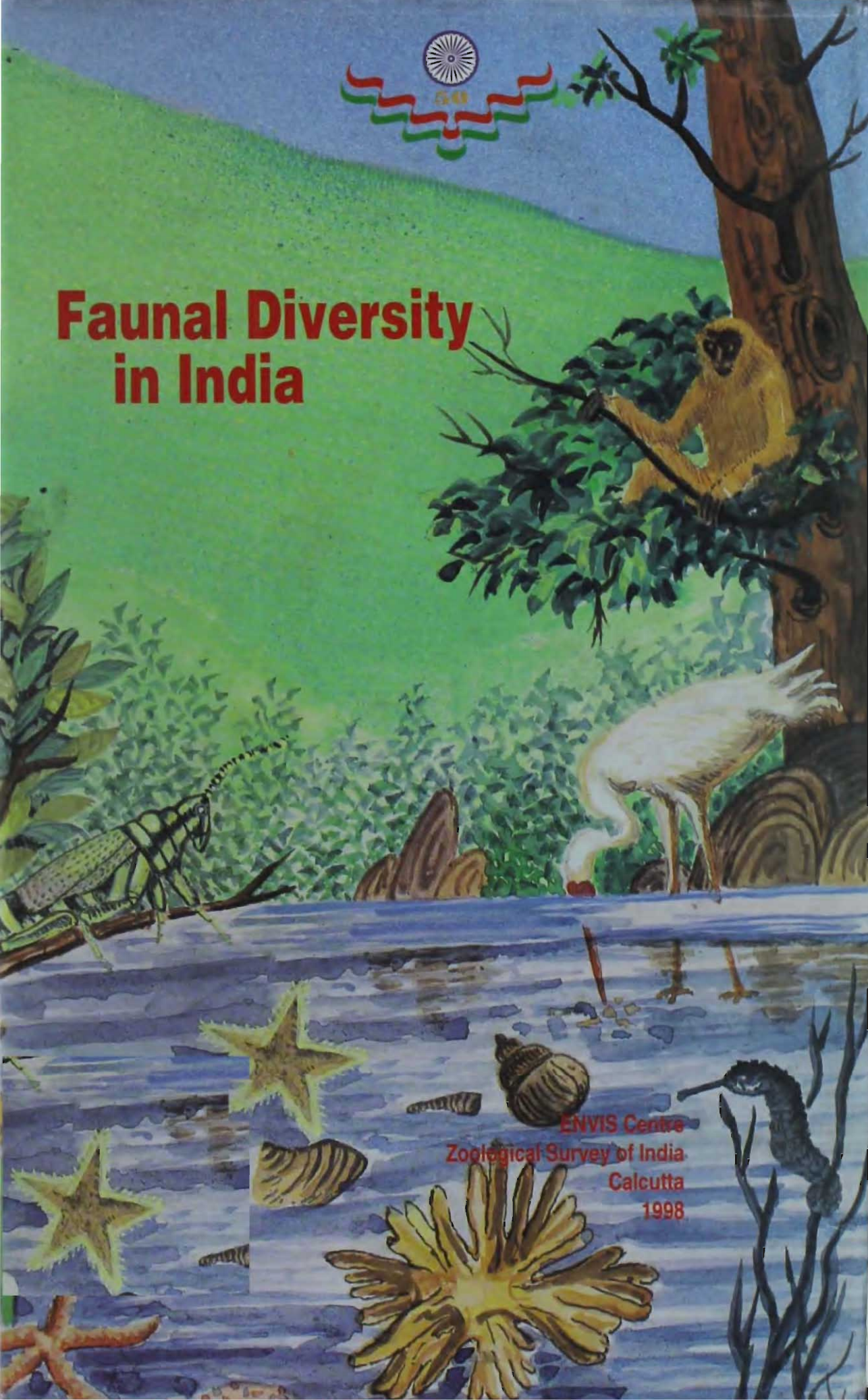




Faunal Diversity in India



ENVIS Centre
Zoological Survey of India
Calcutta
1998

India is very rich in biological diversity due to its unique biogeographic locations, diversified climatic conditions and enormous ecodiversity and geodiversity. Occupying only 2 per cent of the World's total landmass India harbours about 89,500 animal species comprising a little more than 7 per cent of the World's known animal species.

The present book provides an updated information on the status, distribution, biological diversity, endemism, value, threats and conservation strategies of Protista (Protozoa) and animal groups from Mesozoa to Mammalia occurring in India, with an appendix identifying Indian expertise on each group.

The book will serve as a valuable source of information for all those who are concerned with animal diversity and animal resources of the country for their conservation and sustainable utilisation.

FAUNAL DIVERSITY IN INDIA

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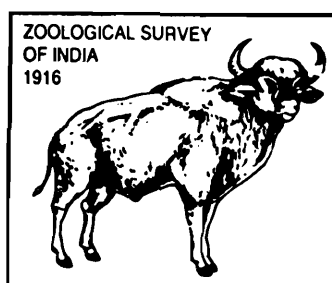
*A Commemorative Volume in the 50th Year
of India's Independence*

Edited by

J. R. B. Alfred

A. K. Das

A. K. Sanyal



**ENVIS Centre
Zoological Survey of India
Calcutta
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PREFACE

India is recognised as one of the twelve megadiversity countries of the world with two biodiversity hot spots, the North-East Region and the Western Ghats, of a total of 18 such sites identified throughout the globe. In fact, our country is very rich in terms of not only species diversity but is blessed with an enormous variety and variability (genetic diversity) within species along with the presence of a large number of endemic species. Around 1,27,000 species of plants, animals and micro-organisms have been reported so far from India, of which the animal species (about 89,500 species) including protozoa constitute the major share and comprise 7.28 per cent of the total world animal species. As per experts opinion, another 4,00,000 species are yet to be explored and identified, majority of which are expected to be micro-organisms and invertebrates.

The Ministry of Environment & Forests, Government of India, has set up an Environmental Information System (ENVIS) Centre on Faunal Biodiversity in the Zoological Survey of India at Calcutta to collect, collate, computerise and disseminate all available information on the enormous animal diversity of the country. The Ministry has also directed the ENVIS Centre to publish a special volume befitting with the subject allotted to the Centre to commemorate the 50th year of India's independence. As such, the present book, the **Faunal Diversity in India** has been published to cater to that need.

The Zoological Survey of India had already brought out two significant publications, the **State of Art Report : Zoology** and the **Animal Resources of India** in 1980 and 1991 respectively, giving an account of the animal groups available in India with estimated number of species and names of experts available in each animal group. The present book provides an updated information on the status, distribution, biological diversity, endemism, value, threats and conservation strategies of Protista (Protozoa) as well as that of different animal groups from Mesozoa to Mammalia. A total of 57 articles written by the animal group experts have been incorporated in the book with an appendix, identifying Indian expertise in each group. In this connection we thank the authors and the co-authors of the articles for their timely contributions and efforts in revising the same and to Mr. Rati Ram, Publication & Production Officer for his assistance in printing this document. Thanks are also due to

Mr. Nikhil Bhowmik and Pradip Saha for preparing the cover design of this book. A few of the articles are abridged and edited for keeping the uniformity of the book. We would like to thank the Ministry of Environment & Forests, Government of India, for the financial support in bringing out this book.

We hope this book will serve as a valuable source of information for all those who are concerned with animal diversity and resources of the country and their conservation and sustainable utilisation, and for biodiversity in general.

July, 1998
Calcutta

J. R. B. Alfred
Director
Zoological Survey of India

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Faunal Diversity in India : An Overview

J. R. B. Alfred

Zoological Survey of India

M-Block, New Alipore, Calcutta - 700 053

India is very rich in terms of biological diversity due to its unique biogeographic location, diversified climatic conditions and enormous ecodiversity and geodiversity. India embraces three major biological realms, viz., Indo-Malayan, Eurasian and Afro-tropical and is adorned with 10 biogeographic zones and 26 biotic provinces (Table-1). This country possesses diversified ecosystems from snow clad high mountain ranges to sea coasts of all categories (sandy, muddy, rocky, shingle, coralline) including deserts and semi-arid regions, almost all “types” of forests, grass lands, lakes, and rivers, estuaries, lagoons, islands and the ocean. The climate ranges from arctic in the Himalayas to very hot in the Thar Desert of Rajasthan while annual rainfall varies from 100 mm in the deserts to 5000 mm in the Cherrapunji hills. It is, therefore, quite inevitable that India having only 2 per cent of the total land mass of the world could harbour little over 6 per cent of the world’s known plant and animal species.

Table - 1

Biogeographic Zones and Biotic Provinces in India

Sl. No.	Biogeographic Zone	Biotic Province
1.	Trans-Himalayan	Upper Regions
2.	Himalayan	North-West Himalayas West Himalayas Central Himalayas East Himalayas

Sl. No.	Biogeographic Zone	Biotic Province
3.	Desert	Kutch Thar Ladakh
4.	Semi-Arid	Central India Gujarat-Rajwara
5.	Western Ghats	Malabar Coast Western Ghat Mountains
6.	Deccan Peninsula	Deccan Plateau South Central Plateau Eastern Plateau Chhota Nagpur Central Highlands
7.	Gangetic Plain	Upper Gangetic Plain Lower Gangetic Plain
8.	North-East India	Brahmaputra Valley North-Eastern Hills
9.	Islands	Andaman Islands Nicobar Islands Lakshadweep Islands
10.	Coasts	West Coast East Coast

Source : "Conserving our Biological Wealth", WWF for Nature-India

Based on data currently collected from the experts of different animal groups total number of species belonging to the Kingdoms Protista (Protozoa) and Animalia reported from India is presented in Table-2 and compared with those known from the world. It needs to be mentioned here that the following species estimate is an updated one and varies little from earlier estimates in some of the animal groups (Anon., 1991; Alfred and Subba Rao, 1997).

Table - 2
Estimated number of described species

Taxonomic group	No. of species		% in India
	World	India	
PROTISTA			
Protozoa	31250	2577	8.24
Total (Protista) :	31250	2577	8.24
ANIMALIA			
Mesozoa	71	10	14.08
Porifera	4562	486	10.65
Cnidaria	9916	842	8.49
Ctenophora	100	12	12.00
Platyhelminthes	17500	1622	9.27
Nemertinea	600	—	—
Rotifera	2500	330	13.20
Gastrotricha	3000	100	3.33
Kinorhyncha	100	10	10.00
Nematoda	30000	2850	9.50
Nematomorpha	250	—	—
Acanthocephala	800	229	28.62
Sipuncula	145	35	24.14
Mollusca	66535	5070	7.62
Echiura	127	43	33.86
Annelida	12700	840	6.61
Onychophora	100	1	1.00
Arthropoda	987949	68389	6.90
Crustacea	35534	2934	8.26
Insecta	867391	59353	6.83
Arachnida	73440	5818	7.90
Pycnogonida	600	16	2.67
Pauropoda	360	—	—
Chilopoda	3000	100	3.33

Taxonomic group	No. of species		% in India
	World	India	
Diplopoda	7500	162	2.16
Symphyla	120	4	3.33
Merostomata	4	2	50.00
Phoronida	11	3	27.27
Bryozoa (Ectoprocta)	4000	200	5.00
Entoprocta	60	10	16.66
Brachiopoda	300	3	1.00
Pogonophora	80	—	—
Priapulida	8	—	—
Pentastomida	70	—	—
Chaetognatha	111	30	27.02
Tardigrada	514	30	5.83
Echinodermata	6223	765	12.29
Hemichordata	120	12	10.00
Chordata	48451	4952	10.22
Protochordata	2106	119	5.65
(Cephalochordata + Urochordata)			
Piseces	21723	2546	11.72
Amphibia	5150	209	4.06
Reptilia	5817	456	7.84
Aves	9026	1232	13.66
Mammalia	4629	390	8.42
Total (Animalia)	1196903	86874	7.25
Grand Total (Protista + Animalia)	1228153	89451	7.28

From the table it is quite evident that India possesses little more than 7 per cent of the total animal species of the world. This percentage is higher than that of the plant species. Several invertebrate phyla, *viz.*, Nemertinea, Nematomorpha, Pogonophora, Priapulida and Pentastomatida are yet to be reported from India. Out of total 86,874 animal species of this country Insects alone comprise 68.32 per cent and Chordates only 5.70 per cent.

A total picture of endemism in Indian fauna is not available. However, based on data submitted by the experts an estimated number/percentage of endemic species in India is presented in Table-3.

Table - 3
Estimated number/percentage of endemic species in India

Taxon	No. of species		Percentage (%)
	Total	Endemic	
Protozoa			
Freeliving	1247	90	7.21
Parasitic	1330	550	41.33
Mesozoa	10	10	100.00
Porifera			
Freshwater	31	13	41.93
Cnidaria	842	10*	—
Platyhelminthes	1622	1160	71.88
Rotifera	330	23	7.00
Gastrotricha	100	64	64.00
Kinorhyncha	10	7	70.00
Nematoda	2850	400*	—
Acanthocephala	229	203	88.64
Mollusca			
Terrestrial	1487	498	33.50
Freshwater	183	77	41.80
Echiura	43	12	28.00
Annelida			
Oligochaeta	473	368	77.80
Hirudinea	59	25	42.37

Taxon	No. of species		Percentage (%)
	Total	Endemic	
Arthropoda			
Crustacea	2934	501	17.07
Insecta	59353	20717**	34.90
Arachnida	5818	2623	45.08
Phoronida	11	1	1.00
Bryozoa	4000	12*	—
Entoprocta	10	1	1.00
Chaetognatha	111	3	2.70
Chordata			
Pisces	2546	223	8.75
Amphibia	209	128	61.24
Reptilia	456	214	47.00
Aves	1232	176	14.28
Mammalia	390	36	9.23

*Completed data not available, hence % not calculated.

**Order-wise details of insects available in the following article by Varshney (p. 153).

Table-3 clearly reveals that amongst invertebrates parasitic forms (e.g. Mesozoa, Acanthocephala and Platyhelminthes), some meiofauna (Kinorhyncha, Gastrotricha) and soil fauna (earthworms) exhibit a very high degree of endemism at species level. Over all 34.90 per cent of insect species are endemic to the Indian region whereas more than 40 per cent of Indian leech and, freshwater sponges and molluscs also show endemism. Among vertebrates highest degree of endemism at species level is seen in Amphibia followed by Reptilia, Aves, Mammalia and Pisces.

It needs to be mentioned here that the number of workers engaged in animal species identification in this country is significantly minimum to deal with such a large number of species as discussed in the foregoing account. Table-4 reveals that there are no experts in several groups (e.g. Phasmida, Psocoptera and Mecoptera) and there are only a few experts in most of the groups. This is also alarming that while large number of animal species are yet to be explored and identified, the number of experts is gradually declining. Many of them have retired from service. On the other hand there is no replacement for them since taxonomic studies in the universities are discouraged. There is also scarcity of standard taxonomic collections and institutional facilities to develop taxonomic experts.

Table - 4
No. of experts on different animal groups

	Total No. of Experts in India	Zoological Survey of India		In other Institutions/ Universities
		In service	Retired	
Protozoa	10	3	1	6
Mesozoa	1	—	—	1
Porifera	5	1	1	3
Cnidaria	5	—	1	4
Ctenophora	2	1	—	1
Platyhelminthes	14	—	5	9
Rotifera	14	2	—	12
Gastrotricha	1	—	1	—
Kinorhyncha	1	—	1	—
Nematoda	23	2	1	20
Acanthocephala	7	1	1	5
Sipuncula	1	1	—	—
Mollusca	19	7	4	8
Echiura	2	1	—	1
Annelida	25	4	3	18
Crustacea	10	4	—	6
Apterygota	3	2	—	1
Odonota	8	5	—	3
Plecoptera	2	2	—	—
Orthoptera	8	4	3	1
Phasmida	—	—	—	—
Dermaptera	2	1	—	1
Embioptera	4	—	—	4
Mantodea	2	1	—	1
Blattariae	1	1	—	—
Isoptera	7	3	2	2
Psocoptera	—	—	—	—
Hemiptera	27	8	3	16
Thysanoptera	6	3	1	2
Neuroptera	1	—	1	—
Coleoptera	27	9	6	12
Strepsiptera	2	—	—	2
Mecoptera	—	—	—	—

	Total No. of Experts in India	Zoological Survey of India		In other Institutions Universities
		In service	Retired	
Diptera	19	5	2	12
Lepidoptera	17	6	5	6
Trichoptera	2	1	1	—
Hymenoptera	17	4	—	13
Myriapoda	5	3	—	2
Arachnida	39	8	2	29
Phoronida	1	1	—	—
Bryozoa	12	—	—	12
Entoprocta	2	1	—	1
Chaetognatha	2	1	—	1
Tardigrada	2	1	1	—
Echinodermata	8	4	—	4
Hemichordata	3	—	1	2
Protochordata	4	—	1	3
Pisces	25	7	6	12
Amphibia	5	1	1	3
Reptilia	29	2	4	23
Aves	23	8	6	9
Mammals	28	16	6	6

In view of above there is an urgent need to take measures to alleviate this situations in India. The Ministry of Environment & Forests, Government of India, has already taken cognizance of this aspect and has proposed an All India Project in Taxonomy. Within next five years this project hopes to overcome most of the impediments as outlined above.

In addition, it is felt that in strengthening the taxonomic base, consideration must be given to the information needs for bioprospecting, habitat conservation, sustainable agriculture and the sustianable utilisation of biological resources. For taxonomic studies to be encouraged, there is a need to provide employment opportunities to the taxonomists and this should integrate into the programme of capacity building. The importance of establishing regional and subregional training programmes in taxonomy should be recognised. Attention should also be given to the training of specialists, parataxonomists and technicians in this field (ABRS, 1998).

The following activities related to capacity building in taxonomy are to be initiated :

- i) Developing national, regional and subregional training programmes.
- ii) Strengthening of reference collections and modern facilities for preservation.
- iii) Preparing, publishing and distributing national and regional faunal guides.
- iv) Development of information : Compilation and organisation of basic data from biological collections into data-bases, regional check lists, maps, etc.
- v) Development of knowledge : synthesis of data into monographs, maps, keys, field guides, etc.

All these could be achieved by the existing networks of active taxonomists which form a national and regional base upon which a more comprehensive effort would be built into. Subsequently based on expertise developed national and regional infrastructure including training and research centres, could be established with the Zoological Survey of India acting as the nodal agency for coordination.

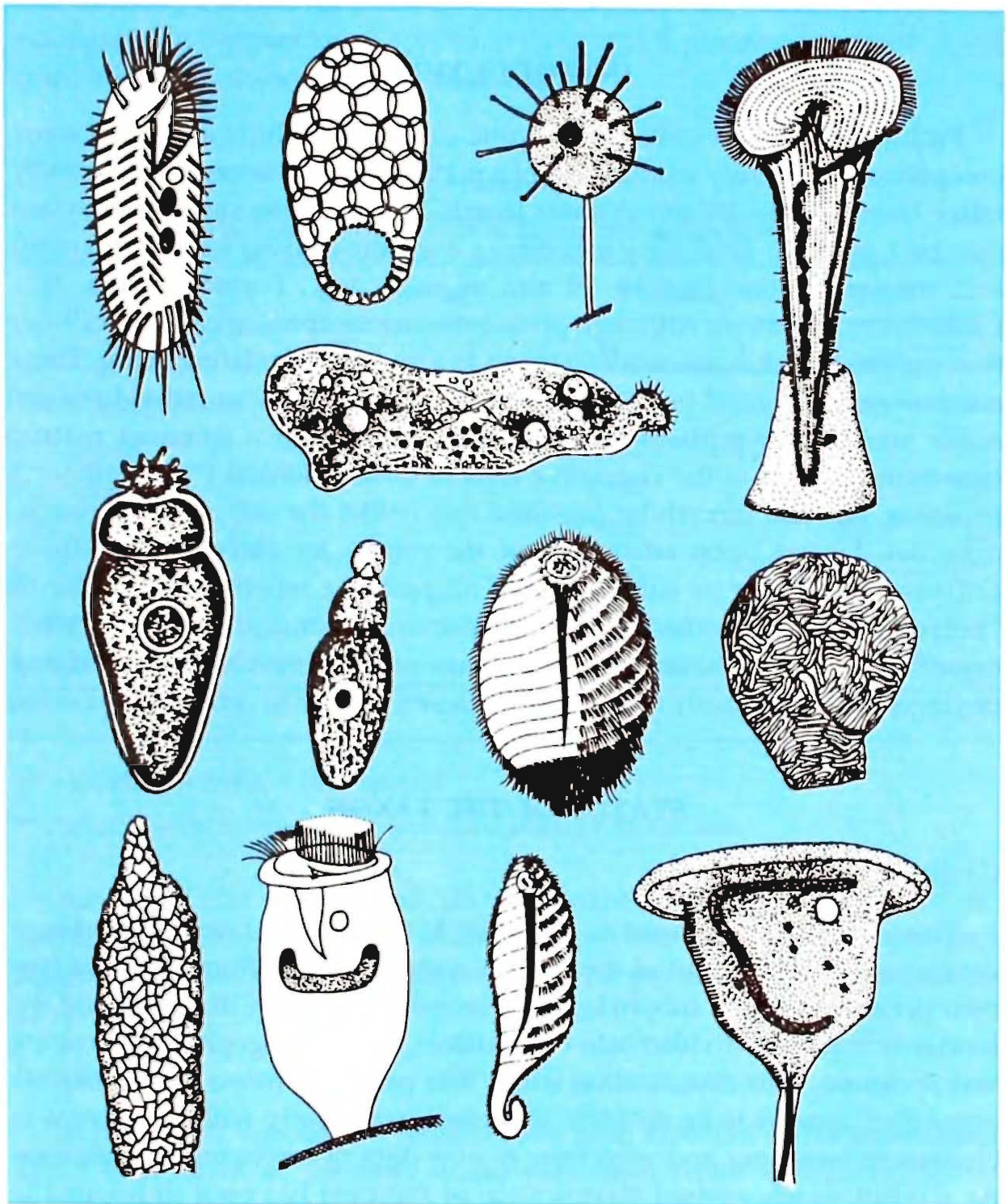
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Faunal Diversity in India : Protozoa

A. K. DAS

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Protozoa are single-celled eukaryotic organisms which are, with some exceptions, visible only with the aid of a microscope. These organisms mostly range from 5 μm to 250 μm in linear length. However, the smallest protozoa may be 1 μm (e.g., *Leishmania donovani*, a flagellate causing kalaazar in man) and the largest one may be 50 mm or more (e.g., Foraminiferida, viz., *Cycloclypeus carpenteri*). Although protozoans are morphologically unicellular they manifest all characteristics common to a multicellular living being. There are, however, colonial protozoa also (e.g., *Volvox* sp.) whose individuals are either joined by cytoplasmic threads or embedded in a common matrix. Interestingly, each of the vegetative cells of these colonial ("polycellular") protozoa, just like unicellular protozoa and unlike the cell of any metazoa, does not depend upon other cells of the colony for carrying on cellular activities needed for its survival. Thus all protozoa whether unicellular or "polycellular" are unified by the fundamental concept of single-celled organisation. They constitute an assemblage of innumerable diversified and phylogenetically distantly related taxa with very simple to complex life cycles.

STATUS OF THE TAXON

Global Status

Protozoa were considered as a phylum in the classical taxonomic scheme developed about the turn of the present century. The phylum Protozoa was then divided into two subphyla, viz., Plasmodroma and Ciliophora and the former was further divided into three classes, viz., Mastigophora, Sarcodina and Sporozoa. This classification which was primarily based on locomotory organelles appears to be obsolete at present particularly with the advent of electron microscopes and with flow of new data of taxonomic significance. As a result, newly revised classification of Protozoa has been developed in 1980 by the Society of Protozoologists. According to this classification taxonomic status of Protozoa has been elevated to Subkingdom under the

Kingdom Protista. The Subkingdom Protozoa has been divided into seven phyla, viz., Sarcomastigophora, Labyrinthomorpha, Apicomplexa, Microspora, Ascetospora, Myxozoa and Ciliophora. In the classical classification Protozoa were considered as the most primitive animals but in the current classification they have been treated more primitive than animals and placed under the Kingdom Protista.

There are about 65000 species of Protozoa known so far from the world. Out of these, a little over half are fossils and 10,000 species are parasitic. An estimate of living protozoan species of the world is presented in Table 1 and compared with those reported from India.

Table – 1
Phylum-wise estimate of living protozoan species

Phylum	Freeliving		Parasitic**		Total	
	W	I	W	I	W	I
Sarcomastigophora	16,400	847	2,050	233	18,450	1,080
Ciliophora	4,700	400	2,500	200	7,200	600
Apicomplexa	–	–	4,550	750	4,550	750
Microspora	–	–	550	20	550	20
Myxozoa	–	–	500	125	500	125
Ascetospora	–	–	*	2	*	2
Labyrinthomorpha	–	–	*	–	*	–
Total	21,100	1,247	10,150	1,330	31,250	2,577

W =World; I = India; * Few species

** Parasitic includes symbiotic and commensal protozoa also.

Amongst the living species of world protozoa known so far Sarcomastigophora represent about 60 per cent, Ciliophora 23 per cent, Apicomplexa 13.75 per cent and Myxozoa 1.5 per cent of the total number of species.

Indian Status

In India 2577 species of Protozoa have been reported so far constituting about 8 per cent of the total world protozoan fauna. Moreover, Indian Protozoa are represented by 52 per cent freeliving and 48 per cent parasitic species, while world Protozoan species constitute 68 per cent freeliving and

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Total number of families, genera and species known so far from India is shown in Table-2.

Table – 2

Group		Approximate number of			
		Family	Genera	Species	
Phylum	Sarcomastigophora				
	Subphylum	Mastigophora	28	60	400
	Subphylum	Sarcodina	35	85	650
	Subphylum	Opalinata	1	4	30
Phylum	Ciliophora	70	150	600	
Phylum	Apicomplexa	20	42	750	
Phylum	Microspora	2	4	20	
Phylum	Myxozoa	4	12	125	
Phylum	Labyrinthomorpha	—	—	—	
Phylum	Ascetospora	1	1	2	
Total		161	358	2577	

Out of 2577 protozoan species listed in Table-2 1247 species are freeliving and 1330 species are parasitic. These parasitic species have been recovered from 585 host species, group-wise details of which are presented in Table-3.

Table – 3

Host group	Number of host species from which parasites recovered	Number of parasite species
Mammals	70	150
Birds	120	260
Reptiles	25	110
Amphibians	25	110
Fishes	125	350
Invertebrates	220	350
Total	585	1330

It is worth mentioning here that in India freeliving protozoa have been collected from freshwater, brackish and marine water, soil, sand and moss. Indian parasitic protozoa (which include symbionts and commensals also) have been found to occupy diversified host environs. These environs may be broadly demarcated under 5 categories, viz., (i) epizoid (usually sedentary ectocommensals found on the body surface of the aquatic animals), (ii) luminicolous (inhabiting lumen of the gut of both vertebrate and invertebrate hosts), (iii) coelozoic (inhabiting coelom of invertebrates, especially annelids), (iv) histozoic (found in blood, lymph and tissues of different organs of both vertebrate and invertebrate hosts) and (v) coprozoic (found in faecal matter of various animals and inhabiting waters rich in decomposing organic matter).

ENDEMICITY

Endemicity of freeliving protozoa in India is nearly 7 per cent while that of parasitic protozoa is around 40 per cent. Around 90 species of freeliving protozoa and 550 species of parasitic protozoa are endemic in India. From the data available, none of the Protozoan species has been demarcated as threatened or endangered.

VALUE

Planktonic protozoa (mainly flagellates and ciliates) play a significant role in the food web as primary consumer in aquatic ecosystems. Bottom living marine protozoa of the neretic region (foraminifera and radiolaria) also have a significant contribution in the formation of littoral deposits. Soil inhabiting protozoa (mainly rhizopods and ciliates) help in humification and mineralisation of leaf litter on the forest floor in association with other microorganisms. They also contribute much in soil ecosystems mainly as primary consumers of microarthropods and soil nematodes which have significant role to determine soil fertility. Some protozoa (flagellates and ciliates) help in natural recovery of putrefied sewage water.

Protozoa may be conveniently used for environmental biomonitoring particularly in evaluating water quality. Several experimental studies reveal that ciliates actively contribute to the regulation of entire complex of purification plants by regulating bacterial population and controlling BOD level, by controlling pathogenic and faecal bacteria and by releasing mucous substance to facilitate floc formation and successive sedimentation. Some ciliates can be used as indicator species. For example, occurrence of the ciliate, *Metopus es* in any water body indicates the presence of hydrogen

sulphide in the habitat. Presence of this ciliate species along with other ciliates belonging to the genera *Caenomorpha*, *Epalexella*, *Pelodinium*, *Plagiopyla* and *Saprodinium* in the putrefying sludge indicates that self-purification in the water body has been stopped due to lack of oxygen and presence of high concentration of hydrogen sulphate.

There are, however, several parasitic protozoa which are well-known pathogens causing various fatal diseases in man and his live-stocks. For example, *Plasmodium falciparum* and *P. vivax* cause severe human malaria; two species of *Leishmania* (*L. donovani* and *L. tropica*) cause kalaazar and tropical sore; *Entamoeba histolytica* and *Giardia lamblia* cause amoebic dysentery and giardiasis respectively. Similarly several species of coccidia are responsible for coccidiosis in poultry birds, myxozoa for fish disease and microspora for pebrine disease in silkworm.

THREATS AND CONSERVATION STRATEGY

No human-biodiversity relation is established as far as Indian protozoa are concerned. None of the species of protozoa in India can be demarcated as keystone species in marine, freshwater or terrestrial ecosystem. Protozoans are not thoroughly surveyed in India. Therefore, it would not be proper to indicate any protozoan species as rare since it is well known that protozoans are microscopic and are capable of rapid multiplication by both sexual and asexual reproduction. Threats to these organisms, more particularly freeliving protozoa appear to be remote unless there is indiscriminate destruction and distortion of habitats. However, parasitic protozoan species will be threatened if their hosts are threatened and endangered. Protozoa will be conserved if their habitats and hosts are conserved. So, no separate conservation strategy is required for them.

FUTURE STUDIES

Protozoa are cosmopolitan in distribution. It has been discussed earlier that : (i) freeliving protozoa are available in all habitats of aquatic and terrestrial ecosystems, (ii) symbiotic protozoa are obligatory in the gut of wood eating termites as well as in the rumen of ruminant mammals and (iii) at least one species of parasitic protozoa in average is expected to be recovered from every animal species of India. Even then this group is least explored in this country except in West Bengal, Rajasthan, Orissa and some north-eastern states.

In view of above, at least some rapid surveys covering all underexplored and unexplored states of India need to be conducted for the collection of all the major groups of protozoa from different environs. Subsequently taxonomic study and state and ecosystem wise inventorisation of these organisms are to be made to get a first hand estimate of the protozoan diversity of the country. Further, expertise on protozoa is to be developed in the country for identification of the group.

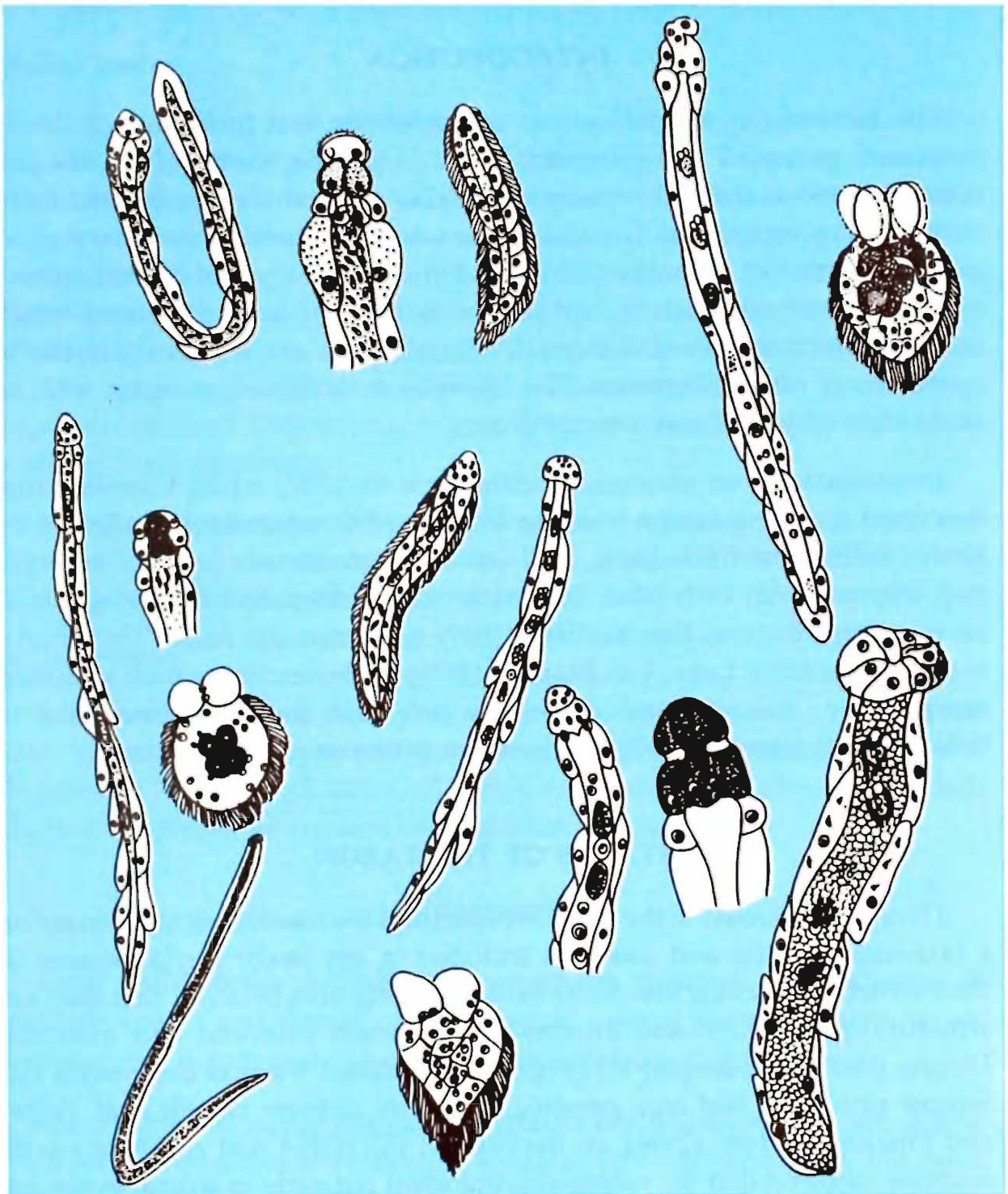
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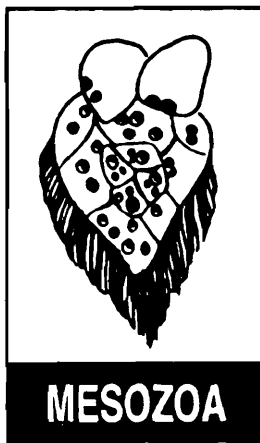
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Faunal Diversity in India : Mesozoa

C. KALAVATI

*Department of Zoology, Andhra University
Visakhapatnam – 530 003*





INTRODUCTION

The mesozoa is a small group of interesting but little known, lowly organised group of endoparasites found in the nephridia of squids and octopuses and in the body spaces and tissues of various other invertebrates, such as, nemertines, annelids and brittle stars. Structurally, they are simple, minute, worm-like organisms composed of an outer layer of ciliated cells or syncytium, the somatoderm and one or more inner axial cells from which the reproductive cells are formed. These layers are not comparable to epidermis of other metazoans. The life-cycle is, however, complex with an alternation of sexual and asexual phases.

Investigations on mesozoans date back to 1787, when Cavolini first described these organisms from the kidneys of Octopus later confirmed by Krohn (1839) and Erdl (1843). Erdl (*op. cit.*) noticed two types of embryos that alternate with each other in the life cycle of Mesozoa. Denoting this as an important feature, Von Kolliker (1849) suggested the name 'Dicyemida' to these organisms. Later, Van Beneden (1876) while describing their structure, morphology, life-cycle and phylogeny proposed the name 'mesozoa' to indicate their transitory position between protozoa and metazoa.

STATUS OF THE TAXON

Though discovered in the early 19th century, the mesozoans still constitute a taxonomic puzzle and were not included in any major phyla because of their structural peculiarities. Some earlier investigators believed that they are structurally primitive and intermediate between protozoa and metazoa. During later years, several investigators considered them as degenerate flat worms since they had true gametogony. More recently Hanelt *et al.* (1996) and Powlowski *et al.* (1996), on the basis of 18S rDNA and rRNA sequence analysis, showed that the mesozoans branched out early in animal evolution close to nematodes and myxozoans. Further, the studies also indicated that the 2 classes, Dicyemida and Orthonectida probably had separate origins.

Orthonectids, according to Hanelt *et al.* (op. cit), are more closely aligned with triploblastic metazoan taxa rather than platyhelminthes suggesting a need for the revision of the phylum.

Originally phylum Mesozoa included a large number of heterogenous organisms of uncertain, unrelated affinities, such as *Trichoplax*, *Treptoplax*, *Salinella*, living inside radiolarians (Protozoa), *Neresheimeria* in the gonads of tunicates, all of which are now shifted to different phyla, thus making Mesozoa a better defined group. At present, phylum Mesozoa is comprised of 2 classes, namely Orthonectida and Dicyemida (Melhorn, 1988).

Global Status

Altogether 71 species of dicyemids represented by 4 genera namely, *Dicyema*, *Dicyemennea*, *Conocyema* and *Dodecadicyema* were described from 59 species of sepioids and octopuses belonging to 18 genera. On occasions, each cephalopod may harbour a complex of assemblages of dicyemid mesozoans belonging to different genera. For instance, *Dicyema balamuthi*, *Dicyemennea obscura* and *Conocyema adminicula* coinhabit the kidneys of *Octopus rebescens*; *Dicyema australis*, *D. platycephalum* and *Conocyema marplatensis* in *Octopus tehuelchus*; *Dicyema benthoctopi*, *Dicyemennea littlei* in *Benthoctopus magallansicus* and *Dicyemennea gracile*, *Dicyema turncatum* and *Conocyema vespa* in *Sepia officinalis*.

Among orthonectids, the genus *Rhopalura* is widely distributed and represented by several species whereas genera *Stoecharthrum* and *Pelmatosphaera* have only one species each.

Indian Status

In the Indian context, studies on mesozoa are sporadic and scanty. So far, only 10 species of dicyemids represented by 3 genera namely, *Dicyema*, *Dicyemennea* and *Dodecadicyema*, all from Bay of Bengal, have been recorded. There is no record of any orthonectid from this region.

DISTRIBUTION

Class Orthonectida include a heterogenous group of rare parasites of coelomic spaces and tissues of a number of marine invertebrates, such as, turbellarians, polychaetes, molluscs, echinoderms and ascidians.

Mesozoans belonging to Class Dicyemida are widely distributed. These are most common and characteristic parasites of excretory organs and renal appendages of cephalopod molluscs, particularly the benthic and epibenthic

forms. Hochberg (1983) noticed that in temperate and polar regions prevalence of infection of these mesozoans could be as high as 100% where as it is always less in subtropics (10-20%) and absent all together in and off oceanic islands. Nevertheless, Nouvel (1934) and Kalavati *et al.* (1978) recorded dicyemids from truly tropical locations, *viz.*, West Africa and East Coast of India. Indian mesozoans have so far been collected from East Coast only from the hosts belonging to *Sepia*, *Loligo* and *Octopus*.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The Orthonectid mesozoans are identified by the formation of agametes from multinucleate plasmodia belonging to both sexes. Somatoderm of sexual individuals bears transverse grooves. Sexes are separate. Egg cells are fertilised while inside the female and give rise to ciliated larva which later develops into amoeboid plasmodia.

There is an alternation of generations, a short lived, free swimming sexual phase alternating with a period of asexual reproduction and parasitic existence. The parasitic asexual stage is a multinucleate syncytical amoeboid mass, reproducing by simple schizogony in host tissues producing agametes. The agametes develop into male and female adults which escape from the host tissues and lead a short free-swimming life. Both male and female individuals are minute in size, with an outer ciliated somatoderm of definite number of cells arranged in concentric circles. The inner cells may give rise to either spermatogonia or ovocytes which in turn give rise to sperms and eggs. Fertilisation is internal. Zygote develops inside the female into a ciliated larval stage, which eventually released to reinfect a new host.

The dicyemid mesozoans exhibit truly unique characters without definite affinities to any other group. Their life-cycle is still incompletely known. Despite reports of frequent occurrence of the parasites, their mode of entry into a new host is not known. It is generally believed that initial infections normally occur in very young cephalopods. Infection takes place after hatching in forms with demersal juveniles or after settling at the bottom in forms with planktonic larval stages. However, according to Lapen and Morowitz (1972) the germinal cells from the urn of the infusoriform could directly infect the circulatory system of the host and then penetrate the kidneys. The earliest known stage in the juvenile cephalopod is termed as stem nematogen. Subsequently, they develop into ciliated vermiform embryos with one axial cell and specific number of somatic cells known as primary nematogens. The stage of the dicyemid life cycle depends on the maturity of the host. Immature host harbour populations of nematogens. The adult nematogens are long, slender and vermiculate measuring 0.05-10.0 mm in size. They attach

themselves to the renal appendage with the calotte embedded in the inter cellular spaces. The remaining part of the body floats freely in the coelomic fluid. The calotte is covered with thigmotactic cilia which interdigitate with the brush border of the renal epithelial cells. It consists of 8-10 cells arranged in 2 tiers. The first tier of cells is known as propolars, while the second as metapolars. Body is covered with specific number of somatic cells, the diapolars which encircle the central axial cell. The central axial cell contains axoblasts and accessory nuclei. Vermiform embryos develop asexually from axoblasts and resemble the parent nematogen at the time of release. There is always a constant proliferation of daughter nematogens.

