Fauna of Protected Areas: 14

DIVERSITY, ABUNDANCE, AND HABITAT ASSOCIATIONS OF BUTTERFLY SPECIES IN BONDLA WILDLIFE SANCTUARY OF GOA, INDIA

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(web supplement 1653li & lli-ii)

ABSTRACT

Bondla Wildlife Sanctuary is a very popular wilderness destination for the tourists visiting Goa. One of smallest wildlife protected area in the state, its flora comprises of a mixture of evergreen and moist deciduous forests, besides some riparian patches. The tourist zone of the sanctuary has artificial landscape in form of animal enclosures, a formal garden and orchards. Against the backdrop of increasing interest in eco-tourism, it was envisaged to compile a species inventory of butterflies of this region, and find out the best seasons for butterfly sightings. The investigation on species diversity and abundance was carried out in three distinct habitat types, within the sanctuary viz. forests, orchards and formal gardens. Habitat associations of 91 butterfly species were determined by analyzing weekly sighting records from the three habitat types. The recorded species belonged to 66 genera, 14 subfamilies and five families. Nymphalidae dominated the list with 40 species, followed by Lycaenidae (19 species), Papilionidae (14 species), Pieridae (12 species), and Hesperiidae (6 species). Of the total butterfly species listed in this sanctuary, 71 species are habitat generalists and 20 species are habitat specialists, 13 figure in the scheduled categories of the Wildlife (Protection) Act, and eight are endemics. Based on the analysis of weekly data, flight periods and seasonality of species have been worked out. The findings have been based on one year of fieldwork. Species have been classified based on their relative estimates of abundance. Such studies on monitoring the species diversity and abundance of butterflies can give valuable information on their population dynamics.

KEYWORDS

Abundance, Bondla Wildlife Sanctuary, butterfly diversity, conservation status, flight periods, Goa, seasonal variations

Goa, being one of the states that contribute to the stretch of Western Ghats, has an amazing diversity of plant and animal life. The entire east zone of this state is a part of either of the four wilderness Protected Areas, *viz*., Madhei Sanctuary, Bondla Sanctuary, Netravali Sanctuary and Cotigao Sanctuary. Of these, the Bondla Wildlife Sanctuary is the smallest wildlife protected area in Goa, with an area of just 7.98km^2. Being declared as a game sanctuary, in January 1968 vide section 18 of Wild Animals and Wild Birds Protection Act 1965, Bondla boasts of a Mini Zoo, Deer Safari Park, Formal Gardens, Botanical Garden with a nursery and a few interesting icons which have been salvaged during excavations elsewhere in the state. Around 1.19km^2 of this sanctuary is set aside for the use of visitors. The vegetation of this sanctuary is predominantly mixed deciduous with intermittent patches of bamboo undergrowth. The flowing streams within the sanctuary create riparian patches.

Though great varieties of butterflies, moths and skippers are seen in this place supported by their food and host plants, there has been a complete dearth of authentic information on the lepidopteran fauna of Bondla Wildlife Sanctuary of Goa. The work presented here is based on the presumption that preparation of a checklist of butterflies, the most impressive element of insect diversity could bring about a lot of value addition to the potential of this sanctuary as an eco-tourism destination. Apart from check listing of butterfly species, an attempt has also been made to highlight their flight periods, seasonality and relative abundance in the different habitats of this sanctuary. The present study is undoubtedly the first comprehensive effort to investigate the lepidopteran diversity of the state of Goa in general and the area under investigation, the Bondla Wildlife Sanctuary in particular.

METHODOLOGY

The findings presented here are based on the field investigation carried out from July 2001 to June 2002. The fieldwork commenced only after obtaining permission from the office of the Director of Wildlife and Eco-tourism, Govt. of Goa vide letter No: 1-238-92-WLD-1270, under the UGC sponsored research program. The entire field protocol has been designed in compliance with the terms and conditions of the Wild Life (Protection) Act and its amendments.

To understand the diversity, abundance and habitat association of butterflies in this sanctuary, transects were laid in the three habitat types: Forests, Orchards and Gardens. Transects in each of the representative habitat were surveyed on foot every one day every week between 0900hr to 1700hr for a period of 46 weeks. Collection details and observations were recorded for subsequent computation and analysis. As a conservation policy, over collection was avoided and in fact, some rare specimen were collected only if doubts persisted in their specific identity.

