family Centropomidae (Pisces: Perciformes). *Bulletin of the British Museum (Natural History) 29(1)*: 1-81.

HAMILTON, F. (1822): An account of the fishes found in the River Ganges and its branches. Archibald Constable and Company, London. 405 pp., 39 pls.

HOLLISTER, G. (1934): Clearing and dyeing fish for bone study. *Zoologica 12*: 89-101.

HORA, S.L. & D.D. MUKERJI (1934): Notes on fishes in the Indian Museum. XXII. On a collection of fish from the S. Shan states and the Pegu Yomas, Burma. *Record of Indian Museum 36*: 125-138.

LI, X., P. MUSIKASINTHORN & Y. KUMAZAWA (2005): Molecular phylogenetic analysis of snakeheads (Perciformes: Channidae) using mitochondrial DNA sequences. *Ichthyological Research 53*: 148-159.

MCCLELLAND, J. (1845): Description of four species of fishes from the rivers at the foot of Boutan Mountains. *Journal of Natural History, Calcutta 5(18)*: 274-282.

MENON, A.G.K. (1954): Further observations on the fish fauna of the Manipur State. *Records of Indian Museum 52(1)*: 21-26.

MUSIKASINTHORN, P. (1998): *Channa panaw*, a new channid fish from the Irrawaddy and Sittang River basins, Myanmar. *Ichthyological Research 45*: 355-362.

MUSIKASINTHORN, P. (2000): *Channa aurantimaculata*, a new Channid fish from Assam (Brahmaputra River basin), India, with designation of a neotype for *C. amphibeus* (McClelland, 1845). *Ichthyological Research. 47*: 27-37.

NATH, P. & S.C. DEY (2000): Fish and Fisheries of north-eastern India (Arunachal Pradesh) Narendra Publishing house, Delhi. Pp. 1-217.

NG, H.H., P.K.L. NG & R. BRITZ (1999): *Channa harcourtbutleri* (Annandale, 1918): a valid species of snakehead (Perciformes: Channidae) from Myanmar. *Journal of South Asian Natural History 4(1)*: 57-63.

PLAYFAIR, R.L. (1867): On the fishes of Cachar. *Proceedings of Zoological Society, London* (Pt. 1): 14-17, pl. 3.

SEN, N. (1999): Notes on a collection of fishes from Lohit, Tirap and Changlang districts of Arunachal Pradesh: India. *Records of zoological survey of India, 97(Part 2)*: 189-204.

SEN, T.K. (2006): Fauna of Arunachal Pradesh. State Fauna Series, Zoological Survey of India, 13 (Part 1): 317-396.

SHAW, G.E. & E.O. SHEBBEARE (1937): The fishes of Northern Bengal. *Journal of Royal Asiatic Society of Bengal, Science*: 137, 6 pls.

VIERKE, J. (1991): Ein farbenfroher neuer Schlangenkopffisch aus Assam *Channa bleheri* spec. nov. *Das Aquarium. 259*: 20-24.

VISHWANATH, W. & KH. GEETAKUMARI (2009): Diagnosis and inter-relationships of fishes of the genus *Channa* Scopoli (Teleostei: Channidae) of northeastern India. *Journal of threatened taxa 1(2)*: 97-105.

■ ■ ■

REVIEWS

1. CONSERVATION BIOLOGY: A PRIMER FOR SOUTH ASIA by Kamaljit S. Bawa, Richard B. Primack and Meera Anna Oommen (2011). Universities Press, Hyderabad. 589 pp. Size: 24.2 cm x 14.6 cm. Paperback. Price: Rs. 595/-.

This book was first published by Sinauer Associates, Inc. in 2004 as A PRIMER OF CONSERVATION BIOLOGY. ATREE and Universities Press need to be congratulated for publishing the revised and updated version in the present form, mainly for students, field researchers and field managers. The book covers almost every possible topical conservation topic so there is something for every category of reader: from genetics of marine turtles of India to reserve size and characteristics; from reconciliation ecology to repairing the rain forest. The language is lucid with relevant references, wherever required. Topics that do not fit in the flow of the text are given as box items, which can be read along with the chapter or separately.

This voluminous book with 589 pages consists of only seven chapters but each chapter is divided into sub-chapters, sections, boxes etc. Each chapter ends with a Summary and Suggested Readings; the references listed under Suggested Readings too are explained in brief. I hope such minor details will greatly help students of conservation biology. The papers selected in the suggested readings (among thousands of papers published during the last 30-35 years) are chosen with great care and should be read or referred to by conservation biologists, protected area managers and decision makers. Besides the suggested readings, the reference section runs to 77 pages, which itself shows the in-depth research done by the authors.

As the book is a primer, it has some basic information about biodiversity, food chain and food web, natural extinction rates, but at the same time the book contains information on new topics such as ecological economics, common property resources, environmental ethics, extinction vortices etc. Good black-and-white pictures are added for emphasis and they make the book very interesting. Captions to pictures and diagrams provide a wealth of information.

All in all, it is a good book particularly for students and young field biologists, but I think protected area managers, who may have undergone various trainings, will also benefit from this book. While reviewing it, I learnt many things from this book; it is indeed true that there is no limit to knowledge!

■ ASAD R. RAHMANI

2. THE VANISHING HERDS: THE WILD WATER BUFFALO, by Anwaruddin Choudhury (2010). Critical Ecosystem Partnership Fund, ATREE, Gibbon Books and The Rhino Foundation for Nature in NE India. Guwahati, Assam. 184 pp. Size: 18.0 cm x 24.3 cm. Hardbound. Price: Rs.1,250/-.

Dr. Anwaruddin Choudhury is one of India's most prolific natural history writers with an enviable credit of nearly 500 research papers and popular articles, and nearly 20 books and booklets. He is also a widely travelled naturalist, particularly in north-east India. Basically a geographer by education, his knowledge is reflected in his meticulous writings of areas, locations and habitats. Anwar also takes pictures, sometimes seemingly uninteresting at the time of photography, but he uses them very intelligently in his papers and books to emphasize a point. This book is a classical example of how good photographs can be woven into a story. In this book, one can get good information on the Wild Water Buffalo from the photographs and their captions.

The text is also a classical Anwar standard and style: meticulous research quoting even *Babur-nama* (1483-1531) to the latest papers (2009), including websites (latest download July 10, 2009), detailed personal observations (for example see Table 11, page 93), interesting box items (see Box 5, p 47-48), and easy-to-read text.

The book is divided into seven chapters, excluding Appendices, Glossary and Bibliography. It is sad to see from the maps how the historical distribution of the Wild Buffalo has contracted from millions of sq. km, comprising areas from southern Iran, Pakistan, India, to the whole of East Asia, to present-day distribution in a few protected areas such as Manas, Kaziranga, Dibru-Saikhowa and a few others. From millions of animals a couple of hundred years ago, the total estimated population today is not more than 5,000 globally and in India, one time its main stronghold, the total suitable habitat left for the Wild Buffalo is only 2,500 sq. km. There are only two small areas in south-east Asia, one in Thailand and another in Cambodia, where currently Wild Buffalo are reported in very small numbers, not more than 30-40 animals each. Anwaruddin has also described the famous 'Wild'

Buffaloes of Sri Lanka, but as he rightly says, they had originated from domestic animals, like the 'Wild' Buffaloes of Australia. Interestingly, the so-called Wild Buffalos of Australia are a fair 'game' and people pay hundreds of dollars to hunt them.

The fourth chapter *Ecology and Behaviour* is very interesting to read. Although Anwaruddin has not worked full-time on this species (he is a full-time government officer in Assam), he has collected and collated all the information on Wild Buffalo behaviour in this chapter, and added his own observations of the last 20 years. In the next chapter, he describes the controversy of wild, domestic and hybrid buffaloes. The sixth chapter, *Conservation*, makes sad reading of what we have done to this majestic animal. The Wild Buffalo is not only a majestic animal, but it is extremely important for our agricultural economy, as all the domestic buffalos have originated from their wild relative. If the Government of India implements the recommendations given in the final chapter of this book, it may possibly increase the number of Wild Buffalo and perhaps reintroduce it in the areas where it was lost, such as Dudhwa National Park in Uttar Pradesh.

In a nutshell, this is a very useful book on an economically useful animal. I hope the Government of India and other range countries will take effective measures to restore, protect and save the Wild Buffalo. For this to happen, we need inter-state and international collaborations. Looking at the false pride, strained inter-state relationships and geopolitics, collaboration for Wild Buffalo conservation appears more difficult than writing a well-researched book.

■ ASAD R. RAHMANI

MISCELLANEOUS NOTES

1. FIRST RECORD OF THE SLENDER LORIS *LORIS LYDEKKERIANUS* CABRERA 1908, IN CHENNAI CITY, TAMIL NADU, INDIA

Tara Gandhi[1], Sai Archana Para[2,3] and Amrita Sivakumar[2,4]

[1]A1 Uttaravedi, 7 Second Seaward Road, Valmiki Nagar, Chennai 600 041, Tamil Nadu, India. Email: tara_gandhi@yahoo.com
[2]Kalakshtra Foundation, Tiruvanmiyur, Chennai 600 041, Tamil Nadu, India.
[3]Email: saiarchie@gmail.com
[4]Email: riya2009kshetra@gmail.com

Slender Loris was sighted on February19, 2010, in the campus of an educational institution located in a busy residential area in south-east coastal Chennai. It was first observed and photographed by two of us (Sai Archana and Amrita) who are full-time students. We noticed it for its strange and endearing appearance, but were unable to identify it or realize its significance. After studying the photographs of February 19, 2010, and making actual observations for a few days, Tara Gandhi identified it as the Slender Loris. The identification was further authenticated and confirmed by wildlife experts. We wish to report our sighting as the first record of the species within an urban environment in Chennai.

The Sighting

Our first sighting was in a clump of low thorny trees overgrown with creepers in a secluded area of the campus where we were trying to photograph an owl at about 17:00 hrs in the evening. Archana notes, "We saw a pale greyish bundle in the tree. On first glance, I thought it to be the owl; Amrita thought it was a bat. After a series of guesses we had settled on a small monkey. As we looked at it, the bundle began to separate and we realized that the creature was not one, but two! They stared at us with their large, round, marble-like eyes with dark markings surrounding them, and we at them. They slowly began ascending the branches of the canopy, always keeping a steady gaze on us. We lost track of one of them, but although clearly increasing the distance between us, the other one still maintained eye contact. The higher it went, the more difficult it became to distinguish it from the dead leaves of the branches."

Subsequently, over the next few weeks (February 20-March 15, 2010), we made several more observations at the same site as well as at other spots in the campus, and we counted four individual animals, including one infant clinging to its mother's underbelly. Sometimes they would be curled up in a bundle, either separately, or two or more together, and at other times we saw them moving slowly along the thin branches of trees. As there were two distinct spots more than 200 m apart where the lorises were seen repeatedly, we were unsure as to whether there were two separate groups or whether they were the same individuals who had moved from one place to the other. We took several more photographs on these occasions. All the photographs were taken with a small amateur camera with a limited zoom lens. The flash was used only when the lorises were seen in shady recesses.

Status of the Species

The Slender Loris *Loris lydekkerianus* belongs to a group of lesser-known arboreal primates characterised by small body with long slender limbs and no tail, rounded head with short sharp muzzle, large round eyes, insectivorous diet and generally solitary, nocturnal lifestyle. Sexes are alike though males are slightly larger. There are only two strepsirrhine primate genera found in India, *Loris* and *Nycticebus*. The Slow Loris (*Nycticebus*) occurs in north-east India and parts of South-east Asia, and the Slender loris (*Loris*) is found in southern India, south of the Tapti and Godavari rivers up to 800 m, and in Sri Lanka (Menon 2003). The general habitat of the Slender Loris is open scrub jungle, dry deciduous and evergreen forests, but there are records of the species occurring in human-dominated landscapes like plantations or other cultivations and even in the greener parts of some urban and rural areas.

To quote Radhakrishna (2004), "The slender loris is called *kadupapa* in Kannada, which quite literally translates as 'forest baby'. In Tamil, it is called *thevangu*. According to popular folklore, various body parts of the slender loris, most particularly its eyes, impart strength when consumed and potions made out of boiling its flesh and organs are recommended to cure ailments. Hunted for use in folk medicine, killed due to superstitious beliefs about the ill-luck it brings, trapped for laboratory dissections, and driven out of its natural habitat by forest fragmentation, the slender loris is being driven towards gradual extinction. Only pocket populations of the species survive today in scrubland, forest patches and orchards in some parts of peninsular India.

Slender lorises are nocturnal in their activity pattern. They actively forage and explore during the night and sleep during the day. They are almost completely arboreal and prefer to move on thin branches that can be grasped by the digits of their limbs. Insects like ants, termites, walking sticks, and grasshoppers are eaten most often, though fruits of particular plant species like *Securinega* and *Ziziphus*, and gum from tree species like *Acacia* are also consumed".

Lorises are endangered species in India (Schedule I Wildlife Protection Act 1972). On account of their tendency to move out of protected areas, they are in need of stringent conservation measures by way of habitat improvement and protection. Poaching is a serious threat. Their slow movement, especially when they descend to the ground, makes them victims of road-kills when they encounter vehicular traffic (Mewa Singh pers.comm).

Methods

Since the sighting was by chance, no scientific methodology was followed. The search for the lorises was mostly in the evenings, before dark at the known sites as well as at other likely secluded areas with similar tree clumps. An attempt was also made to search for areas in the trees where the light did not reach through and then determine if it was leaves or fur, or perhaps owls. For majority of the time, bunches of dry leaves misled the attempts. The lorises blended in so well that they were hard to detect until they moved.

No records were made between April and September 2010, partly because of summer vacations from May to July. From July onwards, no lorises were seen, though the known sites were frequently searched; this could also be because the vegetation had grown denser during the rainy season (Chennai experienced heavy rainfall between June and September 2010), making visibility difficult. All the previous sightings made during this study were in the dry season when the leaves on the trees were sparse and there was dried leaf litter on the ground that had been swept into mounds. During the second half of the year, a single individual was recorded on October 05, 2010, and again on November 10, 2010, at 17:00 hrs three lorises, an adult and two darker coloured juveniles were sighted. These were initially sleeping in a group on a tree branch, but later began to move.

We made enquiries with other students, teachers and staff on the campus and were told that some of them had seen small animals that fitted the description of lorises as far back as three years ago. Some students had seen them two years ago as well. They had mostly been spotted on the ground while crossing from tree to tree, or walking slowly along the road. However, apart from noticing the reddish shining eyes and slow movement, they had attached no importance to the animal and therefore did not report it.

The Habitat

Coastal Chennai south of the Adyar river is characterized by a number of fairly quiet housing colonies with tree-lined avenues linked by crowded commercial roads with shops and restaurants. Several schools and cultural institutions have extensive gardens and good tree cover that provide the greenery that the area is known for. Most of these campuses were built on what was originally sandy land that was planted about fifty years ago with mixed local tree species such as Neem, Ficus varieties, Jamun, *Laburnum* and *Morus* sp. and exotics like Gulmohur, Eucalyptus, Casuarina, Cashew and various ornamental flowering plants. These are interspersed with native *Acacia* and *Prosopis* species.

The present campus is an educational institution with continuous activity and movement of people from early morning till evening. Often there are activities and programmes after dark during which there is vehicular traffic. Paths and roads within the campus are well lit at night. The fauna include over 35 species of birds, several species of snakes, geckos, lizards and amphibians, and an abundance of insects, spiders and other invertebrates like snails and slugs. The other small mammals found on the campus are palm squirrels, mongooses, domestic cats and dogs, shrews, rats and mice.

Previous Records

The last and perhaps the only previous record of the Slender Loris in the general vicinity of Chennai city was sometime around 1970, when it was seen in the campus of the Madras Christian College (MCC), located in the western suburb of Tambaram. At that time Tambaram was outside the city limits and the MCC abutted the Vandalur reserve forest, an extensive scrub jungle that was still relatively undisturbed. Several rare wildlife species were recorded by the zoology department of the college, among which the loris was one (Sanjeeva Raj 1973). Since then, there have been no recorded sightings of this animal in the entire area of greater Chennai. The species has now disappeared from the MCC site as well. At present, the nearest geographical location where a population of over 200 Slender Loris are known to occur is Sriharikota island (Manakadan 2008), which is about 115 km north of Chennai.

While Slender Loris is known to occur in large well-wooded urban campuses in the city of Bengaluru, there are no previous records of the species within an urban environment in Chennai.

Discussion

The occurrence of a shy and highly endangered primate like the Slender Loris in an urban setting comes as a surprise and an exciting discovery, particularly as they are evidently breeding successfully and there is some indication of their presence at this site during the past few years. It is known that lorises do adapt to certain human-dominated landscapes (Honnavalli *et al.* 2009), and they have also been recorded in the city of Bengaluru, where there are over 100 individuals inhabiting its few and fast disappearing green pockets (Gandhi 2008).

However, the history of these animals at this particular site in Chennai is still puzzling. At present we can only speculate about the origins of this group that we have found. They could perhaps have escaped from captivity, or they may be released pets that had managed to survive in the wooded campus surroundings. On the other hand they could be wild lorises that had somehow adventurously migrated from their natural habitat, though it is hard to imagine since there are no natural corridors left in-between the congested urban development. It is also possible that the animals had been there all along, but had not been noticed on account of their reclusive nocturnal habits.

The Guindy National Park which is an extensive forest in Chennai dating back to colonial times is located less than 6 km from this site. Despite its rich biodiversity, it has no records of the loris and the only primate known to occur there is the Bonnet Macaque *Macaca radiata*. Though Chennai has an active community of birdwatchers and nature photographers, the loris has never been recorded in their urban wildlife checklists.

An extended study is required before any conclusions can be drawn on the status of this species in the city and it is important to conduct detailed surveys of similar green pockets in the immediate vicinity as well. These will provide insights into the occurrence of the Slender Loris in Chennai and will help put conservation action into place.

We hope to continue our investigations to gather more information and intend to maintain careful records of all further sightings of this curious and enigmatic animal.

ACKNOWLEDGEMENTS

We wish to express our gratitude to Mr. Preston Ahimaz, Prof. Dr. Sanjeeva Raj, Mr. K.V. Sudhakar, Dr. Ravi Chellam, Dr. Ajith Kumar, Prof. Mewa Singh and Mr. Kumaran Sathasivam for generously providing papers, articles and information.

REFERENCES

Gandhi, D. (2008): Touch and go for the Slender Loris. The Hindu, May 14, 2008. Bangalore.

Honnavalli, N.K., Mohammed Irfan-Ullah, S. Kumar (2009): Mapping potential distribution of slender loris subspecies in peninsular India. *Endangered Species Research 7*: 29-38.

Manakadan, R. (2008): Sriharikota – Wilderness Regained? *Hornbill* Oct-Dec 2008. Pp. 107-111.

Menon, V. (2003): Field Guide to Indian Mammals. Dorling Kindersley (India).

Radhakrishna, S. (2004): Sociality in a Solitary Primate: How Gregarious is the Slender Loris? *Resonance* January, 2004.

Sanjeeva Raj, P.J. (1973): Mammals of our Campus. *The Madras Christian College Magazine* Vol. XLII.

2. A NOTE ON THE DIET OF TIGER *PANTHERA TIGRIS* LINNAEUS AND DHOLE *CUON ALPINUS* PALLAS IN A MONTANE SHOLA FOREST, WESTERN GHATS, INDIA

Tharmalingam, Ramesh[1,2] and Riddhika Kalle[1,3]

[1]Wildlife Institute of India, Chandrabani, P.O. Box 18, Dehradun 248 001, Uttarakhand, India.
[2]Email: ramesh81ngl@gmail.com
[3]Email: riddhikalle@gmail.com

Diet studies of large carnivores from the montane shola grasslands are poorly understood. Food habits of large carnivores have been reported from the scrub jungle (Cohen *et al.* 1978; Arivazhagan *et al.* 2007) and deciduous forest (Johnsingh 1983; Karanth and Sunquist 1995; Venkataraman *et al.* 1995; Andheria *et al.* 2007; Ramesh *et al.* 2009) of the Nilgiri Biosphere Reserve, Western Ghats. We present notes on the diet of tiger and dhole from a three-day survey in Mukurthi National Park in February 2010. The study was conducted in the Mukurthi National Park (>1,800-2,500 m above msl) of the Nilgiris, which comprises of rolling hills and mountains of the evergreen shola grasslands. The sholas are confined to depressions and folds in the mountain characterized by small (7-15 m) and medium (15-20 m) sized trees (Von Lengerke and Blasco 1989). Annual rainfall ranges from 1,500-2,000 mm. Frost is frequent from December to February.

During this survey, scats of tiger (n = 30) and dhole (n = 37) were collected opportunistically whenever encountered along roads and trails. Prey species hair remains from each scat were observed under a high magnification microscope and compared with reference slides at the research laboratory of Wildlife Institute of India, Dehradun.

Scat analysis revealed the presence of three prey species in tiger scats and five prey species in dhole scats. Percent occurrence of prey items in tiger and dhole scats was calculated. Tiger scats comprised of Sambar *Rusa unicolor* (78.8%), Rodent (18.4%) and Wild Pig *Sus scrofa* (2.6%), while dhole scats comprised of Sambar (51.6%) rodent (35.5%), Wild Pig (6.5%), Black-naped Hare *Lepus nigricollis* (3.2%) and bird (3.2%) remains. It is evident that tiger and dhole depend mainly on sambar as the major prey along with secondary prey species like small mammals. In comparison to the deciduous forest, which is considered as a prey rich habitat with a much wider choice of large body-sized prey (Ramesh *et al.* 2009), the shola grasslands of Mukurthi harbour low density of prey species and absence of chital (a major prey in other tiger habitats) in the area. Large carnivores have the potential to survive even in low densities in Mukurthi National Park. Further comprehensive studies are needed to document food habits of large predators from montane sholas of India.