As the cycle progress, all nematogens are eventually transformed into rhombogens. In sexually mature hosts, the shift in phase is more evident. Many investigators attribute this to hormonal flux and host maturity while other assume that crowding triggers the transformation (Lapen and Morowitz, 1975). The axial cell of this stage forms gamete producing infusorigens and infusoriform larvae. Each infusorigen consists of a spherical axial cell and all the stages leading to the maturation of spermatozoa which are enveloped by a layer of oogonia or oocytes. Amoeboid spermatozoa emerge from the central axial cell, penetrate the peripheral oocytes resulting in the formation of a zygote which eventually develops into a infusoriform larva. These ciliated infusoriform larvae escape from the renal fluid and their life cycle outside the host is still not known. According to Nouvel (1947), McConnaughey (1951) and Stunkard (1954), they infect a secondary benthic host before they reenter the cephalopod host. However, Lapan and Morowitz (1975) showed experimentally that sepia reared in the laboratory were infected when exposed to infusoriform larva indicating a possible direct life-cycle.

HOST-PARASITE RELATIONSHIP

A spectrum of conditions ranging from a purely commensal to a true parasitic life is exhibited by mesozoa. Most dicyemid species adhere lightly to the renal tissue of the host by the ciliature of the calotte or the adhesive tuft (Nouvel, 1931). However, presence of many dicyemid species appears to have no influence on the host tissue. On the contrary, orthonectids parasitize gonadal tissues of their host and destroy the cells. Host castration by the parasite is evident in the geneus *Rhopalura*.

Very little information is available on the physiology of these parasites. According to Nouvel (1933), most dicyemids derive their nourishment from cephalopod urine. Carbohydrate reserves are mainly in the form glycogen.

ENDEMICITY

As mentioned earlier, 10 species of mesozoans belonging to the genera *Dicyema* (5 spp.), *Dicyemene* (4 spp.) and *Dodecadicyema* (1 sp.) have been recorded so far from India, that too from Bay of Bengal. Interestingly, all of them are endemic to this country.

FUTURE STUDIES

Mesozoa being one of the least explored animal groups in India need to be thoroughly surveyed. Foregoing discussion reveal that mesozoans have so far been collected from 4 few species of Cephalopod molluscs of Bay of Bengal off the East Coast India. Therefore, besides Cephalopod molluscs other marine invertebrates, viz., polychaetes, echinoderms, ascidians, etc., are to be examined for mesozoan diversity from both East and West Coast as well as Andaman and Nicobar and Lakshadweep Islands. Further, expertise needs to be developed to identify these animal groups.

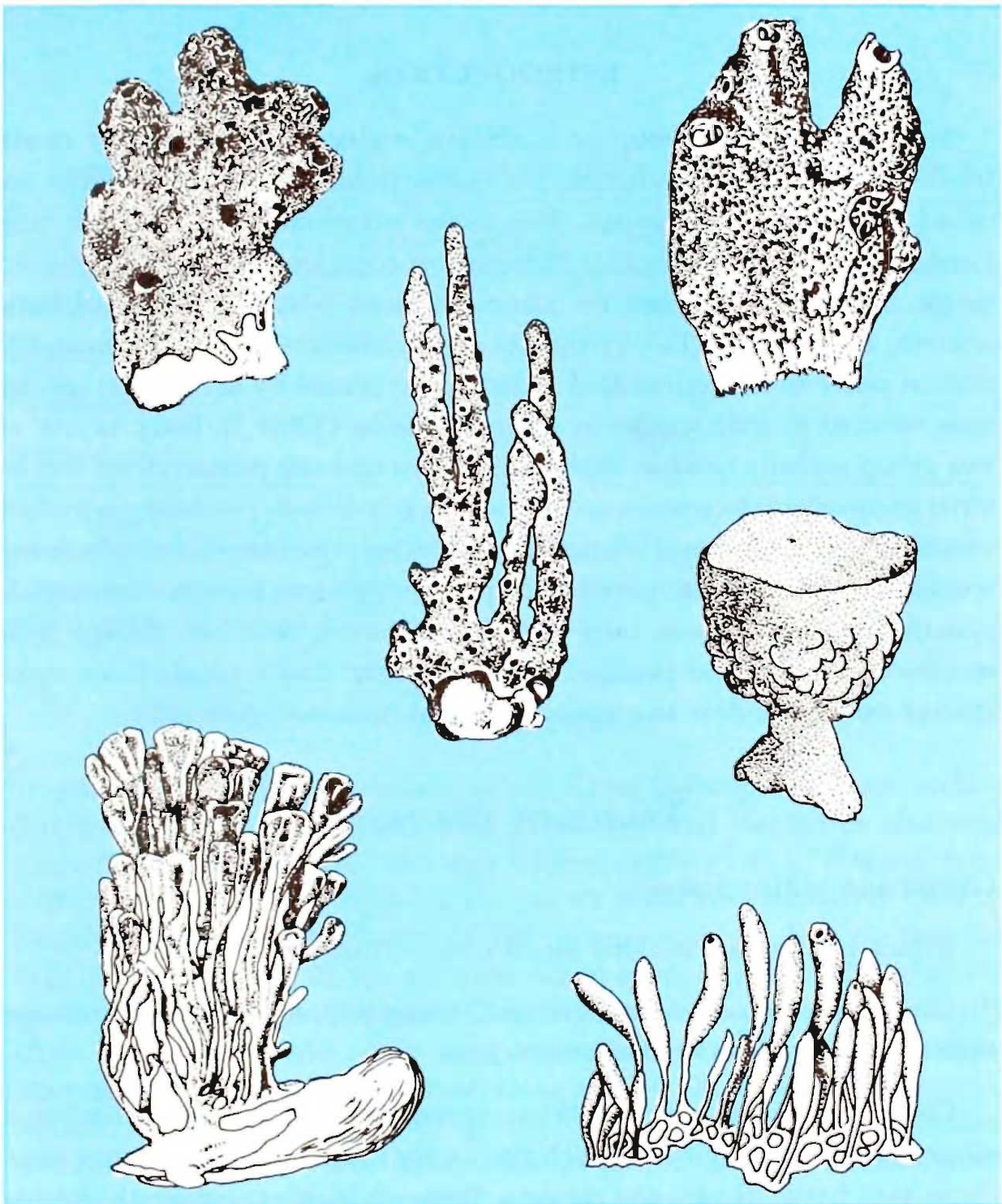
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Faunal Diversity in India : Porifera

P. A. THOMAS

Central Marine Fisheries Research Institute, Cochin





INTRODUCTION

Sponges include a group of sedentary, multicellular, marine or rarely freshwater filter-feeding animals possessing porous body. Hence these are called porifera or pore-bearers. This group is included under the phylum Porifera under the subkingdom Parazoa and occupies a position in between single celled protozoa and the most advanced 3-layered or triploblastic animals, the metazoa. This group has an evolutionary history of about 570 million years and is represented in the extant oceans by about 5000 species now reduced to 4562 species by a latest revision (Table 1). Body 'layers' in this group are only two (*i.e.*, diploblastic) with an outer pinnacoderm and an inner choanoderm (ectosome and endosome respectively) enclosing a middle undifferentiated mesohyal containing wandering cells. Flagellated cells lining specialised chambers are peculiar to sponges. Sponges have no histological system, but they possess only functional systems; cells can change their structure, function and position as per necessity. These peculiarities make sponge cells quite dear to physiologists and immunologists alike.

STATUS OF THE TAXON

Global and Indian Status

Extant sponges are divided into 4 Classes; they are :

Class I. Calcaria or Calcispongiae or Calcareous sponges : Typically marine, skeleton made of CaCO_3 and microscleres.

Class II. Demospongiae or Silicious sponges : Skeleton made of hydrated silica in the form of spicules which are divisible into mega and microscleres. Some may have spicules and spongin fibers while others have only spicule or spongin fibers. Some may incorporate arenaceous objects (sand grain, foraminiferan test and so on) into their body for rigidity.

Class III. Hyalospongiae or Hexactinellida or Hexactinellid or Glass sponges : Skeleton of hydrated silica, the spicules 6-rayed as the name denotes and divisible into mega and microscleres, the former may, in some cases fuse to form a compact felt-work.

Class IV. Sclerospongiae : A very recently discovered group with spicules made of silica, CaCO_3 and spongin.

A comparison of the World and Indian poriferan diversity is shown in Table – 1.

Table – 1
Showing number of species of Porifera reported from world and India

Class	World species	Indian species	%
Calcispongiae	47*	14	
Demospongiae	4000	428	
Hyalospongiae	500	44	
Sclerospongiae	15	—	
Total	4562*	486	10.65

* 500 species reduced to 47 species by a latest revision and thus reducing 5000 world species of Porifera to 4562 as shown above.

DISTRIBUTION

Among the sponges members of the Class Demospongiae are widely distributed. They inhabit intertidal areas to hadal depths in different concentrations. In the intertidal area these sponges grow to massive form within the reach of any collector, and hence these are extensively used in biochemical studies. Data collected after intensive survey indicate that the Gulf of Mannar and Palk Bay are quite rich in sponge growth. A total of 275 species has been already recorded from these two areas. Specimens usually attain massive size and hence form source material for bioactive assays. Numerical abundance from other areas are : Gulf of Kutch-25 species, Andaman and Nicobar group—61 species. Nothing is known on the numerical abundance of sponges from other areas of the Indian seas. Lakshadweep group of islands have been surveyed in the past thoroughly and these surveys revealed the presence of 91 species of silicious sponges in the various Islands.

Another interesting finding is the wide distribution of coral boring sponges (mainly *Cliona* spp.) in the atolls of the Archipelago. 18 species of boring sponges are known from the atolls of Lakshadweep.

List of species that are abundant in different areas is given below :

Andaman and Nicobar : *Dysidea herbacea* (Keller), *Phyllospongia foliascens* (Pallas), *P. papyracea* (Esp.) ssp. *polyphylla* de Laubenfels.

Visakhapatnam coast : *Tethytimea repens* (Schmidt), *Callyspongia diffusa* (Ridley), *C. fibrosa* (Ridley and Dendy).

Rameswaram area : *Callyspongia* spp., *Dysidea fragilis* (Montagu), *Ircinia fusca* (Carter), *Fasciospongia cavernosa* (Schmidt), *Dendrilla nigra* (Dendy), *Haliclona tenuiramosa* (Burton), *Sigmatocia fibulata* (Schmidt), *Iotrochota baculifera* (Ridley), *Tedania anhelans* (Lieberkuhn), *Endectyon fruticosa* (Dendy), *Clathria frondifera* (Bowerbank), *C. procera* (Ridley), *Biemna fortis* (Topsent), *Spirastrella inconstans* (Dendy), *Prostylyssa foetida* (Dendy), *Cinachyra cavernosa* (Lmk.), *Aurora globostellata* (Carter).

Tuticorin area : *Petrosia testudinaria* (Lmk.), *Clathria frondifera* (Bowerbank), *Axinella donnani* (Bowerbank), *Spirastrella inconstans* (Dendy), *Prostylyssa foetida* (Dendy).

Lakshadweep : *Heteronema erecta* Keller, *Callyspongia fibrosa* (Ridley and Dendy), *Tedania anhelans* (Lieberkuhn), *Sigmatocia fibulata* (Schmidt).

Distribution of boring sponges in the natural molluscan beds of chank, mussel, rock oyster, pearl oyster, etc., found along the southwest coast of India has been worked out. It could be seen from the survey that 6 species of boring sponges are very active in these beds and all are potentially capable of devastating the beds totally. Above studies further revealed that some boring species, which are totally inactive in natural condition, may suddenly become active at time causing wide-spread mortality to molluscs.

Detailed investigations made in the past on boring sponges infecting the economically important molluscan beds and coral reefs revealed the existence of 32 species of boring sponges referable to 13 genera under 3 orders, viz., Hadromerida, Epipolasida, and Carnosida, the dominant family being Clionidae of the Order Hadromerida.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

An examination of the sponge fauna of Indian seas reveals that it is dominated by Demospongean species (88.8%) followed by those of

Hyalospongiae (9.1%) and Calcispongiae (2.1%) (Table 2). This composition is in full agreement with that in the world oceans. It is stated in literature that only 60% of the total Indian sponge fauna is documented till date. A thorough qualitative appraisal only will reveal the actual.

There are about 100 species of freshwater sponges world over under 20 genera of a single family—the Spongillidae. 31 species under 10 genera are known from India as per the latest work of Soota (1991).

Diversity of Indian sponges is shown in Table 2.

Table – 2
Showing number of genera and species of sponges in India

Class	No. of genera	No. of species
Clacispongiae	11	14
Demospongiae	173	428
Hyalospongiae	19	44
Sclerospongiae	—	—
Total	203	486

ENDEMIC AND THREATENED SPECIES

13 species of freshwater sponges are reported to be endemic to India based on our present level of knowledge. In the marine realms it is impossible to evaluate endemism as many of our inshore areas and also of other countries are poorly investigated. No sponge of Indian seas is considered a 'threatened species' in the strict sense of the term. No species of sponge from India is included in the Indian or International Scheduled list, and are presently not covered under any law.

VALUE

Recent studies revealed that sponges contain several peculiar chemical compounds which are not found in any other animals. Arabinose nucleosides

isolated from *Tethya crypta* have proven cancer inhibiting properties and this discovery has triggered off a world-wide interest in the biochemistry of this group. In India too, several institutions have taken up the extraction and characterization of several pharmacologically active compounds from sponges.

Freshwater sponges cannot be said to be of any use to man as they pollute water, block up water pipes and cause irritation to human skin through contact. Some recent publications show that these sponges would be of much help in water quality and palaeoclimatic studies. Sponge cells of both marine and freshwater may also serve as a mighty tool in both cellular and immunological studies.

The boring sponges cause widespread mortality among corals. These sponges etch out minute CaCO_3 particles of identical size and shape from the coral substrate, both living and dead and hence this can be considered bioerosion on a microlevel. Since this type of etching out is going on in a microlevel nobody will take notice of it easily. Such weakened coral substrate may crumble at slightest pressure causing landslides. This problem should be tackled by both geologists as well as biologists alike for a better understanding of the impact of waves and tides on a completely riddled out coral frame-work with a view to suggesting remedial measures in time.

Boring sponges can cause considerable damage to the outer hard shells of live molluscs (chank, oyster, mussel, etc.) producing several physical and physiological manifestations. Investigations made in the past have revealed that these boring sponges can migrate to culture systems from wild stocks of molluscs causing both physical and physiological 'stress' to cultured stocks resulting in diseases. So far 12 different diseases have been documented from live molluscs. When a boring sponge infects a live pearl oyster shell the oyster will have to waste a lot of nacreous material and energy to repair the holes made at the inner aspect of the shell by sponge. In this process, the pearl producing capacity of the oyster is considerably curtailed. More work in this line is necessary to assess whether sponge infection will reduce the pearl producing capacity of the oyster or not. Two species of boring sponges (*Cliona margaritifera* and *C. lobata*) have entered into active phase in our beds around 1980, and these are now spreading in our molluscan beds. The former species caused widespread depletion of the Ceylon pearl oyster beds around 1902 and then entered into a quiescent stage later. The reappearance of this species in the southwest coast of India poses a serious threat to both southwest and southeast coasts of India where many economically important molluscan beds are located.

It could also be seen that the incidence of boring sponges on the cultured molluscs (raft culture) was higher than that seen on natural molluscan beds.

Number of boring species infecting the cultured molluscs was also found high. The reason is that nature plays an important role in keeping the abundance of these pests at a lower level when untampered by external influences. But increased incidence and also the numerical abundance on cultured molluscs might be an indicating that the ecological equilibrium which is at play in the natural beds is no longer in operation in these artificial systems.

One species of boring sponge, viz., *Cliona vastifica*, could succeed in migrating to the estuarine realms of our coasts by virtue of its low salinity tolerance. This species might pose a serious threat to our future molluscan culture farms along the various estuaries.

THREATS, CONSERVATION AND FUTURE STUDIES

Since no commercial exploitation and export of sponges are attempted at present there is no need to think of any imminent threat of depleting the beds. But in future any attempt to initiate exploitation and export of this commodity should be discouraged. However, those species mentioned against each area under the subhead "distribution" should not be destroyed beyond a certain level even for experimental purposes by the various institutions in India. Scientists from India, interested in getting samples for research, may collect them judiciously without depleting the resources. This may be done by adopting 'conservative pruning' or cutting parts of the specimen leaving the rest *in situ* to regenerate and grow. Blasting and dredging will generate much silt and this may settle on the surface of sponges killing them and hence such activities should be banned. Specimen collectors use certain chemicals to make specimens immobile for a while. Such chemicals are likely to affect sponges which grow in neighbouring areas. So specimen collection using such chemicals should be banned altogether. Pumping out hot-water/effluents into the coastal areas by Thermal Plant/Factories should be banned as any rise in temperature might prove detrimental to marine life as a whole. Those who make collections from the intertidal areas may be advised not to turn any stone or coral piece upside down. Some species of sponges, unable to tolerate direct sunlight, settle on the undersurfaces of hard objects and grow. When they are kept exposed to direct sunlight they may perish in a day or two.

Sponges constitute a major group among fouling organisms. But hitherto, no exhaustive work has been done on sponges in this regard. An exhaustive survey in this line may be undertaken with reference to culture systems, intake pipes of thermal plants, etc.

A variety (*ceylonensis*) of the common 'bath sponge' *Spongia officinalis* is distributed in good concentration along the Gulf of Mannar coast. Ecology and biology of this variety should be studied in detail as it forms a 'store house' of several chemicals with biomedical properties.

Though India has a vast coast line practically no survey has been made to study the benthic life either quantitatively or qualitatively. This is true with all other minor groups of animals such as alcyonarians, antipatharians, ascidians as well. All these animals have come into the limelight recently on account of peculiar chemical compounds they elaborate. Prostaglandins extracted from gorgonids, arabinose nucleosides from sponge *Tethya crypta* are examples to cite a few. Some of the above resources are now being exported to foreign countries for a paltry sum and these countries are making immense profit from our resources. So what seems quite plausible is that we should step up synthesising these chemicals that act as 'wonder drugs' and then release them in market. Speaking revenue-wise this could be a better deal than sending the valuable resources for a paltry sum.

As the first step in this direction an attempt may be initiated to assess the availability and magnitude of all such minor resources possessing biomedical properties. Extensive survey along the continental shelf of India using unified sampling procedures should be undertaken. The data thus amassed should be entrusted to various experts for further studies leading to the assessment both in time and space. At present we have no expert to study groups such as alcyonaria, ascidian, antipatharia, etc. The responsibility of training hands, wherever necessary, should be shouldered by National Institutions that are competent.

Sponges, as mentioned in the introductory part, form an ancient group which can elaborate peculiar chemical compounds with biodynamic potentials. Arabinose nucleosides isolated from *Tethya crypta* and its use in the treatment of cancer have recently triggered off a world-wide interest in this group and since 1963 several groups all over the world are interested in the biochemistry of sponges. In India also several institutions are now actively engaged in this challenging field of research. Though our efforts are still at infancy more and more funding agencies are coming forward to finance any such venture liberally. No doubt, it is a good sign, but unless the activities of each research group are monitored well from the inception itself there is every chance that research activity of one group may get duplicated by others unknowingly.

It is generally seen that chemical studies relating to a particular species of sponge culminate in the isolation and characterisation of a particular chemical compound, but its potential as drugs is neither assessed nor attempts

to release it in market as drugs are made. This will relegate the status of these peculiar chemicals as mere subjects of academic interest. Hence, institutions competent enough to tackle the follow-up action should come forward to assess the potential of these chemicals as drugs and their use in the treatment of systemic diseases in man and animal.

Perusal of literature dealing with marine products chemistry reveals that many species that are distributed in the Indian seas have been thoroughly worked out in the past by other countries. As such, an inventory of such species becomes inevitable and this could be done partly by gleaning through existing literature and partly through direct contact with foreign research organisations.

It is also necessary to have proper interaction with major museums of the world as well as with experts in the various fields of zoology for training our Scientists in the respective fields.

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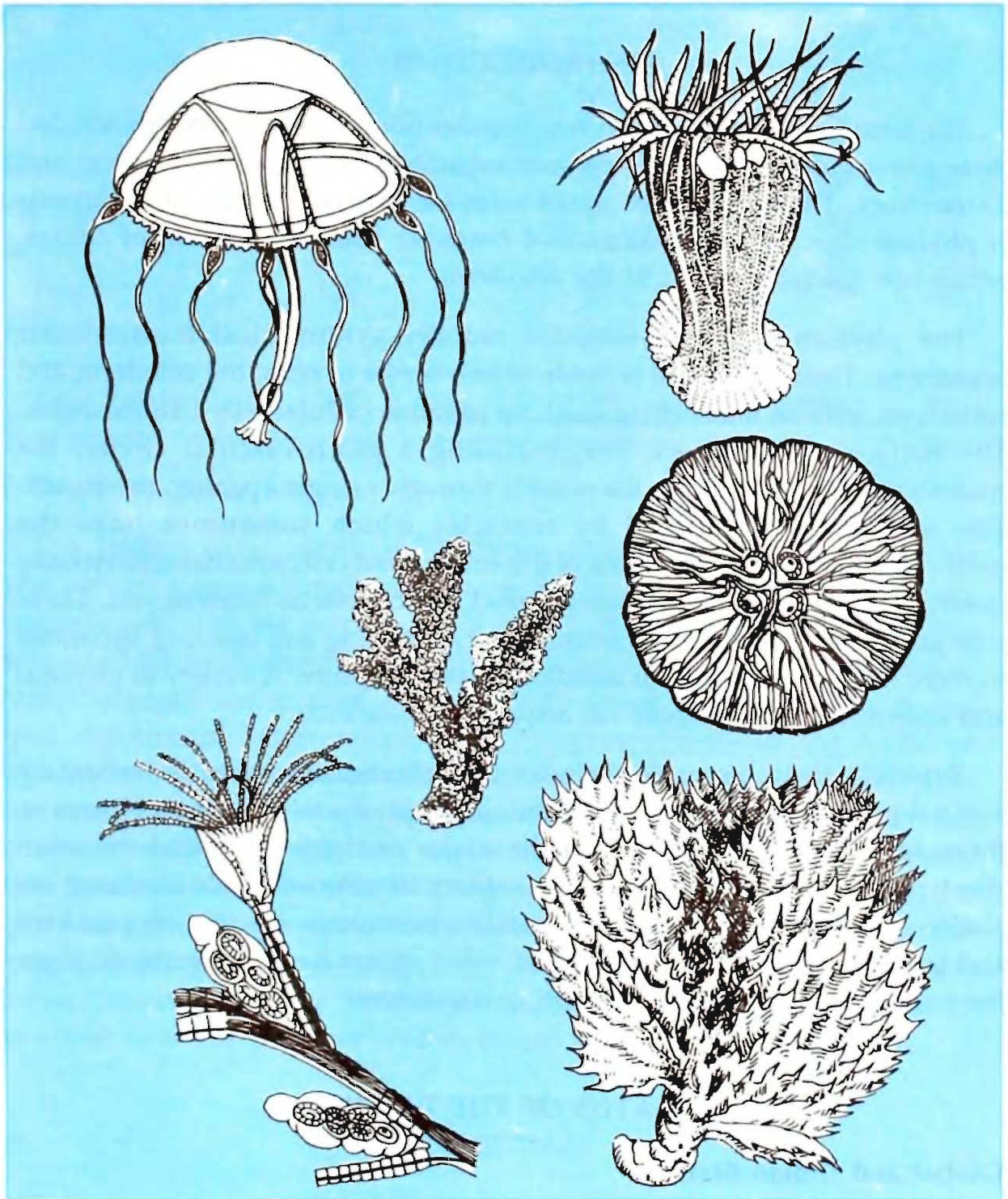
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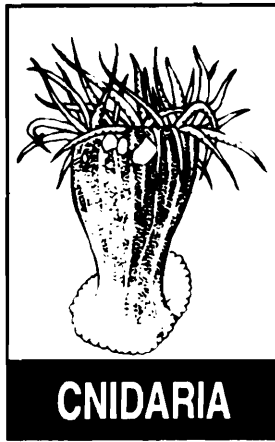
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Faunal Diversity in India : Cnidaria

N. V. SUBBA RAO AND D. R. K. SASTRY

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The term Coelenterata which was popular till recently, originally included three groups, of which two have been separated into the phyla Porifera and Ctenophora. The currently accepted term for the third group of organisms is phylum Cnidaria, their distinctive character being possession of cnidae, which are specialised cells of the ectoderm.

The phylum Cnidaria includes radially symmetrical multicellular organisms. Their body wall is made of two layers of cells, the ectoderm and endoderm with an intervening acellular to rather cellular jelly-like mesoglea. The body is basically sac-like, enclosing a gastrovascular cavity, the coelenteron, which opens to the outside through a single opening, the mouth. The mouth is surrounded by tentacles which sometimes have the gastrovascular extensions. Some of the ectodermal cells are characteristically modified into specialised elements called cnidoblasts or nematocysts. These cells possessing poisonous secretions have a stinging and injecting apparatus to serve the dual functions of defense and prey-capture. A variety of physical and chemical stimuli trigger the activity of these cells.

Typically their life cycle includes two alternating stages—a sedentary asexual polyp and another free swimming reproductive medusa. However, there are forms with only one of the stages predominating and the other shortened or absent. Polyps may be solitary or colonial while medusae are always solitary. They are predominantly carnivorous, feeding on plankton and larger organisms such as fish. Yet, many others harbour symbiotic algae for nutrition or for growth promoting substances.

STATUS OF THE TAXON

Global and Indian Status

The global estimates of cnidarian diversity vary between 9,000 and 12,000 species. According to Groombridge (1992), the current description rates

estimated for various animal groups during the period from 1978 to 1987 show an annual growth rate of 0.63 per cent for Cnidaria with about 57 species per annum described as new. On the other hand, revisionary studies on certain groups of Cnidaria are bringing down the total figure by a larger percentage. On collating information from different sources, we estimate the cnidarian diversity to a modest 10,000 species. A comparison of the global and Indian cnidarian diversity as per available information is shown below.

Phylum	Families (N)		Genera (N)		Species (N)	
	W	I	W	I	W	I
Hydrozoa	96	53	385	120	2700	212
Scyphozoa	24	15	70	18	200	25
Cubozoa	2	2	6	3	15	5
Anthozoa	125	46	650	150	7000	600
Polypodiozoa	1	—	1	—	1	—
Total	248	116	1112	291	9916	842

W =World; I = India;

The Indian component of Cnidaria given above as per available information, forms a small portion of the world diversity (8.49%), but compares well with the percentages of other Indian faunal components. This percentage however should not be constructed as an accurate reflection of reality, since all the groups of Cnidaria have not received adequate and equal attention of Indian taxonomists. Excepting the pioneering works of Annandale, Leloup, Menon, Ganapati and Nagabhushanam recent studies are few and scattered. Comprehensive accounts are available only for siphonophores by Daniel and for scleractinian corals by Pillai. Further, many of the groups need revision and an accurate inventory of valid species is yet to be attempted. A synonymized compilation of coral species of the Indian Ocean and adjacent seas by Sheppard (1987) has reduced 796 species to 439 species. Similar exercises in other groups may upset the species diversity presented above at global as well as Indian level.

DISTRIBUTION

Cnidarians show a great diversity in habit and habitat. Their body size ranges from less than a millimetre in meiofaunal members, such as,

Halammohydra to several metres in pelagic forms like *Physalia* commonly known as Portuguese man-o'-war, provided with very long tentacles. The reef building corals often attain a massive size with a large diameter and considerable height.

Though Cnidarians are predominantly marine, three families of the hydrozoan order Hydroida (Hydridae, Limnocythidae and Moerisiidae) are exclusively freshwater or brackishwater inhabitants, while two others (Clavidae and Olindiidae) have freshwater or brackishwater representatives.

The polypoid stages lead a sedentary life attached to hard substrata like molluscan shells, rocks, corals, etc., or live buried or in tubes in the soft substrata. The medusae, with a few exceptions, are free swimming planktonic, pelagic or bathypelagic. Their bathymetric distribution extends to depths exceeding 4,000 metres.

There are a large number of cnidarians which live symbiotically with a variety of organisms as commensals or mutualists, or as epiphytes or epizoa, with the sole exception of *Polypodium hydriforme* which is parasitic on freshwater fishes.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

There are some general accounts of medusae. These are found in the classes Scyphozoa, Cubozoa and Hydrozoa. Pelagic medusae have a wide geographic distribution in the world oceans. A total of 118 species of Siphonophora are reported from the Indian Ocean, of which 89 species are known from the coastal waters of India (Daniel, 1991). The other medusae are represented by 67 families, 272 genera and over 900 species in the world. The comprehensive account of Kramp on medusae of the world and some recent literature reported 47 families, 77 genera and 111 species of medusae in Indian waters. Kerala and Tamil Nadu coasts are rich with 54 and 51 species respectively, followed by Andhra Pradesh (45 species) and Andaman waters (35 species). Regarding the polyps, 24 species have been reported from Tamil Nadu, followed by Orissa (12 species). Pennatulids (15 species) and Gorgoneans (32 species) are abundant at the Andaman and Nicobar Islands.

MONOTYPIC GENERA AND ENDEMICITY

There are several monotypic genera in different families, of which near about 40 genera or more have been reported from Indian waters. The most

common genera though not endemic to India are *Pelagia*, *Solmundella*, *Liriope*, *Physalia*, etc. The monotypic genera endemic to India are *Coeloseris* (Scleractinia), *Mena* and *Nevadne* (Actiniaria) among others. Among the species endemic to India, though not of monotypic genera, mention may be made of *Amphicaryon intermedia*, *Anactinia pelagia*, *Bythocellata cruciformis*, *Limnocrnida indica*, *Moersia gangetica*, *Phialucium multitentaculatum*, etc.

A list of monotypic genera and endemic species of India is given in Table-1.

Table – 1

A. Some monotypic genera endemic to India	
<i>Anactinia</i> , <i>Bythocellata</i> , <i>Coeloseris</i> , <i>Mena</i> , <i>Nevadne</i> and <i>Mansariella</i>	
B. Some species endemic to India	
<i>Acromitus rabanchatu</i>	<i>Meliceritissa platygastra</i>
<i>Amphicaryon intermedia</i>	<i>Mena chikaea</i>
<i>Anactinia pelagia</i>	<i>Bythocellata cruciformis</i>
<i>Edwardsia tinctoria</i>	<i>M. limnicola</i>
<i>Halammohydra andamanica</i>	<i>Moersia gangetica</i>
<i>H. chauhani</i>	<i>Octophialucium solidum</i>
<i>H. gangetica</i>	<i>Pelocoetes exul</i>
<i>Lensia gnanamuthui</i>	<i>Phialucum multitentaculatum</i>
<i>L. tottini</i>	<i>Phytocoetes gangeticus</i>
<i>Limnocrnida indica</i>	<i>Rathkea rubence</i>

VALUE

With their varied feeding habits, cnidarians play a very important role in the food web of the environment. There are also carnivores preying on larger organisms such as fish. Many organisms such as sea anemones and hermatypic corals harbour and depend to some extent on zoochlorellae and zooxanthellae for nutrition as well as for growth promoting substances. Some of these symbiotic algae are known to survive only with the association of their respective cnidarian hosts. Some freeliving planktonic forms are restricted to water masses of typical temperature-salinity characteristics and thus serve as indicators of water movement and circulatory processes in the marine environment. The hermatypic corals are the chief reef builders

protecting the shoreline. In addition, they support a rich biodiversity ranging from protozoans to fish, with consequent complex community relationships. Coral skeletons are of ornamental and decorative value and as such are important in curio trade. The precious red coral, *Corallium rubrum* of Mediterranean is highly valued in jewellery. The coral skeleton is composed of more than 98% of pure calcium carbonate and it is a rich source of calcium.

The antipatharians are commonly and commercially exploited for jewellery and it is believed that by wearing these health improves.

The pharmacological importance of Cnidaria, particularly of sea anemones, soft corals and jelly fish is well-known. They contain a number of antibiotics, substances of physiological importance and substances useful in detecting and sometimes curing a variety of cellular and bone diseases. Their study in India is in the initial stages and is showing great prospects.

In spite of having the poisonous nematocysts in cnidariaus, a number of organisms such as crabs, molluscs and fishes enjoy a symbiotic relationship with many of them sometimes for protection from enemies and sometimes for mutual advantage. However, cubozoans and some siphonophores can be considered venomous as they cause great misery to even human beings with fatal consequences. Though an open ocean form *Physalia*, for example, occasionally drifts into coastal waters and unwary bathers on the coast get entangled in their long tentacles measuring several metres. Their numerous nematocysts cause unbearable pain and swelling of the body to the victims.

THREATS AND CONSERVATION

Natural calamities and disturbances in the high seas cause drifting of oceanic forms to coastal waters resulting in large scale mortality. But they never proved a threat to any species though they may damage coral and intertidal fauna in restricted areas. Discharge of toxic effluents and untreated sewage cause great harm to pelagic as well as benthic cnidarians of coastal regions. In addition, damage to the natural habitat and wanton collection by unguided individuals may totally destroy the intertidal fauna of restricted areas.

The most threatened and vulnerable cnidarians are the reef building corals and their inhabitants. In addition to protecting the shore line, they support a rich gene pool. Unintelligent and greedy exploitation of corals for domestic and industrial purposes and damage to the habitat by visitors with added exploitation of coral inhabiting fauna for curio trade evidently damaged the ecosystem in the Gulf of Kutch, Gulf of Mannar and Andaman & Nicobar

Islands. On one hand, exploitation of corals causes erosion of shore line and on the other such action destroys the coral associated fauna. Exploitation of coral associated fauna selectively for curio trade disturbs the natural balance in the community, resulting in population explosion of unwanted species threatening the corals and coral fauna.

Subsequent to control of exploitation and damage to the ecosystem and establishment of Marine National Park at Gulf of Mannar, the entire region has almost recouperated to normalcy. The same measures are being taken at Andaman and Nicobar Islands before considerable damage is done. The effect of establishment of National Marine Park and a Sancturay in Gulf of Kutch is yet to be felt probably due to the large scale damage already done and continued exploitation of the area. Developmental projects are to be well planned and control over their discharges and human interference effectively implemented so as to protect these fragile ecosystems.

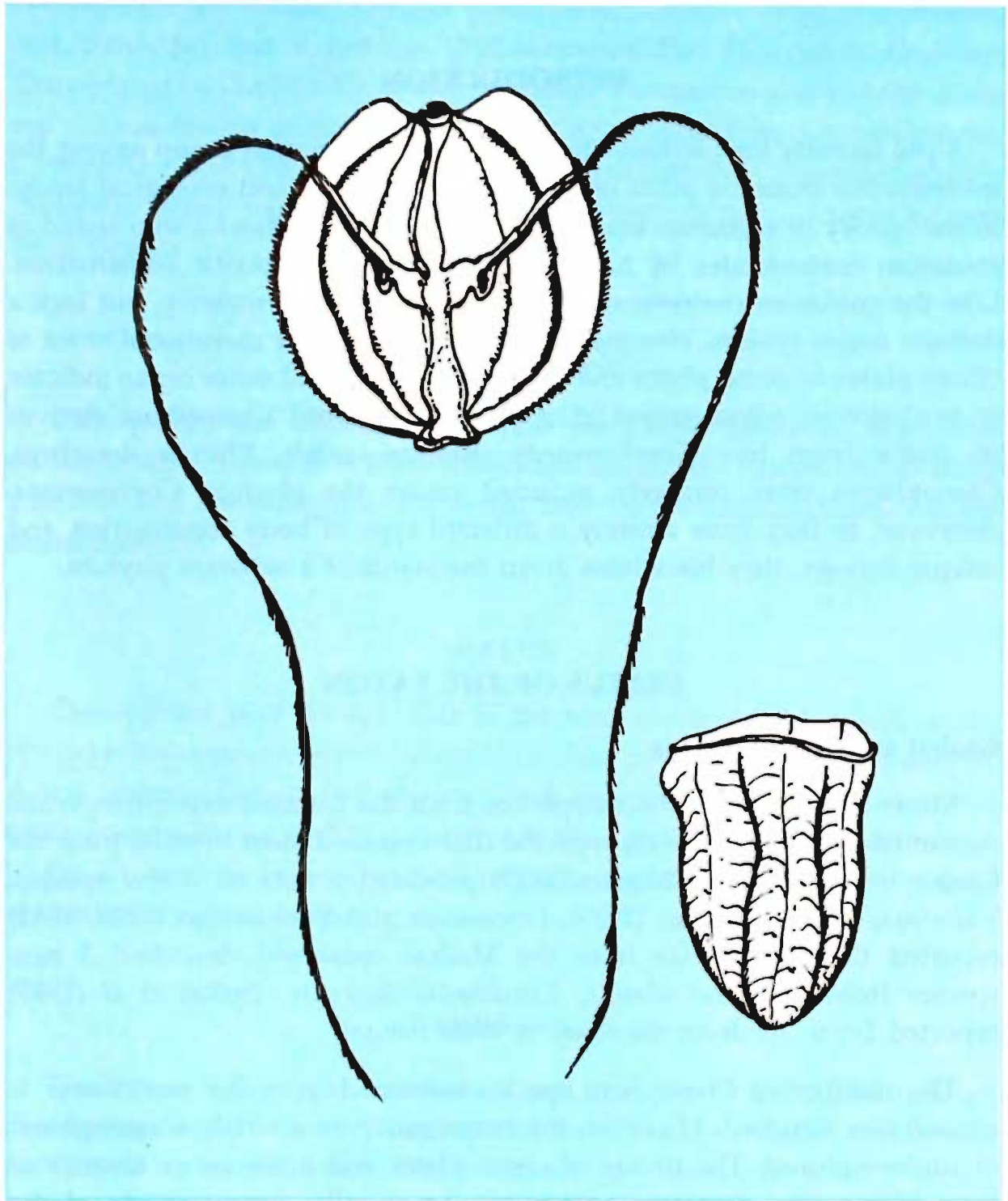
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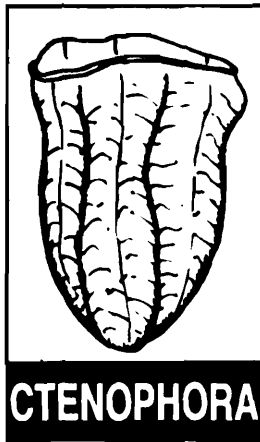
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Faunal Diversity in India : Ctenophora

RAMAKRISHNA AND J. SARKAR

Zoological Survey of India, Digha, West Bengal





INTRODUCTION

Uptil recently the phylum Ctenophora was a neglected group among the invertebrates from the point of view of its taxonomic and ecological study. In the history of metazoan evolution, the ctenophores stand a step ahead of cnidarian coelenterates by having a low grade triploblastic construction. Like the cnidarian coelenterates, they possess radial symmetry, but lack a definite organ system. However, the presence of eight meridional rows of ciliary plates or comb plates and the presence of aboral sense organ indicate an evolutionary advancement on cnidarians. The word 'Ctenophora' derives its name from two Greek words (Ktenos—comb, Phoros—bearing). Ctenophores were formerly included under the phylum Coelenterata. However, as they have entirely a different type of body construction and unique biology, they have been given the status of a separate phylum.

STATUS OF THE TAXON

Global and Indian Status

Moser (1909) recorded Ctenophores from the German expedition while Annandale and Kemp (1915) were the first to record them in India from the Chilka lake expedition. Menon (1927) provided a note on a few species. Varadarajan (1934), Aiyar (1939), Devanesan and Varadarajan (1939, 1942) reported their occurrence from the Madras coast and described 3 new species from Krusadai islands, Tamilnadu. Recently, Sarkar *et al* (1997) reported *Beroë* sp. from the coast of West Bengal.

The number of Ctenophore species estimated from the world over is around one hundred. However, the entire group as a whole is unexplored or underexplored. The nature of comb plates and presence or absence of long filamentous tentacles containing 'Lasso-cells' (counterparts of the nematocysts of Coelenterates in function and not in structure) are the taxonomic features generally used for identification of this group. Cilia

bundled into combs or ctenes are an evolutionary innovation that allow comb jelly to swim faster. The size, shape and swimming behaviour, however, may be constrained by the mechanisms that co-ordinate comb-plate oscillations. It can be said that propulsion of comb-plate oscillations has played important role in the evolution of Ctenophores and may have divided into two evolutionary lineages.

At present 12 species are reported from India under two classes (Tentaculata and Nuda), 5 orders (Cydippida, Lobata, Cestida, Platyctenea, and Beroidea) and 6 families (Pleurobranchiidae, Ocyroidae, Cestidae, Ctenoplanidae, Coeloplanidae and Beroidae). The species known from India are : *Pleurobrachia globosa*, *Ocyroe* sp., *Cestum amphitrite*, *Cestum veneris*, *Ctenoplana indica*, *Ctenoplana kowalevskii*, *Coeloplana mesnili*, *Coeloplana sophiae*, *Coeloplana agniae* var *striata*, *Coeloplana gonoctena* var *rosea*, *Beroe ovata* and *Beroe forskalii*.

DISTRIBUTION

Ctenophores are exclusively marine planktonic group of organisms (Holoplankton) found in oceanic waters and are usually referred as off-shore plankton and are brought to the neritic zone by the sudden changes in the ocean currents.

VALUE

Ctenophores play a major role in the food chain and food web of the coastal ecosystem as small and large fishes feed on these group of organisms. A few species, during their bloom, attack fish eggs, larvae of prawns and other crustaceans as well as ctenophores. The lysosomal property exhibited by the lasso cells is believed to have biomedical importance. All ctenophores are brilliantly phosphorescent.

THREATS

Thousands of Ctenophores are destroyed everyday by the local fishermen during Bagda (Tiger prawn) netting and Sarini netting (local drag net) and are cast-off on the dry bench. Death of these organisms is reported in recent years in the brackish water prawn fisheries as they employ specific poison to eradicate this group.