The year was divided into three seasons viz. monsoons (June-

This paper was presented by the lead author at the 14th All India Congress of Zoology held at Vivekananda College Agaastheeswaram, Kanyakumari on 21 - 23 December 2003.

Manuscript 1192; Received 26 April 2004; Finally accepted 31 July 2004; © Zoo Outreach Organisation; www.zoosprint.org

September), Post-monsoons (October-January) and Pre-monsoons (February- May), based on general observations on the climate. The relative abundance of butterfly species was determined adopting modification of the scheme proposed by Rajsekhar (1995). The butterflies were classified based on number of sightings in a single day of observation as follows: Abundant (>30%), Very Common (10-30%), Frequent (5-10%), Occasional (1-5%) and Rare (<1%). The identification of butterfly species was based on standard keys provided by Wynter-Blyth (1957), Haribal (1992), and Kunte (2000). Collected specimens were subjected to detailed scrutiny through a comparative study with the reference material at the Bombay Natural History Society, Mumbai. The data has been compiled to determine seasonal variations in butterfly species diversity of this sanctuary.

Results and Discussion

In all 91 species belonging to 66 genera representing 12 sub families and five families were recorded over a period of one year covering all seasons from July 2001 to June 2002. Of the total butterfly species listed in this sanctuary, 71 species were habitat generalists, whereas 20 species were habitat specialists, 13 figure in the scheduled categories of the Wildlife Protection Act, and eight are endemic (Table 1). Nymphalidae dominated the list with 40 species followed by Lycaenidae (19 species), Papilionidae (14), Pieridae (12) and Hesperiidae (6), respectively. Similar hierarchy pattern have also been reported from Parambikulam Wildlife Sanctuary by Sudheendrakumar *et al*. (2000).

It is apparent from the analysis of weekly records that the relative abundance of butterflies is species specific and under a distinct influence of seasons (Table 2[w]). Further, the population dynamics of individual species vary in relation to habitat. Majority of papilionids and some members of Pieridae and Nymphalidae exhibit perennial occurrence; though varying in relative abundance. Seasonal variations in the relative abundance of species are more pronounced among lycaenids, hesperiids and some members of nymphalids. Among papilionids, Spot Swordtail and the jays show a smooth and predictable transition of relative abundance between rare and very common, reaching a peak in the summer months. The red-bodied swallowtails have their flight period peak during the cooler months; and as far as the Common Mime is concerned, such a peak even gets extended into the early summer. The Blue Mormon is very common at least for a month during the transition between monsoons and post-monsoons. Red Helen has its flight period during the late monsoons and early winter. Species such as the Common Wanderer appear from mid monsoons and continue till the end of season.

As far as pierids are concerned, the yellows have very emphatic peaks of abundance lasting for as many as five months at a stretch as seen in case of Common Emigrant and the Small Grass Yellow during early winter. The Common Grass Yellow is abundant all through the monsoons, its relative abundance changing to very common throughout the winter until the advent of summer.

The lycaenids are characterized by fairly discontinuous flight periods and seasonality. Some forms such as Angled Sunbeam, Monkey Puzzle, and Fluffy Tit though rare, occur in more than one season. Among the nymphalids, the browns and the rings have a greater relative abundance in the monsoons, steadily showing a decline throughout the cooler months until they become rare or absent in the dry summer months. The pansies are at their peak of abundance following rains. Among the pansies, the Soldier is predominant, maintaining a large population from the mid monsoons until the commencement of summer. On a scale of relative abundance, the Grey Pansy ranks next followed by the Peacock and Lemon Pansy, in order of declining abundance. The Blue and the Yellow pansies are rare, yet occur in the monsoons and post monsoons. Egg flies show peaks of abundance during the late winter months of December and January.