ACKNOWLEDGEMENTS

We thank the Tamil Nadu Forest Department for providing logistic support and permits. We also thank our assistants, C. James and S. Mathan for field support.

REFERENCES

Andheria, A.P., K.U. Karanth & N.S. Kumar (2007): Diet and prey profiles of three sympatric large carnivores in Bandipur Tiger Reserve, India. *J. Zool. (Lond.) 273*: 169-175.

Arivazhagan, C., R. Arumugam & K. Thiyagesan (2007): Food habits of leopard (*Panthera pardus fusca*), dhole (*Cuon alpinus*) and striped hyena (*Hyaena hyaena*) in a tropical dry thorn forest of southern India. *J. Bombay Nat. Hist. Soc. 104(2)*: 247-254.

Cohen, J.A., M.W. Fox, A.J.T. Johnsingh & B.D. Barnett (1978): Food habits of the dhole in south India. *J. Wildl. Manage. 42*: 933-936.

Johnsingh, A.J.T. (1983): Large mammalian prey-predators in Bandipur. *J. Bombay Nat. Hist. Soc. 80(1)*: 1-57.

Karanth, K.U. & M.E. Sunquist (1995): Prey selection by tiger, leopard and dhole in tropical forests. *J. Anim. Ecol. 64*: 439-450.

Ramesh, T., V. Snehalatha, K. Sankar & Q. Qureshi (2009): Food habits and prey selection of tiger and leopard in Mudumalai Tiger Reserve, Tamil Nadu, India. *J. Sci. Trans. Environ. Technov. 2*: 170-181.

Venkataraman, B.A., R. Arumugam & R. Sukumar (1995): The foraging ecology of dhole (*Cuon alpinus*) in Mudumalai Sanctuary, Southern India. *J. Zool. (Lond.) 237*: 543-561.

Von Lengerke, H.J. & F. Blasco (1989): The Nilgiri Environment. *In*: Hockings, P. (Ed.): Blue Mountains: the Ethnography and Biogeography of a South Indian Region. Oxford University Press, Oxford. Pp. 20-78.

3. THE SECOND LOCALITY RECORD OF *TAPHOZOUS LONGIMANUS* HARDWICKE, 1825 (CHIROPTERA: EMBALLONURIDAE) FROM NEPAL

S.B. Thapa[1], M.J. Pearch[2] and G. Csorba[3]

[1]Small Mammals Conservation and Research Foundation, P.O. Box 13153, Sundhara, Kathmandu, Nepal. Email: sanjan_thapa@yahoo.com
[2]Harrison Institute, Centre for Systematics and Biodiversity Research, Bowerwood House, 15 St. Botolph's Road, Sevenoaks, Kent TN13 3AQ, England. Email: hzm@btinternet.com
[3]Department of Zoology, Hungarian Natural History Museum, H-1088 Budapest, Baross 13, Hungary. Email: csorba@nhmus.hu

Introduction

Six species of Emballonuridae (*Saccolaimus saccolaimus*, *Taphozous longimanus*, *T. melanopogon*, *T. nudiventris*, *T. perforatus* and *T. theobaldi*) are recorded from the Indian subcontinent (Bates and Harrison 1997). The sole representative of the Family from Nepal is *T. longimanus*, six specimens of which were collected by R.M. Mitchell from Jhapa (26° 29' N; 87° 51' E) in the eastern Terai of Nepal in January, 1966 (Worth and Shah 1969; Mitchell 1978). In February 2009, a single dead male specimen of *T. longimanus* was found by the first author in Samrat Chowk, a suburb of Biratnagar, 56 km due west of Jhapa (Fig. 1). This is the second locality record of the taxon in Nepal.

Nepal lies within the Himalaya Hotspot as defined by Conservation International (www.biodiversityhotspots.org) and both Biratnagar and Jhapa are located in the critical/ endangered Global 200 terrestrial ecoregion number 91, Terai-Duar Savanna and Grasslands (Olson and Dinerstein 2002).

Material and Methods

The voucher specimen was transferred from the collection site to the Central Department of Zoology (CDZ), Tribhuvan University, Kathmandu, where it is retained as a

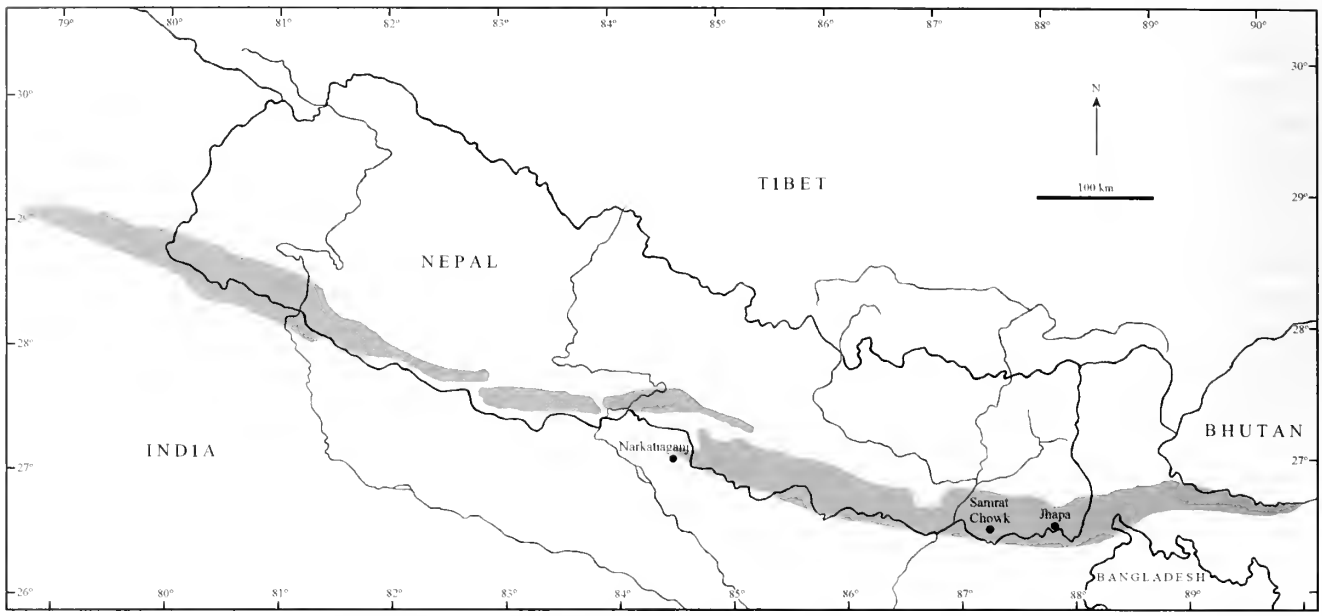


Fig. 1: Map showing the recorded distribution of *T. longimanus* in Nepal, the northernmost record of the species from Narkatiaganj in India, and the delineation of the Terai-Duar Savanna and Grasslands (shaded area)

Table 1: Selected external, cranial, and dental measurements of *T. longimanus* from Samrat Chowk, Nepal (to the nearest 1.0 mm) and of *T. longimanus* from India and Sri Lanka (to the nearest 0.1 mm)

	Samrat Chowk, Nepal (CDZ_BAT 7)	India and Sri Lanka (Bates & Harrison, 1997)			
		n	mean	range	n
HB	73.0	1	78.3	73.0 - 86.0	33
T	25.0	1	24.4	20.0 - 30.0	32
TIB	25.0	1	-	-	-
HF	12.0	1	11.5	8.0 - 14.0	30
FA	61.0	1	59.2	55.6 - 62.0	31
3mt	61.0	1	59.8	55.8 - 64.0	22
1ph3mt	22.0	1	21.6	20.4 - 22.7	22
E	18.0	1	17.2	16.0 - 19.0	33
GTL	22.0	1	21.4	20.2 - 22.0	29
CCL	19.0	1	20.0	19.2 - 21.6	30
ZB	12.0	1	12.5	12.0 - 12.9	27
BB	10.0	1	9.9	9.5 - 10.2	28
C-M3	9.0	1	8.9	8.7 - 9.2	32
c-m3	10.0	1	9.8	9.4 - 10.2	30
M	16.0	1	15.8	15.4 - 16.4	30

HB – head and body length; T – tail length; TIB – tibia length; HF – hindfoot length; FA – forearm length; 3mt – third metacarpal length; 1ph3mt – length of the first phalanx of the third metacarpal; E – ear length; GTL – greatest length of skull; CCL – condylo-canine length; ZB – zygomatic breadth; BB – breadth of braincase; C-M3 – maxillary toothrow length; c-m3 – mandibular toothrow length; M – mandible length.

wet specimen in 70% ethanol with the skull extracted. Fifteen external, cranial, and dental measurements were taken and these are presented in Table 1 together with comparative measurements of specimens of *T. longimanus* from India and Sri Lanka listed in Bates and Harrison (1997).

Systematic Review

Taphozous longimanus Hardwicke, 1825.
Transactions of the Linnean Society of London, 14: 525.
Type Locality: Calcutta (now Kolkata), India
Common Name: Long-winged Tomb Bat

Variation

Bates and Harrison (1997) and Simmons (2005) refer all *T. longimanus* in the region to the nominate form, as the taxa *brevicaudus*, *cantori*, and *fulvidus* are no longer regarded as being distinct. Csorba *et al.* (1999) refer specimens from Nepal to the nominate subspecies on the same grounds.

IUCN (2010) status - Least concern (Bates *et al.* 2008).

Material

1 ♂ (adult): Reg No: CDZ_BAT 7; Samrat Chowk (26° 28' 46.30" N; 87° 17' 8.18" E), Pokharia, Biratnagar-1, Nepal, 72 m above msl; 25.ii.2009, Coll. Thapa, S.B.

The collection site is located in the eastern part of the Terai-Duar Savanna and Grasslands (Terrestrial ecoregion IM0701; Global 200 ecoregion no. 91) (Fig. 1), which is a composite mixture of tropical and subtropical grasslands, savannas, and shrublands supporting mainly an Indo-Malayan fauna (WWF 2001).

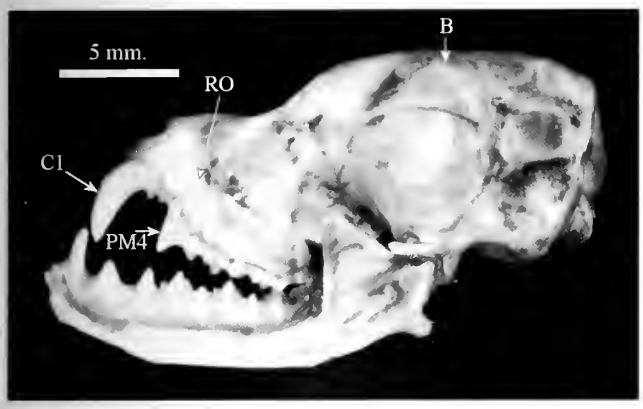


Fig. 2: The skull of CDZ_BAT 7 showing the relative lengths of the upper canine (C1) and the second upper premolar (PM4) and the elevation of the braincase (B) above the rostrum (RO)

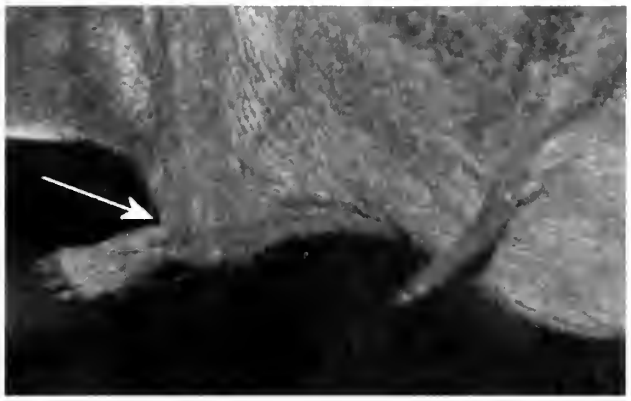


Fig. 3: Detail of the hindfoot and leg of CDZ_BAT 7 showing the attachment of the wing to the ankle (arrowed) and the protrusion of the tip of the tail from the mid-point of the interfemoral membrane

Diagnosis and Description

The specimen has a long third metacarpal (61 mm); a naked chin; a prominent gular sac; and a moderately developed radio-metacarpal pouch at the junction of the forearm and the fifth metacarpal. The wing is attached to the ankle. Fur on the dorsal and ventral areas extends approximately to one half the length of each humerus and femur; the wings are otherwise naked. In the skull, the braincase is elevated above the rostrum. In the dentition, the second upper premolar (PM4) is robust and extends roughly to three-quarters the height of the upper canine (C1) (Fig. 2).

One of the external diagnostic characteristics most helpful in distinguishing between the Emballonurid species known from the Indian subcontinent is the attachment point of the wing. In *Taphozous melanopogon*, *T. nudiventris*, *T. perforatus*, and *T. theobaldi*, the wing is attached to the tibia; in *T. longimanus* and *Saccolaimus saccolaimus*, it is attached to the ankle (Fig. 3). Characteristics that may be used to distinguish between the last two species include the chin, which is naked in *longimanus* but which is covered in short hairs in *saccolaimus*, and a radio-metacarpal pouch, which is present in *longimanus* (Fig. 4), but absent in *saccolaimus*.

Ecology and Habitat

The bat was found dead on a road in Samrat Chowk, which is a small residential area of Pokharia located within Biratnagar Submetropolitan City Ward no. 1. Approximately 50 m from the road lies a small group of teak trees *Tectona* sp. The road terminates 1 km to the east of the collection site at the Singia river, where there is a wooded area dominated by the Indian Rosewood *Dalbergia sissoo*. Beyond the Singia river, there are large, open fields, in which rice *Oryza* sp. is grown in summer and wheat *Triticum* sp. in winter. There are a few small areas of cultivated sugarcane *Saccharum* sp. Areas to the immediate north, south, and west of the collection site are dominated by buildings. The average annual daytime temperature range is 18-31 °C (DHM 2006) and the average annual minimum night-time temperature is 7.7 °C (Central Bureau of Statistics 2009). Annual rainfall is approximately 157 mm (DHM 2006).

Elsewhere in its range, *T. longimanus* has been collected from hollows in the trunks of banyan and peepal trees, the crowns of palm trees, the domed roof of a church (Sinha 1986) and from the partially sunlit eaves of houses (Wroughton 1913). The species has been observed to be a solitary forager, flying commonly at heights of 25 to 62 m with occasional fast, swooping runs close to the ground at sites of high insect activity (Pearch and Writer 2009). Sinha (1986) considered the species' favoured diet to be cockroaches and beetles.

Fig. 4: Right wing of CDZ_BAT 7 showing the presence of a radio-metacarpal pouch (arrowed) and the extension of the fur to one half the length of the humerus

Discussion

The collection of *T. longimanus* from Samrat Chowk represents the second record of the species, of the genus, and of Family Emballonuridae from Nepal. It is also the fourth most northerly collection locality of the taxon, the most northerly being Narkatiaganj (*c.* 27° 06' 30" N; 84° 27' 40" E) in India (Sinha 1986) (Fig. 1).

T. longimanus is a well-documented taxon throughout its range with 16 locality records alone in the adjacent Indian state of Bihar (Bates and Harrison 1997). The Chiroptera of Nepal and the small mammal fauna of the country in general, however, remain under-researched and this is evinced by the fact that *T. longimanus* is one of the 11 bat species (or 22% of Nepal's documented bat fauna) known from no more than two localities in the country. A further 14 bat taxa (28%) are known only by a single specimen or from just a single locality (Pearch *in press*).

Of the 50 bat species with substantive collection records from Nepal, only *T. longimanus* and *Murina cyclotis* are restricted exclusively to the critical/endangered Terai-Duar Savanna and Grasslands (Pearch *in press*). Although *T. longimanus* may not be directly affected by these changes, major and persistent threats to the ecoregion include the clearance of rare tall grasslands for agriculture, over-grazing, logging, erosion, poaching, and the diversion of watercourses for irrigation (WWF 2001). The main driver of such ecological disturbance is over-population, which is occasioned largely by the resettlement of workers from growing communities in highland areas, where human expansion is limited by topographical constraints. Accordingly, research into methods of reducing such resettlement would be of tangible benefit to the endangered habitats in the southern part of the country.

With the recent improvements in access to many parts of the country, a tremendous opportunity presents itself to revitalise the study of the nation's fauna and it would seem sensible to suggest that surveys be undertaken to determine the small mammal composition of some of the country's more threatened areas, including the Terai, before the growth of habitat degradation gathers pace. This point was addressed by Pearch (*in press*), who propounded a series of recommendations for biodiversity assessments in protected and other areas of Nepal.

ACKNOWLEDGEMENTS

In Nepal, the first author is pleased to acknowledge the encouragement provided to him by Dr. Sarala Khaling and Ang Phuri Sherpa of the Critical Ecosystem Partnership Fund and would like to thank Sagar Dahal of the Small Mammals Conservation and Research Foundation for assisting with skull preparation. In India, we thank Sally Walker, Sanjay Molur, B.A. Daniel, R. Marimuthu, and the Zoo Outreach Organization, Coimbatore. The authors are indebted to David Harrison and Paul Bates of the Harrison Institute, Sevenoaks, England, for their diagnostic contributions.

The first author wishes to express particular gratitude to Prof. Paul Racey for his continuous support and encouragement.

REFERENCES

BATES, P.J.J. & D.L. HARRISON (1997): Bats of the Indian Subcontinent. Harrison Zoological Museum. 258 pp.

BATES, P.J.J., C.F. FRANCIS, T. KINGSTON, M. GUMAL & J. WALSTON (2008): *Taphozous longimanus*. *In*: IUCN. 2010. IUCN Red List of Threatened Species. Version 2010. 4. <www.iucnredlist.org>. Downloaded on 4th December, 2010.

CENTRAL BUREAU OF STATISTICS, GOVERNMENT OF NEPAL (2009): Compendium on Environment Statistics. http://www.adb.org/Documents/EDRC/Statistics/Environment/nepal.xls Downloaded on 29th December, 2009.

CSORBA, G., S.V. KRUSKOP & A.V. BORISSENKO (1999): Recent records of bats (Chiroptera) from Nepal, with remarks on their natural history. *Mammalia 63(1)*: 61-78.

DHM (2006): Climatological and Agro-meteorological Records of Nepal, 2006. Department of Hydrology and Meteorology, Ministry of Environment, Science, and Technology, Kathmandu, Nepal.

HARDWICKE, T. (1825): Description of a new species of sheath-tailed bat (*Taphozous*) found in Calcutta. *Transactions of the Linnean Society of London 14*: 525-526.

MITCHELL, R.M. (1978): A checklist of Nepalese bats. *Säugetierkundliche Mitteilungen 26(1)*: 75-78.

OLSON, D.M. & E. DINERSTEIN (2002): The Global 200: priority ecoregions for global conservation. *Annals of the Missouri Botanical Garden 89*: 199-224.

PEARCH, M.J. (*in press*): A review of the biological diversity and distribution of small mammal taxa in the terrestrial ecoregions and protected areas of Nepal. *Zootaxa*.

PEARCH, M.J. & T.O.D. WRITER (Eds) (2009): South-East Asian Bat Database. Harrison Institute, Sevenoaks, U.K.

SIMMONS, N.B. (2005): Order Chiroptera. Pp. 312-529. *In*: Wilson, D.E. & D.M. Reeder (Eds): Mammal Species of the World. A taxonomic and geographic reference. Third edition, volume 1. The Johns Hopkins University Press, Baltimore. 743 pp.

SINHA, Y.P. (1986): The bats of Bihar: taxonomy and ecology. *Records of the Zoological Survey of India, Miscellaneous Publication, Occasional Paper No. 7*. 60 pp. + 7 pls.

WORTH, R.M. & N.K. SHAH (1969): Nepal Health Survey, 1965-1966. Honolulu (University of Hawaii Press). ix + 158 pages.

WROUGHTON, R.C. (1913): Report No. 6: Kanara. Bombay Natural History Society's Mammal Survey of India. *J. Bombay Nat. Hist. Soc. 22(1)*: 29-44

WWF (2001): www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0701_full.html. Downloaded on 4th December, 2010.

4. HIGH DAY TEMPERATURE AND SLEEP OUT BEHAVIOUR OF ELLIOT'S GIANT FLYING SQUIRREL *PETAURISTA PHILIPPENSIS* (ELLIOT) IN SITAMATA WILDLIFE SANCTUARY, RAJASTHAN, INDIA

CHHAYA BHATNAGAR[1,3], SATISH KUMAR SHARMA[2] AND VIJAY KUMAR KOLI[1,4]

[1]Department of Zoology, College of Science, M.L. Sukhadia University, Udaipur 313 001, Rajasthan, India.
[2]Forest Research Farm (Banki) Sisarma, Udaipur 313 001, Rajasthan, India. Email: sksharma56@gmail.com
[3]Email: bhatnagarchhaya@yahoo.co.in
[4]Email: vijaykoli87@yahoo.in

The Elliot's Giant Flying Squirrel *Petaurista philippensis* is confined to Mahuwa *Madhuca indica* belt of southern Rajasthan (Tehsin 1980; Chundawat *et al.* 2002; Menon 2003; Sharma 2007). This species is commonly seen in two wildlife sanctuaries of southern Rajasthan, namely, Sitamata and Phulwari-ki-nal.