CONSERVATION AND FUTURE STUDIES

It is necessary to check large scale destruction of ctenophores by the local fishermen while netting, particularly Bagda netting for the collection of prawn seeds. Ctenophores thus netted should be isolated from the collection and released in the ocean as soon as possible. Brackish water Prawn fishery farms should use fine nets to isolate ctenophore species from the tidal water entering into the farm.

The lysosomal property can be utilised under enzyme chemistry or in biomedical study. The comb-plates of Ctenophores are interesting structures and these may serve as key character for separating one species from another by Scanning Electron Microscope study. Such study should be undertaken.

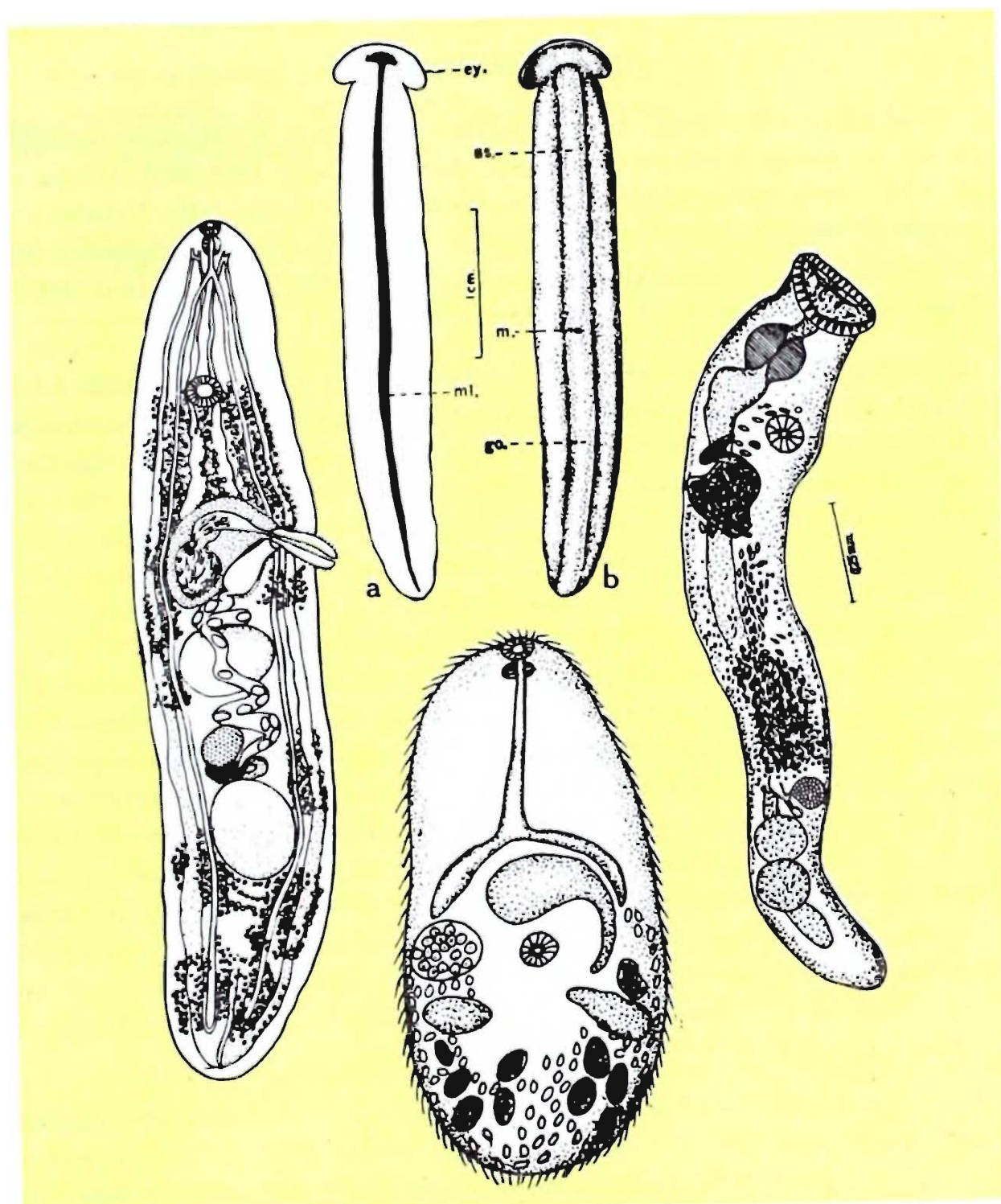
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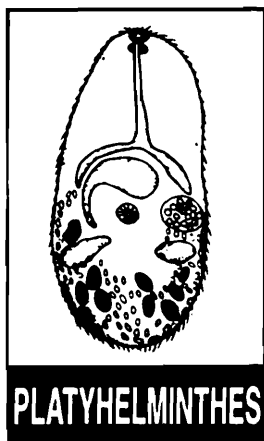
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Faunal Diversity in India : Platyhelminthes

R. K. GHOSH

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Platyhelminthes could well be defined as a group of extremely variable, mostly parasitic animals with body dorsoventrally flattened having an excretory or osmoregulatory system composed of flame cells, tubules and excretory vesicles. Majority of them are either ecto or endo parasites and hermaphrodite in nature. The phylum Platyhelminthes comprise four classes Turbellaria, Monogenea, Trematoda and Cestoda.

Among Platyhelminthes, Turbellaria are mostly freeliving though a few of them are parasitic or commensals. The remaining groups of Platyhelminthes are parasitic and contain many important pathogenic forms from veterinary and medical point of view. They cause various disease among all wild and domesticated animals including man. Some of these parasites were known from almost prehistoric time, such as liver fluke, *Fasciola hepatica* and broad tape worm of the genus *Taenia*. Zoologically they are very interesting in the sense that they have modified their body organs and physiology to a very great extent for successful parasitic existence. Some of them altogether discarded digestive, respiratory and circulatory systems and developed the mechanism to live either in anaerobic condition or with very little oxygen. Most of the endoparasitic forms develop enormous capacity to reproduce. A single *Fasciola hepatica* may produce in its life time about 1/2 million ova. This ova after being released from vertebrate host could reproduce itself asexually in molluscan host to rediae, daughter rediae and finally cercariae, the freeliving infective stage. The total comes out to 4.2×10^8 offspring from a single ova. Egg production in trematode is probably the highest among animal kingdom. Fortunately most of them die due to nonavailability of suitable host both in larval and infective stages.

Stoll (1947) estimated that 72 and 148 million human being are infected with cestodes and trematodes respectively out of 2200 million of global population at that time. Parasitic diseases caused by helminth parasites are almost equally important as those of bacterial or viral diseases. Bacterial diseases are devastating but not of regular or frequent occurrences. They

attack suddenly and cause considerable loss for a specified period of time, in a limited geographical area. But parasites are present almost always in animals throughout the globe and cause damage every day and year after year.

STATUS OF THE TAXON

Global and Indian Status

Number of species, genera and families known India and percentage of species diversity in relation to world fauna in different classes of platyhelminthes is shown in Table 1.

Table – 1

Class	Indian families	genera	species	World species	%
Turbellaria	8	15	47	4000	1.17
Monogenea	28	110	295	2500	11.80
Digenea	47	250	750	6500	11.54
Cestoda	33	156	530	4500	11.78
Total	116	531	1622	17,500	9.27

DISTRIBUTION

Platyhelminthes are found mostly as ecto or endo parasites; so their distribution is related with those of their hosts. Tropical countries provide most optimum condition for survival and propagation of these parasites; as such, they are more abundant both in number and variety in this part of the globe. Distribution of Platyhelminthes is of course in some cases confined within a limited geographical area because of the limited distribution of intermediate hosts which are mostly molluscs and arthropods.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The parasitic platyhelminthes are vey much host specific. A particular species is capable of infecting only a definite species of host or taxonomically and ecologically closely related host species. In larval stages also they are very host specific. Not only the hosts but even site of location within the host organ is also very much fixed for a particular species. A negligible record of freeliving turbellarian species is available in literature. Parasitic

Platyhelminthes are also yet to be explored from large number of vertebrate hosts as shown in Table – 2.

Table – 2

Vertebrate hosts available in India and approximate number of species examined for helminth collections.

Group	No. of host species reported from India	No. of host species examined for platyhelminths
Pisces	2556	250
Amphibia	204	25
Reptilia	228	60
Aves	1228	225
Mammalia	372	75

The phylum is broadly divided into four classes, Turbellaria, Monogenea, Digenea (fulkes) and Cestoided (flatworms).

Most of the Tuberllaria are small and freeliving, some are commensal or parasitic; large forms have also been recorded. Their size ranges from less than 2 mm to 50 mm.

Survey of available turbellarian species is far from complete. Only about 4000 species have been recorded all over the globe from marine, freshwater and terestrial habitats. Study of this group remained very much neglected in India. In India, studies mostly remained confined to terrestrial fauna in high altitude Himalayas, Khasi, Jayantia and Nilgiri hill region. Considering the vast area lying unexplored and diversified habitats being present in India, large number of species are expected to be available. Species diversity in Himalayan region with high humidity and evergreen forests, expected to be most interesting, both in number and variety as far as terrestrial species are concerned.

Morphologically, most of the species are Monogenea bear close similarity with some turbellarians of the order Rhabdocoela. They are mostly small, almost all are ectoparasitic. Life cycle is simple with direct development from egg. Larva is ciliated, with a short freeswimming period before it gets anchored in final host. Final hosts are almost exclusively fishes, though a few species have been reported from mouth and urinalry bladder of amphibia and reptiles. Monogeneans are mostly host specific. Very little work has been done on this group in India. About 2500 species of freshwater and marine fishes are available in India and only 7% so far been screened for monogenea.

The adult trematodes could broadly be divided morphologically into the two broad groups or subclasses, Aspidogastrea and Digenea. Species of this class in their sexually mature stage live as parasites in vertebrates. They have been recorded from almost all body organs. Size and shape are extremely variable, from less than one millimeter to a few centimeters. Most of them are characterised by having one or two muscular sucker and a digestive system. Aspidogastrea and Monogenea have direct one host life cycles, Digenea have complex life cycle, involving freeliving and parasitic stages in different invertebrates, mostly molluscs and adult in vertebrate hosts. The larval stages can also multiply asexually. This is an unique feature in this group.

Members of Cestoidea are almost exclusively parasitic in vertebrate intestine. In their adult stages some species, of course, inhabit bile ducts of liver. Body shape and size are variable-2 mm to several meters and with a single segment to many hundred. The most interesting feature in all cestodes is the complete absence of digestive organ. Life cycle involves more than one host which may be either vertebrate or invertebrate. The class Cestoidea are broadly divided in two subclasses Cestoderia and Encestoda.

ENDEMICITY

Present knowledge does not throw much light on endemicity of different species of Platyhelminthes because of pausity of such studies and large number of host species are still to be examined for platyhelminth parasites. In Table – 3 a very rough extimate of number of endemic species in India is given based on the presently available data.

Table – 3

Class	Genera	Endemic species
Turbellaria	10	60
Monogenea	60	250
Digenea	100	500
Cestoda	40	350

VALUE

Stoll (1949) estimated an outstanding figure that humanhelminth infection in the world stood at 2 billion. Peters (1978) observed that 4-5 billion people are suffering from helminth infection. It is indeed a challenging medical

problem, considering many more further millions of infection in domestic and wild animals, belonging to vertebrate and invertebrate fauna. Helminths are well represented in Animal kingdom and almost all animals are directly involved as definitive, intermediate, paratenic or accidental hosts. No animal, great or small is immune to the ravage of helminth parasites and all the species so far screened for parasites have yielded some species or other.

THREAT, CONSERVATION STRATEGIES AND FUTURE STUDIES

Wild animals are all the more vulnerable to diseases caused by parasites because no effective prophylactic measure could be introduced. The faecal content which normally contains the egg and larvae are capable of spreading the parasites to other animals. Uncooked food and drinking water from ponds and streams may contain the larval forms of parasites which get transmitted into suitable hosts. Their bodies with hair and fur provide very suitable habitat for lice, mites and ticks which in turn serve as intermediate hosts to many tapeworms. All these factors explain the reason of heavy load of parasites in wild animals as well as, in livestock animals. The concentration of wild animals in National Park, Zoo Garden and reservoirs also provide an unique opportunity for the parasites to propagate and complete their life history. Due to shrinkage of grazing field and home ranges the eggs, larvae and other infective stages of parasites get easy access to suitable host which was rather difficult when the home range and forest cover were much wider than at present.

Control of known pathogenic parasites in wild animals sometimes becomes more complex. As liver fluke *Fasciola* sp., blood parasite, *Schistosoma* sp., or lung parasite, *Paragonimis* sp., could be controlled by eradicating mollusc shell from the home range of wild animals. Similarly, some soil mites are responsible for the spread of Anoplocephalid cestodes, which are major intestinal tape worms of grazing animals, such as, deer, antelope, wild buffalo, elephant, etc., and are causing heavy mortality particularly in younger stages. But complete eradication of mollusc shell or soil mites is neither possible nor desirable, as they will disturb the food chain, ultimately causing harm to the animal which is intended to be saved. Other prophylactic measures, such as, improvement of sanitary condition and change of food habit can not be applied effectively in case of wild animals. Well controlled experiments to obtain accurate information on the effect of a particular parasite on wild animal have not been undertaken. Studies and record of parasites of wild animals in captivity do not reflect the true picture to be encountered in natural condition. Therefore, it is very difficult to differential pathogenic symptoms cause by parasite from nutritional disorder or by other factors.

Moreover, some worms may cause damage when present in a small numbers while others, though present in large numbers, may not cause any or produce only negligible problems. At the present state of our knowledge, no effective control method for the control of platyhelminth parasites could be suggested until parasitological survey of wild animals is undertaken and parasites thus obtained are identified.

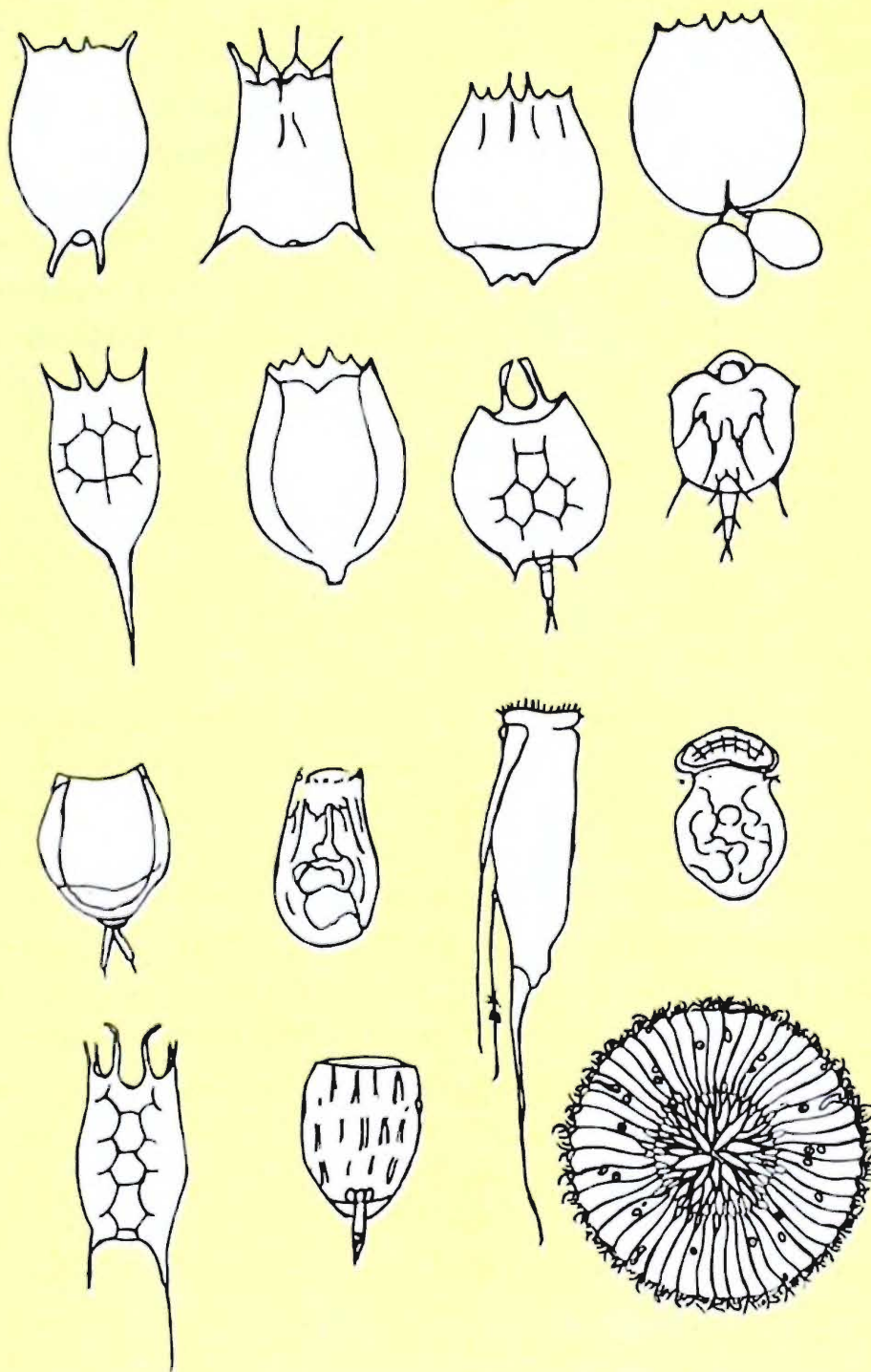
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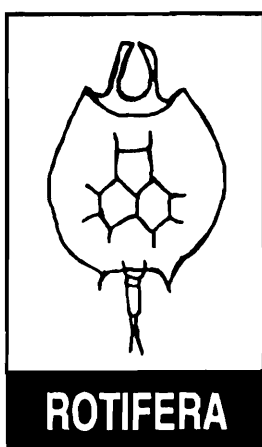
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Faunal Diversity In India : Rotifera

B. K. SHARMA

*Department of Zoology, North-Eastern Hill University,
Umshing, Shillong - 793 022*





INTRODUCTION

Phylum Rotifera represents a small group of animal kingdom which is, however, well known for its very distinct qualitative and quantitative significance in freshwater biotopes. The rotifers are pseudocoelomate micro-organisms and their body size usually ranges between 40-250 μm but certain larger species (size upto 2.0 mm) can, however, be observed with unaided human eye as small dots, sacs or rods. They depict intricate structure and endless profusion of body forms which, in turn, are morphologically well adapted to their living habits as well as closely associated with their habitats. Besides, a number of species exhibit interesting ecotypic and cyclomorphic variations and have, therefore, resulted in frequent allocation of infraspecific categories by various workers. The rotifer descriptions in the literature usually refer to the commonly occurring parthenogenetic females. The males, on the other hand, are rare, diminutive and shortlived.

The rotifers are commonly termed as 'Rotatoria' or 'wheel-animalcules' because of their characteristic anterior 'corona' or 'wheel organ' which imparts an illusion of a pair of rotating wheels as well as imparts typical 'rotating' locomotion to these organisms. They are also characterized by their jaw-like elements of 'trophi' located in the pharynx; the trophi are modified according to feeding habits of the different species. 'Lorica', yet another salient feature of this group, is formed by thickening of cuticle around the trunk region of their bodies. Depending on the presence or nature of lorica, these organisms are classified as 'loricate', 'semi-loricate', and 'illoricate or bdelloids'

STATUS OF THE TAXON

Global and Indian Status

Rotifera have attracted worldwide attention of naturalists and specialists ever since the invention of the microscope because of their widespread distribution and intricate structure. As a result, these micro-invertebrates

have been documented and described from distant parts of the globe and from localities ranging from the Arctic to Antarctic regions as well as transgressing the continents.

Phylum Rotifera includes about 2500 species spread over 200 genera. Of these, 241 species belonging to 21 eurotatorian families and 48 genera were recorded by Sharma and Michael (1980) in 'Synopsis of taxonomic studies on Indian Rotifera'. Sudzuki (1989) compiled a list of 575 taxa from the Oriental region which included 250 species from this country. A state of the art report by Sharma (1991), however, incorporated 310 species belonging to 24 families and 60 genera while Sharma (1996) referred to 316 species spread over 24 families and 62 genera. The documented overall biodiversity has not significantly increased since then and 330 species (excluding some doubtful taxa) belonging to 25 families and 63 genera are known to occur presently (Sharma, 1997) in India. The rotifer species known from this country, however, comprise about 14.8% of the global Rotifera. A conservative estimate (Sharma, 1997), however, indicates occurrence of over 500 species of Rotifera in this country.

GEOGRAPHICAL DISTRIBUTION IN INDIA

About 95% of the rotifer species occur in freshwater which is considered as their original habitat; less than 5% species are reported from continental oceanic environs while they do not occur in open sea. The rotifers colonize littoral, limnetic and benthic regions of inland waters and occur in practically all kinds of ecosystems ranging from small tree-holes or ephemeral pools to large lacustrine and riverine systems as well as pristine subterranean groundwaters. In addition, they are found in manure-pits, psammon, wet bryophytes and lichens as well as in aqualine of the pitcher plants.

Rotifera, as a group, are known for their cosmopolitan distribution yet certain taxa exhibit distinct distributional ranges and, hence, merit significant biogeographical interest. This generalization also holds true for Indian Rotifera which are so far noticed to occur in diverse geographical regions of this country (Sharma, 1996, 1997). At the same time, a number of genera and species are observed to register restricted distribution. This fact is apparently well supported by restricted occurrence of predominantly 'temperate' genera namely *Notholca*, *Cephalodella* and *Synchaeta*. Various species of the former genus are known to be primarily restricted to the Kashmir Himalayas, the report of *N. labis* in the river Yamuna near Delhi (Sharma, 1988) is, however, attributed to its drift from higher altitudes. On the contrary, the report of six species of this genus from the river Betwa, Madhya Pradesh (Central India)

needs confirmation. The limited information so far available relating to occurrence of species of the other two genera in the Indian waters also reflects their affinity for northern temperate environs. *Kellicottia*, another distinct temperate element, has interestingly not yet been reported from India. The stated geographical considerations are further augmented by greater species richness of two important 'tropic-centred' genera i.e., *Lecane* and *Brachionus* particularly in its tropical waters as well as their relative paucity in the rotifer communities from northern latitudes. Besides these salient distributional features, the rotifer fauna of this country exhibits fewer species of 'temperate-centred' brachionid genus *Keratella*.

Indian Rotifera includes several biogeographically important elements which exhibit both global as well as local or regional distributional interest. Among these, *Brachionus dichotomus reductus*, *Lecane batillifer* and *Testudinella greeni* are interesting additions to the fauna of this country; the stated taxa represent Australasian elements which are so documented exclusively from North-Eastern India. In addition, *Keratella edmondsoni*, *Brachionus donneri*, *Lecane acanthinula*, *L. bifastigata*, *L. blachei*, *L. nodosa*, *L. bulla* f. *diabolica*, *Trichocerca flagellata* and *Habrotrocha melicetra* are typical Oriental elements. Various Holarctic species reported from India include *Euchlanis alata*, *Dicranophorus lutkeni*, *Lecane elongata*, *L. lauterborni*, *L. levistyla*, *L. tryphema*, *L. galeata*, *Notommata saccigera*, *Pleosoma hudsoni*, *Polyarthra euryptera* and *P. longiremis*. Besides, a number of cold-water species particularly belonging to the genus *Cephalodella*, *Notholca* and *Synchaeta* are examined from this country.

A number of taxa of local or regional distributional importance are noticed in the rotifer fauna of India and these include *Brachionus dimidiatus*, *B. leydigi*, *B. mirabilis*, *B. pterodinoides*, *Keratella edmondsoni*, *K. lenzi*, *K. javana*, *K. ticinensis*, *Platytias leloupi*, *Crytonia tuba*, *Euchlanis brahmae*, *E. alata*, *E. deflexa*, *Pseudoeuchlanis longipedis*, *Tripleuchlanis plicata*, *Mytilina acanthophora*, *M. bisulcata*, *Wolga spinifera*, *Colurella adriatica*, *C. sulcata*, *Lepadella aspida*, *L. costatoides*, *L. dactyliseta*, *L. kostei*, *L. longiseta*, *L. minuta*, *L. triba*, *Lecane acronycha*, *L. bifastigata*, *L. braumi*, *L. althausi*, *L. haliclysta*, *L. ligona*, *L. nodosa*, *L. rutterni*, *L. simonmeac*, *L. sola*, *L. blachei*, *L. syngenus*, *L. acanthinula*, *L. bifurca*, *L. furcata*, *Cephalodella gigantea*, *C. intuta*, *C. hiulca*, *Eosphora anthadis*, *Taphrocampa selemura*, *Trichocerca brazieliensis*, *T. chattoni*, *T. jenningsi*, *T. kostri*, *T. tropis*, *Dicranophorus dolerus*, *D. lutkeni*, *D. tegillus*, *Sinantherina spinosa*, *S. semibullata*, *Hexarthra bulgarica*, *Filinia camascela*, *F. cornuta*, *F. saltator*, *F. pejleri*, *Testudinella brevicaudata*, *T. tridentata*, *Pompholyx complanta*, *Cupelopagis vorax*, *Adineta valga*, *Habrotrocha angusticulis*, *H. aspersa*, *H. constricta*, *H. lata*, *H. leitgebii*, *H. perforata*, *Philodina indica*, *Embata laticeps*, *Macrotrachela bullata*, *M. formosa*, *M. habita*, *M. musculosa*, *M. papillosa*, *Rotaria mento* and *R. sordida*.

Interestingly, a number of species described earlier from India now exhibit extended distributional ranges. Dhanapathi (1974) described an interesting brachionid rotifer i.e., *Brachionus durgae* from Andhra Pradesh; this species is presently reported to depict Cosmo (sub) tropical distribution (Segers *et al.*, 1994). In addition, *B. donneri* and *Keratella edmondsoni* were described by Brehm (1951) and Ahistrom (1943) respectively from Tamil Nadu in Southern India. These two species are considered (Sanoamuang *et al.*, 1995) to be Oriental elements. *Lecane lateralis* is yet another example of distributional interest; this lecanid was described from West Bengal (Sharma, 1978), later on reported from Orissa, was believed to be an Indian endemic. It, however, is now known to be a palaeotropical element (Segers, 1996). On the other hand, the rare *L. sola*, described from Tamil Nadu (Hauer, 1936) exhibits pantropical distribution (Segers *loc. cit.*); besides type locality' in South India, it is recently reported from Tripura State, in North-Eastern region (Sharma and Sharma, 1997) and, hence, its distributional range is considerably extended in this country. Further, *Trichocerca tropis*, described from Tamil Nadu (Hauer, 1937a), is a cosmotropical species (Segers *et al.*, 1993). *Horaella brehmi*, an interesting illoricate rotifer described from Bihar (Donner, 1949), exhibits pantropical distribution (Sharma, 1991). Moreover, Segers *et al.* (1993) examined certain neotropical specimens identical with *Lepadella bicornis* which was, in turn described earlier by Vasisht and Battish (1971) from North India.

Qualitative diversity of Rotifera in different States of India (Fig. 1) reflects a distinct uneven picture of their species richness. Apparently, the rotifer fauna of West Bengal (148 species) is fairly well documented and is followed by the report of 110 species from Meghalaya (Sharma and Sharma, 1997) as well as an equal number of species from the State of Tripura (Sharma, unpublished). Ironically, information about distribution of the rotifers in mentioned States is also yet far from complete because of inadequate analysis of taxa particularly of the littoral, benthic and bdelloid communities. The number of species known from different States, in fact, provides a misleading information about their overall rotifer diversity, the reality, however, is otherwise as the presently available information is based on contestedly insufficient collections and do not include representatives of various communities. On the contrary, the reports of 90 and 82 species by Edmondson and Hutchinson (1934) and Wulfert (1996) respectively and based on analysis of limited but heterogeneous samples obtained from diverse aquatic biotopes also supports the stated remarks. The above generalizations focus emphasis

on exsistensive state-wise/regional faunistic surveys involving collections from various habitats/ecosystems and following suitable sampling techniques. Due attention is also required on the examination of more material from already studied regions to provide an exhaustive information on the distribution of Rotifera and to explain latitudinal and longitudinal distribution patterns of various taxa (if any).

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The members of sub-class Monogononta (300 species) comprise the significant fraction (90.9%) of the Indian Rotifera and are spread over 56 genera. On the other hand, only 30 species of the digononts, belonging to seven genera, are represented in this country. The former are dominated by the Ploimida (255 species, 77.3%) while order Gnesiotrocha constitutes a relatively smaller fraction (45 species, 13.6%) of the documented species. The observed pattern of species richness of the stated two orders is in conformity with general composition of the Oriental fauna (*vide* Sudzuki, 1989) and indicates paucity of information relating to the bdelloids in particular. Family-wise break up of the rotifer fauna of India (Table – 1) depicts qualitative importance, in the stated sequence, of Lecanidae > Brachionidae > Colurellidae>Notommatidae>Trichocercidae; these families comprise a notable fraction of overall species richness (193 species, 58.5%). In addition, three other monogonont families namely Euchlanidae, Floscularidae and Testudinellidae form a valuable component (37 species, 11.2%).

Table - 1
Composition of Indian Rotifera (after Sharma, 1997)

Families	Number of Species	Number of Genera
Order : Ploimida		
Family : Epiphanidae	7	4
Family : Brachionidae	39	6
Family : Euchlanidae	13	5
Family : Mytilinidae	7	2
Family : Trichotridae	6	3
Family : Colurellidae	29	3
Family : Lecanidae	74	1

Contd.

Table - 1. (Contd.)

Families	Number of Species	Number of Genera
Family : Proalidae	2	1
Family : Notommatidae	28	7
Family : Gastropodidae	4	2
Family : Trichocercidae	23	1
Family : Asplanchnidae	7	2
Family : Synchaetidae	9	3
Family : Dicranophoridae	7	2
Order : Gnesiotrocha		
Family : Floscularidae	14	5
Family : Conochilidae	4	1
Family : Hexathridae	4	1
Family : Filiniidae	7	1
Family : Testudinellidae	10	2
Family : Trochosphaeridae	1	1
Family : Collothecidae	4	1
Family : Atrochidae	1	1
Order : Bdelloidea		
Family : Adinetidae	1	1
Family : Philoidinidae	22	5
Family : Habrotrochidae	7	1
Total	330	63

The rotifer taxocoenosis of India depicts broadly a tropical character as characterized by abundance of 'tropic-centred' genera namely *Lecane* and *Brachionus* species. Such a generalization is applicable to the rotifer communities from different parts of this country in general except those from its northern latitudes. The indicated nature is also supported by fewer species (10 species) of 'temperate-centred' brachionid genus *Keratella* and restricted occurrence of other 'cold-water' genera namely *Cephalodella*, *Notholca* and *Synchaeta*. As mentioned earlier, various *Notholca* spp. reported so far from India are primarily restricted to the Kashmir Himalayas.

Cosmopolitan elements comprise a significant component (about 52%) of the Indian Rotifera. In addition, tropical and pantropical species are well represented (about 20%) in the rotifer communities examined from this country. The documented taxocoenosis includes three Australasian elements and several Oriental, Holarctic and Palaetropical species while a number of species described from India are now reported from elsewhere and, hence, assume global distributional importance. Such examples have been discussed separately in this account under the section of 'geographical distribution'

The rotifer biodiversity registers interesting variations in hard-alkaline waters in different parts of tropical India as well as in soft and acidic to slightly alkaline aquatic biotopes particularly in its North-Eastern region. Planktonic Rotifera from the former are characterized by abundance of alkalophilic *Brachionus* species and *Keratella tropica*. On the contrary, the latter are marked by common occurrence of *Keratella cochlearis* and certain eurytopic brachionids such as *Brachionus angularis* and *B. calyciflorus* while *Keratella lenzi*, *B. forficula*, *B. falcatus* and *B. donneri* are frequently noticed in limnetic communities. The relative paucity of *Brachionus* spp. in the second category of waters is attributed their acidic nature; this important feature is in conformity with the observations by Fernando and Zankai (1981), Sanoamuang *et al.* (1995) and Segers (1996). Further, a number of typical acidophilic elements so far reported from India are represented by *Brachionus mirabilis*, *Platyonus patulus macracanthus*, *Euchlanis triquetra*, *Mytilina bisulcata*, *Colurella sulcata*, *Lepadella cristata*, *L. nartiangensis*, *L. dactyliseta*, *Lecane doryssa*, *L. jaintiaensis*, *L. haliclysta*, *L. pertica*, *L. inermis* and *L. scutata*.

The limited nature of investigations from India does not provide adequate information about the biological diversity of Rotifera in different ecosystems. Referring to the lentic biotopes with aquatic macrophytes, fairly extensive observations by the author from West Bengal indicated total 72 species and those from Meghalaya reflected overall qualitative diversity ranging between 58-64 species while Sharma and Dudani (1992) documented 53 species from five such ponds from Bihar. Further, Sharma and Sharma (1997) indicated upto 50-55 species from ephemeral paddy-field ecosystems of Meghalaya with maximum of 28-33 species/sample in contrast to upto 18-22 species/sample recorded earlier from the state of West Bengal. Planktonic rotifer communities, however, depicted maximum 18-22 species/ ecosystem in Meghalaya and 28-33 species/ecosystem in West Bengal while Michael (1968) reported a total of 30 rotifer species from a fishpond in the latter state.

The flood-plain lakes, interesting ecotones with considerable variations in micro-ecological conditions, serve as unique habitats for colonization of diversified aquatic communities in general and the rotifers in particular.

However, species richness of this phylum in the stated biotopes is yet very poorly documented in India and the published literature reflects very poor diversity i.e., maximum upto 40 species because of the study of inadequate collections. The samples examined by this author (Sharma, unpublished) from certain flood-plains of the Upper Assam region of the Brahmaputra basin have revealed about 90 species as well as occurrence of upto 54 species/samples outlined the significance of the hypothesis proposed by Segers *et al.* (1993b) for (sub) tropical flood-plains and an urgent more data on their rotifer diversity in India.

Among other lentic habitats, the limited studies undertaken in pristine waters of the domestic wells has so far revealed only 16 species of monogonont rotifers. In addition, preliminary observations in insular freshwater from the greater Andamans (Sharma, unpublished) indicated only 45 species. More collections from the stated biotopes need to be examined to assess qualitative diversity of Rotifera.

The rotifer communities of the riverine ecosystems of India appear to be less diverse since a majority of workers reported upto 20 species while Adholia (1979) examined 33 species from the river Betwa (Madhya Pradesh) and Sampath *et al.* (1979) observed 35 species in the river Kaveri. On the other hand, the recent study by Sharma and Naik (1996) dealt with distinctly higher species richness (72 species) from the river Narmada in Central India, thereby, indicating the importance of proper sampling from lotic waters.

Referring to two 'global hot-spots' of biodiversity significance, the studies initiated by this author from certain states of North-Eastern India provide useful information while the rotifer communities from Western ghats are still poorly documented. In all 132 species belonging to 32 genera and 19 families are so far reported from the former region. These, in turn represent 40.6% and 50.8% of total species and genera known from this country respectively. Needless to mention, the rotifer taxocoenosis of N. E. India requires further updating and as per a conservative estimate over 250 species are expected to be recorded from this region. Further, the rotifer richness examined from this region is broadly comparable with other S. E. Asian countries.

The rotifer fauna of North-Eastern India is characterized by more qualitative diversity of *Lecane* and relative paucity of *Brachionus* spp.— a feature well in conformity acidic nature waters and fewer permanent lentic biotopes as also suggested earlier by Fernando and Zankai (1981), Sanoamuang *et al.* (1995) and Segers (1996). The former aspect is supported by occurrence of various acidophilic elements namely *Brachionus mirabilis*, *Plationus patulus macracanthus*, *Euchlanis triquetra*, *Mytilina bisulcata*, *Colurella sulcata*, *Lepadella cristata*, *L. nartiangensis*, *L. dactyliseta*, *Lecane doryssa*, *L.*

jaintiaensis, *L. haliclysta*, *L. pertica*, *L. intermis*, *L. scuata* and *Testudinella emarginula*. Interestingly, three Australasian elements i.e., *Brachionus dichotomus reductus*, *Lecane batillifer* and *Testudinella greeni* ascertain a close relation of the rotifer fauna of N. E. India with southeast Asia and Australia. Besides, the holarctic *Lecane levistyla*, reported recently (Sharma and Sharma, 1997) from Tripura State of this region comprises the first record of this rare lecanid outside the northern Hemisphere.

ENDEMICITY

The rotifer fauna of India includes only 23 endemic species which, in turn, represent nearly 7.0% of the documented species; these mainly belong to *Lecane* (9 spp.) and *Lepadella* (4 spp.) and therefore, support the remarks of Dumont (1983) on the presence of unusual endemics of the stated genera in southeast Asian faunas. On the other hand, the absence of Indian endemic species in the family the Brachionidae is believed to be secondary (Dumont, *loc. cit.*) and this aspect is attributed to the loss of characteristic taxa after the Indian plate hit Asia and invasion of the Oriental faunal elements to the near East especially during the Pleistocene. In addition, the Indian Rotifera includes two monotypic endemic genera namely *Pseudoeuchlanis* and *Pseudoembata*; of these, the taxonomic status of the former warrants confirmation (refer : Segers, 1996). These general remarks are not an index of paucity of the endemics in this country. However, the fact is that future investigations on the littoral rotifers are expected to consolidate the list of endemic species since these communities, in particular, are known to include interesting endemic elements (Segers, *loc. cit.*).

INTRODUCED AND THREATENED SPECIES

The classical instances of individual introduced species refer to extension of distributional ranges of *Kellicottia bostomiensis* in Scandinavia, *Keratella tropica* in Holland, Belgium, France and Spain, *Brachionus variabilis* in Belgium and *B. falcatus* in South-western France. However, in all cases human participation in introducing resting eggs along with import of fish, water plants, etc. is anticipated. No attempt has so far been made to evaluate the rotifer species of this category in the faunas of the Oriental region as well in Indian Rotifera. Apparently, occurrence of several Arctic-temperate, Neotropical, Australasian and Holarctic elements in this country presents ample proof of introduced elements. Hence, it will be worthwhile to focuss special attention on this aspect in future investigations. However, no information is yet available relating to 'threatened species' of Rotifera in India or elsewhere in the world.

VALUE

Rotifera invariably comprise an important qualitative and quantitative component of freshwater microinvertebrate biocoenosis in general and limnetic as well as littoral zooplankton communities in particular. Various taxa of this phylum exhibit interesting latitudinal distributional patterns and, hence, serve as valuable material for biographical considerations. They represent an integral link in aquatic food-chain and also themselves comprise an important component of food-spectrum of fry, fingerlings and even adults of various commercially cultivable freshwater fish species. In addition, their importance as supplementary food in various aquaculture practices is undisputed. The rotifers contribute significantly to overall biological productivity in freshwaters because of their rapid turn-over rates and metabolism and also due to the fact that many species of this group feed on detritus and bacteria and are, therefore, consequently to a great extent independent of autotrophic production.

Various rotifer taxa serve as useful bioindicators of water quality of their environments within the limits of limnosaprobity, this fact has been ascertained by the reports from different parts of the world. Even the ratio between *Brachionus* : *Trichocerca* species (Sladeczek, 1983) is regarded as an important index to depict trophic status of different ecosystems or of individual plankton collections. Their ability to colonize diversified aquatic and semi-aquatic biotopes and an inherent quality to build up substantial densities within short time-intervals makes them ideal objects for ecological considerations as well as valuable tools for population dynamics studies. Further, the soil-rotifers play an active role in promoting the soil fertility. The members of this phylum are being increasingly used in ecotoxicological studies and environmental bioassay experiments. The latest biotechnological advances dealing with mass rearing of fast-growing strains of selected species of these organisms merit special interest. Above all, there is yet no evidence that the Rotifera are injurious to any animal or plant that is of importance to human beings.

THREATS

The species composition and abundance of the rotifers is intricately influenced by ecological changes/perturbations in their environments. The phenomena of cultural eutrophication, acidification, siltation, vertebrate (fish) predation, habitat destruction due to removal of aquatic macrophytes for fisheries development and influx of the different pollutants exercise drastic impact on their community structure and may threaten the survival of

Rotifera. In addition, ecological changes associated with ontogeny of aquatic environs influence and change the structure and production of the rotifera communities.

FUTURE STUDIES

Systematic studies on the rotifer taxocoenosis of Asia in general and the Indian subcontinent in particular are still in initial stage. Hence, updating of the rotifer fauna of this country as well as providing detailed species inventories from different regions/States of India holds the main scope for future studies. All such endeavours, however, must be supported with SEM observations on various morphological attributes as well as detailed structure of trophi of various taxa which undoubtedly serve as important diagnostic features. Illustrated taxonomic keys to the regional rotifer faunas or to the fauna of India are highly desired to resolve the existing nomenclatural discrepancies and to ensure correct identification of taxa in limnological investigations. Detailed statistical analysis of morphometric variations of different population of various species shall go a long way to explain questions related to morphospecies and to resolve aspects of vicariance. Further, more observations on ecotypic and cyclomorphic variations are required in the Indian taxa.

Ironically, a number of rotifer workers in this country have invariably resorted to descriptions of new species without allocation of type-specimens or even without making any reference to such material in their original publications. Hence, proper allocation of type-specimens must be ensured. A national depository of rotifer collections from different parts of India is desired to serve as ready reference for future workers.