The Blue Oak Leaf is seasonal, confined to the monsoons. Among the sailors, the Common Sailor has flight period from mid August to early January with a peak in September whereas the Chestnut Streak variety is more restricted for its flight period during monsoons. The Colour Sergeant has a very sporadic occurrence. The Commander and the Grey Count show peaks of activity during the post-monsoons. The Common Baron occurs throughout the year, but shows a peak in the cooler months. Clipper shows peak activity during post-monsoons between October and December. Of the two Heliconiinae species, namely, Cruiser and Tamil Lacewing, the former is seen throughout the year with disjunctive occurrence whereas the latter is more active with the commencement of rains; with its population showing decline with the advent of post-monsoons. Tawny Coster, the only representative of Acraeinae appears in the monsoons, with a build up of its population in the post monsoon season. Among the danaiids, the Common Indian Crow is present round the year with distinct peaks in between late monsoon and early winter and on the eve of southwest monsoons.

Among the tigers, the Plain Tiger occupies the apex of the hierarchy of abundance followed by the Glassy, Striped and the Blue Tiger. The tigers normally reach the peak of their flight period in the post-monsoon months, whereas their population becomes scarce with the approach of summer. Malabar Tree Nymph, an endemic species of this region shows greater activity during the monsoons and post-monsoons, being absent in this range during the hotter months.

Thus, it is apparent that there are familial and specific variations in flight periods and seasonality. Such variations can be attributed to a synchrony with the phenology of food plants. In case of perennially occurring butterflies, availability of seasonal food plants round the year is implicated. In spite of the seasonal variations in the flight period of different species it is apparent that species diversity is distinctly high in certain seasons. For the area under investigation, the highest weekly averages for the number of species sighted are recorded for

[w] See Table 2 on the web at www.zoosprint.org

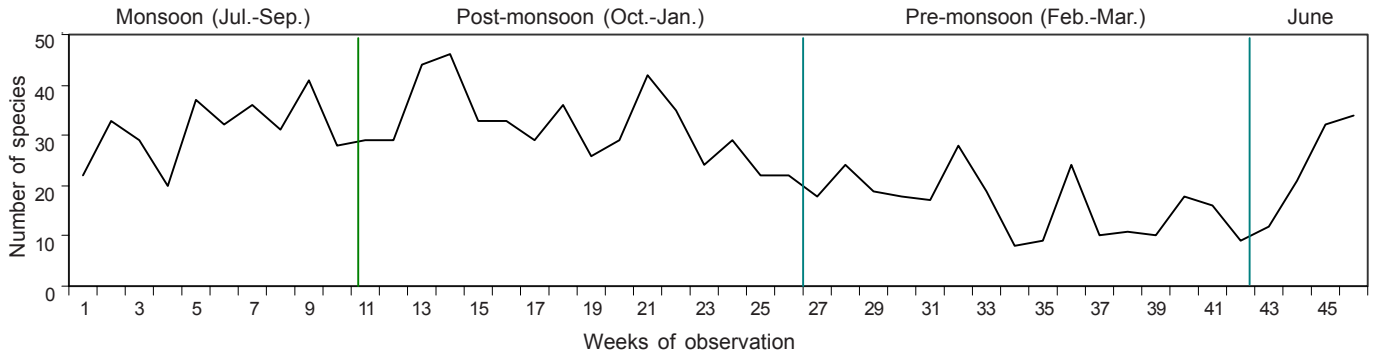

Figure 1. Seasonal variation in the butterfly species diversity of Bondla Wildlife Sanctuary, Goa

seasons extending from October to January (31.68%). The average number of species sighted for monsoon season is next in rank (28.92%), whereas the least average number is recorded for the summer season from February to May (16.06%). Thus, species diversity of post monsoon months is emphatically higher suggesting that the months from October to January are ideal for butterfly sightings in the Bondla Wildlife Sanctuary (Fig. 1). The seasonal averages of species number for individual families are depicted in Fig 2.

Population dynamics of butterfly species as reflected through relative abundance reveal their habitat character and status. These insects select their habitat in relation to their food and host plants. Thus, it becomes imperative to understand the habitat associations for managerial interventions. The butterflies recorded from Bondla Wildlife Sanctuary reflect rich species diversity despite limitations of space. All the major families are represented in the butterfly fauna of this place, indicative of diverse habitats available. The least weekly count was nine species recorded during the first week of April and last week of May; whereas on the higher side, maximum of 46 species was recorded in the last week of October (Table 2).