It is a nocturnal animal, which usually roosts in hollows of trees or sheltered places among the branches. It comes out from its hiding sites at dusk and retires before dawn (Prater 2005).

Arampura, a forest outpost of Sitamata Sanctuary is famous for its Mahuwa groves and Elliot's Giant Flying Squirrel *Petaurista philippensis*. On May 22, 2010, the maximum temperature of Dhariwad, a station 20 km away from Arampura, was 47.7 °C. The temperature of a few surrounding stations on May 22, and 23, 2010, is given in Table 1.

Nearly a 50 m away from the outpost building, we observed a *P. philippensis* repeatedly peek from a hole in a Mahuwa tree. Despite the presence of many humans, it emerged from its hiding site at about 15:40 hrs. Within no time it skulked in the foliage slightly away from its hole. It remained hidden in the foliage for five minutes after which it slept on its back on a thick bough keeping its belly upward. Dense shade was available at this sleeping site, though a few thin light beams were penetrating down through the foliage. The squirrel remained in this posture for *c.* 15 minutes and then retired to its hole.

According to Prater (2005), during hot weather, flying squirrel may sleep on its back with legs and parachute outspread. The animal cools itself in this manner in the tropical forest.

In the present case, though a nocturnal animal, flying squirrel emerges even during day time for sleeping outside the hole. The animal was probably uncomfortable inside the hole due to the high temperature and hence ventured out to get relief from the heat.

Table 1: Maximum temperature of a few stations near Arampura on May 22 and 23, 2010

Date	Locality	Max. temp. recorded (°C)
22.v.2010	Mt. Abu	40
22.v.2010	Udaipur V	45
22.v.2010	Dhariwad	47.7
22.v.2010	Bhilwara	47
22.v.2010	Dabok	45
23.v.2010	Chittorgarh	47.5
23.v.2010	Udaipur	45.2
23.v.2010	Dhariwad	48.6
23.v.2010	Bhilwara	48

During April to June 2010, the temperatures ranged from 40-48 °C in southern Rajasthan. The internal temperatures of the hollows probably became unbearable for the flying squirrel due to high temperature conditions. To rid itself of the unpleasant temperature of the hollows, the squirrels dared to come out for sleep. This "sleep out" behaviour was seen four times in the Sitamata Sanctuary. The "sleep out behaviour" in all cases was observed during afternoon session between 14:00 hrs and 16:30 hrs. This behaviour was also noticed in Phulwari-ki-Nal Sanctuary from April to June (Hankla Gameti pers. comm. 2010).

Since Mahuwa growth is thick in Sitamata and Phulwari sanctuaries, and squirrels remain undetected due to dense foliage, it is likely that the animals feel safe under the dense cover of foliage. No natural predator was seen, so far, in the study area. It is the safety factor and high heat inside the holes which induced the "sleep out" behaviour in the squirrels.

ACKNOWLEDGEMENTS

We are grateful to the officials of the Sitamata Sanctuary for providing facilities during the study.

REFERENCES

CHUNDAWAT, P.S., S.K. SHARMA & H.S. SOLANKI (2002): Occurrence of the Large Brown Flying Squirrel (*P. petaurista philippensis*) in Phulwari Wildlife Sanctuary. *Zoos' Print Journal 17(11)*: 1941.

MENON, V. (2003): A Field Guide to Indian Mammals. Dorling Kindersley (India) Pvt. Ltd.
PRATER, S.H. (2005): The Book of Indian Animals. Bombay Natural History Society. Oxford University Press, UK.
SHARMA, S.K. (2007): Study of Biodiversity and Ethnobiology of Phulwari Wildlife Sanctuary, Udaipur (Rajasthan). Ph.D. Thesis. MLS University, Udaipur (Raj.).
TEHSIN, R.H. (1980): Occurrence of the Large Brown Flying Squirrel and Mouse Deer near Udaipur, Rajasthan. *J. Bombay Nat. Hist. Soc. 77(3)*: 498.

5. FIRST RECORD OF ALBINO SAMBAR *RUSA UNICOLOR* (KERR) FROM CORBETT NATIONAL PARK, INDIA

ANANT PANDE[1,2], DEBMALYA ROYCHOWDHURY[1], DEVLIN LEISHANGTHEM[1], SUDEEP BANERJEE[1], PUSHKAL BAGCHIE[1], NEHA AWASTHI[1], RUBI KUMARI SHARMA[1], PRIYANKA RUNWAL[1] AND SHIKHA BISHT[1]

[1]Wildlife Institute of India, P.O. Box No. 18, Chandrabani, Dehradun 248 001, Uttarakhand, India.
[2]Email: anant_pande@rediffmail.com

A rare sighting of an albino Sambar *Rusa unicolor* (Kerr 1792) was made on June 19, 2010, in the core area of the Corbett Tiger Reserve. The forest department informed us about the occurrence of a white-coloured Sambar in the Jamunagawd beat of Jhirna range. As a part of the tiger monitoring team, we visited the area to get photographic evidence.

At 29° 30' 0.8" N and 78° 55' 30.3" E, we observed a white Sambar fawn (Fig. 1) accompanied by its normal coloured mother. The fawn was pure white with reddish snout and red eyes. The inside of the ears was pinkish. The fawn was feeding on grass and did not exhibit any abnormal activity.

Fig. 1: Albino Sambar *Rusa unicolor* sighted at Corbett Tiger Reserve

Earlier Champion (1938) sighted an albino Sambar hind in the mixed Sal and Chir pine forest near Chaukhamb in the hills of Kohtri valley. Pillay (1953) also reported seeing an albino Sambar hind and an albino Sambar stag from Talamalai range of north Coimabatore. Another record of a museum specimen of albino Sambar from the Archaeological Museum of Udaipur was given by Tehsin (2006). Sangai Express (March 30, 2010) published the birth of a white coloured fawn on March 23, 2010, at Manipur Zoological Garden, Iroishemba.

REFERENCES

CHAMPION, H.G. (1938): An Albino Sambar. *J. Bombay Nat. Hist. Soc. 40(2)*: 322-323.
PILLAY, B.S. (1953): An Albino Sambar. *J. Bombay Nat. Hist. Soc. 51(4)*: 935.
TEHSIN, R.H. (2006): An Albino Sambar *Cervus unicolor* Kerr. *J. Bombay Nat. Hist. Soc. 103(1)*: 97.

6. CONSERVATION STATUS OF RAJAJI-CORBETT CORRIDOR FOR TIGER AND ELEPHANT MOVEMENT

A.J.T. JOHNSINGH[1], BIVASH PANDAV[2,3], K. RAMESH[2,4] AND QAMAR QURESHI[2,5]

[1]Nature Conservation Foundation, Mysore and WWF-India. Email: ajt.johnsingh@gmail.com
[2]Wildlife Institute of India, P.O. Box 18, Chandrabani, Dehradun 248 001, Uttarakand, India.
[3]Email: bivash.pandav@wii.gov.in
[4]Email: ramesh@wii.gov.in
[5]Email: qnq@wii.gov.in

Rajaji-Corbett corridor, composed of two stretches of forests, connects two tiger-elephant national parks in northern India. The southern stretch (*c.* 300 sq. km), including the forests of Haridwar forest division and Bijnor plantation division, is highly fragmented and heavily disturbed. Although used by elephants (*Elephas maximus*), due to high levels of

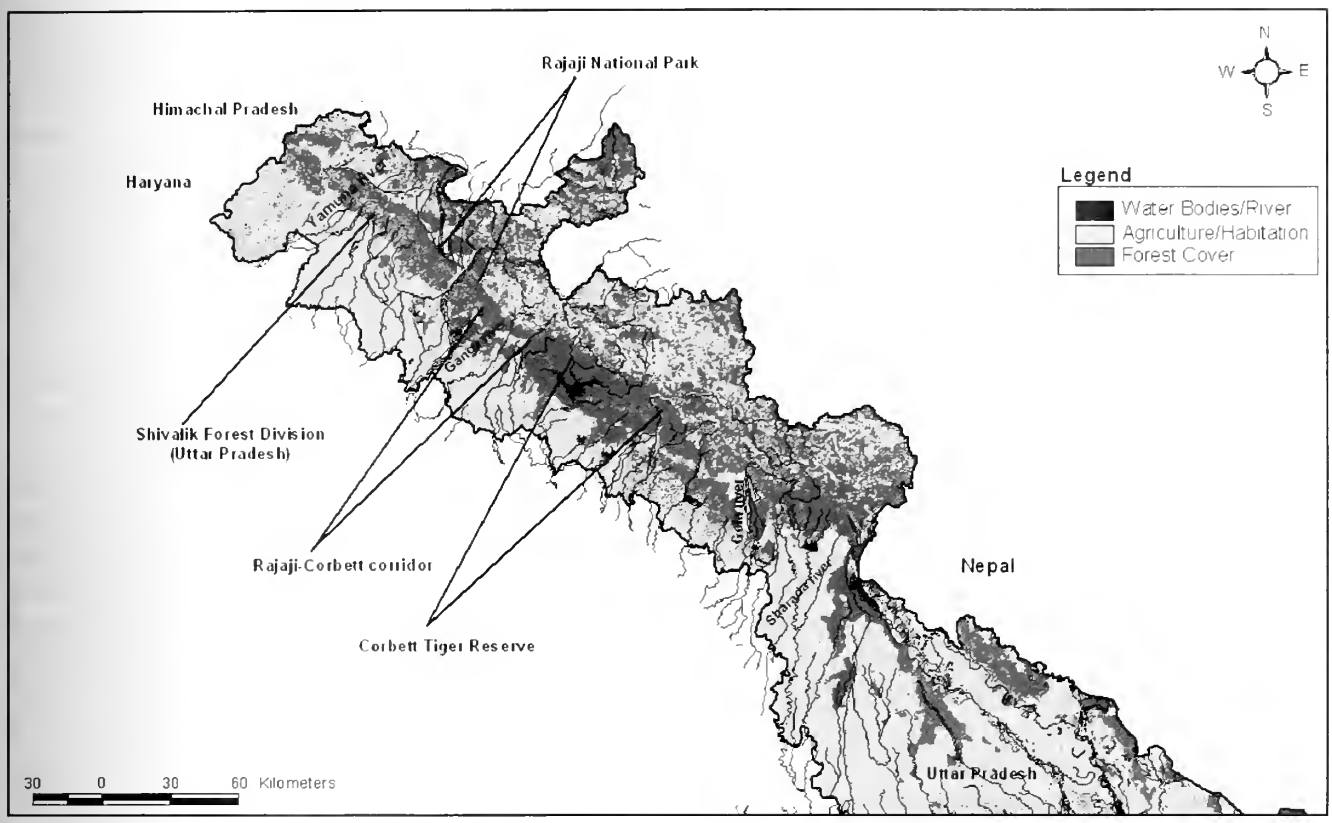


Fig. 1: Tiger-Elephant landscape in Uttarakand, northern India

disturbance, this strip of forest is avoided by the tiger (*Panthera tigris*). On the contrary, although disturbed, the northern stretch (*c.* 200 sq. km), formed by Kotdwar and Laldhang ranges of Lansdowne forest division, as it is hilly, is used both by the tiger and elephants. The future of the 60,000-70,000 people, who live on the southern boundary of the northern corridor, is closely related to the ability of these forests to sustain the water flow in the streams that arise from these forests. The best way of protecting these forests would be to highlight their importance as watershed through conservation awareness programmes to the people. Protection and management of these forests would ultimately benefit not only the tiger and elephant, but also people.

One important area for the long-term conservation of the northern Indian populations of Tiger and Elephant is the forest tract (*c.* 7,500 sq. km) between Yamuna and Sharda rivers (Fig. 1). Although the habitat connectivity in this range is broken along Ganga and Gola rivers (Johnsingh *et al.* 1990, 2004), this tract has been identified as Rajaji-Corbett Tiger Conservation Unit (TCU), one of the 11 Level I TCUs in the Subcontinent (Wikramanayake *et al.* 1998), and as Shivalik Elephant Range, one of the 11 Elephant Ranges identified in India (Bist 2002). The largest contiguous block of *c.* 4,000 sq. km habitat in this tract falls between the left bank of Ganga and Gola rivers, and evidently supports breeding populations of these species. This area encompasses the eastern part of Rajaji National Park (RNP), Corbett Tiger Reserve (CTR) and the adjacent forest divisions, including the areas between RNP and CTR, known as the Rajaji – Corbett corridor, the most crucial habitat connectivity here (Fig. 2). The eastern part of RNP has shown remarkable recovery of prey populations and tiger number after the resettlement of pastoral *gujjars* (Harihar *et al.* 2009a) and CTR supports one of the high density tiger populations (*c.* 16/100 sq. km, Jhala *et al.* 2008).

The forests of this corridor are in two stretches. One lies south of the main Himalaya, along the Shyampur-Chiriyapur forest ranges of Haridwar Forest Division (FD) in the state of Uttarakhand and Bijnor Plantation Division in Uttar Pradesh; this corridor is about 300 sq. km. The other strip of forest is in the north, along the Laldhang-Kotdwar forest ranges of Lansdowne FD in the foothills of the Outer Himalaya. The total area of this stretch is around 200 sq. km and the entire tract is in Uttarakhand. Although both the corridor forests are disturbed by biotic pressures such as grazing, fodder, firewood, gravel and sand collection, our surveys in early 2000 showed that the southern corridor is much more disturbed by the presence of numerous villages and *gujjar* (a pastoral community) camps. Yet this corridor, which is on flatter terrain, is used by elephants (groups as

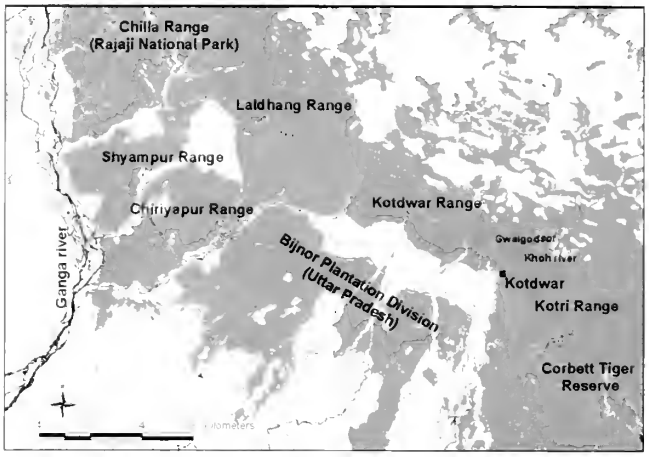


Fig. 2: Rajaji Corbett corridor

well as bulls), Leopard *P. pardus*, Nilgai *Boselaphus tragocamelus*, Chital *Axis axis* and Wild Pig *Sus scrofa*. No evidence of tiger was seen. The northern corridor (Laldhang-Kotdwar ranges) being hilly is used by tiger and other wide ranging mammals such as leopard, Sambar *Rusa unicolor* and elephant. The Himalayan foothills criss-crossed with numerous *nullahs* provide excellent cover to predators such as tiger and leopard, and areas that are free from poaching support a high density of sambar (Harihar *et al.* 2009b).

This large deer is ecologically (preference for dense cover) and behaviourally (being crepuscular and nocturnal, solitary or in small groups and non-aggressive) the most suitable prey for tiger in the hilly and mountainous parts of its range in south and south-east Asia. Sunderraj *et al.* (1993) recorded that elephant bulls use the entire northern corridor. The groups from west were unable to cross as a result of steep terrain at Gwalgod *sot*. Human disturbance was high in the entire tract. For instance, in Laldhang range (94 sq. km), Johnsingh and Negi (2003a, b) found 34 *gujjar deras* (settlements) with 203 *gujjars* and 330 buffaloes, and four *bhotia* (another pastoral community) *deras* with 17 people, 800 sheep and 250 goats. In Kotdwar range (92 sq. km), there were six *gujjar deras* with 57 *gujjars* and 82 buffaloes, and six *bhotia deras* with 38 people, 990 sheep, 290 goats and 17 ponies. *Gujjars* depend on buffaloes for their sustenance, and *bhotias* on goats and sheep. *Bhotias* use the forests only in winter, as they migrate to better pastures high up in the Himalayas during summer. When Sunderraj *et al.* (1993) studied elephants here the eastern part was heavily disturbed as a result of bamboo *Dendrocalamus strictus* collection.

In addition, Johnsingh and Negi (2003a, b) enumerated 50 villages along the southern boundary of the northern corridor (Laldhang-Kotdwar forest ranges) in a width of 5 km from the forest boundary. These villages have about 4,000 families with human population of 20,000 to 30,000. Use of the forest by these people was apparent from over 40 trails/paths into the 27 km long boundary of the corridor forests between Laldhang and Kotdwar. People use these trails for fodder and firewood collection, as well as for livestock grazing. The *gujjars* and *bhotias* living in the forest also use these trails. Similarly, along the northern boundary of this corridor, in a 3 km width, 36 villages were enumerated with about 3,000 families and a human population of 15,000 to 20,000. The Kho river forms the eastern boundary of the northern corridor (Fig. 2). The forests along the river, from Kotdwar town to about 3 km into the forest, are under enormous firewood and fodder collection pressure from the people of Kotdwar. Beyond the iron bridge across the river, this zone is extensively used by elephants.

Due to high biotic pressures, tiger use of this corridor is very much limited. In late 2002, in Laldhang-Kotdwar ranges, 35.2 km were surveyed along eight riverbeds, and only five sets of tiger pugmarks were seen. There were no pugmarks along the Malan river in Kotdwar range, or Chawariya and Nalgadi *sot* (river) in Laldhang range. Occurrence of elephant dung along the Malan riverbed, which was heavily used by villagers as a footpath, was negligible, and absent in Chawariya *sot* (Johnsingh *et al.* 2004). Although Sunderraj *et al.* (1993) did not record evidence of elephant groups east of Gwalgod *sot* in the summer of 2005, frequent movement of groups from the forests east of Kho river (Kotri range) to the river were observed, in spite of heavy traffic along Kotdwar-Lansdowne road. The groups used both banks of the river, and fed heavily on *Mallotus philippensis* and *Dendrocalamus strictus*. However, we are not certain whether they are able to cross Gwalgod *sot* and range into the western part of the corridor.

Reducing the dependency of people on the northern corridor forests, which are vital not only for the long-term conservation of tiger and elephant, but also for the water regime of the area, should be the objective of both Forest Department and conservation NGOs. In this regard, we come up with the following recommendations:

1. Awareness programmes: The best way of getting the support of the local people in protecting these corridor forests, which are vulnerable to summer fires set by people, is by convincing them that this forest is crucial to sustain the flow of water that emanates from the forest. Numerous studies (Meher-Homji 1989; Dudley and Stolton 2003) have highlighted the importance of forests in maintaining water regime and microclimate. Presently three streams (Rawasan, Malan and Kho) are perennial and two (Maili and Sigaddi) have water up to the boundary of the forest till March, remaining dry only from April to June. Kotdwar township, with about 50,000 people (the population has doubled since

1991), gets its drinking water from the Kho river. Protection of the corridor forests, which form the catchment area of these streams, therefore becomes extremely crucial. Massive and sustained conservation awareness programmes in the villages and Kotdwar township about the importance of these forests as watershed, and the need to protect them from fire, would certainly help in ultimately reducing pressures on the forests. Massive planting of local evergreen species such as *Mangifera indica*, *Putranjiva roxburghii* and *Syzygium cuminii* around springs in this corridor, involving local people, particularly school children, is likely to stimulate ecological awareness.

2. Protection: Special efforts should be made to protect the forests (from the iron bridge across Kho river near Kotdwar to Amsod village, a distance of about 5 km) from development and garbage as a result of picnicking at the river. The perennial and scenic, small river can attract encroachers, and the abandoned buildings, past the iron bridge near a small Lord Shiva temple, and in the Department of Water Supply compound, about a kilometre from the iron bridge, might be misused. A restaurant, which is showing signs of expansion, has already come up to the right of the road, just a kilometre short of Amsod. Since the Kho river is used by elephants and other wildlife, it may be necessary to convert the two staff quarters in the abandoned nursery into an anti-poaching camp.

3. Resettlement: On a priority basis, the *gujjar* and *bhotia deras* from Laldhang and Kotdwar ranges should be resettled in the southern periphery of Chiriyapur Range of Haridwar FD.

ACKNOWLEDGEMENTS

Chief Wildlife Warden, Uttarakhand permitted us to do the study, Save the Tiger Fund – USA provided the funds and Director, Wildlife Institute of India, Dehradun, encouraged us to take up the study. Shirish Kumar Kyatham prepared the figures, M.P. Aggarwal word processed the text and Nima Manjrekar read through the manuscript. We thank them all very sincerely.

REFERENCES

Bist, S.S. (2002): An overview of elephant conservation in India. *Indian Forester 128*: 121-136.

Dudley, N. & S. Stolton (2003): Running Pure: The importance of forest protected areas to drinking water. A research report for the World Bank/WWF Alliance for Forest Conservation and Sustainable Use. 112 pp.

Jhala, Y.V., R. Gopal & Q. Qureshi (2008): Status of Tigers, Co-Predators and Prey in India. National Tiger Conservation Authority and Wildlife Institute of India, Dehradun. TR 08/001 pp. 164.

Johnsingh, A.J.T., S.N. Prasad & S.P. Goyal (1990): Conservation status of Chilla-Motichur corridor for elephant movement in Rajaji-Corbett National Parks area, India. *Biological Conservation 51*: 125-138.