Besides general taxonomic considerations, it is necessary to analyze and compare qualitative diversity of rotifers in the varied aquatic biotopes in general and to provide comprehensive information on littoral, benthic, sessile, semi-sessile, colonial and bdelloids in particular. It will be interesting to examine the rotifer species associations in different habitats with reference to the basic parameters of water quality as well as those with different kinds of aquatic macrophytes. Adequate attention is to be focussed on the composition and biological diversity of Rotifera in different lentic and lotic ecosystems with special reference to their community structure in unconventional biotopes such as the flood-plain lakes or beels, wetlands, rice-fields, ephemeral water bodies, riverine systems and pristine groundwaters. The

rotifer *taxocoensis* of insular freshwaters of the Andaman and Nicobar Islands and the Lakshadweep archipelago holds interest for future workers. All the above stated aspects will certainly remain meaningless without analysis of latitudinal and longitudinal distributional patterns. In addition, it is necessary to undertake faunistic surveys in estuarine ecosystems of this country.

The future in-depth synecological studies based particularly on short sampling intervals and detailed analysis of the rotifer communities are desired from tropical, sub-tropical, and temperate freshwater environs of India to acquire meaningful data. The impact of abiotic and biotic parameters on abundance and ecology of this group should be analyzed with support of appropriate statistical tools. Attention is also to be focussed on long-term temporal changes in the rotifers and on horizontal and vertical distributional patterns of various taxa. Influence of invertebrate and vertebrate (fish) predation on the community structure and production of organisms needs to be assessed.

The laboratory and field observations on embryonic durations, turn-over rates, cohort production, instantaneous birth, death and growth rates as well as on other population parameters at least of selected dominant species are much desired to examine their role in zooplankton dynamics and biological productivity in freshwaters. Estimation of biomass of the rotifer communities in the different ecosystems is yet another important aspect which merits attention in the future investigations. Besides, detailed autecological studies on the selected species are desired to supplement initial observations undertaken so far in India. Evaluation of regional target species of the Rotifera as well as attempts at the mass rearing are to be taken up to supply much needed supplementary food for inland pisciculture practices.

Evaluation of regional bioindicator rotifer species deserve attention of the Indian workers. Application of Sladeczek's quotient based on *Brachionus* : *Trichocerca* species ratios should be extended the rotifer communities of different water bodies to assess and compare their trophic status. The limited earlier observations from India have indicated special features of the rotifer species in typical alkaline as well as acidic waters. Further observations are desired to affirm acidophilic and alkalophilic affinity of various species or to supplement related data. Certain Indian taxa namely *Brachionus dimidiatus*, *B. dichotomus reductus*, *B. donneri*, *B. durgae*, *Keratella javana*, *K. lenzi*, *Pseudoeuchlanis longipedis* *Asplanchnopus bimaberaensis* and *Horaella brehmi* have been included earlier under category of those preferring special waters (status yet not determined). Hence, special attention need to be focussed on the stated rotifers to examine their specific ecological requirements.

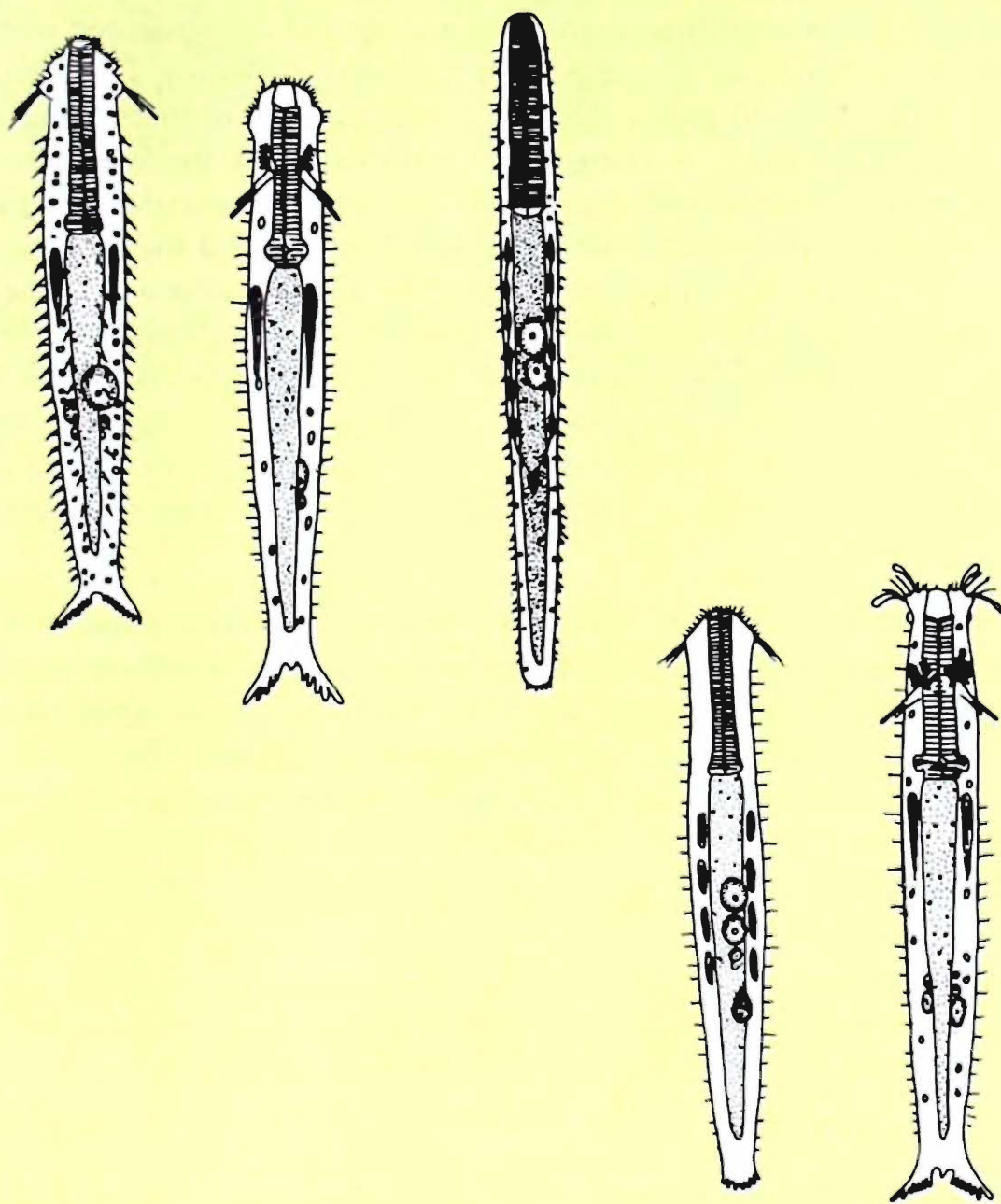
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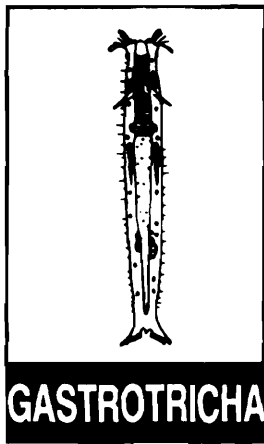
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Faunal Diversity in India : Gastrotricha

G. C. RAO

Zoological Survey of India, Port Blair - 744 101





INTRODUCTION

The Gastrotricha constitutes a group of minute and unsegmented worms which swim or crawl with the help of their ciliated epidermis. Their length is quite variable from 0.1 mm to 3.0 mm, with a majority of them being less than 1.0 mm. The body is elongated, strap-shaped or fusiform. Dorsal surface of the worm is generally covered with a variety of cuticular structures as bristles, scales, spines, adhesive tubes, etc., to withstand the mechanical effects of abrasion in the turbulent habitat. The ventral surface is flattened and covered with patches of locomotory cilia for a smooth gliding over solid substrata. The cuticle is thin, flexible and transparent. Adhesive tubes are quite characteristic of this group of animals. These tubes are supplied with cement glands and are used for adhesion to sand grains or vegetation. Gastrotrichs are mostly hermaphrodites, having both male and female reproductive organs.

All the gastrotrichs are free-living and harmless. They occur in all marine, brackish and freshwater habitats. Marine gastrotrichs are mostly interstitial animals living in spaces between particles of sandy sediments. They largely feed on fine detritus, bacteria and diatoms of the sedimental. Their greatest density and diversity are limited to intertidal and subtidal parts of the sea. They are known to inhabit from top to 1 m depth below surface. Quantitatively, their densities are known to range from 50 to 1500 individuals per 10 cm² of the sediment.

STATUS OF THE TAXON

Global and Indian Status

The Gastrotricha constitutes one of the most interesting groups of meiobenthic invertebrates on this earth. They occur in all freshwater and marine habitats in considerable abundance. Being quite sensitive to ecological stress in the habitat, they are practically eliminated in polluted aquatic

ecosystems. However, the Gastrotricha still remains one of the most neglected groups of the animal kingdom, our present knowledge of the phylum being limited mostly to the work carried out on European, American and Indian coasts. The number of gastrotrich species at the global level is estimated to vary between 2000 and 3000, with many areas remaining largely unexplored or underexplored for this fauna. The phylum is represented by two major orders, 13 families and 50 genera. Hitherto, the 13 genera *Acanthodasys*, *Dinodasys*, *Polymerurus*, *Xenodasys*, *Desmodasys*, *Pseudoturbanella*, *Marinellina*, *Musellifer*, *Chlorodasys*, *Planodasys*, *Megadasys*, *Thiodasys* and *Draculiciteria* remained monotypic in this phylum, each representing a single species. Within the Indian region, about 100 species have been recorded pertaining to 2 orders, 9 families and 21 genera. The taxonomic composition and abundance of the gastrotrich genera and species occurring in this region are more or less in agreement with those known from other parts of the world.

DISTRIBUTION

The gastrotrichs are well represented in all the natural aquatic ecosystems in and around India. Extensive habitats with unpolluted conditions, however, favoured the colonization and evolution of a variety of species and sub-species of the group. Hitherto, only limited areas of this region were explored for the fauna, studied and the taxonomic results reported. These areas include some scattered freshwater bodies on land and littoral sediments along the east and west coasts, including Lakshadweep and the Andaman and Nicobar Islands. Faunistic surveys conducted in recent years at several areas on the Indian coast, however, indicated a remarkable decline of this fauna both in their density and diversity. This is largely to be attributed to the increasing effects of human activities, resulting in pollution of the habitats and degradation of the natural environment.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The phylum Gastrotricha is divided into two main orders, the Macrodasyida and the Chaetonotida. The Macrodasyida are exclusively marine and comprise heterogeneous groups of animals with great morphological diversity. The discovery and study of these worms have made a remarkable contribution to systematic zoology during the present century. A large number of interesting genera and species were described as new to science. The longest gastrotrichs are seen in this order with ribbon-shaped bodies highly modified and well-adapted for interstitial life. The posterior part of pharynx is generally associated with openings. The

characteristic feature of macrodasyidans is the presence of numerous adhesive tubes, occurring typically in three groups, i.e., anterior, lateral and posterior. These worms are highly thigmotactic and contractile to suit life in the turbulent coastal marine environment.

The Chaetonotida are marine, brackish and freshwater inhabitants. However, they are more common in living and decaying benthic vegetation, detritus and floating plants. They are very small in size, with fusiform body, anterior head lobe and two posterior caudal furca, each supporting a single adhesive tube. Tufts of long sensory cilia occur on head lobe. Cuticle has a complex ornamentation, often with spined scales. Pharyngeal pores are lacking. Adhesive tubes are limited to 1-2 pairs on tail forks, but these are absent in pelagic species. The locomotory cilia on ventral body surface are transformed into groups of cirri in the aberrant genus *Xenotricula*. The chaetonotids largely reproduce by parthenogenesis.

Hitherto, about 98 species of freshwater and marine gastrotrichs have been recorded in Indian region Table – 1. They belong to 9 families and the following 21 genera :—*Dactylopodola*, *Cephalodasys*, *Mesodasys*, *Paradasys*, *Macrodasys*, *Urodasys*, *Planodasys*, *Crasiella*, *Turbanella*, *Paraturbanella*, *Dinodasys*, *Thaumastoderma*, *Tetranchyroderma*, *Acanthodasys*, *Platydasys*, *Diplodasys*, *Pseudostomella*, *Chaetonotus*, *Aspidophorus*, *Xenotricula* and *Dasydytes*. Any further extensive exploration of marine, brackish and freshwater habitats is quite likely to reveal the existence of more number of genera and species unknown in these areas. However, the composition of the faunal element hitherto recorded from the Indian region is quite similar to the one recorded on other parts of the world.

ENDEMIC AND THREATENED SPECIES

A high percentage of endemism is generally known for the terrestrial fauna in insular ecosystems due to their isolation for long periods, while in the marine environment they are eurytopic in their distribution due to great scope for dispersal. As an exception, the marine meiofauna and particularly the macrodasyid gastrotrichs of the intertidal sediments exhibit a high percentage of endemism due to their peculiar mode of existence in a restricted habitat. A perusal of the data presented in Table 1 shows that out of the 98 species hitherto known, 64 are endemics, exhibiting interesting morphological variation. The endemism at supra-specific level is quite negligible. Out of the 21 known genera, only 1 genus *Planodasys* has been reported as endemic to the Indian region. The endemism in general is far

more greater in the highly thigmotactic Macrodasysida than in the agile Chaetonotida, which are endowed with great power of environmental tolerance, locomotion and dispersal. As a result, many species of the Chaetonotida have been reported as cosmopolitan in their distribution. These geographical ranges are likely to change as more and more area in the Indian Ocean are intensively investigated and some of the presently supposed endemics may join the rank of eurytopics. However, the probable rate of endemism for gastrotrichs in this region appears nearly to be the same as that reported for this fauna from other parts of the world.

Table – 1
The known distribution of Indian Gastrotricha in marine and freshwater ecosystems

Family	No. of species			
	Marine	Freshwater	Total	Endemics
Dactylopodalidae	2	—	2	2
Lepidodasyidae	6	—	6	5
Macrodasysidae	8	—	8	7
Planodasyidae	3	—	3	3
Turbanellidae	14	—	14	12
Thaumastodermatidae	18	—	18	15
Chaetonotidae	14	22	36	14
Xentrichulidae	10	—	10	6
Dasydytidae	—	1	1	—
Total	75	23	98	64

Although the whole phylum is being threatened with increasing effects of habitat destruction and organic pollution in the environment, no qualitative or quantitative data are available on the percentage of decline of any species or varieties of populations in this region. Due to these reasons, it is not possible to categorize any particular taxa of this group as threatened or endangered. There is also no published record of any introduced biodiversity for this group of worms which are not in any way related with the routine activities of the common man.

VALUE

Many of the interstitial marine gastrotrichs are highly modified both in structure and habit to suit the needs of the specialized environment in which they live. Their morphological diversity has contributed largely to augment our knowledge on systematic zoology. They form excellent material for the study of morphological organization, for which reason they are being extensively utilised in laboratories of western countries as types of study for zoology students. These worms are also used in a variety of experimental and interesting ecological investigations related to aquatic biology. As they are quite sensitive to ecological stress, they are being widely employed as indicators of pollution in aquatic ecosystems. Due to their small size, large numbers and short generation times, they are very well-suited for the study of population biology. Thus, the gastrotrichs both in marine and freshwater habitats offer ample scope for carrying out various types of investigations on taxonomy, biology, ecology and distribution.

Further, the gastrotrichs constituting part of meiobenthos in aquatic ecosystems, play an important role in their trophic cycle by forming food for larger animals and by contributing remarkably to the regeneration of nutrients after their death and disintegration. Hence, their mass destruction, no doubt, results not only in great loss of biological diversity, but also upsets the ecological balance in the natural ecosystems. But, hitherto no keystone species as such has been identified in this phylum, playing an important role in the freshwater or marine ecosystem.

THREATS

A large number of sand beaches are being removed on a large scale for commercial and construction purposes. Further, the aquatic ecosystems are getting increasingly polluted in recent decades, destroying these natural habitats and their associated meiofauna, including the gastrotrichs. As the organic pollution generates a lot of ecological stress in the environment affecting these highly sensitive organisms, many of them are getting easily eliminated. As a result, the species composition, population density and spatial distribution of gastrotrichs have been very much affected in the intertidal sediments in the vicinity of all human settlement areas. For these reasons, many of these strange animals are perishing undiscovered, undescribed and unknown. Thus, the sand beaches are becoming increasingly barren for many of these organisms. The effects of pollution are also quite likely to increase in the following years seriously endangering the life of these micro-denizens.

CONSERVATION

Hitherto, no conservation measure as such has been undertaken to protect these microscopic animals from lethal effects of potential pollution in the aquatic ecosystems. It is a sad augury that the fauna discovered in the present century is also being finished in the same century due to the disturbing activities of man. Thus, the present status of gastrotrichs is also one of the saddest chapters in the recent history of animal discoveries. In the circumstances, these tiny creatures are to be protected from pollution and habitat destruction. Unless effective conservation measures are undertaken in time, it would be difficult to preserve this unique group of organisms from indiscriminate destruction and irreparable loss. But whatever conservation measures we now undertake at this stage, matters have already reached such a critical condition at several areas that the rich variety of animal life we inherited in this region can never be the same again.

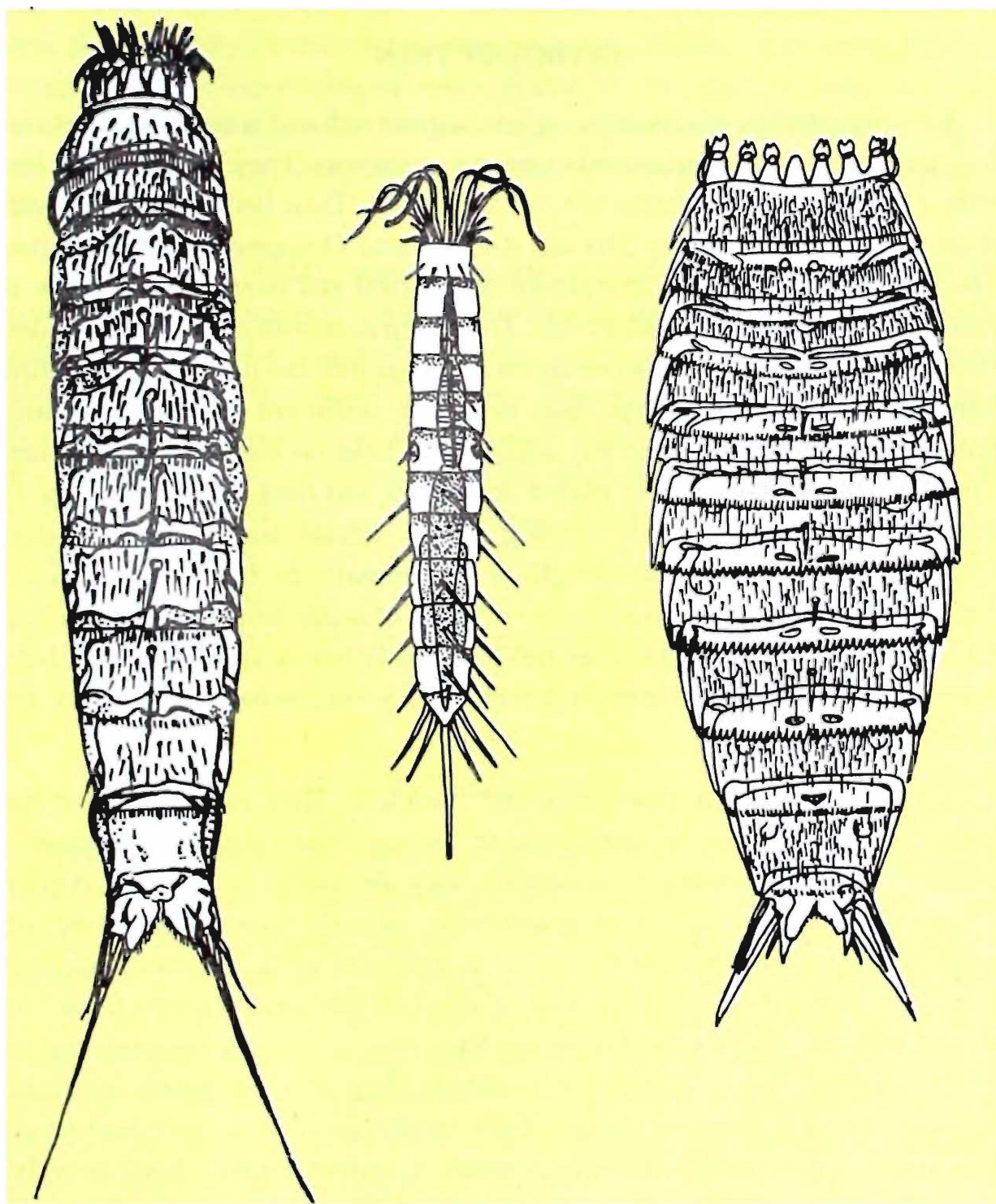
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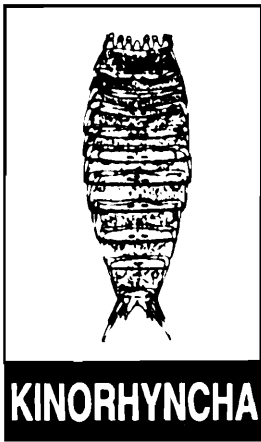
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Faunal Diversity in India : Kinorhyncha

G. C. RAO

Zoological Survey of India, Port Blair-744 101





INTRODUCTION

Kinorhynchs are microscopic, spiny, segmented and worm-like creatures living exclusively in marine and estuarine sediments. They are generally less than 1 mm in length and mostly brown in colour. Their body is covered with thick cuticle, devoid of any cilia and divided into 13 segments called zonites. The head constituting the first zonite is spherical and eversible with several rows of curved spines called scalids. The terminal mouth cone is surrounded by 9 oral styles. The head can easily be retracted into the first few succeeding zonites. The animal moves and feeds in sediment by averting and withdrawing its head, when the scalids gain hold on the solid substratum. The second zonite is largely plated and forms the neck. The remaining 11 zonites comprise the trunk, bearing lateral, dorsal and terminal spines, which sometimes exceed the length of the animal. The trunk segments are often subdivided longitudinally into a series of separate plates. Sand-living kinorhynchs in exposed beaches have lateral adhesive organs, which help them to adhere to substratum and withstand severe wave action. Sexes are separate.

All kinorhynchs are free-living and harmless. They mostly inhabit the upper few millimetres or centimeters of the fine organically rich sediments in shallow coastal waters. Occasionally, they also occur in association with littoral algae and a variety of invertebrate animals. Ecologically they are eurybenthic, occurring from the exposed intertidal upto 5000 m or more in the abyss, euryhaline tolerating a wide range of salt concentration from 7 to 60 ppt and eurythermic withstanding temperature varying between minus 20°C and 40°C. These worms can penetrate deep into the coarse intertidal sediments upto 1 m below surface. They are omnivorous, largely feeding on fine organic detritus and microscopic plant or animal matter. Quantitatively, their densities in marine sediments are known to range from a few individuals to a few hundreds specimens per 10 cm² of the substrate.

STATUS OF THE TAXON

Global and Indian Status

The Kinorhyncha constitutes one of the most fascinating group of the invertebrate animals in marine meiobenthos. This minor phylum has also remained as one of the most neglected group of the animal kingdom. Very few workers are presently engaged in their study. The major difficulty in this research is obviously due to their microscopic size, limited occurrence and the difficulty of their separation from fine muddy sediments. Further, because of their morphological resemblance, kinorhynchs are often mistaken as copepods and missed in the meiofauna collections. As a result, many of the global areas including India, still remain unexplored or underexplored for these worms.

The slow and steady research on the phylum in the past 140 years has resulted in the discovery and description of more than 100 species from different parts of the world. A large number of unreliable descriptions were also made based on juvenile specimens. The phylum is mainly divided into two orders, representing six families and 11 genera. Hitherto, *Semnoderes* is the only monotypic genus known in this phylum and presently confined to the Indian coast. Within the Indian region, the phylum is represented by two orders, 6 families, 6 genera and 10 species. However, the taxonomic composition and abundance of kinorhynch genera and species occurring in this region are more or less in conformity with those known from other parts of the world.

DISTRIBUTION

The kinorhynchs are distributed all along the east and west coasts of India including the Lakshadweep and Andaman and Nicobar Islands. They occur in considerable abundance in all fine muddy sediments, with the exception of the polluted areas. Hitherto, as only limited areas were explored for the fauna on the Indian coast, good scope exists for their survey and study, leading to the discovery of more number of genera and species from this region. However, their population density, diversity and distribution at present have been seriously affected at all the areas having the influence of organic pollution in the habitat.

Table – 1

Kinorhyncha described and recorded on Indian Coasts

Species	Location	Distribution
<i>Echinoderes bengalensis</i> (Timm)	Bay of Bengal	Endemic
<i>Echinoderes ehlersi</i> Zelinka	Indian Ocean	Endemic
<i>Echinoderes andamanensis</i> Higgins & Rao	Andaman Island	Endemic
<i>Echinoderes</i> sp.	Lakshadweep	Uncertain
<i>Condyloderes paradoxus</i> Higgins	Bay of Bengal	Endemic
<i>Sphenoderes indicus</i> Higgins	Bay of Bengal, Arabian Sea	Endemic
<i>Cateria styx</i> Gerlach	Atlantic and Indian Oceans	Eurytopic
<i>Cateria gerlachi</i> Higgins	Bay of Bengal, Arabian Sea	Endemic
<i>Neocentrophyes satyai</i> Higgins	Bay of Bengal	Endemic
<i>Pycnophyes</i> sp.	Andaman Islands	Uncertain

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The phylum Kinorhyncha is divided into two main orders, the Cyclorhagida and the Homalorhagida, based on the number of neck plates. Within the Indian region, the Cyclorhagida is represented by 4 families, 4 genera and 8 species, while the Homalorhagida has 2 families, 2 genera and 2 species (Table 1). The structure of oral styles and eye spots, number and disposition of body plates, spines, adhesive tubes, etc., vary considerably in different taxa, showing great morphological variation. The aberrant genus *Cateria* is represented by two species on the Indian coast, which is a unique feature for this region. As elsewhere, the genus *Echinoderes* supports the largest number of four species. However, the known taxonomic composition of the other genera and species conforms with the pattern known from other parts of the world.

ENDEMIC AND THREATENED SPECIES

Data presented in Table 1 show that out of the 10 species of Kinorhyncha described or recorded from Indian region, 7 are endemics, 1 is eurytopic and the remaining 2 are of uncertain position. Thus, a high percentage of endemism occurs in this group at the specific level probably due to their

peculiar mode of existence in soft sediments. But, the endemism at supra-specific level is found to be nil as all the genera are also known from other parts of the world.

Kinorhynchs are known to be quite susceptible to ecological stress in the environment, resulting from adverse effects of organic pollution which largely affects their population density and diversity in the littoral sediments. Although, the pollution of sea on our coasts is on the increase, in the absence of any detailed investigation or data on the group in this region, it is not possible at present to consider any of the existing taxa as threatened or endangered. There is also no report of any introduced biodiversity for this group of animals.

VALUE

These animals are of no ethical, social and economic values to man. Scientifically, the kinorhynchs are of much academic interest as they present great morphological diversity for study. As these worms are also quite sensitive to ecological stress, they could profitably be employed as indicators of pollution in marine and estuarine ecosystems. Like other groups of meiofauna, kinorhynchs also play an important role in the food web of the coastal ecosystem by forming food for larger animals and in regenerating nutrients after their death and decay. However, hitherto no keystone species as such was identified in this phylum, playing a dominant or significant role in the freshwater or marine ecosystem. Further, as nature has taken millions of years to evolve these strange creatures on earth, it would be the basic responsibility of humanity to conserve these rare species of animals for the future.

THREATS

Threats to this group mainly arise from the adverse effects of organic pollution in our coastal aquatic ecosystems, endangering the life of these sensitive organisms. But, in the absence of any detailed investigation or adequate data on their occurrence, it is not possible at the present to assess the damage being done to these creatures due to pollution. However, the heaviest polluted areas on our coasts can safely be considered as the regions of maximum destruction of these worms.

CONSERVATION AND FUTURE STUDIES

Hitherto, no conservation measures are either contemplated or undertaken to protect these microscopic animals from the adverse effects of potential pollution in the habitat. In the circumstances, it is necessary to maintain our coastal ecosystems clean and free from the pollution to conserve these animals for the future. Further, as no detailed investigation has been made on the biology, ecology, distribution and population dynamics of kinorhynchs anywhere in the world. The phylum offers ample scope for researchers in this field.

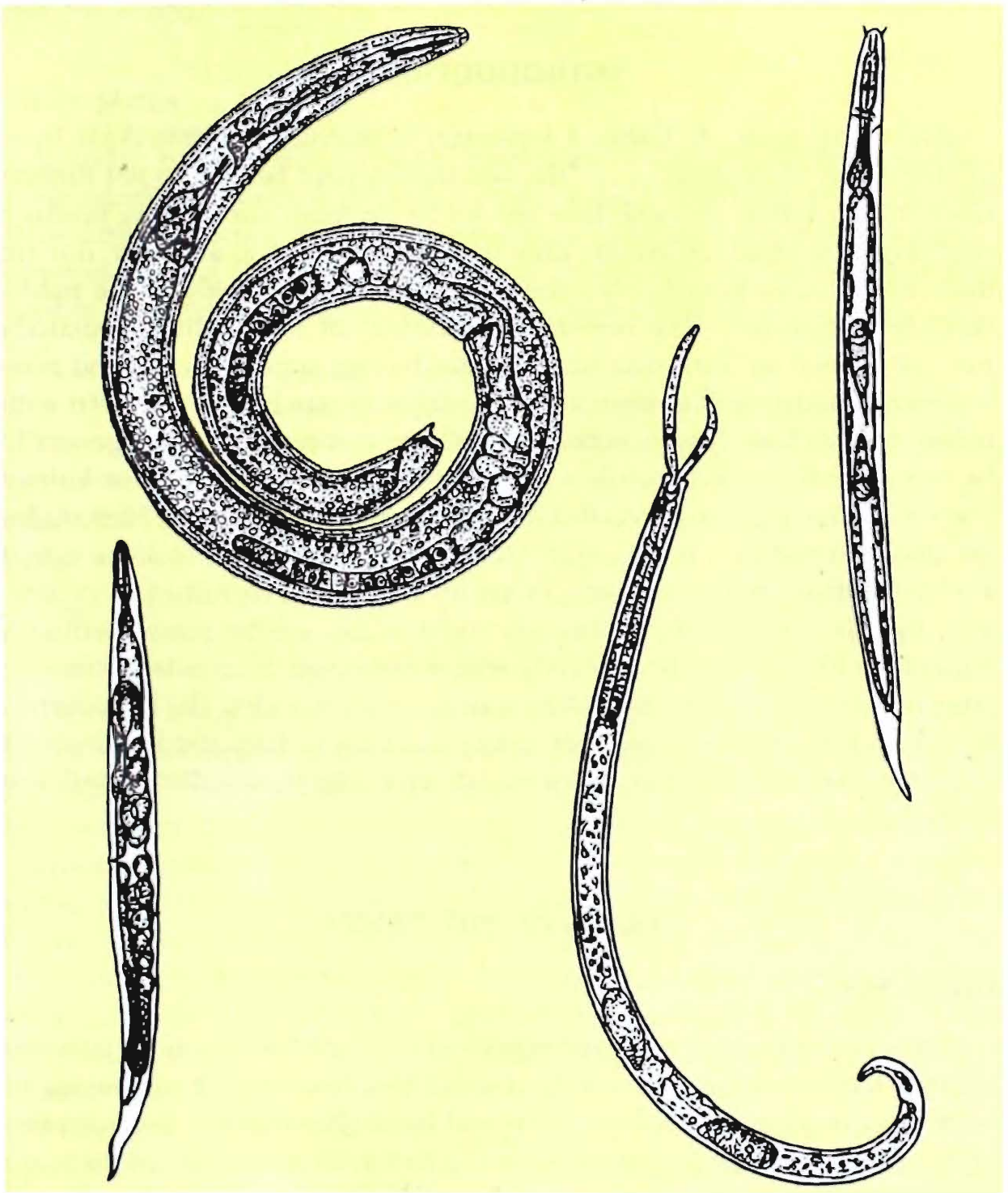
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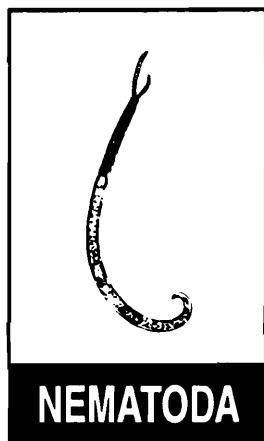
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Faunal Diversity in India : Nematoda

QAISER H. BAQRI

Zoological Survey of India, Desert Regional Station, Jodhpur





INTRODUCTION

According to N. A. Cobb, a legendary nematologist (1890-1933) from United States of America, ... "the nematodes, poor beasts, do not furnish hides, horns, tallow or wool; they are not fit for food, nor do they produce anything fit for food; neither do they sing nor amuse us in any way; nor are they ornamental—in fact, when they are displayed in museums the public votes them hideous" The nematodes, members of the phylum Nematoda may be defined as worm-like invertebrates having appendageless and non-segmented body. Most of them are microscopic in size but may be seen with naked eyes as their length varies from 82 μm to over 8 m. They generally have a cylindrical body while a few may be fusiform, saccate or kidney shaped. Hence, they are also called roundworms or threadworms. Nematodes are characterised by a body cavity, complete digestive tract, to some extent a well-developed nervous system, excretory system and reproductive system. The digestive tract or the alimentary canal is like a tube placed within a larger tube (the body wall). The body wall is composed of an outer protective layer of cuticle underlying hypodermis and somatic muscles. The hypodermis is thin and expands into the body cavity (coelom) to form the longitudinal chords between the somatic muscles, i.e., two lateral, one dorsal and one ventral chord.

STATUS OF THE TAXON

Global Status

The nematodes are found everywhere on this earth, even in uninhabitable habitats like hot spring, ice and deep ocean trenches. A good percentage of them are the parasites of agricultural and horticultural crops, invertebrates and vertebrates (from insects to elephant). However, a majority of them are free living either in the soil or marine, brackish or freshwater while some are predaceous. According to some estimates, if all the species having such a wide range of habitats and feeding habits are explored, then about half a

million nematode species can be recorded on this earth. For the vertebrate parasites alone, N. A. Cobb has calculated ... "if every species of vertebrates is infested with two species of nematodes then 50,000 known species of vertebrates should harbour about 100,000 nematode species" In addition, there are nematode parasites of plants and invertebrates, free-living nematodes in soil and water. According to Poinar (1983), about 0.1-1.0 million marine nematodes may be found per sq. m. Anyhow out of this huge expected number of species, only about 30,000 species are known till date from all over the world.

Indian Status

In India, considerable work has been done on the identification of free-living nematodes from soil and parasites of higher vertebrates and plants while little is known about the parasites of invertebrates and free-living nematodes found in marine, brackish and freshwater, etc. The approximate number of nematode species from India is given below :—

	Parasites of vertebrates and invertebrates	Parasites of plants and free- living nematodes (soil and water)
Order	10	10
Family	60	80
Species	1250	1600

This may easily be inferred from the information furnished above (30,000 known species against half a million estimated species) that our knowledge of nematode fauna remains very poor all over the world. In India three thousand known species include most of the important parasitic nematode species associated with vertebrates and agricultural crops. However, the study on the parasites of low significance, parasites of invertebrates, predacious and other soil inhabiting nematodes has not been undertaken seriously by the taxonomists. The identification work of marine and fresh water nematodes has almost been ignored as only about 300 species have been reported till date, though they form the bulk of the total nematode fauna. This has roughly been estimated that out of 500,000 nematode species over the world, approximately 80,000 nematode species may be existing in India. The exploration targets may be achieved by conducting surveys in the mangrove, desert, islands, estuary, marine, fresh water, high altitude, forest and sewage ecosystems.

DISTRIBUTION

As mentioned earlier, the nematodes are found everywhere. However, the animal nematodes are not only host specific but some also require one or two intermediate hosts before parasitizing the final host in order to complete the life cycle. Under the circumstances, their distribution is correlated with the availability of intermediate host(s), viz., *Dracunculus medinensis* is restricted in those places where significant populations of *Cyclops* is present. There are some plant parasitic nematodes which can only be found in particular habitat or host, viz., *Ditylenchus angustus* in deepwater rice, *Globodera rostochiensis* (potato cyst nematode) on potatoes, *Anguina tritici* on wheat, *Radopholus similis* mainly on banana, *Tylenchulus semipenetrans* mainly on citrus, etc. This pattern of distribution is same all over the world.

Regarding the differences between past and present distribution, the history of nematodes in India is too young. Hence, this is not possible to compare the present state of the art with the past. The first vertebrate nematode was recorded in 1855 while the first plant nematode in 1901.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Due to wide range of habitats and feeding habits, the nematodes are highly diversified multicellular invertebrates and they may only be compared with insects. On the basis of food and habitat, they can be divided into five groups, viz., vertebrate parasites, invertebrate parasites, plant parasites, microbotrophic, saprophagous or free-living and predacious.

On the basis of morphology, the phylum Nematoda has been divided into two classes and 16 Orders.

MONOTYPIC GENERA FROM INDIA

Indoditylenchus, *Dorsalla*, *Diptenchus*, *Baqriella*, *Aporcedorus*, *Coomansinema*, *Gopalus*, *Cephalodorylaimus*, *Indodorylaimus*, *Indokochinema*, *Acephalodorylaimus*, *Amphibelondira*, *Porternema*, *Athernema*, *Oostenbrinkiella*, *Dorella*, *Oostenbrinkia*, *Coronacephalus*, *Gobindonema*, *Paradaxogaster*, *Praeputirhabditis*, *Saprorhabditis*, *Mesodiplogasteroides*, *Operculorhabditis*, *Acrobelinema*, *Leipernema*, *Tetragomphius*, *Rhadinophelenchus* etc.

ENDEMICITY

In fact, it is difficult to provide the full list of endemic nematode species of India because of the definite gaps in informations on the survey and

distribution of nematodes of many groups/ecosystems. Moreover, the list is so exhaustive that majority of species described as new to science from India may be considered endemic today, e.g., more than 400 species in plant and soil nematodes are still known from type localities only. Obviously, this huge number of species will not remain endemic when surveys will be conducted in unexplored areas which come to about 80% of the country. Similar is the case for the nematode parasites of vertebrates and invertebrates in India.

However, a list of important nematode species associated with plants, vertebrates and invertebrates and some free-living groups is given below :

Important Phytophagous, predacious and free-living species

Tylenchorhynchus mashhoodi, *Quinisulcius capitatus*, *Hoplolaimus indicus*, *Helicotylenchus dihystra*, *H. multicinctus*, *H. abunaamai*, *H. crenacauda*, *Scutellonema brachyurum*, *Pratylenchus coffeae*, *P. penetrans*, *P. zae*, *P. pratensis*, *P. thornei*, *P. loosi*, *Radopholus similis*, *Hirschmanniella oryzae*, *H. gracilis*, *H. mucronata*, *Anguina tritici*, *Ditylenchus angustus*, *Rotylenchulus reniformis*, *Tylenchulus semipenetrans*, *Heterodera avenae*, *H. cajani*, *H. mothi*, *H. oryzicola*, *H. zae*, *Globodera rostochiensis*, *Meloidogyne arenaria*, *M. graminicola*, *M. hapla*, *M. incognita*, *M. javanica*, *Hemicaloosia luci*, *Caloosia paxi*, *Criconemoides ornata*, *C. onoensis*, *Hemicriconemoides cocophillus*, *H. brachyurus*, *Aphelenchus avenae*, *A. besseyi*, *A. camposticola*, *Dorylaimus stagnalis*, *Laimydorus baldus*, *L. siddiqii*, *Thornenema mauritianum*, *Opisthodorylaimus cavalcantii*, *Sicaguttur sartum*, *Aporcelaimellus heynsi*, *Enchodelus macradorus*, *Lenonchium oryzae*, *Oriverutus sundarus*, *Paralongidorus citri*, *Xiphinema brevicolle*, *X. insigne*, *Axonchium elegans*, *Dorylaimellus indicus*, *Paraoxydirus gigas*, *Tylencholaimus obscurus*, *Proleptonchus clarus*, *Basirotyleptus basiri*, *Dorylaimoides pakistanensis*, *Paratrichodorus mirzai*, *P. porosus*, *Parahadronchus shakili*, *Mylonchulus hawaiiensis*, *M. mulveyi*.

Important Vertebrate and invertebrate nematode species

Strongyloides stercoralis, *T. trichuris*, *T. globulosa*, *T. ovis*, *Trichinella spiralis*, *Dictyophyme renale*, *Alfortia edentatus*, *Delafondia vulgaris*, *Tridontophorus serratus*, *Ancylostoma dundenale*, *A. braziliense*, *A. caninum*, *Bunostomum trigonocephalum*, *B. bovis*, *B. foliatum*, *Cyathostomum labiatum*, *C. nasatum*, *Murshidia murshidia*, *Oesophagostomum dentatum*, *O. asperum*, *O. columbianum*, *O. radiatum*, *Chabertia ovina*, *Waucheraria bancrofti*, *Dictyocaulus filaria*, *Thelazia callipaeda*, *Setaria equina*, *S. cervi*, *Parafilaria bovicola*, *Metastrongylus elongatus*, *Memmongamus laryngeus*, *Cooperia curticii*, *C. punctata*, *Haemonchus contortus*, *Mescistocirrus digitatus*, *Nematodirus fillicolis*, *Oxyuris equi*, *Enterobius vermicularis*, *Heterakis spumosa*, *Subulura andersoni*, *Ascaris lumbricoides*, *Toxocara canis*, *Habronema megastoma*,

Habronema microstoma, *Ascarps strongylina*, *Simondsia paradoxa*, *Gongylonema pulchrum*, *Dracunculus medinensis*, *Cucullanus alii*, *Paracamallanus singhi*, *Paracammalus sweeti*, *Canimallanus anabantis*, *Camallanus fotedari*, *Procamallanus daccai*, *Spirocamallanus gubernaculus*, *S. singhi*, *Spinitectus minor*, *Panagrolaimus migophilus*, *Schwenkiella atheri*, *S. indica*, *S. aurangabadensis*, *S. basiri*, *Heterotylenchus xanthomelas*, *Iponema hyderabadensis*, *I. timae*, *I. mauriti*, *Mesidionema nordiensis*, *Protrellatus murtii*, *Mermithids*.