Attributes such as abundance and density that are intrinsic to population of species are influenced by change of seasons. Thus, seasonal variations do occur in population sizes of many species of animal (Davidson & Andrewartha 1948; Young 1982; Begon & Mortimer 1986). Such dynamic changes in species population that closely follow seasonal variations are actually brought about by changes in photoperiod; which in turn cast an influence on floral phenology, reproductive behaviour and movements (Erlich, 1986). More often than not, it is a combination of influences rather than a single event that governs the population cycles.

Ideally the value of a tourist brochure of wilderness area would be greatly enhanced if the best season for sighting a particular faunal group were recommended. The application of this knowledge of population fluctuations is seminal to management and conservation of wildlife (May, 1980). As far as butterflies are concerned being phytophagous insects with fair degree of food and host plant specificity, their species diversity and richness is indicative of floral diversity of the habitat in which they occur. Thus it may be well known that a decline in the diversity of these fascinating insects is suggestive of habitat degradation. Conversely, habitat management is best option for management and conservation of butterfly species (Gilbert & Singer, 1975; New, 1992). It implies therefore that habitat associations of butterflies have to be investigated. Regrettably much of the contemporary work on butterfly is restricted to simple inventory and checklists (Palot & Soniya, 2001; Palot & Abdurahman, 2003; Raju *et al*., 2003).

Interesting inferences can be drawn on habitat preferences recorded in this sanctuary (Table 1). Of the 91 species recorded here 20 are habitat specialists, among which 16 are forest dwellers and four are garden species. There is no exclusive orchard species. Of the remaining 71 species, 43 species occur in the entire sanctuary. Analysis of the records also reveals that orchards and garden together offer a better combination of habitat requirement, as 60 species are common to these two habitats. On a scale of commonality of species occurrence,

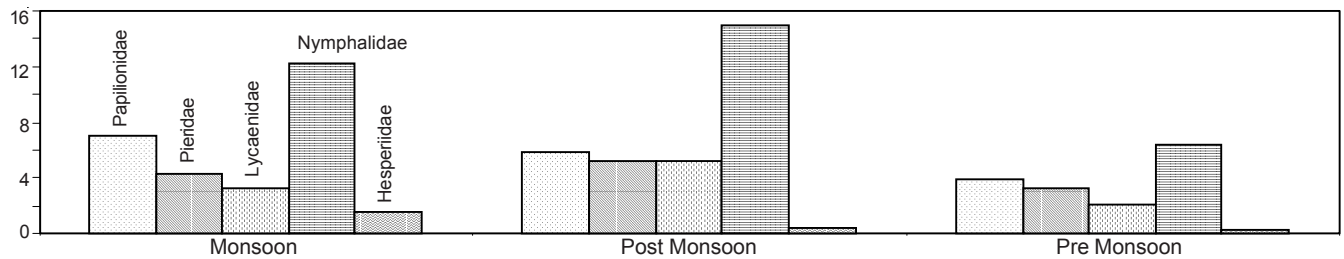

Figure 2. Seasonal averages of family contribution to the butterfly diversity of Bondla Wildlife Sanctuary, Goa

Table 1: Habitat associations and conservation status of butterflies in the Bondla Wildlife Sanctuary, Goa