Johnsingh, A.J.T. & A.S. Negi (2003a): Operation Eye of the Tiger – India. Final report submitted to Save the Tiger Fund, USA, for the period April 1996 - June 2003. Pp.17.

Johnsingh, A.J.T. & A.S. Negi (2003b): Status of tiger and leopard in Rajaji-Corbett Conservation Unit, northern India. *Biological Conservation 111*: 385-393.

Johnsingh, A.J.T., K. Ramesh, Q. Qureshi, A. David, S.P. Goyal, G.S. Rawat, K. Rajapandian & S. Prasad (2004): Conservation status of tiger and associated species in the Terai Arc Landscape, India. RR-04/001, Wildlife Institute of India, Dehradun. Pp. viii+110.

Harihar, A., B. Pandav & S.P. Goyal (2009a): Responses of tiger (*Panthera tigris*) and their prey to removal of anthropogenic influences in Rajaji National Park, India. *European Journal of Wildlife Research 55*: 97-105.

Harihar, A., D.L. Prasad, C. Ri, B. Pandav & S.P. Goyal (2009b): Losing ground: tigers *Panthera tigris* in the north-western Shivalik landscape of India. *Oryx 43*: 35-43.

Meher-Homji, M. (1989): Trends of rainfall relation to forest cover. Pp. 48-59. *In*: Jayal, N.D. (Ed.): Deforestation, Drought and Desertification, Perceptions on a growing ecological crisis. Indian National Trust for Art and Cultural Heritage, New Delhi. pp. 147.

Sunderraj, S.F.W., B.K. Mishra & A.J.T. Johnsingh (1993): Elephant use of Rajaji Corbett forest corridor, northwest India. Pp. 261-269. *In*: Daniel, J.C. & H.S. Datye (Eds): A Week With Elephants. Bombay Natural History Society and Oxford University Press, Bombay.

Wikramanayake, E., E. Dinerstein, J.G. Robinson, U. Karanth, A. Rabinowitz, D. Olson, T. Mathew, P. Hedao, M. Connor, G. Hemley & D. Bolze (1998): An ecology based method for defining priorities for large mammal conservation: the tiger as case study. *Conservation Biology 12*: 865-878.

7. SIGHTING OF A RARE DARK MORPH OF GREY FRANCOLIN *FRANCOLINUS PONDICERIANUS* GMELIN 1789 NEAR SURENDRANAGAR, GUJARAT, INDIA

Aditya Roy[1]

[1]2/B. Haritej Society, Opp. ATIRA/AMA, Behind Apang Manav Mandal, Dr. V.S. Road, Vastrapur, Ahmedabad 380 015, Gujarat, India. Email: adi007roy@gmail.com

On August 16, 2010, around 17:30 hrs, while in the wilderness around Surendranagar city of Gujarat, on a photographic trip I sighted a pair of dark birds moving in a bush in the wild areas. At first I mistook it for a black

francolin but on literature survey, I identified them to be Grey Francolins *Francolinus pondicerianus* (Grimmett *et al.* 1999: POCKET GUIDE TO THE BIRDS OF THE INDIAN SUBCONTINENT. The Helm Guide Series, London. 384 pp.). These Grey Francolins *Francolinus pondicerianus* had an unusually dark plumage due to presence of excessive melanin.

8. RECENT OCCURRENCE OF THE BROWN-HEADED BARBET *MEGALAIMA ZEYLANICA* GMELIN 1788 AND OTHER DRY COUNTRY SPECIES IN PERIYAR TIGER RESERVE, KERALA, SOUTHERN INDIA – ARE THESE RELATED TO ECOLOGICAL CHANGE?

V.J. ZACHARIAS[1] AND RICHARD T. HOLMES[2]

[1]Division of Biology, Northern Virginia Community College, Manassas, Virginia 20109, USA. Email: vjzacharias@yahoo.co.uk
[2]Department of Biological Sciences, Dartmouth College, Hanover, New Hampshire 03755, USA. Email: Richard.T.Holmes@Dartmouth.Edu

Periyar Tiger Reserve, a major part of the Cardamom Hill Reserve, is located on the wet zone of the Western Ghats in Kerala, southern India. The area harbours a rich bird fauna which has been studied periodically since the 1800s (Elwes 1870; Ali 1935-37; Berlioz 1940; Nichols 1944-45; Nair *et al.*1985; Robertson and Jackson 1992; Srivastava *et al.*1993; Santharam 1996; Veeramani *et al.* 2005; Elamon 2006; Sugathan 2008). The Brown-headed Barbet *Megalaima zeylanica*, which is endemic to the Indian subcontinent (Rasmussen and Anderton 2005), has not been previously reported from the Reserve. This note reports the occurrence of the Brown-headed Barbet and other dry country species sighted at about 700 m elevation in the Periyar Tiger Reserve in recent years.

Ali (1935-37), Robertson and Jackson (1992), Nair *et al.* (1985) and Srivastava *et al.* (1993) who have documented the avifauna of Periyar, and Yahya (1988) who studied the biology of barbets in the Reserve from 1977-1980 recorded only two species of barbets, namely White-cheeked Barbet *Megalaima viridis* and Crimson-fronted Barbet *Megalaima rubricapilla*. Prasad (1990) who studied the avian abundance in Idukky Wildlife Sanctuary, around the Hydroelectric area, also on the Western Ghats about 50 km north of Periyar, recorded same two species, and a third species, the Crimson-breasted Barbet *M. haemocephala*. Nichols (1944-1945) also did not record the Brown-headed Barbet in Periyar.

While looking for birds on the Anchuruly road in Periyar on February 21, 2007, we came across two Brown-headed Barbets on a fig tree near the forest edge, behind the Anavachal guest house at about 700 m elevation. The vegetation is moist deciduous forest with teak as the dominant tree species and frequently disturbed by tourists, firewood collectors and cattle grazing. The unmistakable call of the bird attracted our attention. VJZ who worked as a research officer at Periyar from 1991-97, lived at the Anavachal guest house from May to December 1991 and frequently visited the area while working in Periyar, had never previously seen the species in this area or anywhere in the tiger reserve.

The Brown-headed Barbet occurs mostly in the rain shadow region of the Western Ghats in Tamil Nadu and Karnataka, in the deciduous biotope, which include the areas of these states bordering Kerala (VJZ pers.obs.). Little information is available on the status and distribution of this species in Kerala. During the Travancore-Cochin ornithological survey, Ali (1935-37, 1984) noted the bird at Thattekad and collected a specimen from Aramboli near the Tamil Nadu border. However, Ali (1984) did not mention Thattekad as a locality for this bird and wrote that the species was local and apparently confined to the deciduous low country in southern Kerala only. According to Whistler and Kinnear (1935) two races of the Brown-headed Barbet occurred in Kerala, *M.z. zeylanica* in the south and *M.z. inornata* in the north, as evidenced by specimens in the British Museum. But Abdulali (1971) did not admit *M.z. zeylanica* in the Indian mainland. A recently published book, BIRDS OF KERALA (Ali 1999) recorded two races of the Brown-headed Barbet in Kerala. There are recent sight records of the Brown-headed Barbet at Parambikulam and Chinnar Wildlife sanctuaries, Malampuzha, Elivalmala and Palakkad gap, all near the Tamil Nadu border (Jafer Palot pers. comm.). The species is fairly common in Tamil Nadu, adjoining Periyar in the east, at lower elevations. There is a specimen of the species in the Smithsonian Museum collected at Vannathiparai (450 m) in Tamil Nadu, about 12 km away from the site of our observation.

The occurrence of the Brown-headed Barbet within Periyar near Anavachal, which is about 2 km away from the Tamil Nadu border, at about 700 m, raises interesting questions. The species seems to have moved from a dry habitat at lower elevation to a higher elevation where the habitat has become drier and thus more suitable for the species. This illustrates encroachment of a dry habitat, lower elevation species to a higher elevation. The extension in range may be related to the changes in vegetation structure and perhaps consequent changes in weather in the peripheral areas of the Reserve in the Thekkady range.

It is worth mentioning that three other dry country species, the Eurasian Collard Dove *Streptopelia decaocto*,

Pied Cuckoo *Clamator jacobinus*, and the Asian Koel *Eudynamys scolopaceus* found at lower elevations have also been recorded by Srivastava *et al.* (1993) at Periyar. These were listed as uncommon/rare without any details. Since these are common birds and not recorded by Ali (1935-37), it seems that more dry country species from lower elevations have been moving to Periyar in recent years, which is probably related to changing environmental conditions, as evidenced by the drying of the marshes around Anavachal and the recent increase in temperature in the area. This information is reviewed below for these species along with anecdotal information from more recent years.

Eurasian Collared Dove *Streptopelia decaocto* (Frivaldski): Ali (1984, 1999) observed this species only near Kanyakumari (now in Tamil Nadu) in scrub and boulder country with scattered cultivation. VJZ (pers. obs.) sighted two individuals near the Anavachal dormitory in 1992, possibly moving up from the lower camp area in Tamil Nadu, where they are fairly common.

Pied Cuckoo *Clamator jacobinus* (Boddaert): This is a deciduous low country species that occupies lightly wooded and babul shrub habitat (Ali 1984). A fledging cuckoo was found by VJZ being fed by a group of Jungle Babbler *Turdoides striata* in November 2001 near the boat landing across the Aranya Nivas hotel in Periyar. This cuckoo is common in the neighbouring Tamil Nadu in dry thorn scrub habitat at lower elevation, where it often parasitized the Yellow-billed Babbler *Turdoides affinis* in September/October (VJZ pers. obs.).

Asian Koel *Eudynamys scolopaceus* (Linnaeus): This is a fairly common species according to Ali (1984), occurring chiefly at lower elevations in Tamil Nadu. On February 22, 2007, we observed a male and a female feeding on the fruits of *Persea macrantha* on the trail connecting Anchuruly with the Thekkady checkpost. The presence and absence of Koel is evidently governed mostly by the number of its hosts, which are primarily crows (Ali 1984). Since the species is a frugivore, it could likely be a competitor for the endemic frugivores like the hornbills. Vijayakumar (1994) has observed the territorial behaviour of the Koel, which was aggressive to other frugivorous birds like barbets.

In summary, the recent occurrences of several dry country bird species in Periyar, appear to be related to an ongoing drying of the landscape possibly due to climate change confounded by habitat degradation, caused by the increase in tourism/human activity. A regular monitoring of the species composition and population density of birds at key elevations within Periyar, and especially in its border areas would be helpful in evaluating changes occurring in future.

ACKNOWLEDGEMENTS

We thank Bennichan Thomas, Field Director, Project Tiger, for arranging our accommodation at Periyar, Tony Gaston for reading the manuscript and Jafer Palot for providing information on the recent sightings of the Brown-headed Barbet in Kerala and publication of books on the birds of Periyar. VJZ thank James Dean of the Smithsonian Museum for permitting to examine the Indian bird collection and to Martha Rosen at the Smithsonian Library, Washington, D.C. for her help.

REFERENCES

Abdulali, H. (1974): A catalogue of the birds in the collection of the Bombay Natural History Society. *J.Bombay Nat.Hist.Soc. 71(2)*: 244-265.

Ali, S. (1935-37): The Ornithology of Travancore and Cochin, with notes by Hugh Whistler. *J. Bombay Nat. Hist. Soc. 37(4)*: 814-843, *38(1)*: 61-92, *(2)*: 282-320, *(4)*: 484-514, *39(1)*: 4-35, *(2)*: 320-342, *(4)*: 569-593.

Ali, S. (1984): Birds of Kerala. Kerala Forest Department, Trivandrum. Pp. 444 .

Ali, S. (1999): Birds of Kerala. Revised by R. Sugathan. Kerala Forest Department. Thiruvananthapuram. Pp. 520.

Berlioz, J. (1940): Observations Ornithologiques Dans Le Sud De L'Inde. L'Oiseau,Paris. 10, 298-333.

Elamon, S. (2006): Birds of Periyar - Natural History Series 1. Periyar Foundation. Kerala Forest Department. Thekkady. Pp.159.

Elwes, J.H. (1870): Birds of Cardamom hills. Letter to the Editor. *The Ibis,* New Series *4*: 526-528.

Nair, P.V., K.K. Ramachandran, V.S. Vijayan, P.S. Easa & P.V. Balakrishnan (1985): An Ecological study in Periyar Tiger Reserve, with special reference to Wildlife Kerala Forest Research Institute, Peechi, Trichur.

Nichols, E.G. (1944-45): Occurrence of birds in Madurai District. *J. Bombay Nat. Hist. Soc. 44(3)*: 387-407, *(4)*: 574-584, *45(2)*: 122-132.

Prasad, N.L.N.S. (1990): Abundance and diversity of birds in the Idukky hydroelectric Project area, Kerala. *Rec.zool.Surv.of India 87(4)*: 299-316.

Rasmussen, P.C. & J.C. Anderton (2005): Birds of South Asia – The Ripley Guide. Vol. 2. Attributes and Status. 683 pp. Lynx Edicions. London.

Robertson, A. & M.C.A. Jackson (1992): Birds of Periyar – An aid to bird watching in Periyar Sanctuary. Tourism and Wildlife Society of India.

Santharam,V. (1996): Birds of Periyar Tiger Reserve, random notes. *Newsletter for Birdwatchers 36*: 53-54.

Srivastava, K.K., V.J. Zacharias, A.K. Bhardwaj & P. Mohamed Jafer (1993): Birds of Periyar Tiger Reserve, South India. *Indian Forester 119(10)*: 816-826.

Sugathan, R. (2008): Birds of Periyar Tiger Reserve. Periyar Foundation. Kerala State Forest Department. Thekkady.

Veeramani, A., G.K. Pramod & D.N. Kurup (2005): New records of birds in Periyar Tiger Reserve, Thekkady, Kerala. *J. Bombay Nat. Hist. Soc. 102(2)*: 235-236.

Vijayakumar, T.N. (1994): Resource utilization by birds attending figs in South India. Ph.D. Thesis. University of Calicut.

Whistler, H. & N.B. Kinnear (1935): The Vernay Scientific Survey of the Eastern Ghats. *J. Bombay Nat. Hist. Soc. 37(3)*: 515-528.

Yahya, H.S.A. (1988): Breeding biology of barbets, *Megalaima* spp. (Capitonidae: Piciformes) at Periyar Tiger Reserve, Kerala. *J. Bombay Nat. Hist. Soc. 85(4)*: 493-511.

9. AN ALBINO CROW AT SATNA, MADHYA PRADESH, INDIA

ARCHANA SHUKLA[1]

[1]Department of Zoology, Govt. P.G. College, Satna 485 001, Madhya Pradesh, India. Email: archs3@yahoo.com

In end-July 2010, a local newspaper reported the sighting of a white crow (*Corvus macrorhynchos* or *Corvus splendens*) by the people of Madhavgarh area. Madhavgargh is a small town about 5 km from Satna district (24.34° N; 80.55° E) of Madhya Pradesh. Most of the villagers indulge in agricultural activity here and the area is covered with crop field and trees.

This white crow was hunted and wounded by a flock of House crows; the injured crow was scared when it was rescued by an alert wildlife lover Mohd. Islam Shah. It was kept inside a large cage. The bird at first did not look like a crow! Its body was completely white, the beak and legs were pink, and the eyes slightly reddish. It was very aggressive, which could be because of the frequent visits by strangers. The bird was photographed and its call was also recorded for future reference.

The crow was about 3 months old when rescued. Mohd. Shah had observed only a single crow trying to feed the white crow and presumed that it could be the mother. The area where it was found had a growth of vegetables, as well as some variety of trees.

Prior to this sighting three albino crows have been reported from India, i.e., from Kolkata, Kerala and Goa (www.newKerala.com: 2010 and www.nKrealtors.com: 2003), and one Leucistic crow was spotted at Mysore, India (Maramkal 2008). Albino crows have also been reported from outside India. Besides this, there are reports on sighting of albino crows by Baker (1995), Ghose and Khan (2005), Joshua (1996). However, this is the first report from Madhya Pradesh.

Fig. 1: Albino Crow sighted in Madhavgarh area, Satna, M.P.

It is known that albinos are sensitive to their environment, mainly sunlight and are prone to pathogenic attacks, hence a detailed report of this incident has been submitted to the Conservator of Forest, Satna. The Forest Department has ensured that the albino crow will soon be shifted to a safe place.

ACKNOWLEDGEMENTS

I sincerely thank Dr. Shivesh Pratap Singh, Prof. Head of the Zoology Department. Govt. (Autonomous) College, Satna for his guidance and support. I am grateful to Dr. Kailash Chandra, Central Regional Zone of Zoological Survey of India for giving valuable suggestions. I also thank Mr. Pradeep Shukla for his support during field work.

REFERENCES

BAKER, E.C.S. (1995): An albino bulbul. *Rec. India Mus. 11*: 351-352.

GHOSE, D. & S. KHAN (2005): An albino bulbul at Keibul Lamjao National Park, Manipur, India. *J. Bombay Nat. Hist. Soc. 102(1)*: 120-121.

JOSHUA, J. (1996): An albino Red-vented Bulbul *Pycnonotus cafer*. *J. Bombay Nat. Hist. Soc. 93(3)*: 586.

MARAMKAL, M.B. (2008): White Crow gives jitters to Mysore royals. The Times of India, Mumbai, August 28, 2008. Pg. 14.

TIMES OF INDIA (2003): Baby albino crow evokes curiosity. www.nKrealtors.com. Kolkata.

www.wildliofeextra.com: Abbit. B, Leucistic crow spotted in Kendall.

www.webbizzu.com: Malaysia post (2007): Lucky albino crow.

www.newKerala.com: (2010): Rare albino crow rescued in Goa.

10. FIRST AUTHENTIC RECORD OF *RHADINOPHIS PRASINUM* (BLYTH, 1854) FROM MIZORAM, NORTH-EAST INDIA

DAYA NAND HARIT[1]

[1]Department of Zoology, Government Champhai College, Champhai 796 321, Mizoram, India. Email: dnharit@yahoo.co.in

Though *Rhadinophis prasinum* (Blyth, 1854) (Reptilia: Colubridae) is known to occur in north-east India from West Bengal (Darjeeling district) to eastern Arunachal Pradesh (Deban, Changlang district), China, Myanmar, Bangladesh,

Malaysia, Thailand and Vietnam (Whitaker and Captain 2008), and Assam, Meghalaya, Manipur and Arunachal Pradesh (Das 2008), as well as Mizoram (Mathew 2007b), there are no specific locality records. Though, this species was included in their photographic guide, Ahmed *et al.* (2009) do not mention any localities.

On September 04, 2009, around 14:00 hrs while conducting a survey on tiger beetles, a road kill was observed near Mualkawi village of Champhai district of Mizoram, NE India, which was adequate to examine and identify.

Morphometry and scalation: Slender bodied; smooth scales; round snout; eye large with round pupil; supralabials 9 (4 to 6 touching eye); preocular 1; postoculars 2; loreal present; ventrals 199; subcaudals 110 paired; anal 1; temporals 2+1; body scalation 19:19:17.

Coloration: Body green in colour, supralabials and ventral side of the body lighter green than body. Skin between scales black in colour, giving the appearance of black-edged scales.

The road-killed snake was identified as *Rhadinophis prasinum* (Blyth, 1854) (previously *Elaphe prasina*), as per Whitaker and Captain (2008), and Das (2008). Mathew (2007b) has included this species in the FAUNA OF MIZORAM, but without examining or mentioning any specimens or records. Harit and Ramanujam (2002), Mathew (2007a) and Harit (2009) have reported several snakes from the area, excluding this snake. Hence, this is the first authentic record of *Rhadinophis prasinum* (Blyth, 1854) from Mizoram and is worthy of documentation.

ACKNOWLEDGEMENTS

The author is grateful to the University Grants Commission for financing a project on tiger beetles, during which survey this snake was found.

REFERENCES

AHMED, F., A. DAS & S. DUTTA (2009): Amphibians and Reptiles of Northeast India – A Photographic Guide. Aaranyak, Guwahati, India. Pp. i-xiv & 1-168.

DAS, I. (2008): A Photographic Guide to Snakes and other Reptiles of India. Om Books International, Darya Ganj, New Delhi. Pp. 33.

HARIT, D.N. & S.N. RAMANUJAM (2002): Reptilian fauna of Mizoram, India. *Cobra 47*: 5-7.

HARIT, D.N. (2009): Survey and status on the faunal diversity of the state of Mizoram, with special reference to the Reptilian fauna of Champhai District of Mizoram and their status. Final Report of the Research Project. Government Champhai College, Mizoram.

MATHEW, R. (2007a): Additions to the snake fauna of Mizoram. *Cobra 1(1)*: 5-9.

MATHEW, R. (2007b): Reptilia. *In*: Fauna of Mizoram, state faunal series. *Zoological Survey of India 14*: 545-577.

WHITAKER, R. & A. CAPTAIN (2008): Snakes of India, The Field Guide. Draco Books Chennai. Pp. 90.