INTRODUCED SPECIES

Only a few species of nematodes might have been introduced in India, viz., *Globodera rostochiensis* (serious parasite of potato). *Anquina tritici* (wheat gall nematode) is considered to be a native of Europe but this is also found in Bihar, Delhi, Himachal Pradesh, Haryana, Punjab, Rajasthan and Uttar Pradesh.

VALUE

From economic point of view, the nematode parasites of vertebrates, invertebrates and plants are very important because they cause significant damage to their hosts, i.e., human being, livestock and crops. Some serious human diseases like river blindness (onchocerciasis), ascariasis, filariasis, trichuriasis and hook-worm diseases are caused by nematodes. As per report of World Health Organisation (WHO) for the year 1977-1978, people in millions were suffering from the above mentioned diseases in Asian, African and Latin American countries. The same report confirmed the death of about 140,000 people over the world. Besides, hundreds of nematode species also act as pathogens and cause deaths in our livestock. The plant parasitic nematodes are more important because they cause an average loss of 15% in all the agricultural crops. In some cases, the loss may go up to 90%, i.e., *Globodera rostochiensis* (potato cyst nematode) on potato, ufra disease in rice, etc. In 1987, Sasser and Freckman have informed that the crop losses due to nematodes may exceed one hundred billion dollars annually over the world. According to Van Berkum and Sheshadri (1970), the crop losses in India may be up to 10 million dollars to wheat due to *Anquina tritici* (seed gall nematode), three million dollars to coffee due to *Pratylenchus* spp. (root lesion nematode) and in Rajasthan State alone about eight million dollars to wheat and barley due to *Heterodera avenae* (cereal cyst nematode).

All the nematodes are not our enemies. The nematode parasites of insects are considered as good biological agents in the control of agricultural pests.

Some soil nematodes, specially the members of the Order Mononchida, act as a good biological agent in the management of plant parasitic nematodes. Certain nematodes take part in maintaining natural balance in the soil while a few are good experimental animals in the basic research on nutrition, physiology, genetics, etc.

A few species belonging to the families Plectidae, Montysteridae, Desmodoridae and Chromadoridae may be considered as indicator species. These nematodes can be used for determining pollution and other types of aquatic disturbances as they ingest heavy metals and other pollutants settled in the sediments. The species of these families have been found quite sensitive to the pollutants and as a result they may die.

THREATS

As such we do not have any record about the threats to this taxon either in past or present. The only threat in future can be anticipated because of the indiscriminate use of nematicides/pesticides, but now we know that even their application cannot eradicate the nematode populations from the soil. The discharge of industrial wastes, etc., in the soil or water may be harmful to them but the damage to the populations remains restricted in the pollution zone only.

CONSERVATION AND FUTURE STUDIES

Since the members of the phylum Nematoda are not being considered as threatened organisms, there is no need to chalk out any policy for the conservation of this taxon.

The application of nematicides should be avoided in the management of nematode pests of agricultural crops. Attempts should be made to bring down the nematode populations through other organisms (predatory nematodes, bacteria, viruses and fungi), improved management practices, growing antagonistic plants, application of organic and inorganic materials to the soil, crop rotations, summer ploughing, etc.

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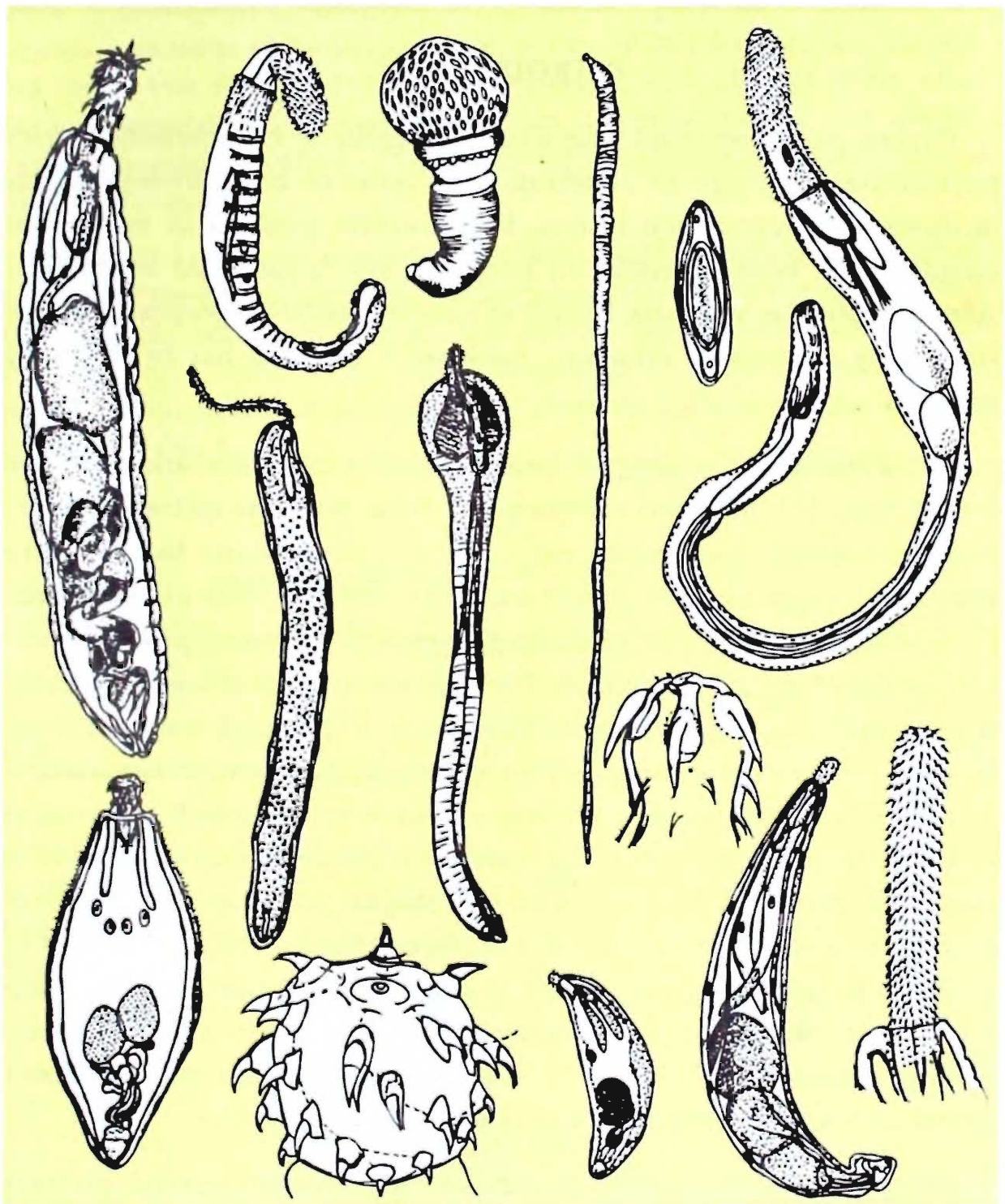
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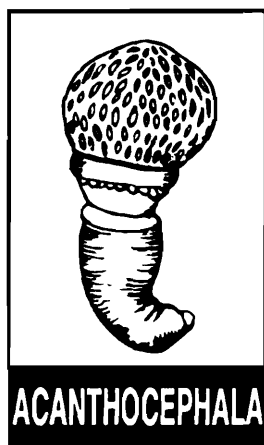
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Faunal Diversity in India : Acanthocephala

S. B. BHATTACHARYA

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Phylum Acanthocephala form a compact group of endoparasitic worms parasitizing all groups of vertebrates and some of invertebrates such as molluscs, crustaceans and insects. Its taxonomic position in the animal kingdom had been uncertain till Lankester (1900) proposed to consider Acanthocephala as a phylum. Later, Van Cleave justified the proposal through convincing arguments. Presently, Lankester's proposal has been widely accepted.

The shape of these worms are fusiform, oval, or cylindrical and their, size ranges from less than one millimetre to more than one metre. They are found in intestine, body cavity, mesentery, etc. These worms lack digestive tract in all stages of development and their nutrition takes place through body wall. The body is divided into the presoma including proboscis and neck, and the body proper or trunk. The body wall consists of cuticle, syncytial hypodermis and parietal muscle layer which is delimited from the body cavity by connective tissue lining. Through hypodermis pass numerous lateral lacunae and smaller lacunae forming a lacunar system which is having a considerable taxonomic value. The body has a unique proboscis armed with numerous hooks of different sizes and shapes except in *Apororhynchus hemignathi*, whose proboscis has pits in place of hooks. The arrangement of hooks on the proboscis, the number of spiral or longitudinal rows, and the number of hooks in the rows are of considerable significance in the taxonomy of Acanthocephala. Cylindrical or sub-cylindrical muscular proboscis, and paired contractile lemnisci are also of great taxonomic value.

Of the reproductive system, position of female genital aperture, position of testes, nature and number of cement glands and presence of Saeftigen's pouch help to determine the individual taxon.

STATUS OF THE TAXON

Global and Indian Status

From the end of 17th century until 1932, about 260 species of *Acanthocephala* were described from the global environment. At present, there are 800 species known from all over the world.

Till 1890 all the species of *Acanthocephala* were contained in a single genus *Echinorhynchus*. Subsequently, Lankester’s proposal to consider the *Acanthocephala* as a phylum was accepted by all (Kholodkovaskii, Skrjabin and Sultz, Van Cleave, Petrotscherko, Golvan, Schmidt and many other modern taxonomists). Today this phylum is represented by four classes, namely, *Eoacanthocephala*, *Palaecanthocephala* *Archiacanthocephala* and *Polyacanthocephala*.

The studies on *Acanthocephala* in India are made sporadically. As a result, majority of the animal hosts are still lying unexplored. Very recently (1990), a checklist on *Acanthocephala* of fishes of India and Pakistan, published by V. Gupta and G. Sinha added to the knowledge of Indian *Acanthocephala* and their distribution. *Acanthocephalan* diversity in India and the world is shown in Table 1.

Table – 1
Acanthocephalan diversity in India and world

Host	Number of						% in India
	Family		Genera		Species		
	W	I	W	I	W	I	
Fish		6		32		140	
Amphibia		3		3		10	
Reptilia		2		2		4	
Birds		6		10		65	
Mammals		3		7		10	
Total	40	20	100	54	800	229	28.62

DISTRIBUTION

Distribution of *Acanthocephala* is largely dependent upon the distribution of their hosts. The animal groups which harbour *Acanthocephala* at larval or

adult stage are found in both terrestrial and qauatic ecosystems. Some of the Acanthocephala are highly pathogenic causing various diseases to swine, rodents and ducks.

Attempts were made by Meyer (1933) to show country-wise distribution of Acanthocephalan species. Later, Petrotschenko (1956) indicated the zoogeographical distribution of these species by demarating several geographical regions. However, based on current report a state-wise and host-wise distribution of acanthocephalan genera and species are shown in Table 2.

Table – 2
State-wise and host-wise distribution of number of genera and species of Indian Acanthocephala

State	Hosts									
	Fish		Amphibia		Reptilia		Bird		Mammal	
	G.	sp.	G.	sp.	G.	sp.	G.	sp.	G.	sp.
Andaman	1	1					5	5		
Andhra Pradesh	4	5					1	1		
Arunachal							1	1		
Assam									1	1
Bihar	6	9					1	1		
Delhi									1	1
Goa	2	2								
Jammu & Kashmir	3	14	2	2						
Karnataka			2	2	1	1				
Kerala	16	32					3	4		
Madhya Pradesh	2	2								
Maharastra	3	3					2	5	1	1
Manipur			1	1						
Meghalaya	3	6	1	1			3	10		
Orissa	10	16							1	1
Punjab	2	6			3	4	3	16	3	4
Rajasthan							2	3		
Sikkim							1	1		
Tamil Nadu	11	15					4	5	2	2
Tripura	3	4	2	2			4	10	1	1
Uttar Pradesh	5	18	1	3	2	6	5	12	3	3
West Bengal	9	20					1	2	3	3

G = genus, sp = species.

ENDEMICITY

Out of 229 species of *Acanthocephala* reported from India 203 species have been known from the indian region only. This indicates a very high percentage of endemicity of these parasites in the present state of knowledge on this group.

The remaining 26 species (2 species from fishes, 1 species from Amphibia, 17 species from birds and 6 species from mammals) have been reported from other countries.

VALUE

As a rule, parasites cause great harm to the hosts' body. *Acanthocephala* being endoparasites are not in exception.

Pathogenicity in relation to wild life :

The pathogenic effect of *Acanthocephala* on the host animals is diverse. Through their body surface they absorb a considerable quantity of nutritive substance from host's body, hindering growth of the host and causing emaciation. Secondly, the thorny proboscis, the hold-fast of the parasite, pierces the intestinal wall of the host causing degeneration. Sometimes it causes peritonitis and usually results in the death of infected animals. This is observed particularly in *macracanthorhynchiasis* of swine. *Acanthocephala* also cause much harm to poultry with the disease *polymorphiasis* and *filicoliasis* in ducks and geese. Commercially valuable animals, such as, birds (ducks, geese, etc.), fishes (salmon, carps, etc.) and many other domestic and wild animals are reported to have been incurring losses with the infection of *acanthocephala*.

Pathogenicity in relation to man

Acanthocephala are not obligatoy parasites of man but reports on human infection by *Macracanthorhynchus hirudinaceus* of swine in many cases show high pathogenicity of the parasite, causing acute anaemia which often leads the diseased to death. *Moniliformis moniliformis* of rodents is also another parasite found to parasitize man, causing considerable harm to him. Two other species of *Acanthocephala*, viz., *Acanthocephalus bufonis* of amphibia and *Corynosoma streemosum* of fish have also been reported to parasitize man. Such reports are available only from Czechslovakia, Italy, Indonesia and Alaska not from India.

CONSERVATION AND FUTURE STUDY

Since acanthocephala are endoparasites, their survival and conservation solely depend upon those of their host species. This group of animal is underexplored. Further, life cycle and pathogenicity of these parasites are also least known. In future, emphasis is to be given to study these aspects besides taxonomic study of this group.

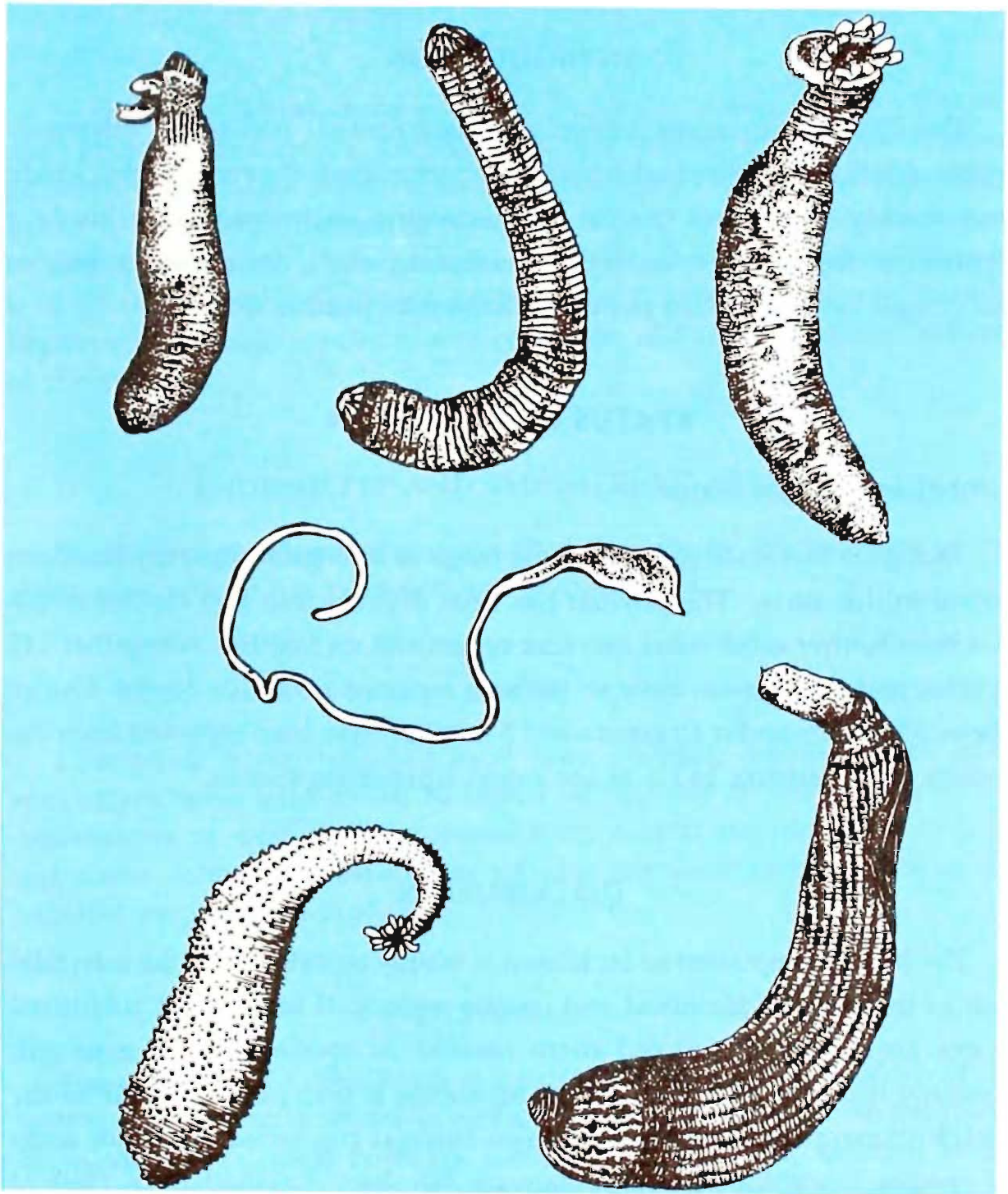
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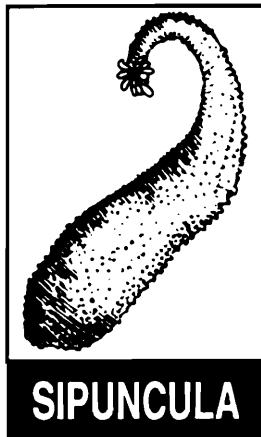
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Faunal Diversity in India : Sipuncula

BADRI PRASAD HALDAR

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The Phylum Sipuncula comprises unsegmented, coelomate, bilaterally symmetrical and soft-bodied invertebrates inhabiting the coral, rocky, sandy and muddy habitats of marine and estuarine environments or inside a protective shelter of a discarded molluscan shell, foraminifera test or polychaete tube. They are popularly known as peanut worms.

STATUS OF THE TAXON

Global and Indian Status

Though it is a small group, a wide range of biological diversity has been found in this taxon. The phylum has been divided into two classes which has been further subdivided into four orders and six families. Altogether 145 species under 17 genera have so far been reported from five oceans. Out of these, 35 species under 10 genera and 5 families have been reported from the Indian coast, sharing 24.1% of the world sipunculan species.

DISTRIBUTION

The faunal component so far known is mainly reported from the intertidal belt of the coast of mainland and insular regions. If littoral and sublittoral zones are properly explored more number of species can be expected. Roughly it can be said that 15% of Sipuncula is unexplored. So far as the distributional pattern of the sipunculan fauna is concerned the major areas of species concentration are Andamans, Nicobars, Lakshadweep, Gulf of Mannar, Tamil Nadu and Gujarat.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The two classes of Sipuncula can be distinguished on the basis of arrangement of tentacles, structure of introvert hooks and attachment of spindle muscle. The magnitude of diversity of distribution along the Indian coast depends upon the habitat in which they live. Most of the species available here are rock borers and rock dwellers. The interaction between coral growth and species diversity is well observed in Andaman and Nicobar Islands, Lakshadweep, islands of the Gulf of Mannar and certain parts of Gujarat as the luxuriant growth of coral provides suitable habitat for this group.

As to the status and abundance, two monotypic genera, viz., *Antillesoma* and *Cloeosiphon* and some of the species like *Themiste lageniformis*, *Phascolosoma perlucens*, *Phascolosoma albolineatum* and *Aspidosiphon steenstrupii* have been found to be widely distributed along the Indian coast. The occurrence of *Lithacrosiphon cristatus*, hitherto known from the Pacific and Atlantic Ocean, is of great geographical interest. So far no work has been done to identify keystone sipunculan species of any ecosystem and none has been declared as threatened.

ENDEMICITY AND THREATENED SPECIES

In this group endemic forms are altogether absent. So far, none of the sipunculan species has been declared as threatened.

VALUE

This group is still regarded as of great scientific interest. Large sized species are being used in the biological laboratories for different scientific experiments as well as in educational institutions for biological studies. *Sipunculus indicus* and *Sipunculus robustus* are used as fish baits in the Lakshadweep and the Andamans respectively.

THREAT

The main threat to this taxon is the destruction of habitats. 40.5% of the total species is coral-and rock-borers and 28.8% of the species inhabit under rocks, stones and coral boulders. Coral is used as a raw material in the cement factories. As a result a good amount of coral from the coral reef area of the Gulf of Mannar and the Gulf of Kutch are reported to be removed in

recent years. Due to this at least two species which were reported earlier are not available at present.

CONSERVATION

Very recently measures have been taken to prevent the habitat destruction. Government has declared the area of Gulf of Mannar and Gulf of Kutch as Marine National Parks and there by prohibiting the removal of natural wealth from the aforesaid areas. Andaman and Nicobar administration also has taken similar measures.

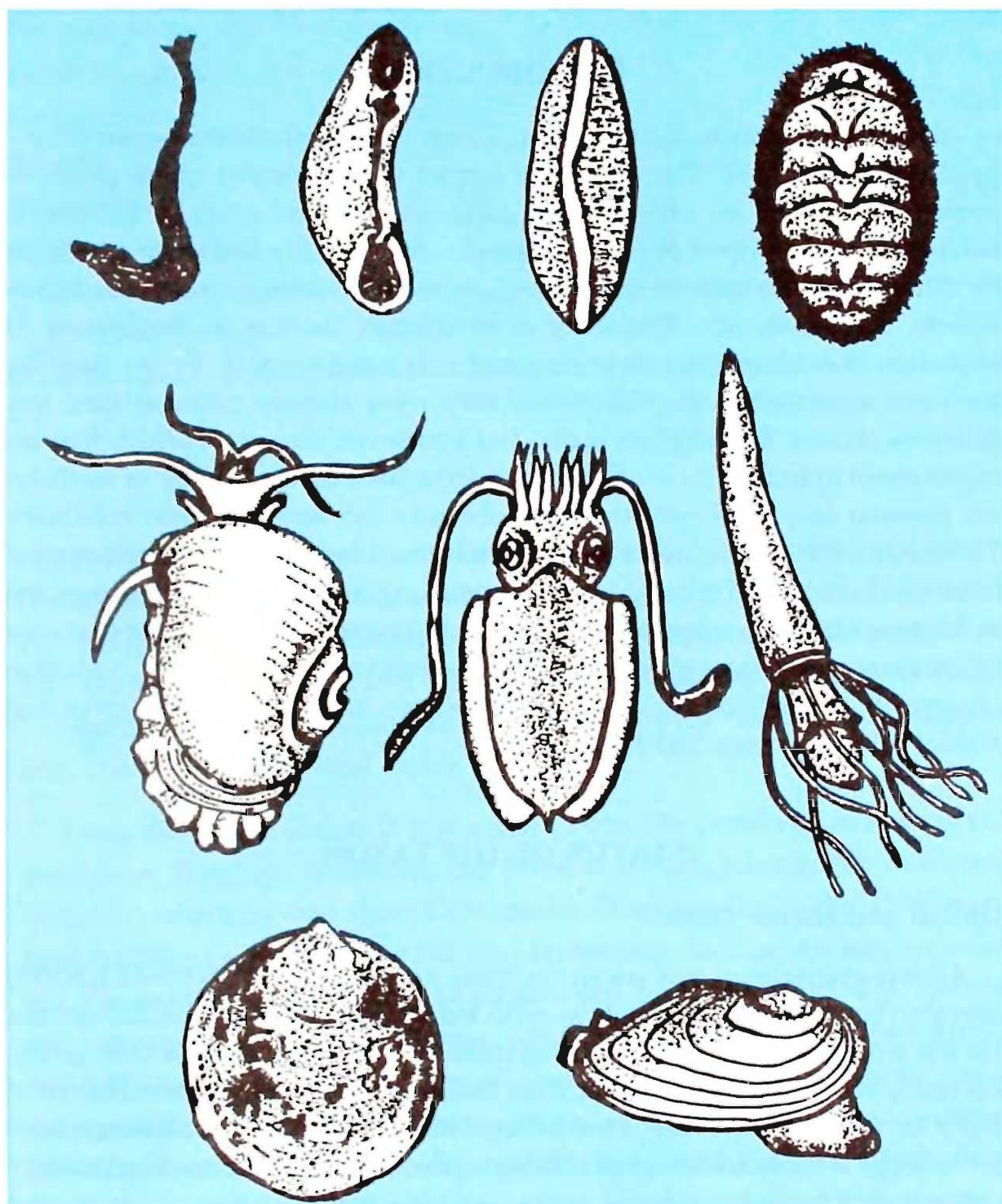
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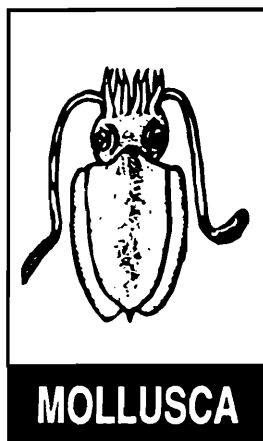
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Faunal Diversity in India : Mollusca

N. V. SUBBA RAO

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Molluscs are soft-bodied animals, a majority of which are covered by a hard calcareous shell. The shell may consist of one, two or many pieces or sometimes it may be internal and cartilaginous. The phylum includes a heterogeneous group of organisms, which are popularly known as 'shells' or by different names such as snails, slugs, mussels, oysters, clams, cuttle fishes, squids, octopuses, etc. The story of molluscan success in the history of evolution is evident from their long and rich fossil records. By the time the molluscs appeared in the Cambrian, they were already differentiated into different classes. The phylum is divided into seven classes, of which five are represented in India. The shells, which are the 'abandoned houses' of molluscs are popular objects of collection for hobbyists and amateur curio collectors. The shells which are beautiful architectural structures with an aesthetic appeal, have fascinated man from prehistoric times, as evidenced by their remains in Mohenjodaro, Harappa and other places. The socio-economic importance of molluscs is reflected in their use in folklore, in currency, valuable ornaments, in their edible value, etc. Molluscs have successfully colonised almost all ecosystems and habitats.

STATUS OF THE TAXON

Global and Indian Status

Global estimates of molluscan diversity vary between 50,000 and 1,50,000 species. A conservative estimate as reflected in Table 1 includes 66,535 species for the world. Molluscan diversity in India is 7.62 per cent of the total global diversity which is in fact higher than that of the total faunal percentage of India i.e. 6.67. The diversity is contributed mainly by marine molluscs, whose knowledge is far from complete. Hitherto, the work in India has been mainly concentrated on common and easily available malacofauna, which do not involve any special techniques of sampling. It is expected that actual diversity may be more than the present estimates.

Table - 1
The estimated species number under each class of Mollusca

Class	Species (n)		% in India
	India	World	
Aplacophora	—	130	—
Polyplacophora	40	500	8
Monoplacophora	—	5	—
Gastropoda	3,619	50,000	7.24
Bivalvia	1,181	15,000	7.87
Scaphopoda	20	300	6.67
Cephalopoda	210	600	35.00
Total	5070	66,535	7.62

DISTRIBUTION

Molluscs have adapted themselves to diverse habitats, from the deep sea (3000 m) of Andamans to higher elevations (about 5000 m) in the Himalayas. But the diversity and abundance is more in the rocky intertidal zone along the coast and in the coral reef ecosystem of Gulf of Mannar, Gulf of Kutch, Lakshadweep and the Andaman & Nicobar Islands. Sandy coasts support less, but typical interstitial fauna.

From the available data it is possible to identify certain areas having rich molluscan diversity. Andaman and Nicobar Islands have a rich molluscan diversity, which include about 1150 species distributed in marine (1000 spp.), land (110 spp.) and freshwater (40 spp.) ecosystems. Gulf of Mannar, including the Coromandel coast, and Lakshadweep have 428 and 424 species, respectively. Gulf of Kutch (Gujarat coast) and Orissa coast account for 350 and 337 species, respectively. The diversity in these areas is mainly due to preponderance of marine molluscs. As far as land molluscs are concerned diversity is concentrated in North eastern India and Western Ghats. From Meghalaya alone, which has been sampled recently, a total of 223 species of land and freshwater molluscs have been reported.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Molluscan Diversity

The phylum Mollusca is distinguished into three subphyla, namely Aculifera, Placophora and Conchifera. The first mentioned includes only one class, Aplacophora, which however, does not occur in Indian Seas. The subphylum Placophora also includes one class known as Polyplacophora, the representatives of which are popularly called chitons. It is a small class with an estimated number of 500 species. The subphylum Conchifera is divided into five classes, namely Monoplacophora, Gastropoda, Bivalvia, Scaphopoda and Cephalopoda. The first mentioned does not occur in Indian seas. Thus out of seven recognized classes of the phylum Mollusca, five classes mentioned, have their representatives in India. Taxonomy of many families of molluscs is still in a confused state. It is difficult to mention precisely the number of families within the phylum. Against general estimated total of 586 families in the phylum, about 290 families presumably occur in the Indian subcontinent and its territorial waters. There are only a few number of taxonomists who have undertaken studies on Indian molluscs and as a result, knowledge on Indian molluscs is far from complete. From the existing knowledge, the following is the break up of families as far as India is concerned.

Table - 2
Number of families from India

Class	Families (n)			Total
	Marine	Freshwater	Land	
Polyplacophora	10	—	—	10
Gastropoda	140	14	26	180
Bivalvia	61	8	—	69
Scaphopoda	3	—	—	3
Cephalopoda	28	—	—	28
Total	242	22	26	290

At the family level, about 62.8 per cent of the families known from the world are represented in India. The occurrence of diverse ecosystems and habitats in India has given scope for rich species diversity. The estimates have been made on the basis of available literature and field observations. The data on land and freshwater molluscs can be taken as a true representation of the position. But these estimates are based largely on the old data. The modern biological species concept and revisionary studies may bring down the number of species. A recent revision of a freshwater family—Lymanaeidae has brought down the number of species from 1000 to 40.

A comparison with the world malacofauna shown in Table 1 reveals that Cephalopods (Cuttle fishes, squids, octopuses, nautilus etc.) represent 35.00 per cent of the total species diversity. These are highly mobile with extensive ranges and support valuable fisheries for the country. The other classes include molluscs which are less mobile and have narrow ecological requirements.

The diversity of molluscs varies with the ecosystem. An analysis has been attempted earlier (Subba Rao, 1991) and the same is presented below, with an up date where necessary.

Table - 3
Molluscan Diversity in Terrestrial and Wetland (Freshwater) ecosystems

Class/Subclass	Families(n)		Genera (n)		Species	
	Terres- trial	Fresh water	Terres- trial	Fresh water	Terres- trial	Fresh water
Gastropoda						
Prosobranchia	5	11	32	26	536	66
Pulmonata	21	3	108	8	951	36
Bivalvia	—	8	—	19	—	81
Total	26	22	140	53	1487	183

Table - 4
Estimated molluscan diversity in marine ecosystem

Class	Families (n)	Genera (n)	Species (n)
Polyplacophora	10	13	40
Gastropoda	140	340	2000
Bivalvia	61	150	1100
Scaphopoda	3	3	20
Cephalopoda	28	85	210
Total	242	591	3370

From the tables 2 and 3, it can be seen that diversity at all levels is more in the marine ecosystem followed by land and wetland ecosystem. Marine species have wider distribution in the Indo-Pacific region whereas land and freshwater species have patchy, restricted and isolated distribution. The species of *Paludomus*, *Cremnoconchus* etc. are restricted to streams either in Western Ghats or North-east India. Similarly majority of land species are restricted to tropical rain forest ecosystems. Thus the diversity is more in Western Ghats and North-east India.

In the absence of a comprehensive data on marine molluscs it is too premature to attempt an estimation of species diversity and the extent of endemism. The available data indicates the existence of about 3370 species, but it may be actually more.

Introduced Species

There are not many introductions as far as molluscs are concerned. The giant African snail, *Achatina fulica fulica* (Bowdich) was introduced by W. H. Benson in 1847. He collected a few specimens from Mauritius and introduced a few in Botanical Gardens, Calcutta and a few in a garden in Shimla. The latter specimens had died, but those released in Calcutta have multiplied and spread to other states of the mainland. During the Second World War, Japanese soldiers had introduced this snail in South Andaman which has now dispersed to Nicobar Islands also. The species has successfully spread to almost all states, except sub-himalayan range, semiarid and arid zones. It became a pest to agri-horticultural crops where ever it occurs. When chemical measures could not control the snail, a carnivorous snail *Euglandina rosea* was introduced in the Islands. But fortunately it did not survive. It needs

mention here that the same snail *E. rosea* has been responsible for the extinction of certain small endemic snails in Hawaii. However, *Achatina fulica* is now identified as a potential foreign exchange earner for us as there is a demand for this snail in French markets. Andaman and Nicobar Islands can provide rich breeding grounds and collecting centres for this.

A number of sedentary marine organisms are carried on inadvertently on the hulls of maritime vessels and ships from their original area of distribution to foreign locations. A central American species, *Mytilopsis sallei*, has spread beyond its original home. The species was first observed in 1967 in Southern Lighter channel in Visakhapatnam harbour and by 1970 it had spread to other areas in the harbour. It was later reported from Bombay harbour (in 1975) and Kakinada Port (1985) (Sàtyanarayana Rao *et al*, 1989). The species was not a fouler in its original home, but in India it has established itself in the fouling communities.

Human-Mollusc Relationships

Man has been attracted by molluscs from prehistoric times because of their aesthetic and gastronomic values. But unlike in vertebrates, man has not contributed anything to the diversity of molluscs. He has been exploiting them from their natural habitats and putting them to different uses. He has been inadvertently responsible for the dispersal of certain species. The common garden slug, *Laevicaulis alte* has its present wide, cosmopolitan distribution since it was carried along with plants. A species of slug, *Kasperia* sp. which is a pest in potato gardens in Nilgiris had probably been introduced along with potato crop.

ENDEMIC AND RARE MOLLUSCS

The malacofauna of India shows some special and distinctive features. These are more evident in non-marine molluscs than in marine molluscs. Against an estimated total of 4000 species and 133 genera of operculate land snails of the World, India's share is about 525 species falling under 32 genera. The estimates for pulmonate land snails and slugs of the world are 667 genera and 15000 species, with 104 genera and 950 species occurring in India. The land operculates of India include a number of zoogeographically significant genera such as *Cyclophorus*, *Diplommatina* and *Alycaeus*, which are typical to oriental region and have number of endemic species. Majority of these species are distributed in peninsular plains and Western Ghats. The pulmonate snails of the genera, namely, *Macrochlamys*, *Sitala*, *Kaliella*, *Ariophanta* *Girasia*, *Austenia*, *Sesara*, *Sophina* and *Durgella* have a number of

endemics confined to tropical rainforest ecosystem in North eastern India and Western Ghats. *Boysia*, *Lithotis*, and *Camptonyx* are endemic to India. These are represented by old collections, made during the last century and their present status is not known. The unique example of Indian land molluscs is the imperial snail of India, *Hemiplecta basileus*, which is common in the teak forests of Western Ghats.

Besides the land snails mentioned above, there are a few genera of slugs such as *Mariaella*, *Incillaria*, *Kasperia* and *Anadenus* which occur at higher elevations and are typical to Oriental region with their major distribution centres in India.

The diversity in freshwater molluscs is comparatively poor than that in land or marine molluscs. Against the estimated 8,765 species of freshwater molluscs in the world, there are about 300 species in the Indian subcontinent. A large number of these (213) were reported from India proper. A few endemic and monotypic genera are reported, namely, *Cremnoconchus* (Western Ghats), *Mysorella* (monotypic genus from Peninsular Plain), *Mainwaringia* (monotypic genus from Gangetic delta and estuaries of Gujarat extending up to Vietnam). A few families of bivalves have contributed a single genus or species to freshwater fauna, namely *Scaphula* (Arcidae), *Novaculina* (Solenidae), *Tanysiphon* (Glaucnoidae) and *Modiolus* (Mytilidae) all living in the Gangetic delta. These provide interesting material for evolutionary and biogeographical studies.

Indian freshwater bivalves have special features in having two families, namely Unionidae and Pisidiidae which are of great antiquity. The family Aetheriidae, whose representatives are popularly known as freshwater oysters, has a restricted distribution in South India.

Endemism in Indian molluscs seems to be more pronounced in freshwater ecosystem. Generic endemism is very much significant being at 66 per cent only, but 41.8 per cent of species are endemic. In land molluscs, about 33.5 per cent of species are endemic with a low (7.14) per cent of generic endemism. No attempt has been made to estimate endemism in marine molluscs as systematics of several families are in a fluid state.

The present state of knowledge does not provide any clue to the threatened species of molluscs. Many of the species were not recollected after their original discovery or their first collection. In this connection the global scenario is not in any way better. There is no documented data on rate of mollusc extinctions.

Van Bruggen and Wells (1992) mentioned that as per World Conservation Monitoring Centre about 170 species of molluscs had become extinct since 1800 A.D. The 1990 IUCN Red List recorded 425 species of molluscs under the threatened category.

Authentic data on the status of various species of molluscs is not readily available. Our recent surveys have shown that species which were once abundant and easily available are hard to find now in their habitat. In Andaman and Nicobar islands, 71 of the known 101 species are endemic. Many species collected last were, at the end of the nineteenth century (Subba Rao and Mitra, 1991). Although it needs confirmation, some of the species in the Andaman and Nicobar Islands are either rare or have probably become extinct. Out of the 85 species for which specimens are available, 39 species are represented by the collections made during the later half of last century. Their present status as viable species is doubtful. The old collections from the Islands have originated from localities around Port Blair, Mt. Harriet, Great Nicobar, Car Nicobar, etc. which were easily accessible at that time. The localities from where Roepstorff, Godwin-Austen, Stoliczka and others made collections during the last century have undergone changes during later years. Land molluscs are highly susceptible to environmental changes and it is presumed that at least a few species may have been wiped out of their habitats. But in the absence of the any concrete evidence we cannot brand them as extinct. Intensive surveys are needed to establish the fact that species (25) which have not figured in recent collections, are either rare or extinct.

In Meghalaya, 223 species of non-marine molluscs were recorded but recent sampling could yield only 131 species. The fate of about 92 species is hard to explain.

Among freshwater molluscs there are a few species which have not been collected second time during the last 100 years. *Lithotis tumida* (Blanford, 1870) which was recorded from Pune district, Maharashtra has not been collected again. *Arcidopsis footei* (Theobald, 1876), a bivalve was not collected after 1912. Another bivalve commonly known as freshwater oyster, *Acostaea* (*Pseudomulleria*) *dalyi* (E. A. Smith, 1898) has not been collected after its original discovery. A very small population of this species was reported last year in Bhadra River, near Kalsa, Karnataka. All the above three species are endemic to the Western Ghats.

VALUE

The value of molluscs to man are manifold. Majority of molluscs belonging to classes Gastropoda, Bivalvia and Cephalopoda have consumptive and

productive uses. Land snails are not of any consumptive use in India. But there are 19 species of freshwater molluscs, both gastropods and bivalves, which are eaten in eastern India and more than two dozen species of marine gastropods, bivalves and cephalopods, which are of edible value. Majority of these are consumed in India, while some are exported out of the country. Squid fishing has developed into a very profitable industry along Gujarat coast.

Freshwater mussels, pearl oysters, turban and top shells are sources of mother of pearl. Fresh water mussels were once popularly used in the manufacture of buttons and a prosperous shell products industry flourished in North Bihar. Shell fisheries in North Bihar are dependant mainly on three species namely *Parreysia (Radiatula) caerulea* (Lea), *Parreysia (Parreysia) favidens* (Lamarck) and *Lamellidens corrianus* Lea. Shell Button Industries, Mehshi, East Champaran Dist., handles Rs. 20 lakhs worth finished products annually (Banerjee & Satish, 1988).

Productive use of molluscs is more pronounced in marine molluscs. In recent years international trade in ornamental shells has been on the rise. Sea shells and cuttle bones are exported to various countries, namely, Saudi Arabia, U. S. A., Malaysia, U. A. E., France, etc. Sea shells are used in the manufacture of ornaments and household articles such as table-lamps, ash-trays etc. The finished shell products are sold either in the local market or exported to foreign countries. Shell lime industry depends completely on sea shells. These are also used in the poultry feed additives. Some of the shells such as *Villorita cyprinoides* and *Villorita cornucopia* are used as raw material in the cement and rayon industry. Recent investigations have shown that some of the molluscs are potential sources of biomedical compounds.

Besides the direct values mentioned above, molluscs have an important role in the ecosystem. They draw a small quantity of calcium for the formation of shell from their environment and release it back into the environment. Molluscs play an important role in litter decomposition in the terrestrial ecosystem and formation of organic detritus in estuaries.