Sl.N	Common names	Scientific names	Habitat			Status	Endemism
Papilionidae			Forest	Orchard	Garden		
1	Spot Swordtail	*Graphium nomius* Esper	+	-	-		
2	Common Blue Bottle	*Graphium sarpedon* Linnaeus	+	+	+		
3	Tailed Jay	*Graphium Agamemnon* Linnaeus	+	+	+		
4	Common Jay	*Graphium doson* C & R Felder	-	+	+		
5	Common Rose	*Pachliopta aristolochiae* Fabricius	-	+	+		
6	Crimson Rose	*Pachiopta hector* Linnaeus	+	+	-	Schedule I	
7	Southern Birdwing	*Troides minos* Cramer	+	-	-	Schedule I	WG
8	Common Mime Clytia)	*Papilio clytia* Linnaeus	+	-	+		
9	Common Mime (Dissimilis)	*Papilio disimilis* Linnaeus	+	-	+		
10	Lime Butterfly	*Papilio demoleus* Linnaeus	+	+	+		
11	Blue Mormon	*Papilio polymnestor* Cramer	+	+	+		PI & SL
12	Common Mormon	*Papilio demoleus* Linnaeus	+	+	+		
13	Red Helen	*Princepes helenus helenus* Hampson	+	-	-		
14	Malabar Banded Peacock	*Papilio Buddha* Westwood	+	-	-	ScheduleII	WG
Pieridae							
Subfamily Pierinae							
15	Psyche	*Leptosia nina* Fabricius	+	+	+		
16	Pioneer	*Anapheis aurota aurota Fabricius*	-	+	+		
17	Chocolate Albatross	*Appias Lyncida elenora* Boisduval	-	+	+	Schedule II*	
18	Common Wanderer	*Pareronia valeria hippia* Cramer	+	+	+		
19	Dark Wanderer	*Pareronia ceylonica*	+	+	+		
20	Pale Wanderer	*Pareronia avatar avatar* Moore	-	+	+		
21	Common Gull	*Cepora nerissa nerissa* Fabricius	+	+	+		
22	Common Jezebel	*Delias eucharis* Drury	+	+	+		SI & SL
Subfamily Coliadinae							
23	Common Emigrant	*Catopsilla Pomona* Fabricius	+	+	+		
24	Mottled Emigrant	*Catopsilla pyranthe* Linnaeus	-	+	+		
25	Small Grass Yellow	*Eurema brigitta rubella* Linnaeus	+	+	+		
26	Common Grass Yellow	*Eurema hecabe contubernalis* Moore	+	+	+		
Lycaenidae							
Subfamily Curetinae							
27	Angled Sunbeam	*Curetis dentata* Moore	+	-	-		
Subfamily Theclinae							
28	Large Oakblue	*Arhopala amantes amantes Moore*	+	-	-		
29	Yamfly	*Loxura atymnus continentalis*	-	-	+		
30	Common Acacia Blue	*Surendra quercetorum quercetorum* M	-	-	+		
31	Monkey Puzzle	*Rathinda amor*	+	-	-		
32	Common Imperial	*Cneritra freja freja*		-	+		
33	Common Silverline	*Spindasis vulcans fusca* Moore	+	+	+		IS
34	Club Silverline	*Spindasis syama peguanus* Moore	+	-	-		
35	Fluffy Tit	*Zeltus amasa*	+	-	-		WG
36	Gram Blue	*Euchrysops cnejus cnejus* Fabricius	-	+	+	Schedule II	
Subfamily Polyommatinae							
37	Angled Pierrot	*Caleta caleta decidia* Cramer	+	+	+		
38	Common Cerulean	*Jamides celeno celeno* Cramer	+	+	+		
39	Pea Blue	*Lamipes boeticus* Linneaus	+	+	+	Schedule II	
40	Dark Cerulean	*Jamides bochus stoll* Cramer	+	+	+		
41	Common Pierrot	*Castalius rosimon rosimon*	+	+	+	Schedule I	
42	Dark Pierrot	*Tarueus ananda*	+		+	Schedule IV	
43	Red Pierrot	*Talidcada nyseus* Guerin-meneville	+	+	+		
44	Plains Cupid	*Edales pandava* Horsefield	-	+	+		
Subfamily Riodininae							
45	Plum Judy	*Abisara echerius suffuse* Moore	+	+	+		
Nymphalidae							
Subfamily Satyrinae							
46	Common Evening Brown	*Melanitis leda ismene* Cramer	+	+	+		
47	Common Palmfly	*Elymnias hypermenstra* undularis	+	+	-		
48	Bamboo Tree Brown	*Lethe ocellata lyncus* De Niceville	-	+	+		
49	Nigger	*Orsotrioena medus medus* Fabricius	+	+	+		
50	Tamil Bush Brown	*Mycalesus subdita*	+	+	+		
51	Common Four Ring	*Ypthima hubenri hubenri* Fabricius	+	+	+		
52	Common Five Ring	*Ypthima baldus baldus* Fabricius	+	+	+		
53	Common Tree Brown	*Lethe rhoria rhoria* Linnaeus	+	-	-		
Subfamily Charaxinae							
54	Common Nawab	*Polyura athamas athamas* Drury	+	-	-		