11. NEW DISTRIBUTION RECORD FOR *HEMIDACTYLUS PRASHADI* SMITH, 1935 (FAMILY: GEKKONIDAE) FROM THE KUDREMUKH FOREST COMPLEX, KARNATAKA, INDIA

ROHIT NANIWADEKAR[1] AND V. DEEPAK[2]

[1]Nature Conservation Foundation, 3076/5, IV Cross, Gokulam Park, Mysore 570 002, Karnataka, India.
Email: rohit@ncf-india.org, rohit.nani@gmail.com
[2]Wildlife Institute of India, Post Box #18, Chandrabani, Dehradun 248 001, Uttarakhand, India. Email: deepaksalea@gmail.com

Kudremukh forest complex (KNP) is one of the less explored mountain ranges of the central Western Ghats (Vasudevan *et al.* 2006). We conducted herpetological surveys for the Karnataka Forest Department from October 2005 to February 2006 in the Kudremukh National Park, the Someshwara Wildlife Sanctuary and the Mookambika Wildlife Sanctuary, which together form the Kudremukh forest complex. On November 02, 2005, at 21:00 hrs, we came across an individual of *Hemidactylus*. It was seen on the wall of the Forest Department bungalow in the Bhagwati Nature Camp (820 m above msl) in the Kudremukh range of the Kudremukh National Park. The specimen was fixed in 70% ethanol and is now deposited in the Collections of the Bombay Natural History Society (Tag No. 324, BNHS No. 1749).

The specimen was identified as *H. prashadi* Smith, 1935 using standard taxonomic key (Smith 1935). The specimen matched the description completely. The coloration of this specimen was similar to Smith's description. The absence of preano-femoral pores suggests that the specimen could be a female.

As per earlier reports, *H. prashadi* was known to occur from Dorle in Ratnagiri district, Maharashtra (Giri and Bauer 2006) to Jog in North Kanara district of Karnataka (Smith 1935; Jadhav *et al.* 1991; Tikader and Sharma 1992; Sharma 2002). After the first sighting of the gecko on November 02, 2005, we have seen the gecko on multiple occasions in the three protected areas of the Kudremukh forest complex. We have seen it from as far south as the Belthangady range of the

Kudremukh National Park (13° 06' N; 75° 18' E). According to the previous reports, this gecko is known to occur on walls of houses, barks of trees, lichen-covered black granite rocks (Jadhav *et al.* 1991; Tikader and Sharma 1992; Giri and Bauer 2006). In addition to spotting the adult geckos on walls and crevices of buildings, barks and within buttresses of trees, we have also seen many individuals on huge rocks along the river courses in the nights. We found the gecko from 40-820 m above msl.

It is thus noteworthy to mention this new locality report, which extends the distribution of this species by *c.* 150 km (aerial distance) towards south. This suggests that this species ranges widely throughout the central Western Ghats and its presence in the forests of Kodagu, which are contiguous with the Kudremukh hills, needs to be confirmed.

ACKNOWLEDGEMENTS

We thank the Karnataka Forest Department and their staff for funding, permission and support. We thank Dr. Karthikeyan Vasudevan, Shri. Vijay Ranjan Singh and Shri. M.S. Chaitra for their guidance, support and encouragement. Thanks to Mr. Varad Giri for the information he provided. We thank Mr. Shashank Dalvi and Ms. Swapna N. for their support during the survey.

REFERENCES

Giri, V. & A.M. Bauer (2006): Notes on the distribution, natural history and variation of *Hemidactylus prashadi* Smith, 1935. *Hamadryad 30*: *55-60*.

Jadhav, S.P., L.T. Mote & P.K. Vadar (1991): Ecological notes on niche of new and rare geckonid lizard, *Hemidactylus prashadi*. *Geobios New Reports 10*: 69-70.

Sharma, R.C. (2002): The fauna of India and the adjacent countries. Reptilia, Volume II (Sauria). Zoological Survey of India, Kolkata. xxv + 430 pp.

Smith, M.A. (1935): The Fauna of British India, including Ceylon and Burma: Reptilia and Amphibia. Volume II: Sauria. Taylor & Francis, London. xiii + 440 pp. + 1 plate.

Tikader, B.K. & R.C. Sharma (1992): The Handbook of Indian Lizards. Zoological Survey of India, Kolkata. xv + 250 pp. + 42 plates.

Vasudevan, K., M. Singh, V.R. Singh, M.S. Chaitra, R.S. Naniwadekar, V. Deepak & N. Swapna (2006): Survey of biological diversity in Kudremukh forest complex, Karnataka. Final Survey Report of Kudremukh WL Division.

12. OCCURRENCE OF FLYING FISH, *CHEILOPOGON ABEI* PARIN, 1996 FROM NEARSHORE WATERS OF THE NORTH-WEST COAST OF INDIA

Sujit Sundaram[1]

[1]Mumbai Research Centre of Central Marine Fisheries Research Institute, 2nd Floor, C.I.F.E old campus, Fisheries University Road, Seven Bungalows, Andheri (W), Versova, Mumbai 400 061, Maharashtra, India. Email: sujitsundaram@hotmail.com

Introduction

Flying fish (Family: Exocoetidae) are common in tropical and subtropical waters. They form an important fishery resource world over, especially in countries such as Indonesia, Japan (Parin 1960), USA (Herald 1969), West Africa (Gibbs 1981) etc. Parin (1961) gave an account of the Exocoetid fauna of the Indian Ocean, and Day (1877, 1889) has described six species of flying fish from India.

Since flying fishes are capable of leaping out of water and gliding for short distances above the surface they are commonly called as 'flying mullet' and they are a significant component of the epipelagic food chain (Parin 1968). In Maharashtra, they are locally known as '*Kawla maasa*' meaning 'Crow fish'. Flying fishes have been occasionally reported from different centres along the coastal strip of India. Rao and Basheeruddin (1973) gave an account of the fishery of the species *Parexocoetus brachypterus brachypterus* (Richardson), including the size-composition, sex-ratio, maturity studies and diet from Madras (=Chennai) waters. Development of egg and larvae studies was carried out by Vijayaragavan (1973). Hornell (1923), Arora and Banerji (1957), and Pajot and Prabhakaradu (1993) described the flying fish fishery along the Coromandel coast, south-east India.

Sundaram and Sarang (2003) and Kizhakudan *et al.* (2002) have reported the species *Cheilopogon furcatus* (Mitchill 1815) from Mumbai and Veraval waters respectively. Three other species of flying fish *Cheilopogon nigricans* (Bennett 1840), *Cheilopogon suttoni* (Whitley & Colefax, 1938) and *Hirundichthys oxycephalus* (Bleeker 1852) were also reported from Mumbai waters (Kamble *et al.* 2007).

Material and Methods

During May 2007, about 75 kg of flying fishes were landed by trawlers at New Ferry Wharf (*Bhaucha Dhakka*), Mumbai, Maharashtra. The depth of fishing operation was at 20-30 m, 50-60 km off north-west coast in Mumbai waters. About 2 kg of sample was brought to the laboratory for identification and further biological analysis. Total length was measured using a digital calliper and total weight (±0.01 gm) was determined using an electronic balance after the specimens were dried on blotting paper. The measurements

were taken as described by CMFRI (1995). Four specimens ranging in total length from 222-247 mm with the corresponding body weight ranging from 73.86-92.17 gm were studied for morphometric and meristic characters.

Results and Discussion

The species was identified as *Cheilopogon abei* Parin, 1996 (Family: Exocoetidae, Order: Beloniformes and Class: Actinopterygii) based on the detailed identification characters as described in Parin (1996). A total of 23 morphometric characters and 5 meristic counts were recorded and are given in Table 1.

The body of *C. abei* is elongate, broadly cylindrical and flattened dorsally. The standard length and fork length of the species is 77.3% and 83% of the total length (TL). The pectoral fin length was 58.2% and 75.3% of the total length and standard length respectively. The other morphometric characteristics in relation to TL was greatest body depth (13.5%), head length (18.6%), pelvic fin length (23.3%), dorsal fin length (9.9%), anal fin base length (9.4%), caudal fin upper lobe (17.5%) and caudal fin lower lobe (25.4%). The pre orbital, orbital length and inter orbital distance was 27%, 34.5% and 45.4% of the head length. Head is slightly shorter than the distance between dorsal fin origin and base. The lower jaw is pointed and is somewhat longer than the upper one when the mouth is closed. The jaw teeth are numerous, of average size, located in 2-3 rows, and palatine teeth are also present. The dorsal fin is rather high, it is the longest second and the origin of anal fin is six rays behind the origin of dorsal fin. The pectoral fins are strikingly long and reach the origin of the upper tail lobe. The pelvic fins reach the beginning of the 2-3rd ray of the anal fin base. The caudal fin is deeply forked and its lower lobe is longer than the upper. The lateral line is without branch at thorax and the scales are large and cycloid. The pectoral fins have 13-14 rays, dorsal fin has 13-14 rays, pelvic fins have 8-9 rays, anal fin has 9-10 rays and caudal fin rays ranged from 23-24.

The dorsal fin is grayish, with two bright black spots between the 4th-6th ray and between 10th-11th ray. The anal fin is without pigmentation. The pectoral fins are black, with a prominent bright yellow band 'mirrow' running through it, narrowing towards the upper margin and reaches the 1-3rd ray. The pelvic fins have a bright black spot in their back half and do not reach the posterior edge of the fin. The caudal fin is evenly dark gray. The body is dark above and pale below and usually iridescent blue in life.

C. abei occurs in the western equatorial part of the Pacific Ocean (up to Solomon Islands in the east), the inland seas of south-east Asia, the Indian Ocean northwards of 15-20° S, the Bay of Bengal and the Arabian Sea. In the Pacific Ocean it is distributed as a neritic species, and in the Indian Ocean as a neritic oceanic species (Parin 1996). The present report of this species from Mumbai waters, north-west coast of India seems to be the first record from this region.

Table 1: Morphometric and meristic characteristics of *Cheilopogon abei*

	Specimen 1	Specimen 2	Specimen 3	Specimen 4
Morphometric (mm)				
Total length	222	232	237	247
Standard length	165	179	188	193
Fork length	182	195	198	204
Greatest body depth	26	32	33	36
Head length	37	44	46	47
Pectoral fin length	122	135	140	149
Pelvic fin length	50	55	56	58
Caudal peduncle length	14	17	18	20
Caudal peduncle depth	13	14	15	17
Dorsal fin base length	33	35	37	39
Dorsal fin length	20	22	24	27
Anal fin base length	17	22	23	26
First anal ray length	10	12	13	15
Pelvic fin base length	6	8	10	12
Pre orbital	9	12	13	13
Eye diameter	14	15	15	16
Inter orbital width	18	19	20	22
Post orbital distance	18	19	19	20
Upper jaw length	10	11	12	13
Lower jaw length	13	17	18	19
Caudal fin upper lobe	39	40	41	44
Caudal fin lower lobe	53	60	61	64
Weight in gm	73.86	82.67	85.21	92.17
Meristic counts				
Pectoral rays	13	14	14	14
Dorsal rays	13	13	14	14
Pelvic rays	8	8	8	9
Anal rays	9	9	10	10
Caudal rays	23	23	24	24

C. furcatus is a common species similar to *C. abei* in appearance but its band pattern on the pectoral fin varies slightly. In addition, it does not have a dark spot on the dorsal and pelvic fins. *C. abei* also appears to be similar to *C. nigricans* but differs well from this species due to the yellow coloration of the 'mirrow' on the pectoral fins and in the presence of a black spot on the pelvic fin.

According to Parin (1996), the maximum length of *C. abei* from the Pacific Ocean does not exceed 210 mm, whereas it is common to find larger fishes in the Indian Ocean, even up to 250 mm. The maximum length recorded in the present observation was 247 mm.

Flying fish is a tropical pelagic fish and characteristic of surface layers of seas (Bruun 1935) and the occurrence of flying fishes in inshore waters may be because they migrate

towards shallow water areas from offshore waters for feeding. According to Rao and Basheeruddin (1973), migration may also be for spawning. The observed specimens of this species were in mature condition. Though flying fishes may show stray occurrences throughout the year, the period of abundance is during post monsoon. In May 2007, the sea was very turbulent off Mumbai. Turbulence generally results in transport of nutrients from deeper waters, inducing increased planktonic productivity, and hence increased abundance of zooplankton on which flying fish feed (Oxenford *et al.* 1995). This phenomenon could have led to the occurrence of this species during this period in Mumbai waters in such large numbers.

According to Parin (1996), flying fishes are objects of fisheries that are fished in many tropical countries, and practical requirements of fishery demand the knowledge of the species composition of this group in certain regions. Regional distribution and relative abundance of flying fishes have not been studied extensively along the Indian coast, and therefore efforts need to be taken in this direction and also regarding the commercial exploitation of these fishes. A specimen of *C. abei* has been deposited in the Reference Collection Museum of Central Marine Fisheries Research Institute, Kochi.

ACKNOWLEDGEMENTS

I am grateful to Dr. N.V. Parin, Institute of Oceanology, Russian Academy of Sciences IO RAS, Moscow for confirming the identity of the species. I thank Dr. V.D. Deshmukh, Principal Scientist and Scientist-in-Charge, CMFRI, Mumbai, Dr. Miriam Paul Shreeram, Senior Scientist, Marine Biodiversity Division, CMFRI, Mangalore, and Mrs. T.S. Naomi, Principal Scientist, Marine Biodiversity Division, CMFRI, Kochi. The help rendered by J.R. Dias, S.D. Kamble and J.D. Sarang is also acknowledged.

REFERENCES

Arora, H.L. & S.K. Banerji (1957): Flying fish fishery along the Coromandel coast. *Indian J. Fish 4(1)*: 80-91.

Bruun, A.F. (1935): Flying-fishes (Exocoetidae) of the Atlantic-Systematic and Biological studies. *Dana Report 2(6)*: 1-106.

CMFRI (1995): A manual for standardised linear measurements of exploited finfish and shellfish. *CMFRI Sp. Pub.* 78 pp.

Day, F. (1877): The Fishes of India. Bernard Quaritch, London Part 3: 369-552.

Day, F. (1889): The Fauna of British India, including Ceylon and Burma. Taylor and Francis, London. Vol. I. 548 pp.

Gibbs, R.H. Jr. (1981): Exocoetidae, flying fishes. *In*: Fischer, W., G. Bianchi & W.B. Scott (Eds): FAO species identification sheets for fishery purpose. *Eastern Central Atlantic, fishing area* 34, 47 (in part), Vol 2. Var. Canada finds-in-trust, Ottawa. Department of fisheries and Oceans, Canada, by arrangement with FAO of the UN.

Herald, E.S. (1969): Living Fishes of the World. Chanticleer Press, New York. 304 pp.

Hornell, J. (1923): The flying fish fishery of the Coromandel coast and the spawning habits of *Cypsihurus. Madras Fish Bull. 15*: 99-108.

Kamble, S.K., S. Sundaram, M.P. Sreeram & J.D. Sarang (2007): Record of three species of flying fish from Mumbai Waters. *Mar. Fish. Infor. Serv., T and E ser.* No. *194*: 19-20.

Kizhakudan, J.K., J.K. Shoba, V.D. Savaria, J.D. Vanvi, A.A. Ladani, J.P. Polara & A.P. Bharanda (2002): Unusual landings of flying fish, *Cheliopogon furcatus* (Mitchill, 1815) in Veraval, Mangrol and Chorward. *Mar. Fish. Infor. Serv. T and E ser.* No.*171*: 10.

Oxenford, H.A., R. Mohon & W. Hunte (1995): Distribution and relative abundance of flying fish (Exocoetidae) in the eastern Caribbean. I. *Adults. Mar. Ecol. Prog. Ser. 117*: 11-23.

Pajot, G. & C.R. Prabhakaradu (1993): Flying fish fishing on the Coromandel coast, 1988-1991. *BOBP/WP/84*, Bay of Bengal Programme, Project Report, Madras. 21 pp.

Parin, N.V. (1960): Flying fish (Exocoetidae) of the north-western part of the Pacific Ocean. *Tr. Inst. Okean. Akad. Nauk* SSSR *31*: 205-285.

Parin, N.V. (1961): On the Exocoetid fauna of the Pacific and Indian Oceans. *Trudy Inst, Okeanol. 43*: 40-92.

Parin, N.V. (1968): Ichthyo fauna of the epipelagic zone. *Israel Program. Sci.Transl.*

Parin, N.V. (1996): On the species composition of flying fishes (Exocoetidae) in the West-Central part of tropical Pacific. *J. Ichthyol. 36(5)*: 357-364.

Rao, K.S. & S. Basheeruddin (1973): Unusual catches of the flying fish, *Parexocoetus brachypterus brachypterus* (Richardson) in inshore waters at Madras. *Indian J. Fish. 20(2)*: 629-634.

Sundaram, S. & J.D. Sarang (2003): Stray landing of flying fish *Cheliopogon furcatus* (Mitchill, 1815) at New Ferry Wharf, Mumbai. *Mar. Fish. Infor. Serv., T and E ser.* No.175: 12.

Vijayaragavan, P. (1973): Studies on fish eggs and larvae from Indian waters. I. Development of egg and larvae of *Hirundichthys (Hirundichthys) coromandelensis* (Hornell). *Indian J. Fish. 20(1)*: 108-137.

13. BEE PASTURAGE PLANTS OF *APIS FLOREA* IN KHAMMAM REVENUE DIVISION, KHAMMAM DISTRICT, ANDHRA PRADESH, INDIA

A. Vijaya Bhasker Reddy[1,2] and P. Ramachandra Reddy[1]

[1]Department of Botany, P.G. College of Science, Saifabad, Hyderabad 500 004, Andhra Pradesh, India.
[2]Email: vijayabhaskerredy@yahoo.co.in

Introduction

Melissopalynology, one of the branches of palynology finds a very significant application in the field of apiculture. A qualitative and quantitative pollen analysis of honey provides the only means of identifying the bee pasturage plants in any locality (Kalpana TP, Ramanujam CGK-1996A).

The present study is carried out to reveal the bee pasturage plants of *Apis florea* in Khammam district.

Material and Methods

Seven winter honey samples were collected from Lakshmipuram (Mudigonda mandal), Khammam (Khammam rural mandal), Nelapatla (Kusumanchi mandal), Chirunomula (Bonkal mandal), Nelakondapalli (Nelakondapalli mandal), Konegudem (Nelakondapalli mandal), and Rejerla (Viamsur mandal). The methodology recommended by the International Commission of Bee Botany (Louveaux *et al.* 1978) was employed for the recovery of pollen contents and their analysis. 1 ml of honey was dissolved in 10 ml of distilled water, centrifuged, and subjected to acetolysis (Erdtman 1960). Three pollen slides were prepared from each honey sample and the pollen types were identified with the help of reference slide collections of local flora and relevant literature.

Table 1: Honey samples collected from Khammam revenue division

S.No	Date	Mandal	Village	Code	Colour
1	03.i.2005	Mudigonda	Lakshmipuram	M-L-K	Amber
2	12.i.2005	Khammam	Khammam Rural	K-K-K	Yellow
3	14.x.2005	Kusumanchi	Nelapatla	K-N-K	Amber
4	27.xii.2005	Bonakal	Chirunomula	B-C-K	Amber
5 *	16.xii.2006	Nelakondapalli	Nelakondapalli	N-N-K	Yellow
6	22.xi,2005	Nelakondapalli	Konegudem	N-K-K	Amber
7 *	18.x.2006	Vaimsur	Rajerla	V-R-K	Yellow

*: Unifloral honeys

Observations

Of the seven honey samples (Table 1), two samples (N-N-K-5 and V-R-K-7) were unifloral and predominant with *Prosopis juliflora* (90.5%) and *Xanthium strumarium* (56%). Remaining five samples were multifloral, having the pollen taxa of *Psidium guajava*, *Capsicum frutescens*, *Phoenix sylvestris*, *Prosopis spicigera*, *Borassus flabellifer*, *Holoptelea integrifolia*, *Croton bonplandianum*, *Dendrophthoe falcata*, *Ageratum conyzoides*, *Ricinus communis*, *Peltophorum ferrugineum*, *Sapindus emarginatus*, *Coccinea grandis*, *Eucalyptus globulus*, *Cocos nucifera*, *Cajanus cajan*, *Tridax procumbens*, *Citrus aurantifolia*, *Leucaena leucocephala*, *Ziziphus mauritiana*, *Justicia procumbens*, *Alternanthera sessilis* and *Tridax procumbens* among others (Table 2).