THREATS

Molluscs, like all other animal groups are threatened by habitat alteration and indiscriminate exploitation by man. The impact of habitat disturbance on mollusc populations is not known because of lack of supporting data. But it is possible to draw certain inference. Molluscs, especially non-marine forms are characterised by low mobility, small populations, patchy and isolated

distributions. These are very sensitive to environmental changes. As mentioned earlier some of the species may have become either rare or endangered, as they do not figure in recent samples. The shrinkage in wetland ecosystem reduces the opportunity for colonisation of molluscs. The genera *Camptoceras* which was collected from the Ganges and its tributaries has become rare in its type locality. Majority of the important marine molluscs are associated with coral reef ecosystem, which is sensitive to any external disturbance. It was reported that the construction of Fishery Jetty at Phoenix Bay, Port Blair has adversely affected the pearl oyster, *Pinctada fucata*, which was once common in that area. Dredging operations in the lagoon of Minicoy caused siltation adversely affecting the population of *Tridacna maxima* (see Patterson Edward & Ayyakkannu, 1992).

In the Gulf of Kutch, pearl oyster population has been on the decline. It was mainly due to habitat disturbance, such as heavy lifting of sand and rock from the natural pearl oyster beds for construction work, lifting of stones by local fishermen for wada fishing and use of DDT and other chemicals by traditional Pagadia fishermen to catch the fish.

The major threat to molluscan diversity is in the form of over exploitation and collection of undersized specimens. Freshwater mussels are sources of the mother of pearl, which was once popularly used in the manufacture of buttons. There was once prosperous shell products industry in North Bihar. The number of industrial units have declined from 350 in 1940 to 84 at present. The decline in the number of these units is mainly due to the non-availability of raw material, of three species as mentioned earlier. These bivalves are collected from the Ganges and its tributaries. The available statistics indicate that there is depletion of natural populations of these mussels.

Sea shells are needed in large quantities by the domestic shell craft industry. Shell craft industry selects those shells which have saleable value and discards others. In the process, a large resource uprooted from its place of occurrence is just discarded and thrown as waste. It was seen that one shell craft industry located at Bombay discarded about 200 tons of sea shells as they do not conform to the standards of the traders.

Clam shell deposits are exploited locally in estuaries (Bahuda) of Orissa, Kakinada (Andhra Pradesh) and Kundapur (Karnataka). There is a large scale exploitation of *Meretrix meretrix* and *Meretrix casta* at several coastal places. Subfossil deposits of *Meretrix* is collected in bulk quantities from Talsari river mouth in Orissa and transported to interior places in West Bengal for use in the poultry feed. In Kundapur estuary, Karnataka,

M. meretrix, *M. casta* and *Paphia malabarica* are dredged regularly and sold to pulp and rayon industries.

If the exploitation of molluscs continues at the current rate without assessing the impact on their populations, soon many species will be wiped out in their natural habitats. The problem of overexploitation creates further complications as there is dearth of essential life history and biological information for a number of species used in trade.

Villorita cyprinoides and *Villorita cornucopia* are two bivalves with restricted distribution in Kerala and Goa. Both the species are collected alive and the shells are used as raw material in the cement and rayon industries.

Commercialisation of sea shells has been on the rise and it has led to indiscriminate collection of sea shells. Since there are no strict regulations in many parts of the country, governing the collection of shells, molluscan resources are treated as "Open access resources" or public goods. At several easily accessible coastal places and at places where tourists frequent, populations of certain common species are on the decline. For example, *Amalda ampla*, the ivory white olive was once common on the Digha beach, but it has become almost rare now. It was collected locally and used in the preparation of curios, necklaces etc.

Marine species are however, not as much in danger as their counter-parts on land or in freshwater. Many of the marine species have a longlived pelagic larvae and hence they are widely distributed in the Indo-Pacific. The well-known tiger cowry, *Cypraea tigris* has its range of distribution extending from the coast of East Africa to Central Pacific. Cones and scorpion conchs are also distributed throughout Indo-Pacific. However, all the species are not uniformly distributed within their ranges of distribution. Populations are concentrated in areas which offer ideal ecological niches.

Gaint clams, which are hermaphrodites, have 9 to 12 days of larval life, and consequently their distributions are also limited. Although majority of the marine gastropods have a freeswimming veliger stage, there are certain gastropods, in which the development is direct, *i.e.*, there is no larval stage. Some marine prosobranchs especially Neogastropoda have no free swimming larvae. The sacred chank of India is one such species. Its distribution is very much restricted. It occurs in the Gulf of Mannar, Gulf of Kutch and Andaman and Nicobar Islands. Even in these areas of its occurrence, it has a localised distribution. Absence of a free swimming larval stage, coupled with long span of life make these molluscs more vulnerable to the adverse impacts of human activities.

Many of the species as mentioned above are harvested indiscriminately without realising the impact of over-exploitation on the species and on the ecosystem. Recently Rama Raju (1991) in an interesting study has brought out the impact of large scale destruction of molluscan fauna on the ecology of Kolleru Lake in Andhra Pradesh. Gastropods were removed in large quantities from the Lake for supply to prawn culturists, who use them as prawn feed. It has created an adverse impact on the duck and bird population for whom molluscs are a source of food.

There is no authentic data on the threats to molluscan fauna in the Indian seas. But it is possible to draw lessons from situations prevailing elsewhere. Over-exploitation has adverse effects on the populations of commercially used species. It was observed that intensive exploitation has led to the disappearance of the pearl oyster *Pinctada margaritifera* from some Polynesian Islands. Ornamental shell trade is causing depletion of local populations in many Pacific Islands, Philippines and on the Kenyan coast.

CONSERVATION

The declaration of Gulf of Mannar, Gulf of Kutch and South Andaman as Biosphere Reserve/Marine National Parks affords protection to marine molluscs. There are also some regulations particularly governing the collection of shells. In Andaman and Nicobar Islands, nine areas are demarcated for collection of shells. A closed season of two years is allowed in all the areas to permit replenishment of population. The collection of undersized specimens of *Trochus* (less than 10 cm) and *Turbo* (less than 6.5 cm diameter) is prohibited. The catches are inspected by the local officials of the Fisheries Department before permitting the export of shells for sale.

In the Gulf of Kutch shell fisheries are under the control and supervision of Department of Fisheries, Government of Gujarat, whereas the Marine National Park is under the control of Gujarat State Forest Department. There are regulations governing the collection of sacred chank (*Turbinella pyrum*), Window-pane oyster (*Placenta placenta*). The rights to collect shells are leased out by the State Government.

There is prohibition to collect undersized specimens—61 mm in the case of chank, 11.4 cm in the case of window-pane oyster. Collection rights for shells are leased out by the government and the leases in their anxiety to make as much profit as possible try to extract maximum mileage out of the deal. In spite of regulations very often, undersized specimens are also collected and sold. A number of shells which are collected with tradeable and desired

species are just discarded and thrown on the shore. As there is no close monitoring of the fishing and no punitive measures, valuable resources are thus wasted (Sarvaiya, 1987). There was once a good pearl fishery, which was a state monopoly. But it is almost non-existent now. The decline in the populations of commercially important species are reflected in their dwindling catches. The lesson are clear that conservation of molluscs should be accorded top priority in the Gulf of Kutch to avoid further loss of this valuable resources.

In the Gulf of Mannar also, there are important shell fisheries like Chank fishery and Pearl oyster fishery. There are regulations governing the collection of shells and shell fishery.

FUTURE ACTION

Althouth several habitats of molluscs are declared as protected, there are no strict rules and regulations regarding collection of molluscs. Hitherto, the emphasis has been on terrestrial habitats. The importance given to conservation of Wetland ecosystem affords some protection to non-marine aquatic molluscs. There is a large scale exploitation of freshwater molluscs in eastern India. It is essential to initiate some control measures to protect the natural populations. Since molluscs serve as a poor man's diet, a complete halt to their collection may create socio-economic problem. Farming techniques have to be developed in case of freshwater molluscs also to make them available to local communities for consumption.

There should be a monitoring of shell collection in most productive and diversity-rich centres of the country. Shell collecting should be restricted to only abundant and common species, guidelines for collection of shells have to be prepared and the same to be made popular among the collectors. Hitherto, no mollusc has been included in the Wildlife (Protection) Act, 1972. Indian Trade classification lists a number of mollusca that are exported out of the country. An illustrated guide book of all the exported items, with the source species, should be prepared. One such book on "Squid and Cuttlefish" has been prepared by the Marine Products Export Development Authority. There should be proper monitoring, and permission to trade should be given to only those items recommended by the experts on the subject.

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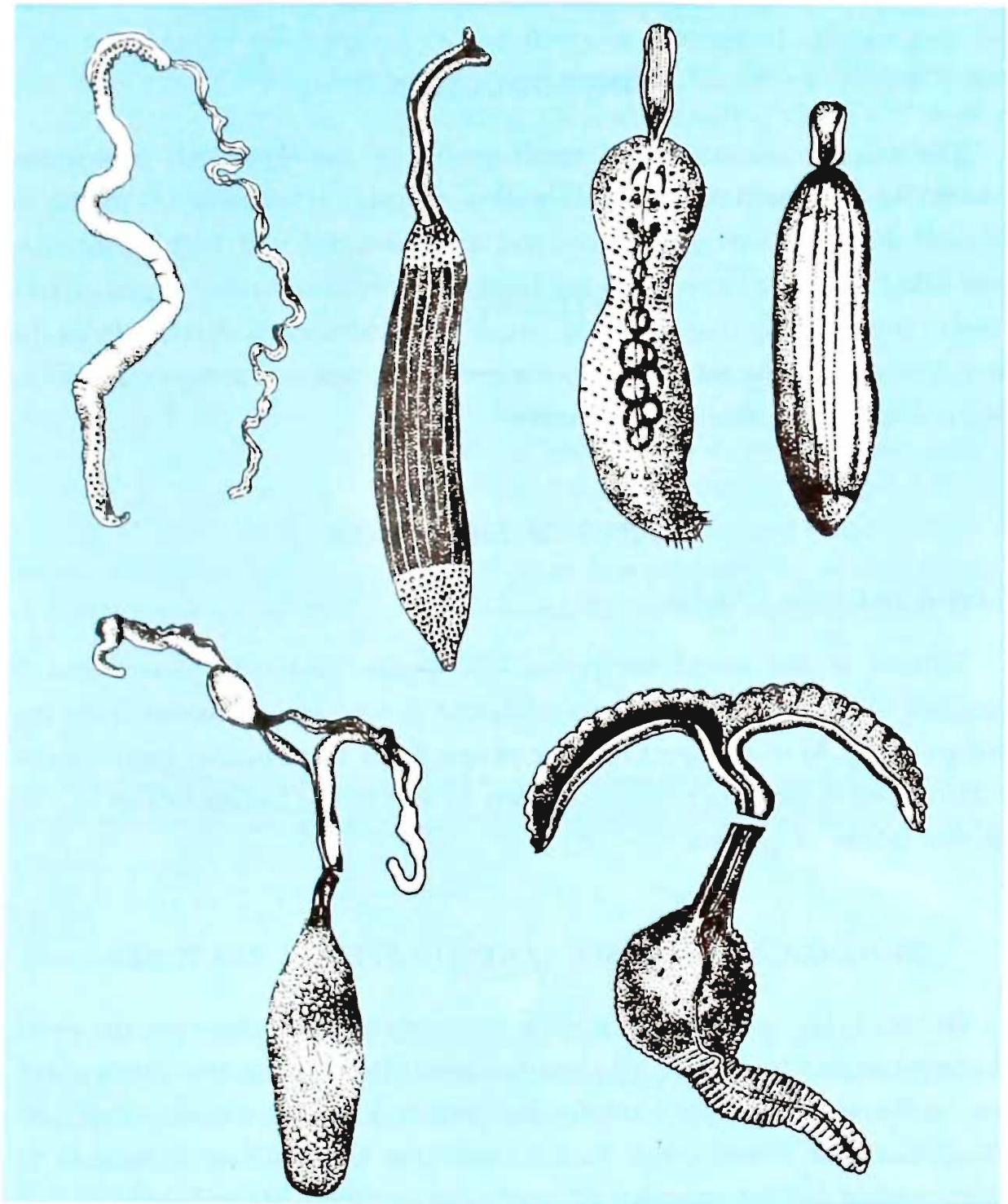
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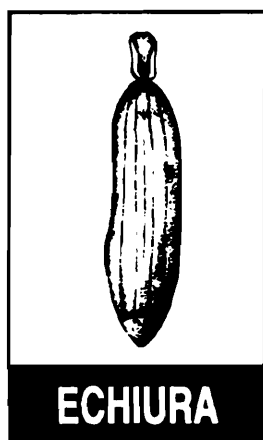
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Faunal Diversity in India : Echiura

BADRI PRASAD HALDAR

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The phylum Echiura is a small group of unsegmented, coelomate, bilaterally symmetrical and soft-bodied worms, cylindrical or ovoid in general shape, with mouth anterior and anus posterior, with highly muscular sacs filled with fluid in which long alimentary canal and other organs freely move. The common name “spoon worm” for echiurans is derived from the shape of the contracted proboscis—a muscular, sensory and non-retractile organ lying at anterior end of trunk.

STATUS OF THE TAXON

Global and Indian Status

Echiura of the world comprises 127 species under 32 genera and 5 families. Of these only 43 species under 14 genera are on record from the Indian ocean. In this respect number of species of the echiuran fauna of the Indian coast is fairly rich in comparison to that of the Indian Ocean i.e., 33 species under 11 genera.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Though it is a small group, a wide range of biological diversity has been observed in this taxon. The phylum has been divided into two classes and one of the class is further subdivided into two orders and five families. Altogether five families are there under this taxon. Class Echiurida is distinguished by the presence of innermost circular and oblique layers of muscles, anal vesicles and collateral intestine or siphon while the aforesaid characters are degenerated or absent in the class Sactosomatida.

DISTRIBUTION

The echiuran distribution along the Indian coast depends upon the habitat in which they live. The habitats range from mud, sand to hard substrate extending from intertidal to great depths of the ocean floor. They are burrowers in sand or mud where they make more or less permanent tunnels, sometimes they live under rocks, mud-filled molluscan shells or rock galleries. The faunal component so far known has been reported only from the intertidal zone of the mainland and insular region. If littoral and sublittoral zones are properly explored, more number of species may be found. About 20% of echiurans need to be explored. Maximum concentration of the number of species is observed at Gujarat including Gulfs of Cambay and Kutch, Lakshadweep, Andamans and Gulf of Mannar. Mud-dwelling forms are few in numbers and found in Kerala, West Bengal and Orissa.

ENDEMICITY

Endemic species are found as follows : four species of *Ochetostoma*, five species of *Anelassorhynchus*, and three species of *Acanthobonellia*. The occurrence of *Eubonellia valida*, hitherto known only from Arctic ocean and *Echiurus echiurus*, hitherto known from the Arctic, Pacific and the Atlantic oceans are reported from the Lakshadweep and hence are of great geographical interest. In India this phylum is represented by eleven genera, out of them *Achaetobonellia*, *Eubonellia* and *Rubricelatus* are monotypic.

VALUE

The Echiura is still regarded as of great scientific and academic interest. Some species are being used in scientific experiments as well as in biological studies.

THREATS

The main threat to this taxon is the destruction of habitats. Out of 33 species, five species are mud-burrowers, nine species are sand-burrowers and the rest inhabit under rocks, stones, coral boulders and inside the coral or rock-crevices. Echiurans are reported from the estuarine bodies of India. None of the echiuran species has yet been identified as a keystone species or reported as threatened species.

CONSERVATION

Presently, certain measures have been taken to prevent the habitat destruction. Areas of the Gulf of Mannar and Kutch have been declared as Marine National Parks by the Government. Andaman and Nicobar administration and Lakshadweep administration may also take similar steps so that removal of the natural wealth can be checked.

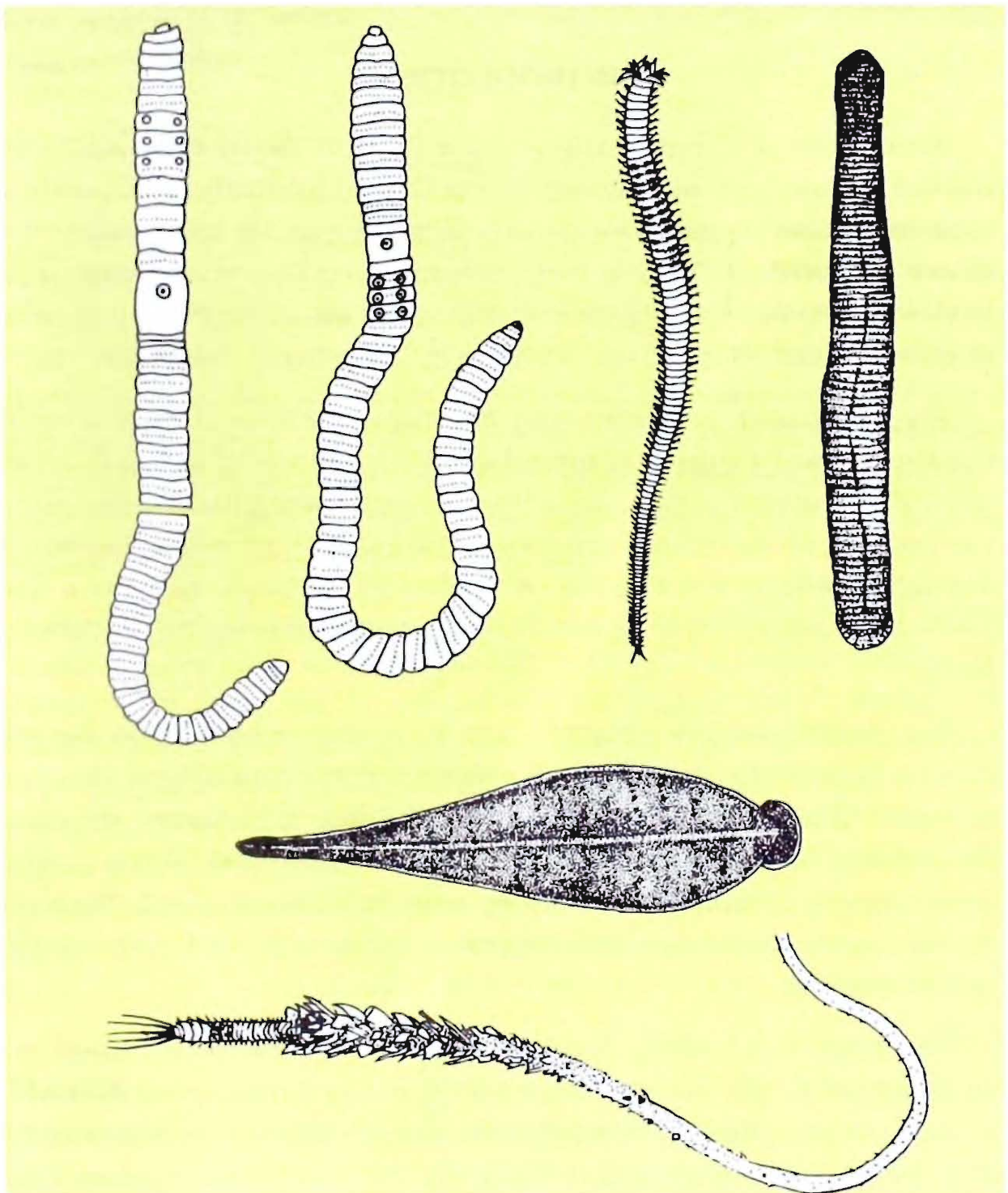
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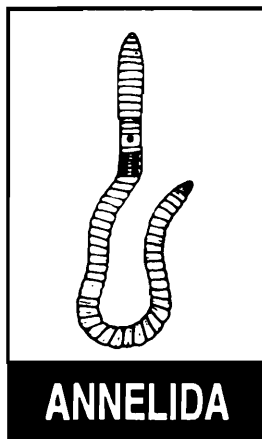
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Faunal Diversity in India : Annelida

J. M. JULKA

*Zoological Survey of India, High Altitude Zoology Field Station,
Solan - 173 212*





INTRODUCTION

Annelids are true worms with a linear series of similar body segments, marked externally by intersegmental grooves and internally corresponding transverse muscular partitions (septa) extending from the body wall to the alimentary canal. A spacious body cavity, the coelom (much reduced in leeches), separates the digestive system from the outer body wall. The phylum includes three classes : Polychaeta, Oligochaeta and Hirudinea.

The polychaetes or bristleworms are characterized by a distinct head, bearing eyes and a number of appendages. Each segment following the head is usually furnished with a pair of lateral bristle-bearing fleshy lobes called parapodia. Sexes are separate in most polychaetes. They are widely distributed throughout marine and estuarine environments, although there are a few freshwater species. These worms comprise both free-living and sedentary forms.

The oligochaetes lack parapodia, but the bristles or setae are implanted directly in the body wall. The head is devoid of any appendages. They are hermaphrodite. On the basis of size and habitat, oligochaetes are often divided into two convenient ecological groups : Microdrili (small, mainly aquatic worms including the terrestrial family Enchytraeidae) and Megadrili (larger, mostly terrestrial forms comprising earthworms and their aquatic representatives).

Hirudinea, the leeches, are devoid of setae or parapodia. They are characterized by the presence of suckers at one or both ends of the body. Like oligochaetes, they are hermaphrodite. Leeches inhabit marine, terrestrial and freshwater environments. Majority of them are blood-sucking ectoparasites and several species are free-living and predatory upon other invertebrates.

STATUS OF THE TAXON

Global and Indian Status

The group Annelida comprises approximately 12,700 species belonging to 1,470 genera and 128 families in the world. As many as 840 species under 312 genera and 80 families, forming 6.6% of the global annelid species, occur in India. This number may substantially increase with the discovery of new taxa, especially of aquatic and enchytraeid oligochaetes, interstitial and deep-sea species.

DISTRIBUTION

These animals are distributed in all the ecosystems of India. Polychaetes are inhabitants of the Bay of Bengal, Arabian sea, Indian ocean and various estuaries. Sedentary polychaetes are commonly found in large number burrowing into the sea bed, forming a major part of the benthic fauna in marine habitats. They are particularly abundant in coastal areas of Andaman and Nicobar Islands, West Bengal, Orissa and Gujarat, Gulf of Mannar, Chilka and Pulicat lakes, and Hugli-Matla, Mahanadi and Godavari estuaries. They are most common between tide marks and on coral reefs and in shallow littoral waters as far as 200 fathoms.

Aquatic Oligochaete fauna is poorly known in India, and most of the species are recorded from littoral zones of small freshwater bodies like ponds, tanks, pools, ditches, etc., all over the country. Several littoral and benthic speices have been reported from a single stream, the Bagga stream at Cuddapah in Andhra Pradesh. The Enchytraeidae (pot-worms) occur in terrestrial, littoral and marine habitats, being abundant in acidic soils with high organic matter. As compared to the world fauna, only 3% of enchytraeid species have so far been reported from this region, mainly from Orissa. Earthworms are widely distributed with major areas of their concentration in tropical rain forests of northeast and peninsular India and the Ghats.

Terrestrial leeches are abundant in most forests of northeast region, Darjeeling and Kumaon hills, Western Ghats and Kerala. Aquatic leeches predominate in streams and lakes throughout the country.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The range of diversity amongst the Indian Annelids comprises 3 classes, 80 families, 312 genera and 840 species as mentioned earlier. Class-wise diversity is as follows :

Class Polychaeta : 61 families, 200 genera and 400 species.

Class Oligochaeta : 14 families, 87 genera and 381 species.

Class Hirudinea : 5 families, 25 genera and 59 species.

Introduced Species diversity

Several species of earthworms have been carried in soil around roots of exotic plants from one zoogeographical realm to another. They have successfully colonized areas of introduction. As many as 49 peregrine species (13% of Indian earthworm fauna) have been introduced on the mainland. Introduced elements belong to the Acanthodrilidae (2 spp.), Criodrilidae (1 sp.), Eudrilidae (1 sp.), Glossoscolecidae (1 sp.), Lumbriciidae (17 spp.), Megascolecidae (16 spp.), Ocnerodrilidae (4 spp.) and Octochaetidae (7 spp.). Peregrine European lumbricids have established in the northwest and western Himalaya with temperate-like climate because of their inherent ability to withstand cold conditions and colonize disturbed habitats due to loss of native vegetation and increase in agricultural activity. Lumbricid earthworms have also been reported from the hills of Darjeeling, Sikkim, Arunachal Pradesh, Nilgiri, Aravali and Palni, mostly around tourist places. They form dominant components of the earthworm fauna of Himachal Pradesh and Jammu and Kashmir. *Pontoscolex corethrurus* (Family Glossoscolecidae), originally from South America, is suspected to have been brought to India after 1500 A.D. and is now well established in lowlands of Kerala and Tamil Nadu. Earthworm fauna of Andaman and Nicobar Islands comprises 27 species of which 74% are exotic. Only a few endemic species of *Amyntas* and *Metaphire* have been recorded; their relationships are probably with Indonesian earthworms.

Introduced diversity in leaches is obscured, but species of *Hemiclepsis*, *Paraclepsis* and *Whitmania* appear to be exotic in this country.

Human Annelid Relationship

Man is responsible to some extent, intentionally or unintentionally, for transporting peregrine earthworms in soil around roots of plants in various parts of the country. Even some endemic species are now wide-spread due to man's interference. Biodiversity among introduced taxa has increased but declined among endemic forms, mainly due to activity of human beings.

List of monotypic genera of annelida in India

A. Oligochaeta

Bahlia Gates

Chaetocotoides Julka

Curgiona Gates

Deccania Gates

Kotegeharia Julka

Octonochaeta Julka

Priodoscolex Gates

Troyia Jamieson

B. Hirudinea

Dinobdella Moore

Calebiella Gates

Comarodrilus Stephenson

Dashiella Julka

Karmiella Julka

Mallehulla Julka & Rao

Priodochaeta Gates

Scolioscolides Gates

ENDEMICITY

Most of polychaete species have very wide distribution and several are cosmopolitan, obscuring their endemism and zoogeographical relationships. About 25% of the known species from Indian waters are also found on the western shores of Europe. The pelagic forms show closer affinities with those of the Atlantic ocean.

Most Indian species of aquatic oligochaetes are also cosmopolitan. Seven species are considered truly endemic, forming 12.2% of known aquatic oligochaete fauna. Another 16 species are suspected to be endemic having close affinities with the fauna of southern hemisphere. The Enchytraeidae are represented by 21 endemic species belonging to 8 widely distributed genera. A real picture of endemism of Indian enchytraeids could be inferred only after further exploration of these worms. Majority of earthworm species are endemic, comprising 87% of known species from the mainland and Andaman and Nicobar Islands.

The endemic elements in leech fauna constitute about 42% of known species from our country. *Oosthichobdella* sp. and *Salifa* sp. are closely allied to African species, whereas species of *Dinobdella*, *Hirudinaria*, *Illebdella* and *Poecilobdella* have affinities with southeast Asian forms. Palearctic species are present in Kashmir and *Theromyzon sexoculatum* is endemic there.

There are some threatened species of annelids as listed in Table 1.

Table - 1
List of threatened species of annelida in India

A. Oligochaeta

1. *Comarodrilus gravelyi* Stephenson
2. *Drawida nilamburensis* (Bourne)
3. *Octochaetoides raoi* Gates
4. *Perionyx macintoshii* Beddard
5. *Priodochaeta pellucida* (Bourne)
6. *Priodoscoles montanus* Gates
7. *Scolioscolides bergtheili* (Michaelsen)
8. *Travoscolides cochinensis* (Michaelsen)

B. Hirudinea

1. *Asiaticobdella asiatica* (Blanchard) —Host : Frog
 2. *Hirudinaria manillensis* (Lesson)
 3. *Ozobranchius papillatus* Kaburaki—Host : *Kachuga tectum*
-

VALUE

Polychaetes have recently gained importance as indicator species of various degrees of marine pollution. They play a significant role in turning over sediments on the sea bottom. Some sea fishes also feed upon these organisms. Aquatic oligochaetes are important in retrieving organic matter from sediments in water bodies. They are also indicators of organic and thermal pollution. Earthworms are known to be friends of farmers. Their activities of burrowing into soil and breakdown of organic matter enhance soil fertility considerably. A large number of worms, comprising a major component to total biomass of soil invertebrates die during unfavourable season. Microbial decomposition of dead worms increases the amount of available mineralized nitrogen for growing plants. Addition of earthworms in sewage sludge and sludge-amended soils hastens in sludge decomposition. Because of their feeding habits, earthworms have been utilized for the disposal of organic wastes through vermiculture techniques for the production

of organic fertilizer or the worm crop as a source of protein in fish meal and poultry feed. A peregrine African earthworm *Eudrilus eugeniae* and an European dung worm *Eisenia fetida* are being cultured on a small scale in some parts of south and west India. Potentiality of endemic *Perionyx excavatus* should also be explored for culture under tropical conditions. Importance of earthworms as bait in angling is well known.

Annelids are useful in medicine as valuable compounds can be extracted from their bodies for treating a variety of ailments like haemorrhoids, jaundice, rheumatism, etc. Leeches have been used as remedies for throat and inflammatory swellings in human beings on account of their property of sucking excess of blood. Anticoagulant secretion (hirudin) from the salivary glands of leeches is being experimented in research to understand the mechanism of blood clotting. These glands also contain highly specified enzymes which dissolve blood clots. Annelids are of considerable value as experimental animals because of their easy availability in all types of ecosystems. They provide popular material for laboratory study at college/university level.

THREATS

Marine polychaetes are not seriously threatened. However, oil pollution in sea may adversely affect their populations considerably. Threats to diversity in aquatic oligochaetes, enchytraeids and leeches have not been documented. However, large scale deforestation in the northwest and western Himalaya has restricted the distribution of a land leech, *Haemadipsa zeylanica agilis*.

However, large-scale deforestation, especially in the northwest and western Himalaya and parts of central India, has resulted in reduction of diversity in leech and earthworm fauna and restricted the distribution of a land leech, *Haemadipsa zeylanica agilis*. Indiscriminate application of pesticides and changes in agricultural practices have affected the population of earthworms. Insecticides are also responsible for changes in the distribution of aquatic oligochaetes and leeches. Host-specific parasitic leech becomes vulnerable along with decline in the population of its host.

Several endemic earthworms have restricted geographical distributions and are highly specialized for certain soil conditions. They face a serious threat from deforestation and subsequent changes; particularly deep burrowing geophagous species, which are unable to withstand altered habitats. *Drawida nilamburensis*, a giant earthworm, inhabits sandy soil on

the bank of river Chaliar near Nilambur in Kerala. Excavation of sand from the area has disturbed the habitat to a great extent, posing a threat to its existence. Species of *Perionyx* prefer soils rich in organic matter and are closely associated with different types of vegetation. Some of *Perionyx* sp. are at risk from deforestation, especially in Darjeeling hills, an area of their major concentration. Repeated surveys have shown a decline in the frequency of occurrence of *Perionyx macintoshii*, another giant worm. Earthworms with very restricted distribution are vulnerable to multifarious human activities. Some of these species are : *Priodosclex montanus* and *Octochaetoides raoi* (Nandi hills), *Octochaetoides kurmagarensis* and *Hoplochaetella kurmagarensis* (Kurmagar Island, Karwar Harbour), *Priodochaeta pellucida* (Coonoor, Nilgiri hills), *Dashiella khandalaensis* (Western Ghats, Maharashtra) and *Scolioscolides bergtheili* (Darjeeling hills), and 4 species of *Travoscolides* (Kerala).

CONSERVATION

There are no specific past and ongoing policies and programmes for conservation of Indian Annelida. But indirect protection is being provided to freshwater oligochaetes, leeches and earthworms in existing wildlife sanctuaries, national parks, biosphere reserves and wetlands.

FUTURE STUDIES

In view of sparse information available on the current status of vulnerable annelids, the following measures are necessary as a first step : (i) to identify vulnerable annelid taxa, (ii) to estimate present status of vulnerable taxa, (iii) to study the ecology and biology of threatened species and (iv) to establish habitat reserves for monotypic earthworm genera with restricted distribution.

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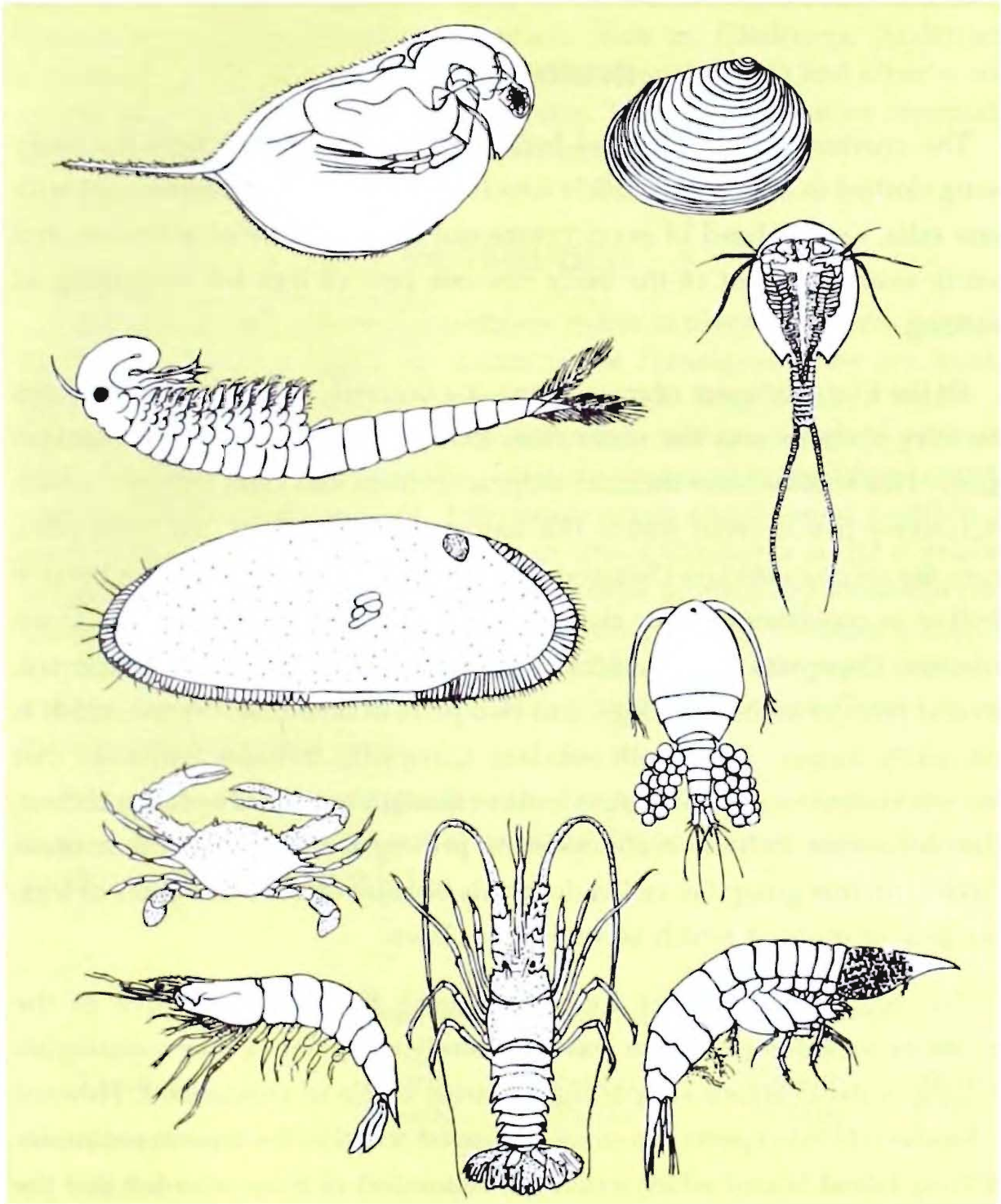
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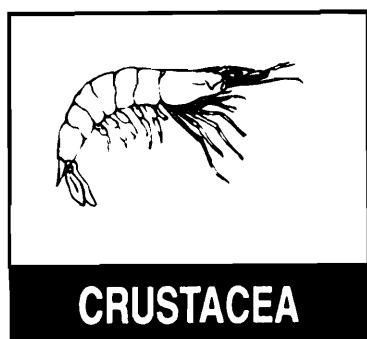
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Faunal Diversity In India : Crustacea

K. VENKATARAMAN AND KRISHNAMOORTHY

Zoological Survey of India, Marine Biological Station, Chennai - 600 028





INTRODUCTION

The crustaceans have jointed bodies as well as jointed legs, the body being clothed in a chitinous cuticle which may or may not be reinforced with lime salts. On the head of every crustacean are two pairs of antennae; and nearly every segment of the body has one pair of legs for swimming or walking.

Of the five subclasses of crustaceans, the first one, Branchiopoda includes the fairy shrimps and the water fleas that live in fresh water or brackish water. This subclass also includes tadpole shrimps and clam shrimps which exclusively live in fresh water. The tiny creatures, such as, the ostracodes, from the second subclass Ostracoda whose distinguishing mark is a bivalve shell as in conchostracans or clam shrimp, formed by the cuticle. The Third subclass, Copepoda has a typically spindle-shaped body with a forked tail, several pairs of swimming legs, and two pairs of antennae, one of which is noticeably longer. The fourth subclass, Cirripedia includes barnacles that are best known to grow on ship's hulls or floating timbers. The fifth subclass, Eumalacostraca includes crabs, lobsters, prawns and shrimps. The animals making up this group are called decapods because of their five pairs of legs, one pair or more of which serve also as claws.

The branchiopods were long considered the most primitive of the crustacea, an assumption that was not entirely acceptable to many zoologists in light of the evidence supporting a marine origin of crustaceans. Howard L. Sanders (1955), reports of a small arthropod found in the bottom sediments of Long Island Sound which eased the discomfort of those who felt that the most primitive living crustacean should be found somewhere in the sea rather than in vernal pools of snow melt or in desert rainwater depressions.

STATUS OF THE TAXON

Global and Indian Status

Global estimates of crustacean species diversity vary between 35,000 and 36,000. In India 2934+ species of crustacea have so far been reported representing about 8.2% of total global crustacean species (Table – 2). The diversity is contributed mainly by marine crustaceans (94.85%) whose knowledge is far from complete. Hitherto the work in India has been mainly concentrated on freshwater crustaceans, such as, Cladocera, Anostraca, Conchostraca and Notostraca of the subclass Branchiopoda and other works on Malacostraca, Ostracoda and Copepoda. The work on marine copepods, amphipods and decapods, still remains incomplete.

DISTRIBUTION

Crustaceans have adapted themselves to live in diverse habitats, from the sea around India to higher elevations of the Himalayas. They are mostly aquatic and a few forms live an amphibious life. They live in a variety of aquatic habitats in India starting from temporary rainwater pools to perennial lakes and rivers. In freshwater they are more abundant in the littoral regions with a variety of macrophytes. Temporary ponds also harbour a variety of small sized zooplankton community in which Cladocera is the dominant group. But the diversity and abundance is more in the rocky intertidal zone along the coast and in the coral reef ecosystem of Gulf of Manner, Gulf of Kutch, Lakshadweep and Andaman and Nicobar Islands with regard to marine crustaceans. Sandy coasts also support a variety of very small, microscopic interstitial fauna.

Distribution of different groups of crustacea in number of species in four major marine regions of the world including Indian marine region (Indowest pacific) is shown in Table – 1.

Table – 1
Number of crustacean species in four major marine regions

Taxon	Eastern Atlantic	Eastern Pacific	Western Atlantic	Indowest Pacific
Ostracoda (Myodocopa)	4	6	34	92
Cirripedia	61	114	90	247

Table – 1 (contd.)

Taxon	Eastern Atlantic	Eastern Pacific	Western Atlantic	Indowest Pacific
(Thoracica)				
Cirripedia (Acrothoracica)	7	4	3	34
Mysidacea	109	73	101	382
Amphipoda	185	125	70	575
Stomatopoda	29	46	71	196
Decapoda (estimate)	1000	1500	1300	5000
Total	1395	1868	1665	6526

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Table – 2 shows the number of family, genera and approximate number of species in the world and in India along with their habitat. The studies done throughout the world shows that for all groups of crustaceans, the greatest number of species is found in the extensive marine regions. Marine species have wider distribution in the Indo-pacific region whereas freshwater species have patchy, restricted and isolated distribution. The species of *Triops* (*Apus*) is found to occur in freshwater ponds of Kashmir, Uttar Pradesh, Rajasthan, Gujarat and Maharashtra and is also available in Tamil Nadu. It is not reported from North-Eastern India. Likewise, *Artemia* a saltwater anostracan, is reported from few coastal regions of India.

Table – 2

Number of species and their habitat

Taxon	Number in the World			Number in India			Habitat
	Family	Genera	Species	Family	Genera	Species	

Subclass : BRANCHIOPODA

Order : Notostraca	1	2	11	1	2	2	Fresh water
Order : Cladocera	11	52	450	9	40	90+	Fresh water

Table – 2 (Contd.)

Taxon	Number in the World			Number in India			Habitat
	Family	Genera	Species	Family	Genera	Species	
Order :							
Conchostraca	5	15	200	5	12	33	Fresh water
Order : Anostraca	7	25	180	5	6	12	Fresh water and Inland saltwater
Subclass : Copepoda	131	964	6970	63	193	540+	Marine & fresh water
Subclass : Cirripedia	29	203	1125	9	48	104	Marine & fresh water
Subclass : Ostracoda	54	693	5448	4	24+	120+	Marine & fresh water
Subclass : MALACOSTRACA							
Order : Stomatopoda	12	68	350	4	36	124	Marine
Order : Amphipoda	97	840	6000	45	128	143+	Marine, fresh water and terrestrial
Order : Isopoda	100	700	4000	22	155	200+	Marine, fresh water and terrestrial
Order : Cumacea	8	102	800	4	0	31+	Marine
Order : Decapoda	105	1200	10000	72	614	1535+	Marine, fresh water and terrestrial
Total	11	560	4864	243	1258	2934+	

The more number of species available in the Indian marine region (Indowest Pacific) may be attributed not only to the vast area but also to the presence of many archipelagoes. Andaman and Nicobar Islands, Gulf of Mannar, Gulf of Kutch and Lakshadweep are the main areas wherein the species diversity is more. For example, the epipelagic copepods of Indian

ocean especially the endemic forms alone amount to 21% which is higher than Eastern pacific (12.5%), Western pacific (13.7%) and Mediterranean (8.3%). Thus, the crustacean diversity is more in Indo-pacific region. Likewise, there are several endemic species available in India and due to the absence of a compreshensive data, it is too premature to attempt on estimation of species diversity and the extent of endemism.