Sl.N	Common names	Scientific names	Habitat			Status	Endemism
			Forest	Orchard	Garden		
Subfamily Nymphalinae							
55	Angled Castor	*Ariadne ariadne pallidior* Frusthorfer	+	-	+		
56	Common Castor	*Ariadne merione assama* Evans	+	-	+		
57	Rustic	*Cupha erymanthis*	+	+	+		
58	Common Leopard	*Phalantha phalantha* Drury	+	-	+		
59	Common Yeoman	*Cirrochroa tyche mithila*	+	-	-		
60	Yellow Pansy	*Precis hierta magna* Fabricius	-	+	+		
61	Blue Pansy	*Precis orithya ocyale* Linnaeus	-	+	+		
62	Lemon Pansy	Precis *lemonias lemonias* (L)	+	+	+		
63	Peacock Pansy	*Precis almana almana* Linnaeus	+	+	+		
64	Grey Pansy	*Precis atlites atlites* Linnaeus	+	+	+		
65	Chocolate Pansy/Soldier	*Precis iphita iphita* Cramer	+	+	+		
66	Painted Lady	*Cynthia carduii* Linnaeus	+	+	-		
67	Danaid Eggfly	*Hypolimnas missippus* Linnaeus	+	+	+	Schedule I	
68	Great Eggfly	*Hypolimnas bolina* Linnaeus	-	-	+		
69	Blue Oakleaf	*Kallima horsefieldi* Kollar	+	-	+		
70	Common Sailer	*Neptis hylas varmona* Moore	+	+	+		
71	Chestnut Streaked Sailor	*Neptis jumbah jumbah* Moore	+	+	+	Schedule I	
72	Colour Seargent	*Parathyma nafte inara*	+	-	-		
73	Commander	*Moduza procis procis* Cramer	+	+	+		
74	Grey Count	*Tanaecia lepidea lepidea* (Butler)	+	-	+	Schedule II*	
75	Common Baron	*Euthalia aconthea suddhodana* Frusthorfer	+	+	+	Schedule II*	
76	Clipper	*Parthenos Sylvia* Cramer	+	-	-	Schedule II	
Subfamily Heliconiinae							
77	Cruiser	*Vindula erota erota*	-	+	+		
78	Tamil Lace Wing	*Cethosia nietneri nietneri*	+	+	+		SI & SL
Subfamily Acraeinae							
79	Tawny Coaster	*Acraea violae* Fabricius	+	+	+		
Subfamily Danainae							
80	Glassy Tiger	*Parantica aglea melanoides* (Moore)	+	+	+		
81	Blue Tiger	*Tirumala limniace* leopardus	-	+	+		
82	Striped / Common Tiger	*Danaus(Salatha) genutia* (Krammer)	+	+	+		
83	Plain Tiger	*Danaus* (Anosia) *chrysippus* (L)	+	+	+		
84	Common Indian Crow	*Euploea core core* (Cramer)	+	+	+		
85	Tree Nymph	*Idea malabarica* Moore	+	-	-		WG
Hesperiidae							
86	Grass Demon	*Edaspes folcus* Cramer	+	+	+		
87	Indian Skipper	*Spialia galbe* Fabricius	-	+	+		
88	Dark Palm Dart	*Telicota spp.*	+	-	-		
89	Common Dart	*Potanthus spp* Fabricius	+	+	-		
90	Rice Swift	*Borbo cinnara* Wallace	+	+	+		
91	Tricolor Pied Flat	*Psedocoladenia indrani* Moore	-	+	+		

+ - Species sighted, WG - Western Ghats, SL - Sri Lanka, IS - Indian Subcontinent, PI - Peninsular India, SI - Southern India

forest-garden combination ranks next with 52 species followed by forest-orchards complex with 48. The progressive diminution in the species number supported by combination of two habitats may be ascribed to a corresponding decline in floral diversity (food plants), due to monoculture-like conditions prevailing in forests and orchards. The higher species richness of butterflies associated with gardens indicates availability of and access to food plants, besides being the most colourful domain in terms of floral diversity. This is further complemented by the lantana hedges here, which support a great diversity of butterflies. Though an exotic invasive species, *Lantana camara* is an important nectar source for several species of butterflies in degraded as well as urbanized habitat. Such a view has also been expressed by Raju and Reddy (1995) following their observation on the butterflies of Visakhapatnam.