Discussion

Bee pasturage plants of *Apis florea* in Khammam revenue division are referred to 3 categories 1) Trees - *Prosopis juliflora*, *Psidium guajava*, *Phoenix sylvestris*, *Prosopis spicigera*, *Borassus flabellifer*, *Holoptelea integrifolia*, *Peltophorum pterocarpum*, *Sapindus emarginatus*, *Muntingia calabura*, *Ziziphus mauritiana*, *Leucaena leucocephala*, *Eucalyptus globulus*, *Cocos nucifera*, *Citrus aurantifolia*, *Bombax ceiba*, 2) Shrubs - *Ricinus communis*, *Cajanus cajan*, *Xanthium strumarium*

Table 2: Frequency classes and frequencies (%) of pollen types recorded from honey samples

Honey sample	Pollen types	Bee pasturage plants of *Apis florea* and frequencies (%) of pollen types
M-L-K-1		
	P-	NIL
	S-	*Psidium guajava*-30.6%, *Capsicum frutescens*-25.6%
	I-	*Phoenix sylvestris*-11.33%, *Prosopis juliflora*-10.86%, *Prosopis spicigera*-5.4%, *Borassus flabellifer*-4.58%, *Holoptelea integrifolia*-4.16%
	M-	*Croton bonplandianum*-2.9%, *Amaranthus viridis*-2.5%, *Ageratum conyzoides*-0.83%, *Celosia argentea*-0.16%, *Cocos nucifera*-0.5%, *Imperata cylindrica*-0.08%
K-K-K-2		
	P-	NIL
	S-	*Prosopis juliflora*-25%, *Celastrus emarginatus*-21.6%
	I-	*Ageratum conyzoides*-15%, *Ricinus communis*-8.3%, *Peltophorum, pterocarpum*-6.6%, *Sapindus emarginatus*-4.6%, *Coccinia grandis*-4.33%, *Muntingia calabura*-3.33%, *Phoenix sylvestris*-3%
	M-	*Sida acuta*-2.6%, *Alternanthera sessilis*-1%, *Bombax ceiba*-0.6%
K-N-K-3		
	P-	NIL
	S-	*Borassus flabellifer*-37%, *Prosopis juliflora*-33.75%
	I-	*Eucalyptus globulus*-14.33%, *Phoenix sylvestris*-10.83%, *Cocos nucifera*-3.5%
	M-	Asteraceae-0.16%

Table 2: Frequency classes and frequencies (%) of pollen types recorded from honey samples (*contd.*)

Honey sample	Pollen types	Bee pasturage plants of *Apis florea* and frequencies (%) of pollen types
B-C-K-4		
	P-	NIL
	S-	*Cajanus cajan*-30.25%, *Prosopis juliflora*-28.16%, *Capsicum frutescens*-22.33%
	I-	Poaceae-4.16%, *Achyranthes aspera*-3.6%, *Tridax procumbens*-3.3%
	M-	*Ageratum conyzoides*-2.3%, *Justicia procumbens*-2.9%, *Sapindus emarginatus*-1%, *Vernonia cinerea*-0.16%, *Leucaena leucocephala*-0.6%, *Cocos nucifera*-0.5%, *Celosia argentea*-0.5%
N-N-K-5		
	P-	*Prosopis juliflora*-90.5%
	S-	NIL
	I-	*Cajanus cajan*-3%, *Citrus aurantifolia*-3%
	M-	*Evolvulus alsinoides*-1.75%, *Ageratum conyzoides*-1.75%
N-K-K-6		
	P-	NIL
	S-	*Prosopis juliflora*-25%, *Ageratum conyzoides*-24.83%
	I-	*Leucaena leucocephela*-14%, *Ziziphus mauritiana*-12.83%, *Justicia procumbens*-12.5%, *Citrus aurantifolia*-3.6%
	M-	*Evolvus alsinoides*-0.16%, *Cocos nucifera*-0.5%, *Acacia nilotica*-0.3%
V-R-K-7		
	P-	*Xanthium strumarium*-56%
	S-	*Ageratum conyzoides*-30%
	I-	*Alternanthera sessilis*-8%, *Tridax procumbens*-5%
	M-	NIL

P = Predominant pollen type (>45%), S = Secondary pollen type (16-45%)
I = Important pollen type (3-16%), M = Minor pollen type (0-3%)

3) Herbs - *Capsicum frutescens*, *Croton banplandianum*, *Amaranthus viridis*, *Ageratum conyzoides*, *Celosia argentea*, *Imperata cylindrica*, *Coccinia grandis*, *Sida acuta*, *Alternanthera sessilis*, *Brassica nigra*, *Portulaca indica*, *Justicia procumbens*, *Vernonia cinerea*, *Celosia argentea*, *Evolvulus alsinoides*, *Tridax procumbens*. Of these three categories, trees and herbs served as major bee pasturage plants of *Apis florea* in this revenue division.

Unifloral honeys collected from Nelakondapalli and Viamsur Mandals are predominant with *Prosopis juliflora* and *Xanthium strumarium*. These two plants serve as chief bee pasturage plants of the Khammam revenue division. *Psidium guajava*, *Capsicum frutescens*, *Cajanus cajan*, *Phoenix sylvestris*, *Borassus flabellifer*, *Cocos nucifera*, *Citrus aurantifolia*, *Ricinus communis*, *Eucalyptus globulus*, and *Leucaena leucocephala* are mainly from the agricultural tracts recorded from various honey samples. These plants serve as secondary or sometimes chief (in maximum blooming period) bee pasturage plants of this division. Some other herbs like *Ageratum conyzoides*, *Tridax procumbens*, *Evolvulus alsinoides*, *Justicia procumbens* and *Croton bonplandianum* grow along road sides or among weeds in agricultural lands and serve as other important bee pasturage plants of this division.

ACKNOWLEDGEMENTS

We are extremely thankful to Prof. C.G.K.Ramanujam for his valuable suggestions and Prof. Y.N.R. Varma and Prof. H. Ramakrishna for their help and encouragement during this investigation.

REFERENCES

Erdtman, G. (1960): The acetolysis method. A revised description. Sven. Botan. Tidskr. *54*: 561-564.
Louveaux, J., A. Maurizo & G. Vorwohi (1978): Methods of Melissopalynology. *Bee World 59*: 139-157.

14. A NOTE ON AN ADDITIONAL LOCALITY FOR *ACANTHASPIS QUINQUESPINOSA* FABRICIUS 1781 (INSECTA: HEMIPTERA: REDUVIIDAE)

RAHUL KHOT[1,2] AND VITHOBA HEGDE[1]

[1]Bombay Natural History Society, Hornbill House, Shaheed Bhagat Singh Road, Mumbai 400 001, Maharashtra, India.
[2]Email: rahul.bnhs@gmail.com

During a faunistic survey at Ansure (16° 33' 56.1" N; 73° 23' 23.0" E) near Jaitapur, Taluka Rajapur, District Ratnagiri, Maharashtra, on July 13, 2009, we collected one specimen of *Acanthaspis quinquespinosa* Fabricius underneath a rock (BNHS - Insect day-book entry No. 14/ 2009).

The measurements (in mm), colour and other details are as follows.

Abbreviations used L = Length, W = Width.

Head – L = 1.5, W = 1.90; Thorax (pronotum including lateral spines) – L = 3.6, W = 4.85; Abdomen – L = 7.5, W = 4.65; Total length – 12; Rostrum – L = 2.5; Scutellar spine – L = 1.5; Tibia – Foreleg – L = 4.35; Tibia – Mid leg – L = 4.5; Tibia – Hind leg – L = 6.4; Colour - black. Four posterior spines on pronotum, two lateral and two discal with transverse discal spots at the basal area. Scutellar spine is long, obliquely ascending. Each forewing with a pale yellow spot.

A. quinquespinosa Fabricius 1781 is an aposematic, crepuscular, entomosuccivorous, polyphagous and multivoltine assassin bug found in the tropical evergreen forests, scrub jungles, semiarid zones and agroecosystems of peninsular India (Sahayaraj 2007). The bioecology (Ambrose 1983), ethology (Ambrose *et al.* 1986), new methods for mass rearing (Lakkundi 1989) and biology in relation to different habitats (Sahayraj 2007) of this bug have been studied.

According to the previous records, the distribution of this bug from Maharashtra was known to be Bombay (now Mumbai) and Bor Ghat (now Bhor Ghat, district Pune) (Distant 1904; Bergroth 1915; Ambrose 2006).

The habitat of the specimen collected was a rocky plateau beside a road with a few trees and shrubs. Throughout the survey, the area was always overclouded and was frequently receiving heavy rainfall. At the time of collection, the insect was found underneath a rock, and was seen active and moving away from the turned rock. Occurrence of *A. quinquespinosa* at Ansure indicates its presence in Ratnagiri district, which is a new locality for this species. *A. quinquespinosa* may be well-distributed in the Konkan region of Maharashtra. In view of the lack of information about the distribution of this species in Maharashtra, the information about its additional locality is noteworthy.

ACKNOWLEDGEMENTS

At the Bombay Natural History Society, we thank Dr. Asad R. Rahmani, Director, Mr. J.C. Daniel, Vice President, Mr. Varad Giri, Curator, Mr. Deepak Apte, Deputy Director-Conservation, Dr. Swapna Prabhu, Taxonomist, Mr. Vinod Patil, Field Assistant and the library staff.

REFERENCES

AMBROSE, D.P. (1983): Bioecology of an alate assassin bug, *Acanthaspis quinquespinosa* Fabr. (Heteroptera, Reduviidae). Pp. 107-111. *In*: Goel, S.C. (Ed.): Symposium on Ecology and Research Management.

AMBROSE, D.P. (2006): A checklist of Indian assassin bugs (Insecta: Hemiptera: Reduviidae) with taxonomic status, distribution and diagnostic morphological characters. *Zoos' Print Journal 21(9)*: 2388-2406.

AMBROSE, D.P., I.J.J. KENNEDY & S.J. VENNISON (1986): Impact of blocking sensory input on the predatory behavior of assassin bug, *Acanthaspis quinquespinosa*. *Envi. Ecol 4(3)*: 469-474.

BERGROTH, E. (1915): Hemiptera from the Bombay Presidency. *J. Bombay Nat. Hist. Soc. 24(1)*: 170-179.

DISTANT, W.L. (1904): Fauna of British India including Ceylon and Burma. Rhynchota Vol. II. Pp. 257-258. Taylor and Francis, London.

LAKKUNDI, N.H. (1989): Assessment of reduviids for their predation and possibilities of their utilization in biological control. Ph. D. Thesis, Indian Agricultural Research Institute, New Delhi.

SAHAYARAJ, K. (2007): Ecotypic variation in the biology of *Acanthaspis quinquespinosa* Fabricius 1781 (Hemiptera: Reduviidae: Reduviinae) from peninsular India. *Egyptian Journal of Biology 9*: 53-59. Egyptian British Biological Society.

15. *BAUHINIA PHOENICEA*: A NEW LARVAL HOST PLANT FOR THE BUTTERFLY, BLUE NAWAB *POLYURA SCHREIBER WARDII* (GODART 1819) (LEPIDOPTERA: NYMPHALIDAE)

C. Susanth[1], K.A. Kishore[2] and K. Baiju[3]

[1]Prakriti, SNRA-20, Indira Nagar, Peroorkada P.O., Thiruvananthapuram 695 005, Kerala, India. Email: c.susanth@gmail.com
[2]Kodapully House, Manikandeswaram P.O., Thiruvananthapuram 695 013, Kerala, India. Email: kishore.ashokan@gmail.com
[3]Sreerangam, Paravoorkonam, Karakulam P.O., Thiruvananthapuram 695 562, Kerala, India.

According to Wynter-Blyth (1957) and Evans (1932), the Blue Nawab *Polyura schreiber wardii* (Godart 1819) is very rare in its range from Assam to Myanmar and S.E. Asia. It has been mentioned that this butterfly is rare in Coorg and other parts of the Western Ghats (Wynter-Blyth 1957). During the last 10 years, there have been only a handful of sightings of this butterfly from the Western Ghats, and no record of its life cycle in recent times. It flies high in the canopy, among flowering trees, and very rarely comes down to mud puddle.

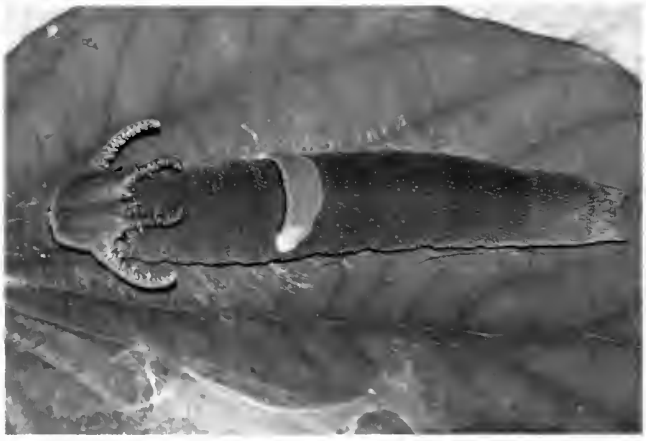


Fig. 1: Prominent yellow crescent-shaped marking on the larvae of *Polyura schreiber wardii*

A monsoon butterfly survey by Warblers and Waders Nature Lovers Forum, Thiruvananthapuram, Kerala, was conducted during July 2010, at Ponmudi-Kallar reserve forest (8°60'-8°79' N; 77°07'-77°20' E), specifically in Ashambu Hills, 52 km from Thiruvananthapuram, Kerala, in the southern range of the Western Ghats. During this survey two larvae of a Nymphalid butterfly were found on a climbing shrub, *Bauhinia phoenicea* (Wight & Arn) belonging to Family Fabaceae, locally known as "Scarlet Bauhinia".

We collected the larvae and reared them in captivity to confirm the species. The larvae were velvety green and had a yellow crescent-shaped marking (Fig. 1) on the third abdominal segment. The head had two pairs of reddish brown horns. The larvae we collected were final instar larvae. The larvae pupated on the 7th day. The pupa was pendant-like, thick, stout and green with lighter markings and a light line laterally connecting the abdominal spiracles, which were brown, as was the top of the head and tail. A longitudinal row of red spots was present on each side (Fig. 2). The duration of pupal stage was 14 days. No change occurred in the pupae during this period. On the morning of the 14th day, the colour of the pupae changed to dead leaf brown. The pupae became transparent and the white band on the wings was visible through the transparent pupal case. The adult butterfly emerged at midday.

Fig. 2: Longitudinal row of red spots during the pupal stage

The butterfly was later identified as the Blue Nawab *Polyura schreiber wardii*. Earlier records state that the known larval food plants are *Rourea santaloides* (Family: Connaraceae) and *Wagatea spicata* (Family: Leguminosae) (Davidson *et al.* 1896)

The successful rearing and emergence of the Blue Nawab *Polyura schreiber wardii* on *Bauhinia phoenicia* confirms it as a hitherto unreported larval host plant.

ACKNOWLEDGEMENTS

We are thankful to Vijayasankar Raman, Post-Doctor Research Associate (Botany), the University of Mississippi (Oxford), for identifying and confirming the plant species. We are grateful to Mr. Kishendas, Lepidopterist, and Dr. Maya Mathew, Head of Department, Zoology, University College,

Thiruvananthapuram, for comments on an earlier draft of the manuscript. We are grateful to Mr. Peter Smetacek, expert Lepidopterist working on Himalayan Lepido-Fauna for reviewing the final manuscript. Special thanks to Dr. Keith Wolf (California) who provided us with most of the older references on the species. We are thankful to P.B. Biju, J. Krishnajith and Satheesh, members of Warblers and Waders survey team for field support and encouragement. We are also thankful to B.S. Aryameher, first author's daughter, for her constant field support for successful rearing of the larvae.

REFERENCES

Evans, W.H. (1932): The Identification of Indian Butterflies, 2nd ed. Bombay Natural History Society, Mumbai. Pp. 464. pl. 32.

Davidson, J., T.R. Bell & E.H. Aitken (1896): The butterflies of the North Canara District of the Bombay Presidency Part I. *J. Bombay Nat. Hist. Soc. 10(1)*: 237-258.

Wynter-Blyth, M.A. (1957): Butterflies of the Indian Region. Bombay Natural History Society. Pp. 523. pl. 147.

16. RECORD OF *HEXABRANCHUS SANGUINEUS* (RÜPPELL & LEUCKART, 1828) FROM LAKSHADWEEP ARCHIPELAGO, INDIA

Deepak Apte[1,2] and V.K. Salahuddin[1,3]

[1]Bombay Natural History Society, Hornbill House, Shaheed Bhagat Singh Road, Mumbai 400 001, Maharashtra, India.
[2]Email: spiderconch@gmail.com
Email: salahag1@gmail.com

Introduction

Indian opisthobranchs have received attention only in the recent times with extensive work by Apte and Bhave along the west coast of India (Apte 2009; Apte *et al.* 2010). Besides Apte (2009), the only work on the Lakshadweep Opisthobranch fauna was by Gardnier (1903) and Rao *et al.* (1974). Valdés (2002) in his paper on *Hexabranchus* discussed taxonomic confusion regarding this genus. Valdés (2002) has provided a comprehensive synonymy for the species. *H. sanguineus* is a widespread species in tropical Indo-west Pacific and it shows remarkable colour variation.

Hexabranchus sanguineus commonly called as the 'Spanish Dancer', is one of the largest nudibranch growing up to 55 cm (Double 1992; Debelius 2004) and an active swimmer. There are unpublished records of the species growing up to 90 cm.

Results and Discussion

On July 14, 2010, during a night search at low tide on the eastern reef of Agatti Island, Lakshadweep Archipelago, west coast of India, we came across two specimens of *H. sanguineus* (Family Hexabranchidae).

The specimen from Lakshadweep shows distinct colour variation from the specimens found in Andaman. Colour of the specimens from Lakshadweep is dark cherry red as compared to pink coloured individuals from Andaman. Both the specimens are illustrated here for comparison (Figs 1 and 2). Gardnier (1903) reported two species of *Hexabranchus* (*H. faustus* and *H. digitatus*) from Maldives. *H. faustus* Bergh, 1878 (Valdes 2002) and *H. digitatus* Eliot, 1903 (Thompson 1972) are now synonyms of *H. sanguineus*. Maldives is located to the south of Lakshadweep Archipelago. Gardnier's expedition to the Maldives and Laccadive Archipelagos in

Fig. 1: *Hexabranchus* cf *sanguineus* from Andaman Island measuring 13 cm

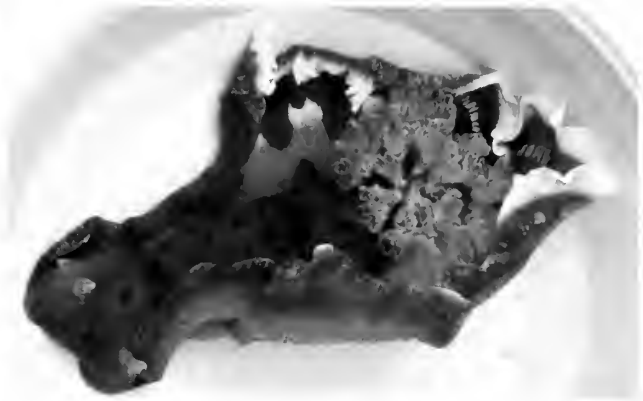


Fig. 2: *Hexabranchus* cf *sanguineus* from Lakshadweep Island measuring 21 cm

1903 was one of the major expeditions to these reefs. However, the expedition in Lakshadweep was confined only to the Minicoy Island, which is the southernmost island of the Lakshadweep Archipelago and nearest to Maldives. The present sighting is from Agatti Island, which is over 300 nautical miles north of Minicoy Island.

The present find extends the range of *H. sanguineus* to the west coast of India.

Size: 20 cm and 21 cm. Of the two specimens only one was collected and stored in 90% ethyl alcohol, after studying the morphological characters. The specimen is deposited in the BNHS Collections.

ACKNOWLEDGEMENTS

We take this opportunity to acknowledge the financial support provided by MoEF, GoI, under AICOPTAX and administrative support provided by the Department of Environment and Forests, Lakshadweep. We are also thankful to LEAD International, Darwin Initiative, for the Whitley Fund for Nature and Shears Foundation, who has supported Project Giant Clam at Lakshadweep. I am also thankful to Mr. Thirunaavukarasu S., CCF, Lakshadweep, and Dr. Sayed Ali for continued support for Project Giant Clam.

REFERENCES

Apte, D.A. (2009): Opisthobranch fauna of Lakshadweep Islands, India with 52 new records to Lakshadweep and 40 new records to India. *J. Bombay Nat. Hist. Soc. 106(2)*: 162-175.

Apte, D.A., V.J. Bhave & D. Parasharya (2010): An annotated and illustrated checklist of the Opisthobranch fauna of Gulf of Kutch, Gujarat, India, with 20 new records for Gujarat and 14 new records for India. Part 1. *J. Bombay Nat. Hist. Soc. 107(1)*: 14-23.

Debelius, H. (1996): Nudibranchs and Sea Snails Indo-Pacific Field Guide. IKAN - Unterwasserarchiv, Waldschulstrasse 166, 65933, Frankfurt, Germany. 321 pp.

Double, T. (1992): Here be Giants. *BBC Wildlife 10(5)*: 34-40.

Gardiner, J.S. (1903): The fauna and geography of the Maldives and Laccadive Archipelagos. Vol. 2, Pp. 1,080. Cambridge University Press.

Rao, K.V., P. Sivadas & L.K. Kumary (1974): On three rare doridiform nudibranch molluscs from Kavaratti Lagoon, Laccadive Islands. *Journal of the Marine Biological Association of India 16(1)*: 113-125.

Thompson, T.E. (1972): Observations on *Hexabranchus* on the Australian Great Barrier Reef (Gastropoda: Opisthobranchia). *Veliger 15*: 1-5.

Valdes, A. (2002): How many species of *Hexabranchus* (Opisthobranchia: Doridiidae) are there? *Molluscan Research 22*: 289-301.

17. AN AMPLIFIED DESCRIPTION OF HITHERTO LITTLE KNOWN THREATENED SPECIES, *PRIMULA GLOMERATA* PAX (PRIMULACEAE)

S. Panda[1]

[1]Laboratory of Taxonomy and Biosystematics, Post Graduate Department of Botany, Barasat Govt. College, Kolkata 700 124, West Bengal, India. Email: bgc.panda@gmail.com; subhaeri@yahoo.com

Introduction

During a field study in North Sikkim (September-October 2007), a species of *Primula* L. was collected about 10 km from Lachung towards Yumthang, at an altitude of about 3,300 m. After critical study, it was identified as *P. glomerata* Pax (identified in CAL by matching type material). Pax (1905) described this species based on J. Scully specimens (no. 287, CAL) from Nepal Himalaya. The species was reported from India as *P. crispa* by Balfer and Smith (1916) based on the collection by Smith (no. 4209, CAL!) from Ningbil in Sikkim. However, herbarium studies (CAL) revealed that the species was first discovered by T. Anderson from Dzongri in West Sikkim in 1862 before the description by Pax (1905). Subsequently, the species was described by Smith and Fletcher (1944), Gould (1982), Polunin and Stainton (1984), Richards (1993), Hu chi-ming and Kelso (1996), and Basak (2001). Foremost among others, Richards and Basak revised in detail, especially Basak (2001) described *P. glomerata* based on the very old herbarium specimens (CAL) collected by T. Anderson (no. 830) and King's collector *s.n.* (acc. nos. 272260, 272261, 272263, 272938) from Dzongri in West Sikkim and described without a line drawing. The present paper embodies an amplified description and detailed line drawing based on live collections from North Sikkim (*S. Panda* 30792, CAL & Barasat Govt. College herbarium) in 2007.