The data on the diversity of crustacean fauna is meager when compared to other groups in india. However, the data on commercially and economically important crabs, lobsters and penaeid prawn resources are found to be satisfactory. A review of the literature reveals that as many as 117 species of prawns, 17 species of lobsters and 12 species of crabs inhabit the marine and estuarine areas of our country.

In India the availability of a large crustacea, coconut or robber crab is noteworthy. This hermit crab *Birgus lutro* is found in the Nicobar group of Islands and South Sentinel Island and is reported to be intensively hunted by the local inhabitants. Protection is to be afforded to this species in these areas.

ENDEMICITY

The crustacean fauna of India shows a variety of endemism in their faunal diversity (Table – 3) and some monotypic genera occur in the freshwater and marine habitats (Table – 4).

Table – 3
Endemic crustacea of India

Sl. No.	Taxon	No. of species	Region	Habitat
1.	Cladocera	2	Maharashtra & North East India	Fresh water
2.	Anostraca	?		
3.	Notostraca	1	Patchy distribution	Fresh water
4.	Conchostraca	2	Andhra Pradesh	Fresh water
5.	Ostracoda	29	East & West coast Kerala, West Bengal	Fresh water & Marine

Table – 3 (contd.)

Sl. No.	Taxon	No. of species	Region	Habitat
6.	Copepoda	221	East & West coast & Indian ocean	Fresh water & Marine
7.	Cirripedia	15	East, West coast & Indian ocean	Marine
8.	Mysidacea	21	East, West coast & Indian ocean	Marine
9.	Cumacea	8	East & West coast (152 in Indian ocean)	Marine
10.	Isopoda	30	East & West coast	Marine
11.	Amphipoda	40	East & West coast and Indian ocean	Marine
12.	Decapoda	132	East & West coast & Indian ocean	Marine

Table – 4
Monotypic genera of crustacea of India

Sl. No.	Taxon	No. of species	Habitat
1.	Cladocera	11	Fresh water
2.	Cochostraca	2	Fresh water
3.	Ostracoda	2 +	Fresh water
4.	Others	27 +	Marine

INTRODUCED SPECIES

Man, both purposefully and accidentally, has influenced the distribution of some crustacean species. In India the introduced species of Crustacea are very few except that of some branchiopod crustaceans which are very small in size. The import of food grain is one of the important sources of fresh water crustacean species introduction in India. Species, such as, *Daphnia*

similis and a few other cladocerans and one or two fresh water ostracods are reported to be introduced in India. Birds are also found to play some role in introducing these branchiopod crustaceans in our country from outside. A few species of barnacle have also been reported to be transported to India by ships from outside.

VALUE

Crustaceans like many other forms of life are of immense value to mankind. Next to fish, prawns and crabs are the major sources of quality protein to man. About 350 species of prawns and shrimps and 20 species of crabs are consumed all over the world.

Among the commercially important crustaceans of India, prawn occupies a dominant place by virtue of the fishery they support. Practically all the species of prawns and crabs are edible and a very large number of these are consumed all over the world. Majority of the commercially important species live in the sea and in estuaries of our major rivers. Some of the commercially important organisms of this group are prawns, lobsters, crabs and *Artemia salina* of inland salt waters.

Many crustacean zooplankton are considered to be pollution indicators. Among them *Maina micrura* is a common cladoceran zooplankton which indicates the organic pollution in fresh water habitats. Some of these crustaceans are also used for genetic studies due to their small size and their transparent body allow microscopic observation of the development and functioning of various organs and organ systems without dissecting the animals. The recent studies on these organisms show that they are very important tool for tissue culture, genetic engineering and aquaculture studies in India.

Zooplankton constitute branchiopod crustaceans and larvae of other groups which act as food for fishes and they form the largest group, viz., 59.9% among the food of fishes. Cladocera are considered to be one of the important groups converting more than 75% of the absorbed energy for reproduction and dominate the whole fresh water habitats. All these crustaceans play an indirect role in the trophic dynamics of fresh water and marine ecosystems. Being a secondary producer they transfer the energy from primary producer level to the next. In the absence of zooplankton, energy transfer from primary producer level to next level is not possible. Many higher invertebrates and vertebrates depend on these organisms as their food source.

In addition to the medicinal purpose for which some of the crustacean are used, there are some among them, whose activities are detrimental to man in the transmission of diseases. In tropical countries such as India and Southeast Asia, they play an important role in the life cycle of some parasites that affects human and other higher vertebrates.

A few crustaceans directly cause economic loss to man. The fouling of ship by barnacles may, at first sight seem to be trivial matter, but a heavy layer of fouling can increase the fuel needed to maintain a given speed by about 50%. Such increased costs of transport will be directly responsible for the increased price of goods carried by them. Damage caused by marine boring organisms is also of great economic importance and of all creatures responsible for such damages, two groups are well known. One is a group of bivalve molluscs the ship worms and the other being the isopod crustaceans of the genera *Limnoria* and *Sphaeroma*. Piles supporting wharfs and piers seem to be specially the targets of these borers and damage caused by them is very considerable.

Apart from food, hermit crabs have become popular as pets in the USA and more recently in Europe. Spiny lobsters are dried, and mounted for the souvenir trade in many parts of Southeast Asia and India. Crustaceans are also used as bait, especially crayfish and crabs.

THREATS

Man has been using the different habitats of these organisms for numerous purposes and for many years. The aquatic habitat of India satisfy domestic and industrial needs and provide transportation, hydroelectric power, a means for sewage and waste disposal, food for fish and sport and other recreation, including aesthetic appreciation. As a consequence of satisfying our various needs, we have created new types of habitats and modified pre-existing natural ones. We have destroyed some segments of the biota while husbanding others, and we have transported species from continent to continent both inadvertently and by design. Natural habitats have decreased and artificial ones increased. Some large impoundments are covered with floating plants-the water hyacinth *Eichhornia*, and the water lettuce *Pistia*, that are notorious nuisances. *Hydrilla*, has become a serious pest in canals, reservoirs and even lakes. Growing luxuriently on muddy substrates, this monocotyledon has ruined the recreation potential and sports fisheries of many water bodies in India. Many natural streams and lakes have been polluted by heavy metals and minerals such as asbestos, persistent biocides, fertilizers, acids, bases, oil, chlorine and the tremendous organic loads imposed

by urban sewage and waste from livestock. The structure and composition of crustacean population change with increasing acidity.

By constructing artificial waters for many purposes including aquaculture, we have increased diversity on one hand even as we have decreased it on the other. The overall picture, however, is probably a lessening of diversity, some of the original native species have disappeared or are endangered because of competition from the new arrivals and alternation of their fragile aquatic habitats. The less number of diversity of branchiopod crustaceans in India is mainly due to the introduction of several predatory fishes in the inland waters. Constant predation by predators is one of the factors that restrict species diversity of these crustaceans. The diversion of sewage into the aquatic ecosystems changes the surrounding population habitat to such an extent that crustaceans and other associated organisms will disappear. For example in the Salt Lake area in West Bengal the emergent littoral vegetation disappears while the phytoplankton blooms, dominated by *Microcystis aeruginosa*, occurring in all the open water. The loss of these ecosystems will ultimately lead to the elimination of rare and unique species of crustacea found in these habitats.

CONSERVATION STRATEGIES AND FUTURE STUDIES

It has now become clear that the problems of conservation are inseparable from the problems of environmental degradation. It is then just a matter of prudent management to approach conservation as a dimension of economic development. It is very well known that with the increasing loss of the habitats resulting from agriculture, urbanisation, industrial development programmes and over exploitation, the utilisation of crustacean resources should be given more consideration for conservation. Prawns and lobsters deserve special attention as these are over exploited in India, causing stress on natural populations. The robber crab or coconut crab, *Birgus latro*, the only crustacean species, occurring in the Little Nicobar Island and South Sentinel Island of Andaman and Nicobar Islands is in danger of extinction.

Conservation of crustaceans has been a subject of recent origin, after the publication of Red Data Book by IUCN. In India, conservation of these organisms is yet to begin as a strategy. Crabs, lobsters and prawns are some important groups which are commercially exploited. Some of the species are subjected to indiscriminate exploitation which also include collection of immature specimen. For example, in Andaman and Nicobar Islands certain regions have been protected and others demarcated for fishing. There are no

specific regulations in prohibiting the collection of important species of crustaceans used in trade. It is true, however, that there is no danger of a marine species getting extinct as majority of them have wide spread distribution in the Indo-pacific region. Recently it has been reported that the population of fiddler crabs has been on the retreat due to oil pollution, human garbage and waste water by blocking the tidal influence all over the world and in India.

The following are some of the measures proposed for protection of crustaceans in general.

The most productive areas of marine crustacean species are Andaman and Nicobar Islands, Lakshadweep, Gulf of Mannar and Gulf of Kutch. There should be strict regulations and monitoring in these areas since many crustaceans breed and flourish in the intertidal zones, mangrove and coral reefs.

Indiscriminate fishing should be stopped and no collection should be allowed till the affected species is able to replenish its natural population.

Comprehensive study and check lists of the available species especially marine ecosystem have to be undertaken in our country.

Deforestation should be totally banned in all areas of the country. Exposure of top soil leads to soil erosion which inturn along with agriculture practices eutrophicate the aquatic habitats. This will lead to habitat loss.

Domestic sewage and industrial wastes should not be allowed to mix with the natural water bodies.

Introduction of alien species of fishes and plants should be avoided. This will have a serious threat on the crustacean diversity especially in fresh water habitats.

There should be proper mangement and monitoring of all aquatic habitats including the marine by developing an integrated management plan.

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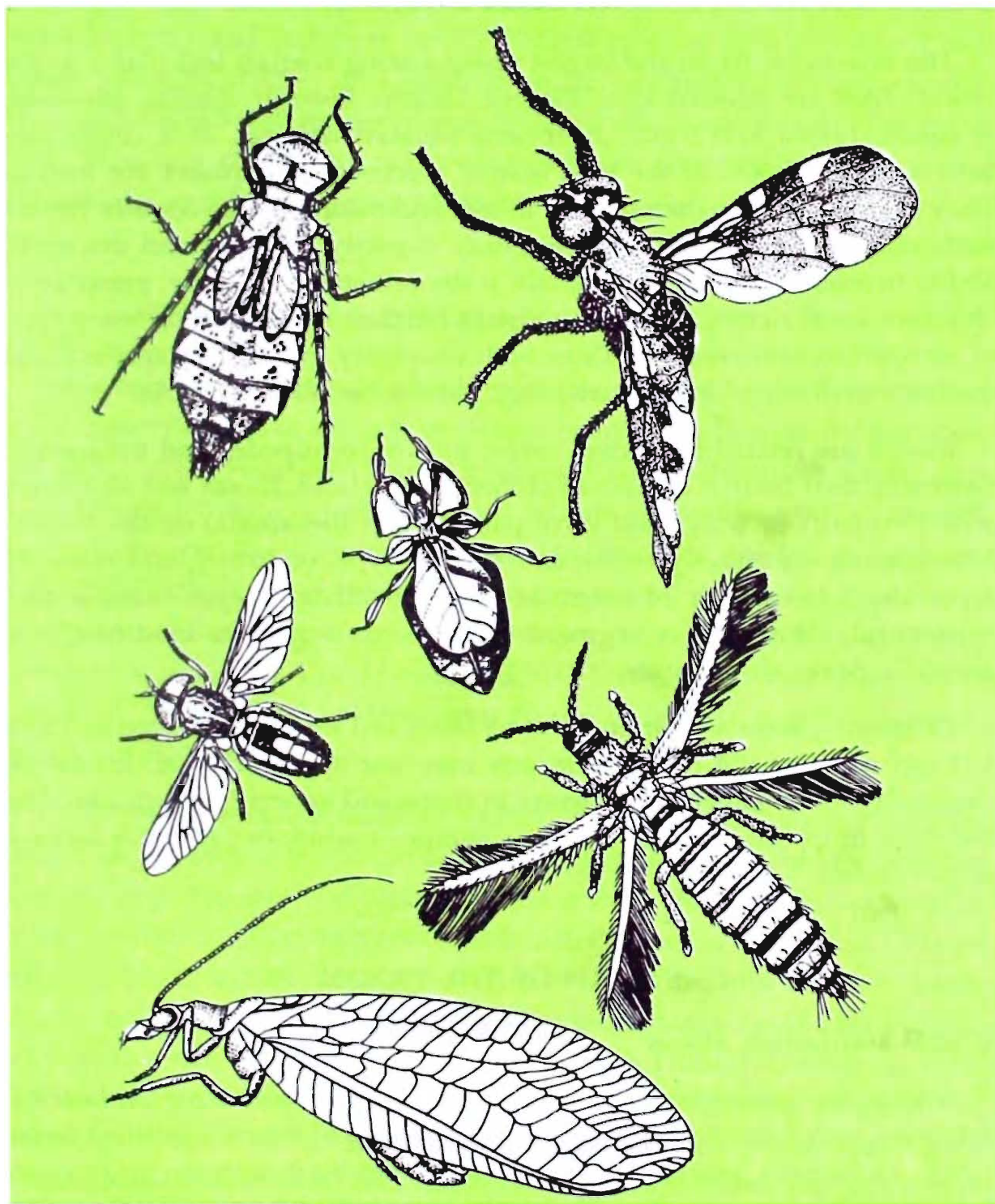
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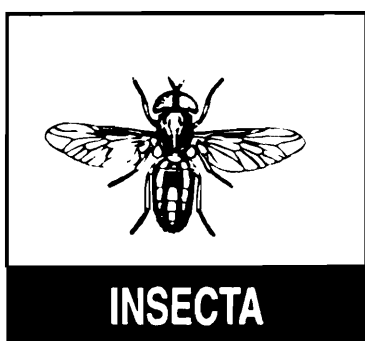
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Faunal Diversity In India : Insecta

R. K. VARSHNEY

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The insects are by far the largest group among animals and plants in the world. They are referred to as *Patanga*, *Shalabh*, *Bhramar*, *Pipilika*, *Makshika*, *Shadpada*, *Laksha Keet*, etc., in ancient Sanskrit writings. It is commonly believed that 75-80% of the total animal species on this planet are insects. They are found everywhere, except in seas and oceans. In this context, factors such as their minute size, high fecundity, capacity for flight and dispersal, ability to feed on variety of materials, water retention capability, presence of chitinous exoskeleton, etc., are important for their survival in different type of ecosystems with success. Thus, both in quality (number of species) and quantity (number of individuals) they outnumber all other biota.

Insects are related to spiders, crabs, prawns, centipedes and millipedes. Generally their body is composed of three parts : head, thorax and abdomen, with two pairs of wings and three pairs of legs (hexapoda) on the thorax. Mouth parts are either piercing and sucking type, or cutting and chewing type. Head has a pair of antennae and two kinds of eyes—simple and compound. Abdomen is segmented, with last segments modified into genitalia. Sexes are separate.

Obviously, there are variations of all kinds and form, as reflected in Table 1. Even some of the common insects may not appear typical. Immature stages (larva) are altogether different in shape and generally worm-like. The life cycle of insects is either (i) egg→ nymph→ adult, or (ii) egg→ larva→ pupa→ adult.

STATUS OF THE TAXON

Global and Indian Status

Insects are predominant biota on all continents including Antarctica. Estimates vary from 600,000 to one million species of insects identified so far which, authorities believe, are a fraction only since a large percentage is yet to be discovered and reported. The beetles alone include some 350,000 species.

Insects are believed to have appeared on this planet in the Devonian Period, some 200 million years ago and since survived the glacial periods and evolved into myriad forms.

The insect fauna of India is vast. In an old estimate, Lefroy & Howlett (1909) in the monumental book 'Indian Insect Life' reported 25,700 Indian species. Beeson (1961) estimated 40,000 and Menon (1965) 50,000 Indian species. Roonwal (1989) opined that insects constitute two-thirds of the total fauna in India and comprise nearly 100,000 species, of which about half remain yet to be studied. In a recent estimate Varshney (1997) has reported 589 families and 51450 species of insects from India (modified after Jairajpuri, 1991). However, the current corrected figures are given in Table 2, showing 619 families and 59353 species of insects from India.

DISTRIBUTION

India provides wide range of ecological, climatic and vertical distribution of the insect fauna. The altitudinal variations from sea level to the snowline and above in the Himalaya present a series of zones. The insect distribution is influenced by these vertical zones on account of their vegetation, rainfall, temperature, etc. Right from Mountain Highlands in Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, West Bengal and Arunachal Pradesh, to desert areas of Rajasthan, Gujarat and Ladakh (cold desert), to tropical Humid Forest areas in Kerala, Tamil Nadu, and N.E. India and to Insular Biomes of Andaman, Nicobar and Lakshadweep groups of Islands, a great variety of insects are known to occur.

The tropical evergreen forests of eastern Himalaya and hills of the north-eastern India harbour maximum number of species. This could be due to the type of vegetation, hot and humid climate and the geographical location of the area, which is a meeting place of the Indian Peninsular, Malaysian, Chinese and Palaearctic regions. A second such rich area is the hills of South India, viz., the Nilgiri, Annamalai, Palni, Caradamom, etc., and the Western Ghats. A third such rich habitat of insects is the western Himalaya, covering foothills and mountainous areas of Jammu & Kashmir, Himachal Pradesh and Kumaon and Garhwal of Uttar Pradesh. With temperate climate and forests of oak, pine, birch, cedar, etc., these areas provide niches for many rare species. It is evident that in the elevated, colder and forested areas of the country, the insect fauna is much varied, colourful and plentiful. Some

localities like the Khasi Hills, Sikkim, Darjeeling, Yercaud, Simla, Mussoorie are famous type-localities of a larger number of insect species including some unique ones.

The Great Indian desert is comparatively poor than moist deciduous forests. About 20 orders of insects are known from the former area (Roonwal, 1982).

There are still areas that have not been adequately explored for its insect wealth. These include Pangi Valley (Himachal Pradesh), Valley of Flowers (Uttar Pradesh), Neora Valley (West Bengal), Tirap (Arunachal Pradesh), Agasthyamalai and Eravikulam (Kerala), etc.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The insects are classified into about 25-30 orders (number varying with different authorities). Some of the Insect orders and the common insects included in them are indicated in Table 1.

Table – 1
Insect orders with common examples

Name of Order (arranged alphabetically)	Insects included (common names)
Coleoptera	— Beetles, Weevils, Fireflies, Ladybirds, Wood Borers
Collembola	— Spring tails
Dermaptera	— Earwigs
Dictyoptera (Blattaria and Mantodea)	— Praying mantids, Cockroaches
Diptera	— Flies, Mosquitoes, Gnats, Midges
Diplura	— —
Ephemeroptera	— Mayflies
Embioptera	— Web-spinners
Hemiptera	— Bugs, Leafhoppers (Jassids), Aphids, Coccids (Scale insects, Mealybugs), Cicadas, Bedbug
Hymenoptera	— Bees, Wasps, Ants, Bumblebees, Sawflies
Isoptera	— White ants (Termites)
Lepidoptera	— Moths, Butterflies

Table – 1 (contd.)

Name of Order (arranged alphabetically)	Insects included (common names)
Mecoptera	— Scorpionflies
Neuroptera	— Lacewing flies, Ant lions
Odonata	— Dragonflies, Damselflies
Orthoptera	— Grasshoppers, Locusts, Katydid, Crickets
Phthiraptera	— Lice
Phasmida	— Leaf insects, Stick insects (Walking sticks)
Plecoptera	— Stoneflies
Protura	— —
Psocoptera	— Psocids, Book lice
Strepsiptera	— Stylops
Siphonaptera	— Fleas
Thysanura	— Silver-fishes, Bristle tails
Thysanoptera	— Thrips, Fringe-wings
Trichoptera	— Caddisflies

Biological diversity is expressed in the large number of insect species reported from India. Current estimate shows that about 59353 species are already recorded from India, which form merely 6.83% of the world insect fauna (Table 2). It may be pointed out here that two insect orders, Grylloblattodea and Zoraptera do not occur in India, hence left out from this Table.

Table – 2
Number of Insect Families and Species in India

Insect Order (arranged systematically)	No. of Families in India	No. of spp. in India	No. of spp. in World	% of spp. in India
APTERA				
Thysanura	5	31	1250	2.48
Diplura	3	16	355	4.50
Protura	3	20	260	7.69
Collembola	8	210	5500	3.81
HEMIMETABOLA				
Ephemeroptera	12	106	2200	4.81
Odonata	17	499	6000	8.31

Table – 2 (contd.)

Insect Order (arranged systematically)	No. of Families in India	No. of. spp. in India	No. of. spp. in World	% of spp. in India
Plecoptera	7	113	2100	5.38
Orthoptera	30	1750 ⁺	17250	10.14
Phasmida	8	146	2262	6.45
Dermaptera	7	320	2000	16.00
Embioptera	2	33	200	16.50
Blattariae	12	186	5000	3.72
Mantodea	6	162	2310	7.04
Isoptera	7	253	2000	12.65
Psocoptera	16	90	2500	3.60
Phthiraptera	8	400	3000	13.33
Hemiptera	77	6500	80000	8.12
Thysanoptera	5	693	6000	11.55
HOLOMETABOLA				
Neuroptera	13	335	5000	6.70
Coleoptera	104	15500	350000	4.42
Strepsiptera	4	18	554	3.25
Mecoptera	2	15	350	4.28
Siphonaptera	8	52	2000	2.60
Diptera	87	6093	100000 ⁺	6.09
Lepidoptera	84	15000	142500	10.52
Trichoptera	19	812	7000	11.60
Hymenoptera	65	10000	120000	8.33
TOTAL	619	59353	867391	6.83

This large number of species of insects occur in a variety of habitats. In fact, some habitats have become indicator of respective insect orders, as depicted in Table 3.

Table – 3
Habitat-wise distribution of some insect Orders

Habitat	Insects therein
1. Green vegetation; different parts of plants	Lepidoptera, Coleopter, Hymenoptera, Hemiptera, Dictyoptera (Mantodea), Thysanoptera

Table – 3 (concl.)

Habitat	Insects therein
2. Under stones; bark and crevices of trees; decaying logs; leaf litter	Protura, Dermaptera, Embioptera, Psocoptera, Coleoptera
3. Drains; godowns; domestic dark and food corners	Dictyoptera (Blattaria)
4. Soil; humus; snow	Collembola
5. Soil; moss; rotten wood	Diplura
6. Logs; mud mounds; under stones; ant's nests; wood work in buildings	Isoptera
7. Open grasslands; foliage; crops; on light	Orthoptera, Hemiptera, Neuroptera, Lepidoptera
8. Book shelves; on wall, behind hanging pictures	Thysanura
9. Near or in water- bodies	Ephemeroptera, Odonata, Trichoptera, Plecoptera, Aquatic Hemiptera, Aquatic Coleoptera
10. Garbage	Diptera
11. Parasitic on other insects	Hymenoptera, Diptera, Mecoptera, Strepsiptera
12. Parasitic on skin of mammals and birds	Phthiraptera, Siphonaptera, a few Hemiptera

It will be interesting to note that insects have adapted to the flowering plants (which evolved later than earliest insects) in a big way. A large number of insects feed on plants, including economically important plants and crops. The latter are thus termed as pests. It is for this reason that insects have been called man's worst enemy. A brief indication is given in Table 4 of the insect groups which generally occur on a typical plant part.

Table – 4
Insects on a typical plant

Part of plant	Insects therein
Root	— Different kinds of larvae; beetles; aphids; coccids
Stem	— Stem borers of moths and beetles; other insects on or under bark
Leaves	— Bugs of various kinds, including aphids, coccids and hoppers; leaf miners; caterpillars; ants
Flowers	— Honeybee; bumble bee; butterflies; beetles; thrips; syrphid flies
Fruits	— Fruitfly and other flies; larvae of moths and beetles; coccids
Grain	— Store-grain-beetles, moths, cockroaches, ants

Besides these habitats, insects are also found on fungi, algae, moss, lichen, rotten wood, leaf litter, under logs, under stones, carrions, dung and other excreta, under bark, in books and papers, wood piles, godowns, haystacks, granaries, on or below snow; on electric light; in running and stagnant waters; in clothes and burrows in ground. Some insects make galls and mines in different parts of the plants and live there.

ENDEMICITY

So far there has been no indepth and standard study of the enumeration of endemic taxa of insects in India for many reasons. Firstly, the number of genera and species to be handled is extremely large; secondly, there has still not been thorough surveys conducted for all groups of insects in the entire country; thirdly, a good number of genera and species are "known from their original record only", giving the impression that they are endemic there, which may or may not be true due to insufficient surveys; and fourthly, the detailed taxonomic studies of all orders and families occurring in India could not be completed for want of experts. Thus, only some superficial estimation have been made on the endemicity. One such attempt was made by the scientists of the Zoological Survey of India in the beginning of this decade, the results of which were published by Ghosh (1996). The number of endemic genera and species given therein is modified and shown in

Table 5, based on recent estimates published in the preceeding articles of the present document.

Table – 5
Number of endemic genera and species of insects in India.

Order	Endemic Genera	Endemic Species
1. Thysanura	12	23
2. Diplura	3	12
3. Protura	4	16
4. Collembola	22	45
5. Ephemeroptera	—	72
6. Odonata	6	115
7. Plecoptera	—	66
8. Orthoptera	77	200
9. Phasmida	—	70
10. Dermaptera	3	117
11. Embioptera	—	14
12. Blattariae	14	60
13. Mantodea	24	86
14. Isoptera	—	170
15. Psocoptera	—	15
16. Phthiraptera	—	16
17. Hemiptera	579	2421
18. Thysanoptera	92	520
19. Neuroptera	13	262
20. Coleoptera	923	3100
21. Strepsiptera	—	15
22. Mecoptera	—	2
23. Siphonaptera	—	15
24. Diptera	107	2135
25. Lepidoptera	100	1500
26. Trichoptera	5	650
27. Hymenoptera	516	9000
Total	2500	20717

Based on Table 5, it may be pointed out that endemic genera are not reported from all insect orders present in India, as has been erroneously stated by Ghosh (1996).

THREATENED SPECIES

Some insect groups in India are now considered endangered and these have been included in the revised lists of 'Schedules' to the Wild life Protection Act, 1972, which have come into force from 2.10.1980 (Anonymous, 1992). These are shown in Table 6.

Table – 6

Insects in Indian Wild Life Schedules

Schedule No.	Insect Group	No. of species included
1. Schedule I : Part IV	Butterflies	126
	Dragonfly	1
2. Schedule II : Part II	Beetles	37
	Butterflies	304
3. Schedule IV	Butterflies	19

Brief particulars of these insects, order-wise are as follows :

Odonata : There is an intermediate suborder between Anisoptera (dragonflies) and Zygoptera (damselflies), called the Anisozygoptera. It is represented in India by a single relict species, *Epiophlebia laidlawi*. It was reported from Darjeeling district in the Eastern Himalaya, where it inhabits pools of hill streams. There is no report of it since last 80 years from India, though it has been found in Nepal.

Lepidoptera : Species included in the 'Schedules' belong to the butterfly families Amathusiidae, Danaidae, Lycaenidae, Nymphalidae, Papilionidae, Pieridae, Satyridae, Riodinidae and Hesperidae.

Earlier Varshney (1986) reported that there are 363 rare and 144 very rare species and subspecies of Indian butterflies. Besides butterflies, some large and beautiful moths like the atlas moth (*Attacus atlas*) and the moon moth (*Actias selene*) and their sister species should also be protected. At present, no species of moths is included in the 'Schedules'. It is known that some beautiful butterflies and moths are exploited commercially.

Coleoptera : Species included in the 'Schedules' belong to the beetle families Carabidae, Chrysomelidae, Cucujidae and Inopeplidae.

Since detailed population studies have not been carried out on majority of invertebrate animals, including insects, it is not possible to clearly demarcate

the species threatened with extinction. However, some insect groups are definitely getting rare. Phasmida (stick and leaf insects) are superb examples of mimicry in nature. This group has become exceedingly rare. Other such interesting insects in India include the rare snake fly (*Inocellia crassicornis*) (Neuroptera), and the curious mole-cricket (*Schizodactylus monstrosus*) (Orthoptera) with its curled long wings. Among butterflies, two most beautiful ones, the oakleaf butterfly (*Kallima*) and the Kaiser-e-Hind (*Teinopalpus*), have been included in Schedule-II. These require inclusion in Schedule -I. The largest Indian butterfly, the birdwing (*Troides*), has not even been included in the list. To conclude, it is feared that with further environmental degradation such as increasing deforestation, increasing use of chemicals in agriculture, pollution, etc., several taxa of Indian insects will be endangered soon and eventually lost forever if not protected.

INTRODUCED SPECIES

A number of insect species have been introduced in the country knowingly or unknowingly. Whereas some insects have been imported for the biological control of some other insect pests and weeds, there the unintentional introduction of insects often takes place alongwith the transportation of grains, fruits, animals and other goods.

One early example of the import of an insect in India is that of the lantana bug, *Teleonemia scrupulosa* (Hemiptera). This species was introduced about 50 years back for the control of lantana bushes. However, the insect was found to be a threat to the teak plants as well, hence, its culture was stopped but by the next few decades it has spread over the major part of country.

In recent times, the erstwhile Indian Station of the Commonwealth Institute of Biological Control introduced a number of parasitic Hymenoptera species and some lady bird beetles for the control of severe coccid and aphid pests. The Department of Plant Protection and Quarantine has intercepted periodically some uninvited insects alongwith the different consignments received at various ports in the country.

VALUE

Insects are pests of significance on all important crops of cereals, pulses, fibre crops, oilseeds, sugarcane, tea, coffee, vegetables and fruit plants. They cause at least 10% loss to the agricultural and horticultural plants and forest products annually. A rough estimate shows that the country is losing an exchequer of worth Rs. ten hundred crores per year due to injurious insects.

Besides, insects are carriers of diseases in men and domestic animals. For the spread of number of serious diseases like malaria, filaria (elephantiasis), yellow fever, dengue, etc., the insects are primarily to be blamed.

However, the beneficial side is no less valuable, as the insects are the pollinators of plants, thus they play an important role in the nature. They serve as food for other insects, spiders, fishes, birds, etc., forming a vital link in the food chain.

Among the beneficial insects, three are foremost—the honey bee, the silk moth and the lac insect. There are four kinds of silks produced in the country from different silk moths. India produces the largest quantity of lac in the world, most of which is exported out in one form or other.

For biological control, some insect species which are either predaceous or parasitic on other insect or mite pests have been utilized the world over. Some other insect species have been found useful in the control of weeds like *Lantana*, *Opuntia* and *Parthenium*.

There are several other kind of values applicable to the insects in scientific, ecological, economic, ethical and educational fields, too many to be enumerated here.

CONSERVATION AND FUTURE DIRECTIONS

While nature is taking care of its majority biota in its own way, some thought ought to be given by the planners to the protection and conservation of threatened species of insects in various ecosystems. For this purpose, the exploration and inventorisation is a primary step.

Conservation of habitat is equally important in case of insects as in the cases of other animals. Since many insects are forest dwellers, afforestation can help in saving some of the insect species from the danger of extinction. Protection of wetlands from pollution and other human interference will be helpful in safeguarding aquatic insect populations.

Insectories as places where insect cultures are maintained, and Insect Galleries of the museums, can be highly educative. For example, bees, wasps and white ants, with their various castes and with actual specimens to observe, can provide a very useful demonstration on the life of social insects.

Nature Clubs can take up the preparation of lists of insects in their area. Such lists are available for every County in England. Films on the role of

insects in spreading disease, or on the succession of populations of pest species, or on the apiculture, sericulture and lac culture can prove quite useful. Insects may be minute in size, yet they are big enough not to be ignored on the issues of interaction with man and environment.

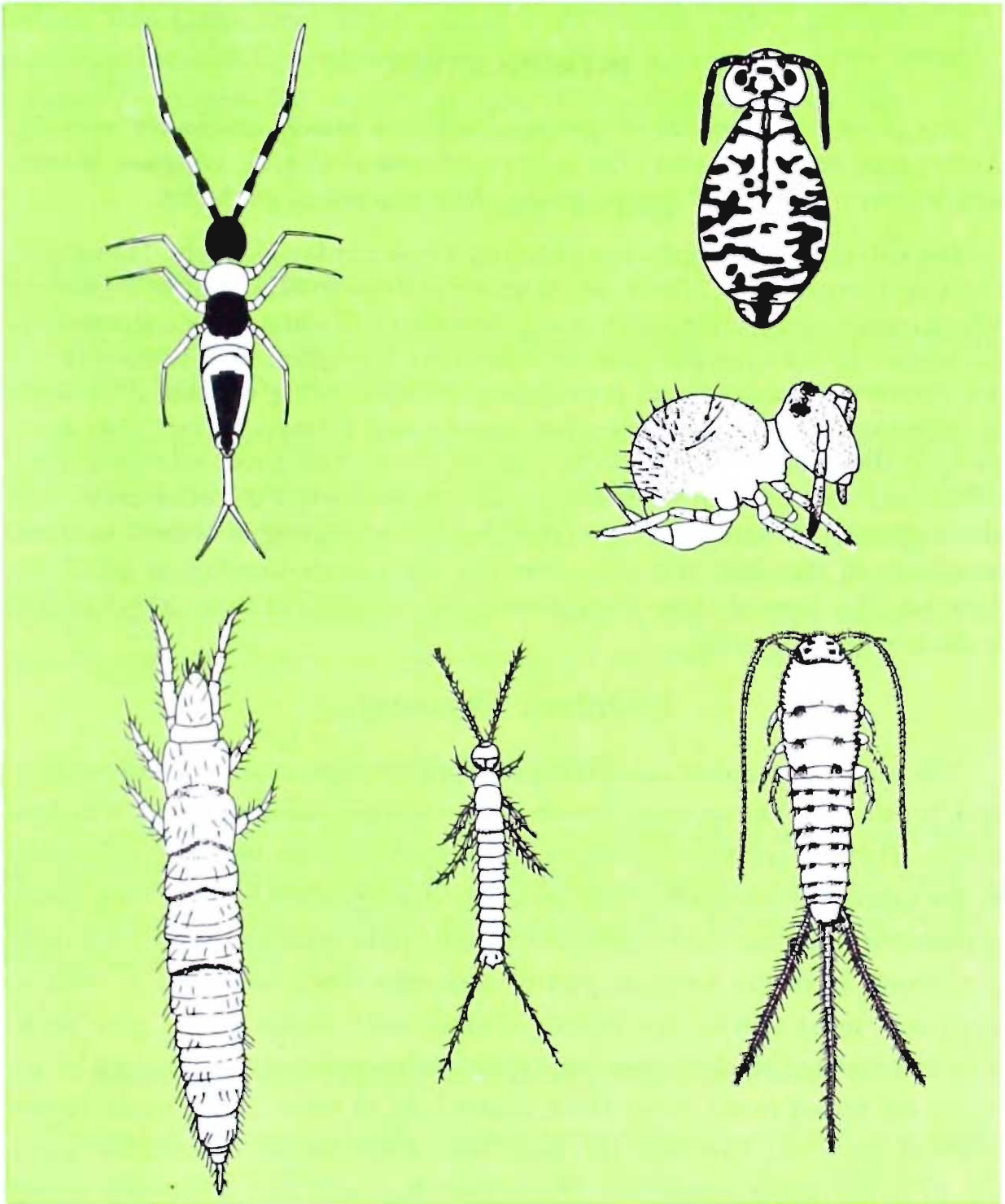
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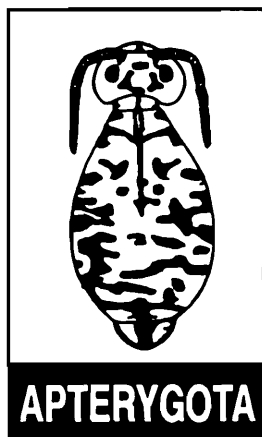
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Faunal Diversity in India : Apterygota (Thysanura, Diplura, Protura, Collembola)

A. K. HAZRA, M. BISWAS AND S. K MITRA

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The present day insects are grouped into two major sub-classes, namely, Apterygota and Pterygota. The Apterygota are primarily wingless insects which never developed wings during their process of evolution.

The sub-class Apterygota comprises four insect orders, namely, Thysanura, Diplura, Protura and Collembola. Majority of these insects play an important role in enriching the soil fertility or in pollination and some of the collembolans are known as the veritable pests of cultivated vegetation. Our knowledge of the Apterygote insect fauna is extremely meagre owing to their difficulties in collection. All the four orders are represented in India. In fact, they have escaped the attention of field collectors owing to their small size, concealed habits and also some of them being dull or unattractive in colouration. It is also necessary to know the special technique employed in collecting these insects from the field and for extracting them from the soil or leaf litter samples. The present state of our knowledge for each of these insect orders is dealt with separately.

1. Order : Thysanura

The order Thysanura comprise popularly known insects of 'Silver fish' and 'bristle tail'. Thysanurans are small, soft bodied, fishlike, scaled, wingless insects. They are considerably larger insects than the other members belonging to the subclass Apterygota. They are easily distinguished by very long many segmented antennae and 2 anal cerci and single median telson projecting posteriorly from the terminal part of abdomen. They are blind as well as eyed and most species are heavily clothed with scales which give these insects a mottled black, brown, silvery or golden appearance. The free living forms are found in the forest floor, under bark of trees, under rocks, in the nests of ants and termites. The members of the family Machilidae occur mostly in the decomposing litter of the forest floor, and are capable of jumping by means of the apical ventral stylets. A few species, such as, *Lepisma saccharina* and *Ctenolepisma longicaudata* cause damage to books, photographs, bakery

and other house hold articles. A fairly large work has been done from the various parts of the world on Thysanura, but in comparison to the world fauna a very little is known on these insects in India. The first record of Thysanura from India is that of Escherich (1903) who described the species *Lepisma indica* and *L. gyriniformis*. Thereafter, Silvestri (1913, 1938, 1948), Janetschek (1964), Wygodzinsky (1941, 1963, 1972, 1994) contributed to our knowledge of Indian species. Since then, works on Indian Thysanuran fauna was neglected for a long time. After that Hazra (1980, 1993) described some Indian Thysanura from West Bengal and Mendes (1990) published on zoogeographic affinities of Indian Thysanura. Extensive and intensive faunistic surveys are required to explore the total Indian fauna of Thysanura.

STATUS OF THE TAXON

Global and Indian Status

The world fauna of Thysanura approximately consists of 5 families, about 130 genera and over 1250 species.

The quite poorly known Indian fauna of Thysanura presently represented by 31 species belonging to 21 genera and 5 families and 2 subfamilies. Under suborder Microcoryphia the family Machilidae has 7 genera, 10 spp., and family Meinertellidae has 1 genus and 1 species. The suborder Zygentoma consists of families Lepismatidae with 8 genera and 13 spp., Nicoletiidae with 1 genus and 2 spp. and Ateluridae with 4 genera and 5 spp.

DISTRIBUTION

The known range of distribution of the taxa in India are as follows : West Bengal, Sikkim, Orissa, Assam, Uttar Pradesh, Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Maharashtra, Kerala, Tamil Nadu, Karnataka and Delhi.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The species belonging to the family Lepismatidae correspond to a quite less known assemblage of cryptic, free living, myrmecophilous or termitophilous thysanurans. Several genera are well represented along wide

areas, although others are known exclusively by their type species only. Within Microcoryphia the genera like *Allopsontus*, *Haslundichilis*, *Himalayachillis* and *Machilanus* have been reported only from the north eastern mountainous states, *Graphitarsus* from the southern India and *Machilontus* from the north eastern India. *Allopsontus* is endemic to India. *Machilanus* has wider geographical range of distribution and includes more numerous species. *Ctenolepisma* has a very wide geographical distribution. *Afrolepisma* and *Xenolepisma* show a clear Afro-Indian distribution. The very primitive genus *Gastrotheus* shows a wide geographical distribution and it has remarkable ecological plasticity, with edaphic, myrmecophilous and termitophilous species. *Lepidospora* is the only genus, included within Nicoletiidae, from India with approximately 20 species distributed in two sub-genera.

On an analysis of the available literature, it is evident that this group inhabits a wide range of ecological niche. Some members of the family Machilidae occur mostly in the decomposing litter of the forest floor and thus have some role in the process of humification, some are localised and adaptive in different environmental conditions like forest floor, under bark of trees, under rocks and in the nest of ants and termites.

ENDEMICITY

Among the known taxa the following 23 species are endemic to India : *Allopsontus annandalei*, *Graphitarsus surindicus*, *Haslundichilis quadri*, *Himalayachilis muriensis*, *Machilanus insensilis*, *Machilanus lapidicola*, *Machilanus schmidi*, *Machilis lefroyi*, *Machiloides lawrencei*, *Machilontus* sp., *Afrolepisma nigrina*, *Ctenolepisma alticola*, *Ctenolepisma boettgerianum*, *Tricholepisma gravelyi*, *Xenolepisma subnigrina*, *Lepisma indica*, *Lepidospora notabilis*, *Assmuthia inermis*, *Assmuthia spinesissima*, *Atelura typhloponis*, *Gastrotheus indicus*, *Platystylea barbifer*, *Stylifera wygodzinskyi*.

VALUE

These insects, such as, *Lepisma saccharina* and *Ctenolepisma longicaudata* frequently commensals of man are found in houses. They feed upon the starchy matter, under wall paper, book, woolen and silk cloth and thus cause an immense damage of household article and books, for which they are as serious house hold and library pest in India. These insects have also some role in the process of humification.