The reasons for fewer habitat specialists can be understood if one takes into account the relatively smaller area of this sanctuary and proximity as well as confluence of discrete habitats.

Conclusion

Despite a very small area, this sanctuary is rich in butterfly species, representing all families. Fortunately, the tourist season in this state coincides very well with the best season for butterfly sightings in this sanctuary thereby enhancing its ecotourism potential. Further, a good deal of butterfly fauna of this wilderness area is endemic and has protected status as per the Indian Wildlife (Protection) Act, 1972. The situation reflects on the availability of diverse habitats as well as microclimatic zones. On the other hand the mounting pressures of Eco-tourism on this sanctuary need to be carefully monitored. One of the most visited wilderness areas of Goa; recently this sanctuary was put on a fast track of Eco-tourism infrastructure development. Any change in landscape at the cost of wilderness here, shall prove detrimental to the butterfly diversity of this

place; as the same would involve changes in land use pattern and loss of vegetation. Given remarkable species richness and endemism of butterfly species, Bondla Wildlife Sanctuary should not allow short term economic gains to prevail over its ecology.

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Acknowledgements

The lead author gratefully acknowledges the funds received from UGC Western Regional office, Pune under Minor Research Project 23-385/99(WRO) for conducting this study. Dr. R.M. Sharma Officer-in-charge of the High Altitude Station of Zoological Survey of India, Solan, Himachal Pradesh, has given valid suggestions in execution of this research project for which we owe our gratitude to him. The authors are also grateful to the Principal and Management of Carmel College of Arts, Science and Commerce for Women for the facilities provided at the Biodiversity Research Cell of Department of Zoology.

MACROMORPHOLOGY OF THE TONGUE OF AN ASIAN ELEPHANT (*ELEPHAS MAXIMUS*)

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(web supplement 1653i)

Macromorphology of the tongue was studied of a sub-adult Asian Elephant which died of an accident. The tongue was fixed in 10% neutral buffered formalin.

The tongue is light pink in colour and consists of three parts – apex, body and root as in other domestic animals (Habel, 1975). The examined tongue was cone shaped, 24.50cm in length, 7.88cm wide and was 3.94cm thick at the torus linguae.

The free rostral portion was the apex which constituted 1/3rd of the total length. The remaining 2/3rd was attached to the floor of the oral cavity. The apex presented the dorsal and ventral surfaces which met at the thin lateral borders. It was 1.87cm in width and 1.66cm thick at the tip.

The body was massive having four surfaces – two lateral on either sides, dorsal and ventral (attached to the floor). The dorsal surface was slightly rounded. The lateral surfaces were nearly flat. The ventral surface was related to the geniohyoideus and mylohyoideus muscles.

The torus linguae was present on the dorsum of the body and was not as prominent as in ruminants (Nickel *et al*., 1979). Fossa linguae were observed as a transverse shallow depression in between the apex and body. Similar observations were reported by Habel (1975) and Qayyum and Beg (1975) on ruminants. The mucosa on the torus was smooth. The root was caudal most part of the tongue being dorsoventrally flattened.

The dorsum of the tongue of elephant contained filiform, fungiform, lenticular and circum vallate papillae (Image 1[w]). Conical papillae were not apparent. The numerous filiform papillae were observed throughout dorsum, fungiform were present on the rostral half of the dorsum and dorsolateral margins of the body. Lenticular papillae were observed on the lateral surfaces in the caudal 2/3rd of the tongue. Circumvallate were present on the lateral aspect of the root of the tongue.

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[w] See Image 1 on the web at www.zoosprint.org

Manuscript 1065; Received 22 July 2003; Finally accepted 9 May 2004