The genus *Primula* L. consisting of about 430 species (Mabberley 2008) is confined to tropical Asia (mostly at high hills), Europe, Africa (Ethiopia) and South America. Among 430 species, about 106 species (Basak 2001) are reported to occur in India (Himalayas and North-eastern India: Assam, Meghalaya, Manipur and Nagaland), mostly in the Eastern Himalayas.

Primula glomerata Pax in Engl. Pflanzenr. 4. 237 (Ht. 22). Primulaceae: 92. 1905; W.W. Sm. and Fletcher, *Trans. Proc. Bot. Soc. Edinburgh* 34(1): 156. 1944; Weibel, *Candollea* 15: 162. 1956; Gould in Hara *et al.* (ed.), Enum.

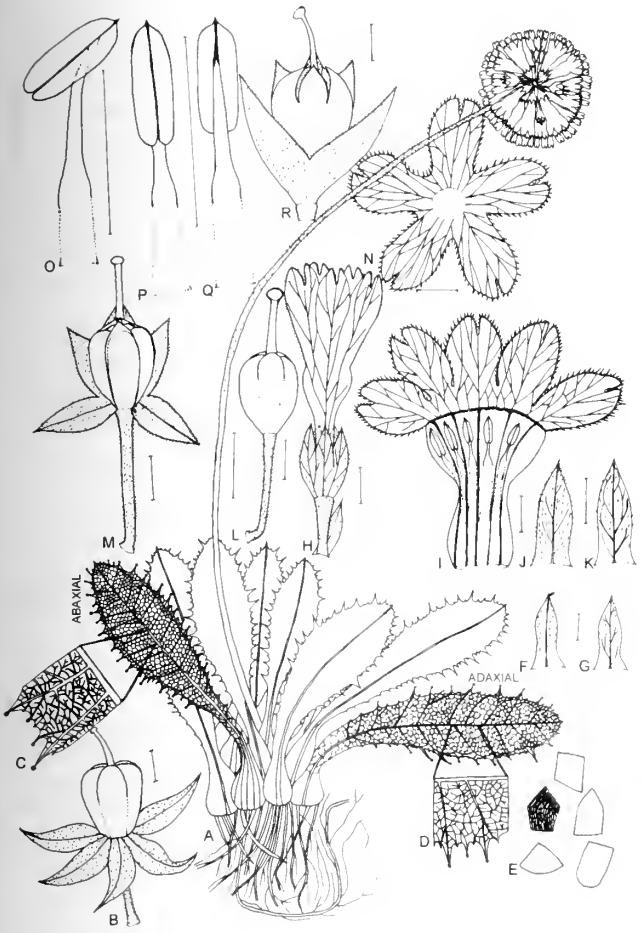


Fig. 1: *Primula glomerata* Pax: A. habit; B. mature capsule; C. abaxial leaf (part magnified); D. adaxial leaf (part magnified); E. seeds; F, G. bracts; H. flower; I. corolla split open; J, K. calyx lobes; L. ovary (without persistent calyx); M. ovary (with persistent calyx); N. corolla lobes (top view); O-Q. stamens; R. immature capsule.
Scale bars: A = 2 cm; B = 1 mm; F-G, L, M, O-R = 1 mm; H-K = 2 mm; N = 3 mm (A-R: drawn from *S. Panda* 30792, CAL & Barasat Govt. College Herbarium). Drawn by S. Panda.

Fl. Pl. Nepal 3: 72. 1982; J. Richards, *Primula*: 260. 1993; Hu chi-ming and Kelso in Wu Zheng-yi and Raven (eds.), Fl. China 15: 180. 1996; Basak, Gen. *Primula* vol. 1: 408. 2001. Type: Nepal, no proper locality, *J. Scully* 287 (CAL!). *P. crispa* Balf. f. & W.W. Sm., *Notes Royal. Bot. Gard. Edinburgh* 9: 160. 1916. Type: India, Sikkim, Ningbil, 3,952 m, 11.viii.1910, *W. W. Smith* 4209 (CAL!). Fig. 1.

Perennial herb, 15-45 cm long; rootstock thick *c.* 12 mm long, bearing tuft of wiry roots, longer root *c.* 12 cm long. Stem rhizomatous, very short beset with rosette of leaf bases, glabrous. Leaves exstipulate, radical, 8-14 in spreading rosette, glabrous, 50-120 × 16-26 mm (incl. petioles), lamina papery, narrowly ovate-elliptic to rarely obovate-elliptic, 30-80 mm long, rounded-erose-denticulate at apex, irregularly erose-denticulate or double denticulate at margin, long teeth gland-headed, cuneate at base, venation craspedodromous type; petioles sheath-like flattened, 20-50 mm long, glabrous, flanked with thin laminar extension. Scape solitary, slender, variable, usually 100-370 mm long, central, erect, covered with white dust-like grains throughout, mealy toward the apex, bearing a terminal globose head. Head perulate, in umbel, usually more than 20-flowered, 30-50 × 35-55 mm, covered with white dust-like grains throughout. Flowers erect, heteromorphic, annulate, bisexual, actinomorphic, pentamerous, 15-18 mm long, deep blue-mauve or intense violet in colour with dark eye at centre, little fragrant, amid of congested imbricately arranged bracts; pedicel short, 1-3 mm long, deep blue, puberulous. Bract 1, basal, ligulate, *c.* 3 × 1 mm, acute at apex, entire at margin, sparsely puberulous. Ebracteolate. Calyx cupular-campanulate, 4-6 × 3-4 mm, purple; lobes 5, oblong-lanceolate, each lobe *c.* 5.0 × 1.5 mm, connate basally, up to 2 mm, free part 3 mm, shortly acuminate at apex, obscurely ciliolate at margin, densely puberulous inside, sparsely outside. Corolla infundibuliform, deep blue-mauve, 12-16 mm long, *c.* 8 mm wide towards apex, tube distinctly cylindric, 6-10 mm long; lobes 5, ovate-obcordate, *c.* 6 × 5 mm, emarginated or notched at apex, ciliate at margin, distinctly veined. Stamens 5, epipetalous, *c.* 1.5 mm long; filaments minute up to 0.5 mm long, grayish-white; anther lobes 2, oblong, light brown, *c.* 1 mm long, shortly apiculate at apex, dorsifixed. Pistil *c.* 3.5 mm long; ovary obovoid-globose, 1.5-2.5 × 1.5 mm, glabrous, 5-locular, syncarpous; numerous minute ovules on axile placenta in each locule; style filiform, *c.* 1.5 mm long, glabrous; stigma capitate to truncate. Fruit loculicidal 5-valved capsule, *c.* 9 × 3 mm including pedicel, glabrous, with persistent calyx; capsule obovoid-globose, *c.* 5 × 3 mm. Seeds obconical, minute up to 0.5 mm long, scariosus.

Distribution: INDIA: Eastern Himalayas (Sikkim: West and North districts); Nepal; Bhutan and China (Se Xizang).

Habitat: This species grows discontinuously in patches along moist and humus-covered rocky slopes in association with *Gaultheria hookeri*, *Rhododendron thomsonii*, *R. niveum*, *R. barbatum* and *Vaccinium nummularia* at altitudes ranging from 3,000-3,300 m.

Flowering and Fruiting: Late September to late October.

Specimens examined: INDIA: Sikkim: north district, about 10 km from Lachung towards Yumthang, *c.* 3,200 m, 04.x.2007, S. Panda 30792 (fl. & fr, CAL, Barasat Govt. College Herbarium); North district, between Lachung and Yumthang, *c.* 3,400 m, 04.x.2007, S. Panda 30799 (fl. & fr., Barasat Govt. College Herbarium); West district: Dzongri ('Jongri'), *c.* 4,000 m, June, 1887, King's Collector *s.n.* (Acc. no. 272263, CAL); Dzongri ('Jongri'), *c.* 4,500 m, 08.x.1862,

Anderson 830 (CAL).

Field notes: Craspedodromous leaf venation, up to 37 cm long scape; perulate head in umbel (3-5 × 3.5-5.5 cm) beset with white dust-like grains throughout; 15-18 mm long flowers; short puberulous deep blue pedicel up to 3 mm long; puberulous bract and calyx lobes; 12-16 mm long corolla; short stamens (*c.* 1.5 mm long) and styles (*c.* 1.5 mm long) and loculicidal 5-valved obovoid-globose capsule (*c.* 9 × 3 mm) not reported earlier.

ACKNOWLEDGEMENTS

I am grateful to the supervisor, Dr. M. Sanjappa, Director, Botanical Survey of India, for guidance and manuscript correction, to Dr. M.S. Mondal, Joint Director, Central National Herbarium (CAL), for his kind permission to consult herbarium specimens in CAL and to Dr. P. Saha, Officer-in-Charge, P.G. Department of Botany, Barasat Govt. College, for his permission to undertake research work in the laboratory of Taxonomy and Biosystematics. Thanks are also due to my P.G. students Mr. Arindam Adhikari and Ms. Rumpa Sarkar for their sincere help and Camera Lucida drawings during stomatal investigation. I desire to express my sincere thanks to Dr. Asok Das, Reader, Mycology and Plant Pathology, and to Dr. Naimuddin, Convenor, P.G. Dept. of Botany, Barasat Govt. College, for providing all facilities and help during the course of study.

REFERENCES

Balfer, I.B. & W.W. Smith (1916): New Species of *Primula*. *Notes from the Royal Botanic Garden Edinburgh 9*: 160.

Basak, S.K. (2001): Study on the genus *Primula* L. (Primulaceae Vent.). Vol. 1: 408-410. University of Kalyani, Nadia, West Bengal (India).

Gould (1982): An Enumeration of the Flowering Plants of Nepal 3: 72. *In*: Hara, H., A.O. Charter & L.H.J. Williams (Eds): Trustees of British Museum (Natural History), London.

Hu, chi-ming & S. Kelso (1996): Flora of China. Pp. 180. *In*: Wu Zheng-yi & P.H. Raven (Eds): Primulaceae, Vol. 15. Publ. Science Press, Beijing and Missouri Botanical Garden, St. Louis.

Mabberley, D.J. (2008): *Primula*. Mabberley's Plant Book: A portable dictionary of plants, their classification and uses. Ed. 3: 698. Cambridge University Press, Cambridge, England.

Pax, F. (1905): *In*: Engler, A. (Ed.): Pflanzenreich 4. 237 (Heft 22): 92.

Polunin, O. & A. Stainton (1984): Flowers of the Himalaya (Primulaceae). Oxford University Press, Oxford. Pp. 243

Richards, J. (1993): *Primula*: 260. Timber Press, Portland, Oregon.

Smith, W.W. & H.R. Fletcher (1944): The genus *Primula*: Sections Corusoides, Malvaceae, Pycnoioba, Dryadifolia, Capitatae. *Trans. Bot. Soc. Edinburgh 34(1)*: 156.

18. NEW ADDITIONS TO THE SEDGE FLORA OF ANDAMAN & NICOBAR ISLANDS

K. Karthigeyan[1,3], J. Jayanthi[1,4], R. Sumathi[1,5] and P.G. Diwakar[2]

[1]Department of Botany, Madras Christian College (Autonomous), Tambaram, Chennai 600 059, Tamil Nadu, India.
[2]Botanical Survey of India, Western Circle, Pune 411 001, Maharashtra, India. Email: pgdiwakar@hotmail.com
[3]Email: karthigeyan.murthy@gmail.com
[4]Email: jayanthi.mcc@gmail.com
[5]Email: sumathi.ramamurthy@gmail.com

During the inventory of floristic diversity of the Mahatma Gandhi Marine National Park (MGMNP) in South Andaman, two Cyperaceae members were collected from the swampy area and along sandy seashores. On critical examination, the specimens were identified to be *Eleocharis acutangula* (Roxb.) Schult. and *Pycreus stramineus* (Nees) C.B. Clarke. Scrutiny of literature revealed that these species were hitherto unrecorded from this archipelago and hence reported here as new additions to the sedge flora of Andaman & Nicobar Islands (Vasudeva Rao 1986; Mathew 1998). Of the two species, *E. acutangula* is widely distributed and *P. stramineus* is found to be distributed in the South-East Asian region. Brief descriptions, illustrations, phenology and notes on their distribution are provided.

Eleocharis R. Br.

Eleocharis acutangula (Roxb.) Schult. in R. & S. Mant. 2: 91. 1824; Ridley, Fl. Malay Peninsula 5: 151. 1925; Baker & Bakhuizen, Fl. Java 3: 461. 1968; Kern in Steenis (ed.), Fl. Malesiana Ser. I. 7: 525. 1974; Koyama in Dassanayke (ed.), Rev. Handb. Fl. Ceylon 5: 256. 1985; Simpson & Koyama in Santisuk & Larsen (eds.), Fl. Thailand 6(4): 285. 1998. *Scirpus acutangulus* Roxb. Fl. Ind. 1: 216. 1820. *Eleocharis fistulosa* Schult. in R. & S. Mant. 2: 89. 1824; C.B. Clarke in Hook. f., Fl. Brit. India 6: 626. 1893; Ridley, Fl. Malay Peninsula 5: 151. 1925. (Fig. 1)

Perennial herbs, stoloniferous. Culms tufted, 40-60 cm long, triquetrous; sheaths 3-8 cm long, pale brown. Spikelet terminal, cylindrical, 2-5 cm long, pale green-yellow.

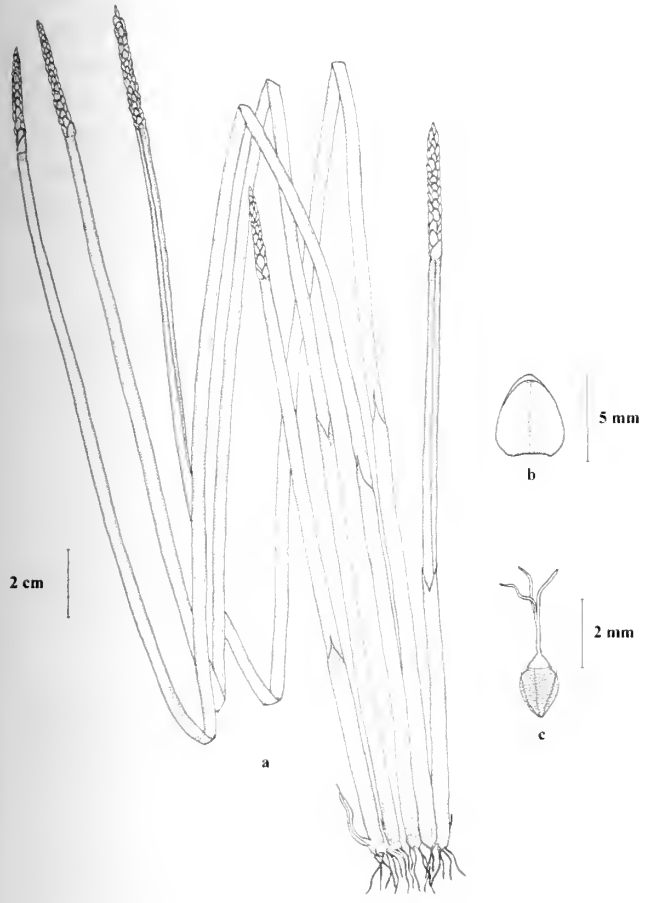


Fig. 1: *Eleocharis acutangula* (Roxb.) Schult. – (a) Habit; (b) Glume; (c) Nutlet

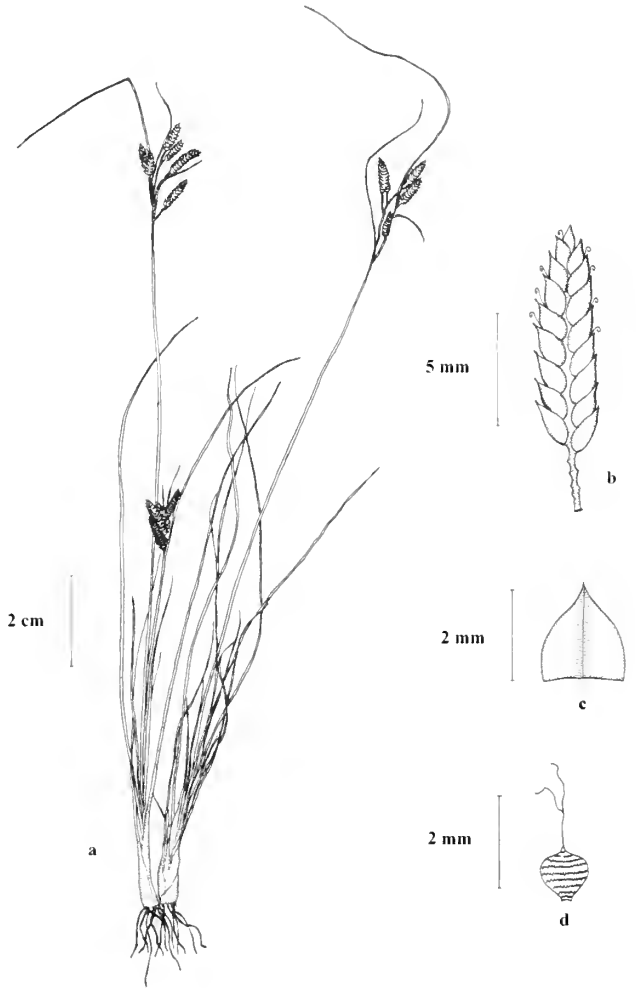


Fig. 2: *Pycreus stramineus* (Nees) C.B. Clarke – (a) Habit; (b) Spikelet; (c) Glume (ventral side); (d) Nutlet

Glumes ovate, 4-5 mm long, 1-nerved, obtuse at apex, hyaline along margin. Nutlets obovoid, *c.* 1.8 x 1.2 mm, compressed, yellow-brown, annular at apex, indistinctly transversely pitted. Hypogynous bristles 6, retrorsely barbellate, *c.* 2 mm long.

Fl. & Fr.: August-December.

Ecology: Occasional; in swampy areas forming large communities near Wandoor.

Specimen examined: South Andaman, Mahatma Gandhi Marine National Park, Wandoor, Karthigeyan 19593 (PBL). 11.x.2003.

Distribution: Pantropical.

Note: This widespread species was so far not recorded from the Andaman Islands. It could be easily recognized from *E. dulcis* (Burm.f.) Trin. *ex.* Henschel, by its triquetrous stem.

Pycreus P. Beauv.

Pycreus stramineus (Nees) C.B. Clarke in Hook. f. Fl. Brit. India 6: 589. 1893; Koyama in Dassanayke (ed.), Rev. Handb. Fl. Ceylon 5: 216. 1985; Simpson & Koyama in Santisuk & Larsen (eds.), Fl. Thailand 6(4): 391. 1998. *Cyperus stramineus* Nees in Wight, Contr. Bot. India 74. 1834. *C. substramineus* Kukenth. in Pflanzenr. 4(20). 101 Heft: 398. 1936; Kern in Steenis (ed.), Fl. Malesiana Ser. I. 7: 653. 1974. (Fig. 2)

Annual herbs. Culms tufted, 8-20 x 0.1-0.2 cm, smooth. Leaves few, linear-filiform, 2-16 x 0.1 cm, acuminate at apex; sheaths 2.0-3.5 cm long, purplish. Bracts 3, 1-8 cm long. Inflorescence slightly congested with 5-8 spikelets, 2-3 cm long. Spikelets oblong-lanceolate, 1.0-1.5 x 0.1-0.2 cm, flattened, acute at apex, straw-coloured. Rachilla straight, wingless. Glumes distichous, broadly ovate, *c.* 2.0 x 1.2 mm, mucronate at apex, dull greenish-yellow, hyaline along margin; keel green, 3-nerved. Stamens 2, *c.* 0.8 mm long. Style 1.0-1.2 mm long; stigmas 2. Nutlets obovoid, *c.* 1.0 x 0.8 mm, biconvex, laterally flattened, transversely wrinkled, dark brown, minutely apiculate.

Fl. & Fr.: September-November.

Ecology: Occasional; in coastal areas along sandy shores.

Specimen examined: South Andaman, Mahatma Gandhi Marine National Park, Rutland Island, Karthigeyan 6164 (PBL). 14.ix.2002.

Distribution: Sri Lanka, India, Bangladesh, Myanmar, Indo-China and Malay Peninsula.

ACKNOWLEDGEMENTS

We thank Dr. M. Sanjappa, Director and Dr. H.J. Chowdhery, Joint Director, Botanical Survey of India, for facilities. The first three authors are also thankful to Dr. C. Livingstone, Head (Retd.) and Dr. D. Narasimhan, Senior Lecturer, Department of Botany, Madras Christian College, Chennai, for encouragement.

REFERENCES

MATHEW, S.P. (1998): A supplementary report on the flora and vegetation of Bay Islands, India. *J. Econ. Tax. Bot. 22(2)*: 249-272.

VASUDEVA RAO, M.K. (1986): A preliminary report on the angiosperms of Andaman & Nicobar Islands. *J. Econ. Tax. Bot. 8(1)*: 107-184.

19. ADDITIONS TO THE FLORA OF MAHARASHTRA

MADHUKAR BACHULKAR[1]

[1]Department of Botany, Shri Vijaysinha Yadav Arts and Science College, Peth Vadgaon 416 112, Kolhapur, Maharashtra, India. Email: principalvyadavcollege@yahoo.co.in

While investigating the flora of Satara, Sangli and Kolhapur districts of Maharashtra, I came across four plant species previously not recorded from Maharashtra. The paper provides their nomenclature, description, distribution and phenology. The species have been arranged alphabetically. All voucher specimens are deposited in the Herbarium of Shivaji University (SUK), Kolhapur.

1. ***Habenaria elwesii*** Hook. f. in Bot. Mag. t. 7478. 1896; Fischer in Fl. Pres. Madras 1468. 1928 (Repr. ed. 3: 1026. 1957) (Orchidaceae).

Herb, erect slender 25-40 cm high; tuber *c.* 2.0 x 1.0 cm, hairy. Leaves 3-6 alternate, about middle of the stem, 4.0-7.0 x 1.0-2.0 cm, lanceolate to oblong, acute. Inflorescence 8-16 cm long, lax-flowered. Flowers white, sessile, bracteate. Bracts 3.0 x 1.0 cm, foliaceous, cymbiform, longer than the ovary, broadly ovate-lanceolate, acuminate at tip, finely puberulous along margin. Lateral sepals obliquely lanceolate, spreading, abruptly acuminate, 5-nerved. Dorsal sepal ovate-oblong, concave, acuminate, finely scabrid, 3-nerved. Lateral petals bipartite, almost to the base, densely hirsute or bearded along the margins; lower segment slightly shorter than the upper segment, curved. Lip spurred, longer than ovary, trilobed below the middle with a narrow claw; lobes narrow, divaricate, midlobe subequal with side lobes. Spur shorter than ovary. Capsule 2.5 cm, long, ribbed, fusiform.

Fl. & Fr: September-October.

Exsiccata: MPB – 20349.

Distribution: Very rare. It grows near the edges of the forest at an altitude *c.* 800 m. Kolik (Chandgad) in Kolhapur district.

Note: Earlier it was known from Nilgiri hills, Tamil Nadu.

2. ***Rhynchosia viscosa*** (Roth) DC. Prodr. 2: 387. 1825; Hook. f.. Fl. Brit. India 2 : 225. 1876. Sharma *et al.* Fl. Karnataka 81. 1984. *Glycine viscosa* Roth. Nov. Pl. Spec. 349. 1821. (Fabaceae).

Twiner or spreading herb; branchlets densely viscid-tomentose. Leaves 3-foliate, 6-8 cm long; leaflets ovate-deltoid, 3.0-5.0 x 2.0-4.5 cm, tomentose; base cuneate, obtuse; apex acuminate, apiculate; stipules lanceolate. Flowers brownish-purple, in 8-15 cm long dense racemes; bracts minute. Calyx tomentose; lobes lanceolate. Corolla exerted; deep brown-purple; wings and keels yellowish. Ovary pubescent. Pods oblong, horned, viscid-pubescent, 2-4 seeded.

Fl. & Fr.: November-January.

Exsiccata: MPB-6054.

Distribution: Rare along ghats. Khadgaon, Pasarni ghat in Satara district.

Note: Earlier it was known from Karnataka and Tamil Nadu.

3. ***Richardia scabra*** L. Sp. Pl. 330. 1753; Balkr. Bull. Bot. Surv. India 6: 85. 1964. Mathew, Ill. Fl. Tamil Nadu Carnatic t. 346. 1982; Sharma *et al.* Fl. Karnataka 132. 1984. (Rubiaceae).

Procumbent herb; branchlets spreading, terete to angular, hispid. Leaves simple, decussate or whorled, elliptic-ovate, 2-4 x 1-2 cm, scabrous; base obtuse; apex acute; petiole 5 mm long; upper leaves sessile; stipules setiferous. Flowers 3-merous in terminal sessile, capitate clusters, subtended by 4 subsessile leaves. Calyx truncate, globose; lobes 6, abovate, scabrous. Corolla white; lobes 6, triangular. Stamens 6, partly

exerted. Ovary subglobose , papillose, 3-celled. Capsules 3-valved; epicarp scabrous.

Fl. & Fr.: August-December.

Exsiccata: MPB-21110.

Distribution: Common weed in groundnut and sweet potato fields. Kargaon in Satara district; Karve, Chandgad in Kolhapur district.

Note: It is a native of Tropical America. Earlier in India, it was known from Karnataka and Tamil Nadu.

4. ***Rotala occultiflora*** Koehne, Bot. Jahrb. 1: 152. 1880; Blatt. & Hallb. *J. Bombay Nat. Hist. Soc. 25*: 705. 1918; Sharma *et al.* Fl. Karnataka 108. 1984; Joseph & Sivaranjan Pl. Sci. 99 (3): 191. t. 5. 1989. (Lythraceae).

Small herb; stem creeping and rooting below; branches erect, 4-6 cm tall. Leaves in whorls of 3, obspathulate, plicate; base dialated, enclosing the flowers, 0.6-0.9 cm long. Flowers shortly pedicillate, solitary in the axils of bractiform leaves. Calyx tube translucent, 1 mm long; lobes 4, triangular. Petals absent. Stamens 2, inserted near the base of calyx tube. Ovary ellipsoidal; style short, persistent; stigma capitate. Capsule ellipsoidal, 3-valved. Seeds semi-ellipsoidal.

Fl. & Fr.: August-October.

Exsiccata: MPB-21242.

Distribution: Rare in wet places. Kaas in Satara district.

Note: An inconspicuous, ephemeral species. Earlier it was known from Karnataka and Tamil Nadu.

ACKNOWLEDGEMENTS

We thank Dr. S.R. Yadav, Professor, Department of Botany, Shivaji University, Kolhapur, for confirming the identity of the specimens and also Shri Vijaysinha Yadav, President, Shri Shahu Shikshan Prasarak Mandal, Peth Vadgaon, for encouragement.

20. *CLITORIA ANNUA* GRAHAM VAR. *EMARGINATA* (VAR. NOV.): A NEW VARIETY OF SPECIES *CLITORIA ANNUA* GRAHAM (FAMILY: FABACEAE) FROM MAHARASHTRA, INDIA

SANTOSH L. YADAV[1] AND PRAMOD B. DHANKE[2]

[1]Magdelin Almeida Environmental Centre, Kharvatkar Temb, P.O. Savantwadi 416 510, Sindhudurg, Maharashtra, India.
Email: santromeet@yahoo.com
[2]Office of the Chief Conservator of Forest, Chandrapur Forest Circle, Chandrapur 442 401, Maharashtra, India.
Email: pbdhanke@yahoo.com

During a floristic survey of flowering plants in Sawarna taluka, Nashik district, Maharashtra, in November 2009, we came across an interesting plant of the genus *Clitoria* in open grassland near the Sawarna river. A few plants from the area were collected, processed and preserved. Comparison with the material deposited at Blatter Herbarium (BLAT) and literature at the BLAT library (Almeida 1990, 1998, 2005; Cooke 1902; Hooker 1876) confirmed it as a new variety of *Clitoria annua* Graham, Family Fabaceae, and was named *Clitoria annua* Graham var. *emarginata* (var. nov.)

Clitoria [L., Gen. ed. 1, 344, 1737]: L., Sp.Pl. 753, 1753; Benth. & Hook. f., Gen. Pl. 1: 527, 1865 (Fabaceae, 1753). Clitoris = an anatomical term in Zoology. Lectotype: *C. ternatea* L. (vide Britton *et* Brown, Ill. Fl. United States and Canada 2: 416, 1913. Type: *C. ternatea* L. spp.: 40 (Sant. & Henry), 70 (Mabb.), Trop. America – 3 in India. *C. ternatea* L., "Aparajita, Shankhapushpi, Butterfly pea" (Trop. America) – Now pantropic in cultivation. *C. annua* Graham, endemic to Mumbai. Found in two varieties, typical one (*C. annua* var. *annua*) and *C. annua* var. *sekharii* Almeida & Chaturvedi, both endemic to Mumbai.

Present variety is the second variety, beside the typical one.

Clitoria annua Graham, Cat. Bombay Pl. 47, 1839; Almeida & Almeida in *J. Bombay Nat. Hist. Soc. 84*: 719-722, 1986; Almeida, Fl. Maharashtra Vol. 2: 29, 1998.

Herbaceous, erect, 40-50 cm high; stem angular, with hairs. Leaves imparipinnate; petioles 9-12 mm long, hairy; stipules 3 mm long, subulate. Leaflets 5, membranous (terminal the largest and lowest pair of lateral leaflets smaller than the rest) 5-8 x 1-4 cm, variable in shape, broadly elliptic-oblong, subobtuse to lanceolate, acute, sparingly strigose above, more densely beneath; petiolules 2 mm long; stipules filiform. Flowers in axillary 2-flowered racemes; peduncles and pedicels very short; bracts linear-lanceolate, subulate; bracteoles 6-8 mm long, ovate or lanceolate, aristate. Calyx tubular, 1-2 cm long, hairy, nerved; teeth shorter than tube, lanceolate, aristate. Corolla 2.5 cm long, blue. Pods 25-50, 6 mm flat reticulately veined, pubescent. Seeds 5-6, turn black after dry.

Fl.: August-October.

Distribution: H. Santapau- 16540 collected from Sasan

high hill on 2.x.1953 and deposited in the Blatter Herbarium-16226 (BLAT).

Clitoria annua Graham var. ***sekharii*** Almeida & Chaturvedi, Fl. Maharashtra Vol. 2: 29, 1998.

This variety differs from the typical variety in having leaves with somewhat acuminate apices. In all other characters it resembles the typical variety.

Fl.: September-October.

Distribution: D.P. Panthaki- 2370, collected from Dang, on 24.x.1955 and deposited in the Blatter Herbarium - 16203. (BLAT).

Clitoria annua Graham var. ***emarginata*** (var. nov.)

This variety differs from the typical variety in having leaves with emarginate apices in the leaflets.

Holotype: Santosh Yadav & M.R. Almeida 1034, collected from Sawarna, Nashik district, on 5.xi.2009, deposited in the Blatter Herbarium (BLAT).

Isotype: Santosh Yadav & M.R. Almeida 1035, collected from Sawarna, Nashik district, on 5.xi.2009, deposited in the Herbarium of Magdelin Almeida Environmental Centre (MAEC), Savantwadi.

Herbaceous, erect, 30-60 cm high; stem cylindrical with ridges, hairy. Leaves imparipinnate; petioles 5-9 mm long, hairy: stipules 2-3 mm long, subulate. Leaflets 3 or 5, membranous (the terminal the largest and lowest pair of lateral leaflets smaller than the rest) 2-4 x 1.5-3.0 cm, variable in shape, broadly linear-oblong, apex emarginate, sparingly strigose above, more densely so beneath; petiolules 0.5 mm long; stipules filiform. Flowers in axillary 2-flowered racemes; peduncles and pedicels very short; bracts linear-lanceolate, subulate; bracteoles 6-8 mm long, ovate or lanceolate, aristate. Calyx tubular, 1-2 cm long, hairy, nerved; teeth shorter than the tube, lanceolate, aristate. Corolla 1.0-1.5 cm long, white. Pods 20-35 mm x 4-5 mm, flat, reticulately veined, pubescent. Seeds 3-5, 6 x 4 mm, black in colour, smooth surface.

Fl.: September-November.

Distribution: Sawarna in Nashik district.

Distinguishing character (in Latin)

Is varietas distinctus ex typical varietas in having coma per emarginated apices in leaflets.

The following species of genus *Clitoria* in literature are published without proper description and are presently treated as *nomina nuda*.

1. *Clitoria vaupelli* Graham, Cat. Bombay Pl. 47, 1839.

Description given under this species is too short to match with any species of *Clitoria* L.

2. *Clitoria brasiliana* L., Sp. Pl. 753, 1753; Graham, Cat. Bombay Pl. 47, 1839.

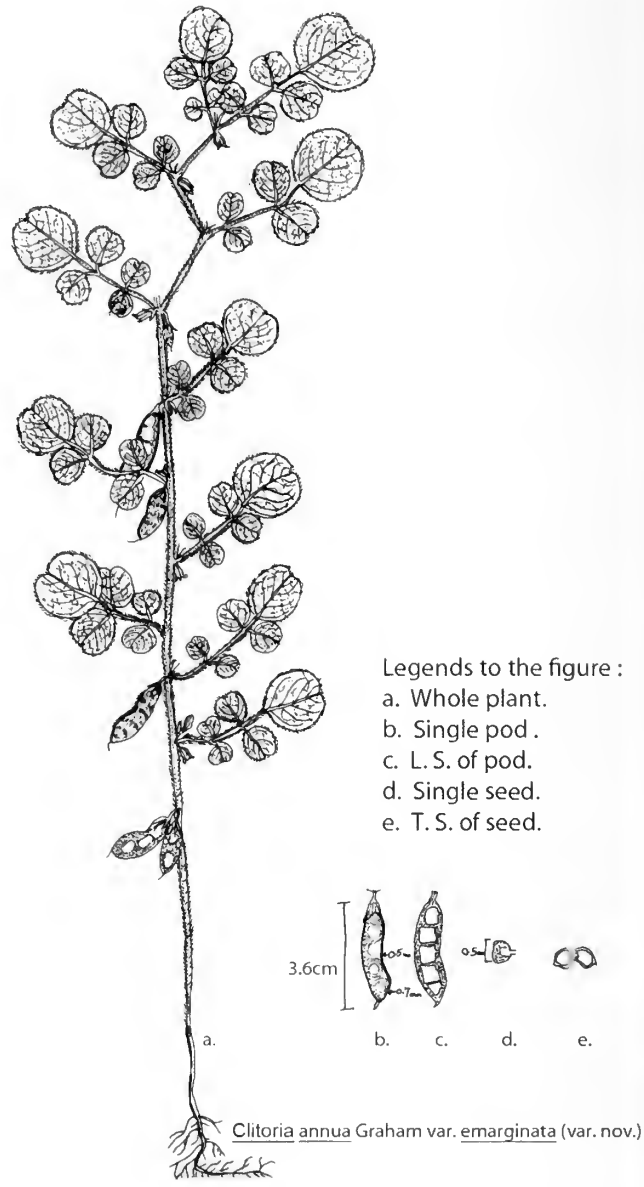


Fig. 1: *Clitoria annua* Graham var. *emarginata* (var. nov.)

The correct name for this species is *Centrosema brasilianum* (L.) Benth., Comm. Leg. Gen. 54, 1837.

ACKNOWLEDGEMENTS

We are grateful Dr. M.R. Almeida, FMASc., DSc., former Herbarium Assistant of BLAT, for guidance and help rendered in the preparation of this communication. We are also thankful to Dr. (Mrs.) Ujwala Bapat, Head of Botany Department, St. Xavier's College, Mumbai, for providing access to the Blatter Herbarium and Library.

REFERENCES

ALMEIDA, S.M. (1990): Flora of Savantwadi, Vol. 1. Pp. 121. Scientific Publisher, Jodhpur.
ALMEIDA, M.R. (1998): Flora of Maharashtra, Vol. 2. Pp. 29. Orient Press, Mumbai.
ALMEIDA, M.R. (2005): Dictionary of Generic names of Flowering Plants and Ferns found in Maharashtra and Adjoining area, Orient Press, Mumbai. Pp. 75.
COOKE, T. (1902): Flora of Presidency of Bombay, Vol. 1. Pp. 405-406. London (Reprinted vols. I-III, 1958).
HOOKER, J.D. (1876): The Flora of British India, Vol. 2. Pp. 208. Published by L. Reeve, London.

■ ■ ■

Printed by Bro. Leo at St. Francis Industrial Training Institute, Borivli, Mumbai 400 103 and published on August 25, 2011
by Dr. Ashok Kothari for Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk,
Shaheed Bhagat Singh Road, Mumbai 400 001, Maharashtra, India.

INSTRUCTIONS TO AUTHORS

The *Journal* welcomes concise reports of original research in natural history, taxonomy and other aspects of zoology and botany of general interest.

SUBMISSION OF MANUSCRIPT

Hard copies of manuscripts (including illustrations) **in duplicate**, typewritten **in double space** on one side of the paper and a copy of the MS on a floppy diskette or CD using MS Word, should be submitted to the Editor, *Journal of the Bombay Natural History Society*, Hornbill House, Shaheed Bhagat Singh Road, Mumbai 400 023. Submission of a manuscript to the *Journal* implies that it has not been submitted for publication elsewhere.

Please do not send manuscripts by e-mail unless requested to do so. We do not download unsolicited material.

PREPARATION OF MANUSCRIPT

Main Papers and New Descriptions

Manuscripts of papers for the Main section and New Descriptions should be as concise as possible. Pages should be numbered consecutively, and the matter on Page 1 should be arranged in the following order: Title of the paper; Name(s) of Author(s), Department(s) and Institution(s); Footnote containing address of Author for correspondence with e-mail id, followed by the List of Abbreviations used in text. A short running title derived from the original title may also be given for main papers. Page 2 should contain the Abstract. The text may be arranged in the following order: Introduction; Material and Methods or Methodology; Results; Discussion; Acknowledgements; References. Abstract, Key Words, Tables and Captions for Figures should be typed separately.

Title: The title should be such as to be useful for indexing and information retrieval.

Abstract: The abstract, not exceeding 200 words, should indicate the scope and significant content of the paper, highlighting the principal findings and conclusions.

Introduction: The introductory part should bear no heading, should be brief and state precisely the objective of the study in relation to the present status of knowledge in the field. Review of literature should be restricted to the essential references.

Material and Methods or Methodology: The nomenclature, sources of materials and the procedures should be clearly stated. New methods should be described in detail, but if the methods are well known, a mere reference to them will do; any modifications made in the methods should be stated.

Results: Only data relevant to the objectives of the study and main conclusions emerging from the study should be included. The data should be arranged in a unified and coherent sequence for clarity and readability. The same data should not be presented in both tables and figures, and such data as can be easily and briefly stated in the text should not be depicted diagrammatically. Only such tables and figures as are necessary should be given.

Tests of statistical significance should be identified and references used should be cited. Statements about the statistical significance of the results must be borne out by the level of significance, preferably provided in the tables and legends. The use of the word "significant" should be restricted to "statistically significant".

Discussion: The discussion should provide an interpretation of the results of the study, without repeating information already presented under Results. It should relate the new findings to the known and include logical deductions. Where necessary, the Results and Discussion can be combined.

Illustrations: The number of illustrations should be kept to the minimum and numbered consecutively in Arabic numerals. Simple linear plots or linear double reciprocal plots that can be easily described in the text should be avoided. Extension of graphs beyond the last experimental point is permissible only while extrapolating data.

Line drawings should be either laser prints of computer generated illustrations or manually prepared in Indian ink on tracing paper, drawn to approximately twice the printed size. The drawings are usually reduced to the page width or column size, and **care should be taken that the size of letters, numerals, dots and symbols is relatively uniform and sufficiently large to permit this reduction.**

Photographs: Photographs for reproduction must be clear, with good contrast. Prints should be at least 9x12 cm and on glossy, glazed paper.

Tables: Each table should have an explanatory title and should be numbered in Arabic numerals. Units (metric) of measurement should be abbreviated and placed below the headings. Negative results should be indicated as Nil (0) and absence of a datum by a dash.

Acknowledgements: Acknowledgements should be brief and relevant.

References: Responsibility for the accuracy of references rests with the author(s). Abstracts of papers presented at scientific meetings may be cited. References to literature should be alphabetically arranged under author's name, with the abridged titles of journals or periodicals in italics and titles of books or papers in Roman type, thus:

Aluri, Raju J.S. & C. Subha Reddi (1995): Ecology of the pollination in two cat-mint species. *J. Bombay Nat. Hist. Soc. 91(1)*: 63-66.

Prater, S.H. (1971): The Book of Indian Animals. 3rd Edn. Bombay Natural History Society, Mumbai. pp. 35-48.

Species names should carry the Author's name and subspecies (trinomials) should only be used where identification has been authentically established by comparison of specimens actually collected.

For the standardised common and scientific names of the birds of the Indian subcontinent refer to *Buceros* Vol. 6, No. 1 (2001).

Miscellaneous Notes: The section accommodates incidental observations on flora and fauna of the Asian region, and need not follow strictly the above section headings. No abstract is required, but key words may be included and references must be cited as in the rest of the *Journal*.

Reprints: 25 reprints will be supplied free of charge to the authors of Main Papers and New Descriptions. Authors of Miscellaneous Notes will be sent one free copy each of the *Journal*.

The Editors reserve the right, other things being equal, to publish a member's contribution before that of a non-member. The Editors also reserve the right to publish invited papers on priority.

Registered with the Registrar of Newspapers under RN 5685/57 ISSN 0006-6982

CONTENTS

NEW DESCRIPTIONS

Printed by Bro. Leo at St. Francis Industrial Training Institute, Borivli, Mumbai 400 103 and published by Dr. Ashok Kothari for Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk, Shaheed Bhagat Singh Road, Mumbai 400 001.
website: www.bnhs.org; Email: bnhs@bom4.vsnl.net.in