2. Order : Diplura

Diplura still remains one of the least studied group of Indian fauna. They are soft bodied wingless insects. White or yellow in colour, body devoid of any scales, eyes absent, their length up to 50 mm, without median telson. They are easily distinguished by a paired long filiform or shorter and annular or forcep like cerci. In accordance with their concealed mode of life, all known species are entirely blind.

They exhibit semi gregarious distribution. They are generally soil inhabitants and usually found in larger number in the humus soil or in the forest floor, and also under stones or logs in damp environment throughout India. A few are commonly found running about in the nests of ants but whether there is any direct association with the ant is unknown.

The knowledge of Indian Diplura is extremely fragmentary, no one in India is actively engaged in studying this group and most part of the country remain unexplored. Whatever information is available about these insects till today is due to the contributions of Silvestri (1913, 1937), Conde (1952, 1972), and Mitra and Rao (1977).

STATUS OF THE TAXON

Global and Indian Status

The Diplura is still unexplored in various parts of the world. The world fauna of this group is represented by approximately about 355 species under 77 genera, of which the family Japygidae embodies the largest number of genera and species.

Only 16 species under 7 genera are so far known from the Indian subregion. They belong to 3 families, namely, Japygidae, Projapygidae and Campodeidae. No one in India is actively engaged in studying this group and most parts of the country remain unexplored.

DISTRIBUTION

The distribution of this order is restricted to eastern and southern parts of India. Information is lacking from other parts of the country due to lack of proper survey in those areas.

BIOLOGICAL DIVERSITY AND ITS SPECIEAL FEATURES

Diplura has two suborders, namely, Rhabdura and Dicellurata. Under Rhabdura there are two superfamilies, Projapygoidea and Campodeoidea. The former superfamily has two families Anjapygidae and projapygidae and the latter has two families, namely Procampodeidae and Campodeidae. The suborder Dicellurata has only one superfamily Japygoidea under which there are two families, namely, Japygidae and Parajapygidae.

The members of Japygidae are rather more robust and predatory in habit. Campodeids are also predators and diet of both of these groups of Diplura consists of small soil arthropods. Ghaisas and Ranade (1981) reported about *Japyx solifugus* and mentioned that only 2 to 4 insects are found per square meter. *Japyx* is more widely distributed than *Anajapyx*, *Campodea* and *Heterojapyx*, where as *Projapyx* is very rare. Veeresh (1983) mentioned largest population (1200/Sqm) of diplurans in the forest soils of Western Ghats. He also reported small population size during summer which increases in the rainy season and reaches maximum in winter months. Singh and Mukherjee (1971) listed different species of Diplura. Ananthakrishnan (1979) also reported on Diplura.

ENDEMICITY

Among the known taxa about 12 species of this group are apparently endemic to India.

VALUE

In accordance with their concealed mode of life and rare occurrence they are of no importance economically. Yet as insect member of the soil fauna the diplurans possibly play an appreciable role in preserving the balance therein. These insects are good bioindicator of organic rich soil.

3. Order : Protura

Proturans are one of the rarest, soil inhabiting Apterygotes. Their body is elongate, slender, antennae and eyes absent, their length usually below 2 mm, white or yellowish in colour. They can be easily distinguished by a

median telson which is reduced or absent, their anal cerci absent, the first leg used as a tactile organ; abdomen in adults with 12 segments.

Indian protura represented by three families of which four species under the family Eosentomidae, eight species under family Protentomidae and another eight species under family Acerentomidae have been reported so far. They are generally found in decaying moist organic matter (wooden logs, leaves, etc.), litter and humus layers in forest floors, grassland, foliage of herbs and shrubs and nest of ants under bark of trees. In general, they are found in such habitats where little organic matter and moisture are available. The study of Indian protura started with Schepoteiff (1909); but, there was a long gap after that till to date. Recent work on Indian Protura has been done by Prabhoo (1960-1988). At present no one has worked on the Indian protura and our knowledge about this group is practically nil and whole of the country needs thorough exploration particularly in tropical rain forest areas.

STATUS OF THE TAXON

Global and Indian Status

According to Tuxen (1978) about 260 species belonging to 27 genera under 4 families have been recorded from the world.

From India only 20 species belonging to 8 genera and 3 families are known. Among the Indian species 15 species have been recorded from Kerala State alone and rest 5 from other State. Prabhoo (1986) reported that about 99% of Indian area is unexplored as far as the Protura fauna is concerned.

DISTRIBUTION

The distribution of this order restricted mostly in the southern part of India. Information is lacking from other parts of the country due to lack of proper survey, although they are supposed to occur in those areas also.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The Proturans are often neglected by soil Zoologists because they are rarely collected and identified. Prabhoo (1986) reported 20 species of Protura

belonging to 10 genera from India. These insects have been also recorded from natural habitats in many districts of West Bengal (Choudhuri and Roy, 1970), in certain cultivated and uncultivated fields at Varanasi (Singh and Pillai, 1975), forest and plantation crop (Prabhoo, 1976) and from cultivated and grass plots (Veeresh and Reddy, 1980). *Eosentomon* is very widely distributed genus and on the other hand, *Protentomon*, *Condeellum* and *Bolivaridia* are restricted in their distribution. Population of Protura is fairly large during monsoon and immediate post monsoon periods while they decline in number during the summer months. Singh and Pillai (1981) reported that Protura prefer humid soil rich in organic matter. Veeresh (1983) reported that Protura are least abundant in summer and maintain highest population in the monsoon. Highest populations of 4800/m² in the soil of Western Ghats and lowest 3200/m² from other adjoining tea fields were recorded from Kerala.

ENDEMICITY

Among the known taxa 16 species of this order are endemic to India.

VALUE

These are the only insects which occur in 20 cms of depth and are devoid of antenna and eyes. Therefore, they are ideal material in the study of insect evolution.

4. Order : Collembola

Collembolans popularly known as 'spring tails' (small and primarily wingless insects) owing to the presence of spring-like forked jumping organ underneath the fourth abdominal segment. Collembolans are though a specialized offshoot from the main evolutionary line, remote from the main line of insect evolution, gave rise to present day insects (Imms, 1936).

Collembolans are small to minute in size with a range of 0.25 mm to 6 mm in length; antennae primarily with 4 segments; many species without springtails are also common, exhibiting only sluggish movement and with beautiful deep coral red or dark blue colour. No cerci and telson is present at the end of abdomen.

STATUS OF THE TAXON

Global and Indian Status

World over this group of insects are known by a 5,500 species under 452 genera, 11 families and 2 suborders. Collembolans are represented in India by approximately 210 species under 86 genera, 8 families and 2 suborders.

DISTRIBUTION

The collembolans have a very diverse distribution, occurring in all parts of the world, inhabiting a wide range of ecological niche and in any climatic region.

They are generally found in the decaying moist organic matter like wooden logs, leaves, etc., litter and humus layers in forest floor, grassland, nest of termite and ant, caves, among moss, fungus, lichens, foliage of herbs and shrubs, snow at high altitude is also known to support certain collembolans. In general they occur everywhere where little organic matter and moisture are available.

The Collembola have wide range of distribution occurring in all parts of India. These insects are so far reported from Uttar Pradesh, Himachal Pradesh, Kashmir, Sikkim, Nagaland, Meghalaya, West Bengal, Orissa, Kerala, Tamil Nadu and certain parts of Maharashtra.

This group occur in different habitats from North the West Himalayan belt to North Eastern part of India and also in the Gangetic belt, Eastern Ghats and Western Ghat side.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The order Collembola are divided into 2 suborders, each characterised by a distinct body form. The Collembola which have elongated body come under suborder Arthropleona. In the Symphypleona, the body is compact and globular. Former represents majority of the collembolan species under families, such as, Isotomidae, Entomobryidae, Poduridae, Hypogasturidae, Oncopoduridae, etc. Other suborder comprises of two major families, viz., Neelidae and Sminthuridae.

These insects are often immensely abundant at a specially suitable patch or stretch of habitat. An acre of meadow has been estimated to support nearly

2,30,000,000 of these insects from the surface to a depth of nine inches (Imms, 1959). Mitra *et al.* (1976, 1979) indicated the rhizospheric effects of various vegetation governing the distribution and diversity of Collembola. He (Mitra, 1993) also pointed out that Collembola can be used as an index of crop production in the Agroecosystem. These insects occur in the vicinity of both south and north poles (upto 80 South latitude in Antarctica); a few species are living permanently on glaciers or snow field. They also occur in the coastal areas as well as in the desert. The diversity as well as the greatest number are found in soil with rich organic matter content. Some species live freely on the surface of water (*viz.*, *Produra aquatica*) and they are less abundant in dry habitat.

The diversity of the Collembola population varied from field to field. Mukherjee and Singh (1970) recorded maximum population of Collembola during March, August and January and minimum during May-June, building up their population during monsoon. Choudhuri and Ray (1967) recorded the highest population in July and August and lowest during February and April. Hazra and Choudhuri (1983) reported an irregular trend of fluctuation usually showing maximum in July and minimum in May. Singh and Pillai (1975) recorded 1077/m² Collembola from banana field where as Prabhoo (1976) estimated 24000/m² from forest and tea fields. Choudhuri and Roy (1976) reported 12 genera from uncultivated fields of West Bengal. *Lepidocyrtus*, *Cyphoderus* and *Proisotoma* were common to all habitats. Singh and Pillai (1981) reported *Onychiurus*, *Subisotoma*, *Isotomurus*, *Folsomides* as predominant genera found in all habitats. Prabhoo (1986) reported about collembolan community from a bamboo grove and grass plot and recorded 20 species. Prabhoo and Pai (1989) recorded 33 species of Collembola in control site and 13 species in a burnt site. These 13 species found in control site are considered as fire intolerent species. Hazra (1982) and Mitra (1990) recorded *Idiomerus* sp., *Entomobrya* sp., *Lepidocyrtus* sp., *Cyphoderus* sp., and *Folsomia* sp. as most dominant collembola fauna in soil and litter of Silent Vally of Kerala. Hazra and Choudhuri (1983) reported 14 genera. *Lepidocyrtus*, *Cyphoderus*, *Isotomina*, *Xenylla* were common both in cultivated and uncultivated sites of West Bengal. Reddy and Das (1983) recorded Isotomidae and Entomobryidae from Pine plantation ecosystem.

Sharma *et al.* (1984) in the Himalayan region recorded that the richness and total abundance of litter microarthropods decreased with the increase in elevation as well the share of collembolans in the total microarthropod population increased with the elevation. Hazra and Choudhuri (1983) found nitrate, organic matter and moisture content of the soil shows significant effects on the distribution of Collembola.

ENDEMICITY

Among the known taxa of Collembola 45 species are endemic to India.

VALUE

Collembola play a significant role in the breakdown of leaf litter along with certain other microarthropods and consequently aiding in the process of humification. Thus they play a key role in enhancing soil fertility. They are also known to enrich the organic content of the soil in the form of faecal matter. Schaller (1950) has shown that a population of 1,00,000 collembola in 1 sq. m. area produces 103 cc of faeces annually. This is equivalent to 0.2 mm deep layer. Collembolans are also being increasingly recognised as bioindicator of soil conditions. These insects are extremely susceptible to changes in conditions. It is also known that certain collembolan species exhibit sustained tolerance against varied strength of pesticides including most toxic DDT. It has also been reported (Mitra, 1993) that Collembola can be used as an index of crop production in the Agro-ecosystem. Some of them are minor pests in agriculture. For example, *Achorutes armatus* is found destructive to mushroom in India. *Sinella curviseta* was reported to infest potato crop at Srinagar, India.

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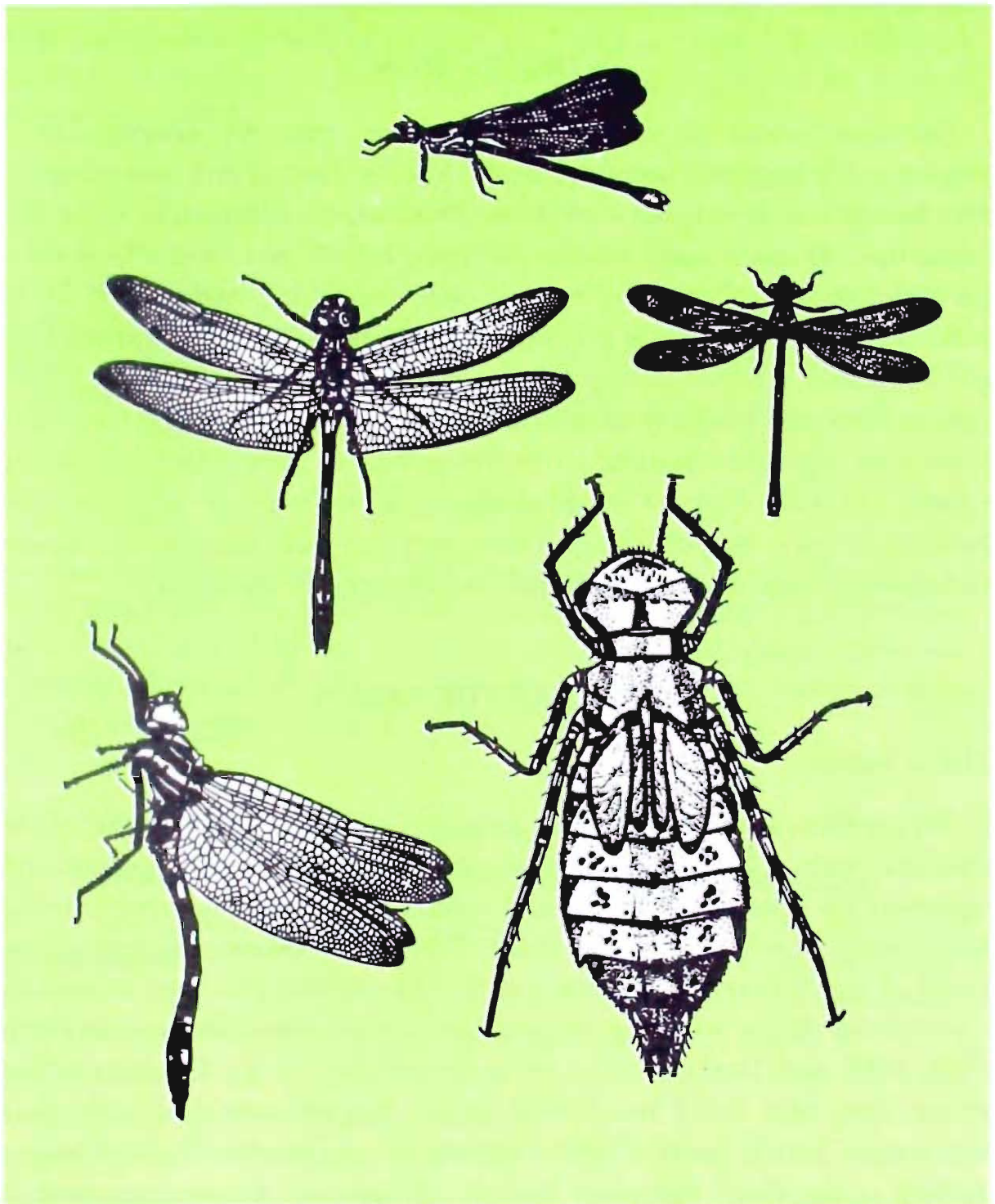
Collembola

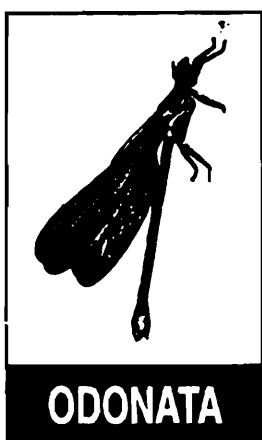
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Faunal Diversity in India : Odonata

M. PRASAD

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Odonates which are commonly known as damselfly (Zogoptera) or dragonfly (Anisoptera), are amphibiotic insects. They spend major part of their life cycle in freshwater ecosystem. This includes oviposition and larval stages upto ultimate stage. Adults are flying insects, but relatively of short life. Odonates have colourful bodies, clear wings and make swift flying movements. Adults are large predacious insects while larvae are carnivorous and voracious feeders. Adults have a peculiar method of feeding. They capture their prey while on wing with the help of mouth parts and forwardly posed fore legs and consume while flying. Larvae, also called naiads, are aquatic and quite different morphologically: Metamorphosis is incomplete, therefore, there is no pupal stage. Larva develops rudimentary wing-sheath during early stage and has very little resemblance to the adult.

STATUS OF THE TAXON

Global Status

Dragonflies are relatively generalised insects comprising the order Odonata. Kirby (1890) has listed about 1800 species in 319 genera and expressed the opinion that the world species might be about four times of that number. Montgomery listed about 6750 species and subspecies from the world. In recent years the taxonomy of the Odonata has also been revised on a worldwide basis, resulting in new synonymies, etc. Davies and Tobin (1984, 1985) and Tsuda (1991) have published lists of the Odonata of the world. They also listed the Indian species but did not deal with their distribution within India. Order Odonata is represented by 37 families clubbed under three suborders namely, Zygoptera, Anisozygoptera and Anisoptera. Approximately 6,000 species and subspecies belonging to 630 genera in 28 families are known from all over the world.

Indian Status

The first mention of an Indian Odonata is available in the Sangam literature, written before eight century A.D. (Bhaduri et al., 1972). The first scientific description available is that of *Nourobasis chinensis* by Linnaeus (1758) based on non-Indian specimens. Johnson (1768), Drury (1773) and Fabricius (1792-1798) contributed to the knowledge of Indian Odonata during the 18th century. Rambur (1842) has added more than 20 species of Odonata from India. Selys-Longschamps (1850-1890) was a keen naturalist whose contributions to Indian odonates could be described as a Selysian-Era in Indian Odonatology as he has described numerous taxa on the basis of material from India.

Earliest consolidated work on the fauna of Indian Odonata is by Fraser (1933-1936) who published Odonata in three volumes in the "Fauna of British India" series. Since then many workers in India and abroad have studied the Indian Odonata and described new taxa from various states. Recently Prasad and Varshney (1995) have published a revised and updated check-list of 499 species and subspecies of Indian Odonata under 139 genera in 17 families, 32 subfamilies and 7 superfamilies.

DISTRIBUTION

Earlier studies on Odonata in India were made from Western Himalayas, Eastern India and peninsular India especially from Eastern and Western Ghats. Recent studies added information from different zones, states and ecosystems. Number of Odonata species and subspecies recorded from different states/regions of India are given below in Table 1.

Table – 1

Number of Odonata species and subspecies recorded from India

No.	State/Region	No. of species
1.	Andaman & Nicobar Is.	27
2.	Central India	39
3.	Esturine areas (West Bengal and Orissa Coast)	42
4.	Goa	22
5.	Gujarat	48

No.	State/Region	No. of species
6.	Haryana	17
7.	Eastern India (Arunachal Pradesh, Assam, Bihar, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Sikkim, Tripura and West Bengal)	315
8.	Punjab	36
9.	Rajasthan	32
10.	South India	38
11.	Western Himalayas (Jammu & Kashmir, Himachal Pradesh and U.P. Hills)	162

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Dragonflies are true amphibiotic insects whose eggs and larvae are aquatic, while the adults are aerial in habits. Their aquatic stages are found in almost all types of waters be they permanent or temporary. Spatial and seasonal distribution of adults is determined to a large extent on the type of the aquatic larval habitat and generally the adults are restricted in their distribution around the aquatic habitats.

Suborder Zygoptera first appeared in Upper Permian period. In this suborder fore-and hindwings are almost of same shape and size, with a definite discoidal cell formed below the arculus. Members of families Coenagrionidae, Platycnemididae and Lestidae breed at the sides of freshwater bodies, while Platystictidae, Protoneuridae, Chlorolestidae, Calopterygidae, Chlorocyphidae and Euphaeidae breed in the hill streams, and sometimes also near waterbodies in the plains.

Suborder Anisozygoptera has a single Superfamily Heterophlebioidea, comprised of 11 families, all of which, except Epiophlebiidae have become extinct world over. This family is represented by a single species within our limits. There is another species found in Japan under this genus.

Suborder Anisoptera includes relatively robust built dragonflies as compared to Zygopterans. Wings are usually held horizontally or descended when at rest. Members of families Aeshnidae, Cordulegasteridae, Corduliidae are found in the hilly tracts and breed in the hill streams, waterfalls, etc.,

while those of family Gomphidae are found in hill streams as well as in the plains. Members of the family Libellulidae are found mostly in the plains near waterbodies. Some species of this family are also found near hill streams.

Only one dragonfly from India, viz., *Epiophlebia laidlawi* Tillyard (Epiophlebiidae) possesses unique morphological features. It was originally reported from Darjeeling, West Bengal (Tillyard, 1921). Its description was based on a single larva, which was collected from a stream flowing at a short distance below Ghoom. This species has characters that link the two suborders of Odonata, viz., Zygoptera, and Anisoptera. Adult of this species is yet to be collected within India. Asahina (1958) rediscovered the larva of *E. laidlawi* from the Himalayas and later a few adults from Chittry Valley in Nepal (Asahina, 1963). Recently Mahato (1993) has also reported this species from Shivapuri in Nepal.

Family-wise details of Odonata species in India and all over the world are given in Table 2. Of these, 6 species, viz., *Rhodischnura nursei* (Morton), *Melanoneura bilineata* Fraser, *Phylloneura westermanni* Selys, *Schmidtiphaea schmidi* Asahina, *Dubitogomphus bidentatus* Fraser and *Davidioides martini* Fraser are monotypic.

Table – 2
Family-wise number of world versus Indian Odonata species

Family	Total world species/ subspecies	Total Indian species/ subspecies	%
Coenagrionidae	1147	65	5.66
Platycnemididae	197	30	15.22
Platystictidae	142	13	9.14
Protoneuridae	244	24	10.07
Lestidae	159	25	15.70
Megapodagrionidae	244	1	0.40
Chlorolestidae	31	6	19.67
Amphipterygidae	19	1	5.26
Calopterygidae	169	10	6.92
Chlorocyphidae	158	20	12.67
Euphaeidae	65	19	29.23

Family	Total world species/ subspecies	Total Indian species/ subspecies	%
Epiophlebiidae	2	1	50.00
Gomphidae	919	90	9.78
Aeshnidae	412	42	10.19
Cordulegasteridae	82	22	26.80
Corduliidae	468	35	7.47
Libellulidae	1139	95	8.34
Total	5567	449	8.96

ENDEMICITY

About 115 species and subspecies, *i.e.*, about 23 per cent of total Indian Odonata species and subspecies are endemic to different ecosystems of India.

VALUE

Ecologically and economically Odonata are significant since they are predators of flies, mosquitoes, smaller moths, etc. As such, they serve as scavengers. Their larvae being consumers form an important link in the food chain of freshwater ecosystem. Being voracious predators in both immature and adults stages they are important components of all environment, except in the high altitude, in temperate and tropical regions, occupying a position at the apex of the food chain of invertebrates. Many species serve as intermediate hosts of helminth parasites (flukes) of birds especially of poultry and wild ducks and thereby help in transmission of parasitic diseases.

THREATS, CONSERVATION STRATEGIES AND FUTURE STUDIES

The concept of Odonata conservation in India or even of insects in general is very recent. In the last decade some awareness of dragonfly conservation in India has been persistently felt and, consequently, Odonata have also been considered worth preserving in the Country. In India

Epiophlebia laidlawi is the first dragonfly which was considered endangered/threatened and was given statutory protection by the Government of India under the provisions of the Indian Wildlife (Protection) Act, 1972, as amended in 1980, and included in the schedule I, part IV. It is certainly a milestone in our efforts to conserve and protect several such species of dragonflies which are vanishing fast today due to destruction of their breeding and perching habitats. In India there are some interesting species of Odonata, such as, *Epiophlebia laidlawi* which also need protection as far as possible as discussed earlier. This can be done along with various other national programmes aimed at conserving all the vertebrate and invertebrate fauna. The Government of India is presently running various nature conservation programmes and the results are highly relevant since the protection of habitats, i.e., forests, lakes, rivers, mountains and their cascades, etc., from otherwise certain destruction has undoubtedly positively affected the conservation of dragonflies.

The need to conserve rare, endangered or threatened species of Odonata is now recognized in this country. Several research papers dealing with the conservation problems on odonata have been published by Tyagi (1981, 1983, 1984 and 1985). He has suggested that (i) Water level of dams, marshes and pools at a constant level should be maintained; (ii) natural bushes and trees stands adjacent to both standing and running waterbodies should be maintained and (iii) siltation of freshwater bodies should be avoided.

To make odonata conservation more effective, a list of endangered and rare species of odonates along with their pictorial illustrations and distributional map should be prepared. Public awareness in conservation of biodiversity in general and this insect group in particular is to be created.

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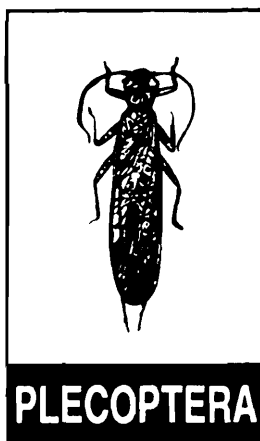
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Faunal Diversity in India : Plecoptera

B. C. DAS

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Plecoptera or Stoneflies are found in high altitude hill streams of cold temperate regions. The nymphs are found on stony surface of these streams and the adults are found near the streams on tree trunks, stones and bushes. They are weak flier and prefer to run to elude predators. They are diurnal except a few species of *Setipalpia* which are nocturnal. Food of the adult consists of algae, lichen and foliage though many species may not feed at all as adults live only few weeks. The composition of Stonefly fauna varies in different seasons and habitats. Brachyptery or winglessness is usually found during the winter season. Probably this group evolved from an ancestral form of Orthoptera and Blattaria type in the permian period.

Very few workers have worked on this group from India, may be due to scanty availability of material. The following workers worked on Indian Plecoptera, viz., Needham (1909), Banks (1914), Kimmins (1964, 1950), Aubert (1959, 1967), Jewett (1958, 1960, 1975), Kawai (1963), Shing (1971, 1977), Zwick & Sivce (1980), Zwick (1981).

STATUS OF THE TAXON

Approximately 2,100 species under 180 genera of 15 families have been recorded from the world. Among these, 113 species under 20 genera of 7 families have been recorded from India, representing 5.38 per cent of the world species.

DISTRIBUTION

In India distribution is mainly restricted to the Himalayan belt with distribution of a few species in hilly areas of South India. The familywise distribution of species are as follows :

Family Nemouridae : This is the largest family recorded. Under this family 66 species of 3 genera have been recorded from Himachal Pradesh, Uttar Pradesh in the North Western Himalaya and Arunachal Pradesh, Assam, Manipur, West Bengal in the North Eastern Himalaya.

Family Perlidae : Under this family 32 species of 8 genera have been recorded. Species of this family have been recorded from Himachal Pradesh, Uttar Pradesh in the North Western Himalaya and Sikkim, West Bengal in Eastern Himalaya. Quite a few species have also been recorded from hilly areas of Kerala and Tamil Nadu.

Family Perlodidae : Under this family only 3 species of two genera have been recorded from Himachal Pradesh, Uttar Pradesh in the North West Himalaya and in hilly areas of Tamil Nadu.

Family Capniidae : This family is represented by six species under 2 genera and is reported from Himachal Pradesh, Uttar Pradesh in North West Himalaya and in hilly areas of Tamil Nadu.

Family Luctridae : This is represented by two species under 2 genera and is reported from Himachal Pradesh and Meghalaya.

Family Taeniopterygidae : This family is represented by two species under 2 genera and is reported from Himachal Pradesh only.

Family Peltoperlidae : This family is represented by two species under one genus and has been reported from Assam and West Bengal in the North Eastern Himalaya.

ENDEMICITY

This group is very much restricted to its special habitat. For this reason their distribution is restricted to high altitude hilly areas only. The nymphs are habituated to live in fast flowing hill streams having stony substratum and are not swept away easily by water current. Respiration took place cutaneously and through gills. Food consists of Diatoms, algae, and other insect larvae. They live only in oxygen rich water. Adults emerge after passing through 22 to 33 instars.

Among 113 species reported so far from India about 66 species are endemic to this country. This shows that 74% of the reported species are endemic.

VALUE

This group is important in the sense that it acts as biological indicator for water pollution. They are the first group of insects to perish in polluted water as larvae of this group can not survive in water with slight drop in dissolved oxygen.

THREATS

Due to human interference in polluting fresh water streams their number is dwindling. The ever increasing human population and their indiscriminate mountain expedition cause great concern for the survival of this group.

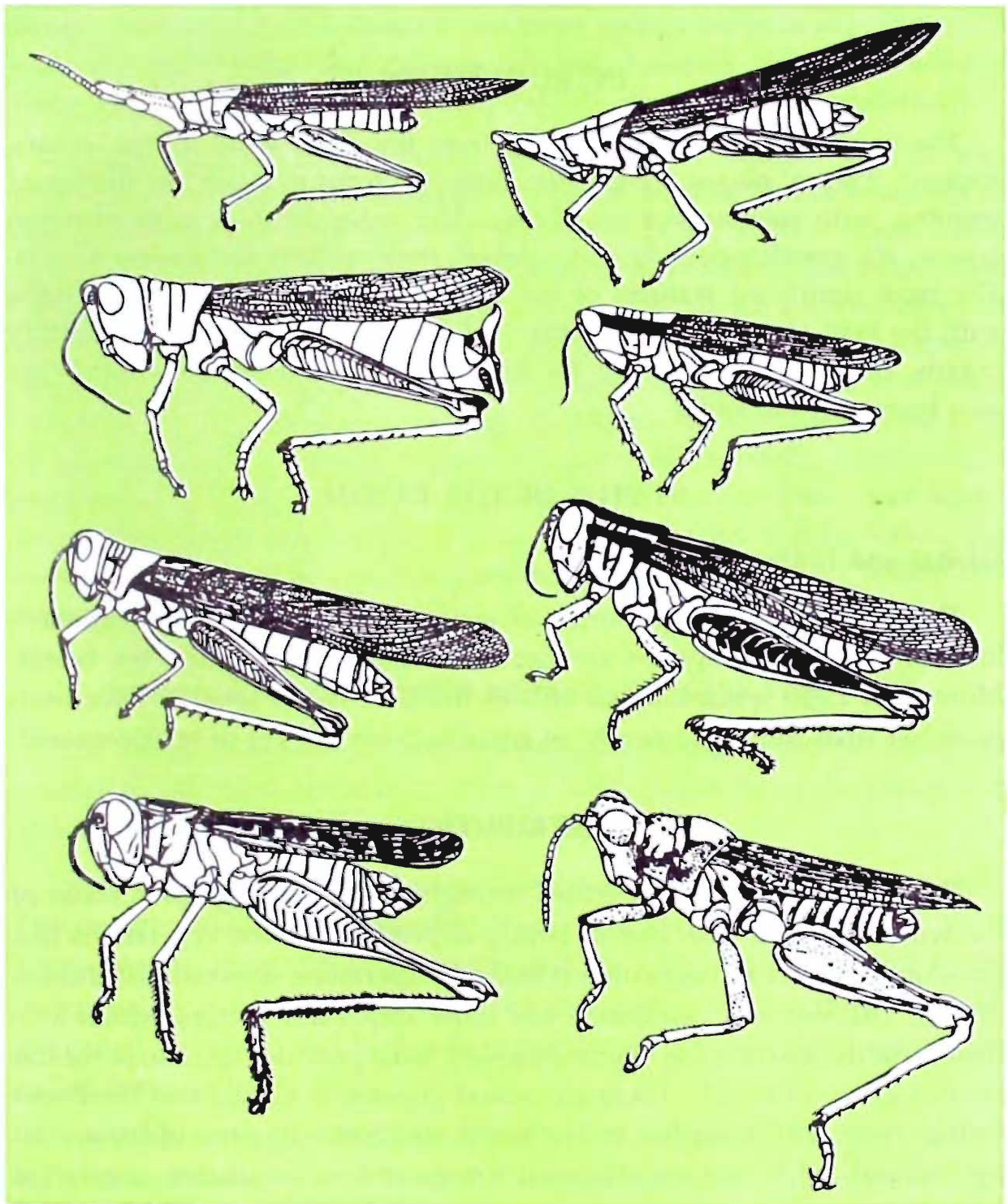
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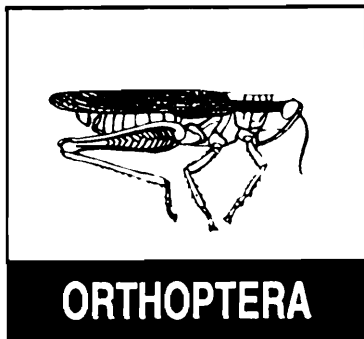
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Faunal Diversity in India : Orthoptera

S. K. TANDON AND A. K. HAZRA

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The name of this order is derived from the greek word 'Ortho' means straight, 'Pteron' means wings. The forewings form more or less thickened tegmina, with submarginal costal vein. The order includes most common insects, *viz*, grasshoppers, locusts, crickets, mole crickets and grouse locusts. The most significant features of this group of insects is its jumping habit with the help of enlarged hind legs, and sound production by its auditory organs. Besides winged forms the brachypterous and apterous forms are also known in this order.

STATUS OF THE TAXON

Global and Indian Status

This is one of the largest order of insects and also includes destructive locusts. Over 17,250 species are known to science throughout the world. More than 1,750 species, about 10% of the total world species, have been recorded from India and nearly an equal number are yet to be discovered.

DISTRIBUTION

The orthopterans are distributed throughout the physiographic zones of the world but their distribution largely depends upon the vegetations like grasslands, forests and agricultural fields. Temperature, seasonal distribution of rain fall and soil conditions are some important factors which also determine the distribution of grasshoppers. India provides an unique habitat for this group of insects. There are humid grasslands in East and Northeast India, semi—arid grassplain in Northwest and Southern parts of India, vast agricultural fields, sub-mountainous forests and scrub jungles, vegetation adjoining lakes, river basins and numerous water bodies scattered throughout the country. The members of this order range well into colder areas of the country and many species are found up to the snowclad Himalayan ranges.

The quantitative concentration of the species varies from season to season and also from one region to other regions of the country. However, in India, maximum concentration of all the species were recorded during monsoon and post monsoon season (June to September) when the growth of all types of vegetation in the natural grassfields as well as in the agricultural fields are in optimum condition. Hazra *et al.* (1981, 84) and Tandon *et al.* (1988) estimated about 200 grasshoppers (22 genera and 24 species) in a natural grassfield and 120 grasshoppers (8 genera and 10 species) in cultivated fields in West Bengal during August-September. The major species common in both natural and cultivated fields were *Oxya fuscovittata*, *Aiolopus thalassinus tamulus*, *Spathosternum pr. prasiniferum*, *Acrida exaltata*, *Atractomorpha crenulata*, etc.

On the other hand, maximum diversity of orthopteran species was encountered in the typical tropical rain forest areas of Northeastern states (Assam, Meghalaya) and Nilgiri, Wynad, Silent valley areas of South India, and the terai and dooars regions of the Himalayan foot hills. The distribution pattern of grasshoppers is changing rapidly due to the encroachment of grasslands and forests for agricultural and industrial purposes. The species which were once abundant in the grassland and forest areas and never considered as pests now occur in huge numbers in the cropfields in the form of minor pests of a potential major pest, e.g. *Phlaeoba infumata*, *Atractomorpha crenulata* and *Oxya fuscovittata*, the former two species were once found only in the grass fields and latter was abundant in the aquatic weeds like water hyacinth, which are now considered as major pests of paddy and vegetables in some states of India.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The range of habitat diversity is exquisite in this group of insects in relation to the shape of the body. In their habits and habitats the group is so specialised that they can be grouped as follows :

Some forms live mostly on ground and are called *terricoles* ; many species live on flat surface of large floating leaves and are called *aquaticoles* ; some forms live on trees and large shrubs and are called *arbicoles* ; some forms living mainly in dense thickets of shrubs and herbs with admixture of grasses are called *herbicoles* ; and finally large number of forms living in grasses are called *graminicoles*.

The order is divided into 2 suborders, viz. , Ensifera and Califera. Ensifera has two superfamilies, viz., Tettigonoidea and Grylloidea. Califera is divided into four superfamilies, viz., Acridoidea, Tridactyloidea, Eumastacoidea and Tetrigoidea. Superfamily Tettigonoidea is divided into 4 families of which

the family Tettigonidae has diversity with about 4,000 species under 21 subfamilies throughout the world. India is represented by about 80 species under 72 genera and 6 subfamilies.

Superfamily Grylloidea has twelve families, with 2,250 species distributed under 12 families and 364 genera in the world of which 181 species and 64 genera have been discovered from India. Superfamily Acridoidea has shown maximum diversity and is divided into five families of which family Acrididae and Pyrgomorphidae are widely distributed in India. Acrididae is divided into 17 subfamilies and altogether over 6,000 species under 1,000 genera are known from the world, of which 310 species under 138 genera and 14 subfamilies are known from India.

Family Pyrgomorphidae has been divided into two subfamilies. The subfamily Pyrgomorphinae includes 440 species under 148 genera from the world, of which 40 species under 19 genera are known from India.

Family Tetrigidae under superfamily Tetrigoidea has been divided into six subfamilies. A total of 988 species under 195 genera are now known from the world, of which 135 species under 36 genera are found in India. Superfamily Eumastacoidea has been divided into 7 families and 31 subfamilies. There are about 80 species occurring throughout the world, of which 28 species under 3 families and 5 subfamilies have been found in India. Superfamily Tridactyloidea is divided into 3 families and is known by 163 species from the world of which 16 species are so far known from India. A list of monotypic genera of Orthoptera in India is given in Table 1.

Table – 1
Monotypic genera of Orthoptera in India

Family	Species
Gryllidae	<i>Sphecoeryllus</i> , <i>Melanogryllus</i> , <i>Parasciabia</i> , <i>Meristoblemmus</i> , <i>Homonemobius</i> , <i>Lenigryllus</i> .
Mogoplistidae	<i>Pachyornebius</i> , <i>Cacoplistes</i> , <i>Laramdopsis</i> , <i>Kempiola</i> , <i>Phalongopsina</i> , <i>Spelunacris</i> , <i>Aspidogryllus</i> .
Eneopteridae	<i>Corixogryllus</i> .
Acrididae	<i>Orthochtha</i> , <i>Paraduronia</i> , <i>Anaptygus</i> , <i>Cariola</i> , <i>Duroniopsis</i> , <i>Phalaebida</i> , <i>Indomerus</i> , <i>Navasia</i> , <i>Assamacris</i> , <i>Bibracte</i> , <i>Coniocara</i> , <i>Naraikadua</i> , <i>Siruvania</i> , <i>Bababuddinia</i> , <i>Dhimubama</i> , <i>Madurea</i> , <i>Mesopsis</i> , <i>Pasiphimus</i> , <i>Phonogaster</i> , <i>Condronotulus</i> , <i>Julea</i> , <i>Meristopteryxe</i> , <i>Casteria</i> , <i>Calamippa</i> , <i>Tinnvrellia</i> .
Tetrigidae	<i>Fieberiana</i> , <i>Mixohyboella</i> , <i>Oxyphyllum</i> .

ENDEMICITY

There are over 200 endemic orthopteran species occurring in India. Therefore, the endemicity of the order comes round about 11% of the total species occurring in India. A beautiful taxon namely, *Schizodactylus monstrosus* under the family Schizodactylidae is on the verge of extinction. Only two genera under this family occur throughout the world. Out of these, only one species as mentioned above occurs in India. This is a large sand burrowing insect found along the sand beds of rivers. Due to discharge of pollutants in the river systems, its population is now sharply declining (Hazra 1983, Hazra and Tandon 1988).

VALUE

The representatives of this group of insects have immense scientific, ecological and economic value. Due to their population size, body size and palatability, major species of this group of insects are indispensable food of many birds and reptiles present in the grassland and forest ecosystems. Their role in the maintenance of ecological balance is beyond doubt. Therefore, they help directly in the protection of endangered species of birds and reptiles. Many species of Acridoidea are also serious pests of crops and pastures in India. They have long been recognised as crop pests probably from the time when cultivation was first practiced about 10,000 years ago. In the middle east in association with destructive locusts. In general it is difficult to separate locusts from grasshoppers specially when one talks about these group of insects in relation to crop damage. Damage by locusts, although spasmodic in both space and time, can completely or near completely destroy crops over large areas causing local famine and concomitant human physiological & psychological depression. Whereas 10% loss each year can be tolerated a 100% loss every year can mean disaster, even though the total loss over the period is no greater. It is this threat of total destruction that makes the locust the most feared of all crop pests. (Bullen, 1966).

THREATS AND CONSERVATION

Human activities have chiefly affected the grasslands and scrub jungle areas of India. Much of the areas have been converted into agricultural land or huge industrial complexes. Due to the shrinkage of the grassland habitat, the population as well as diversity of species are reducing very fast. Some species are also attacking the crop fields due to lack of their natural habitat.

The following are a few threatened orthopteran species as their known habitats are threatened : *Peripolus pedarius*, *Schizodactylus monstrosus*, *Gerenia*

bengalensis, *Mesambria dubia*, *Anacridium flavescens*, *Tagasta indica*, *Deltonotus gibbiceps*, *Coptacra ensifera* and *Coptacra punctaria*.

In recent years, the developmental activities especially in Northeastern States of India, involved more or less intensive deforestation, extended cultivation and road construction which exerted profound influence on the entire hitherto undisturbed ecosystems. The intrusion of man into the habitats of orthoptera while cultivating virgin lands, generally leads to a considerable reduction in the number of species and individuals. But, in small patches of virgin land, in depressions and in fallows grasshoppers are forced to concentrate and develop the potentiality for mass multiplication (Tandon and Khera, 1978). Therefore, measure should be taken to conserve the grassland areas for the protection of these natural foci of threatened animals.

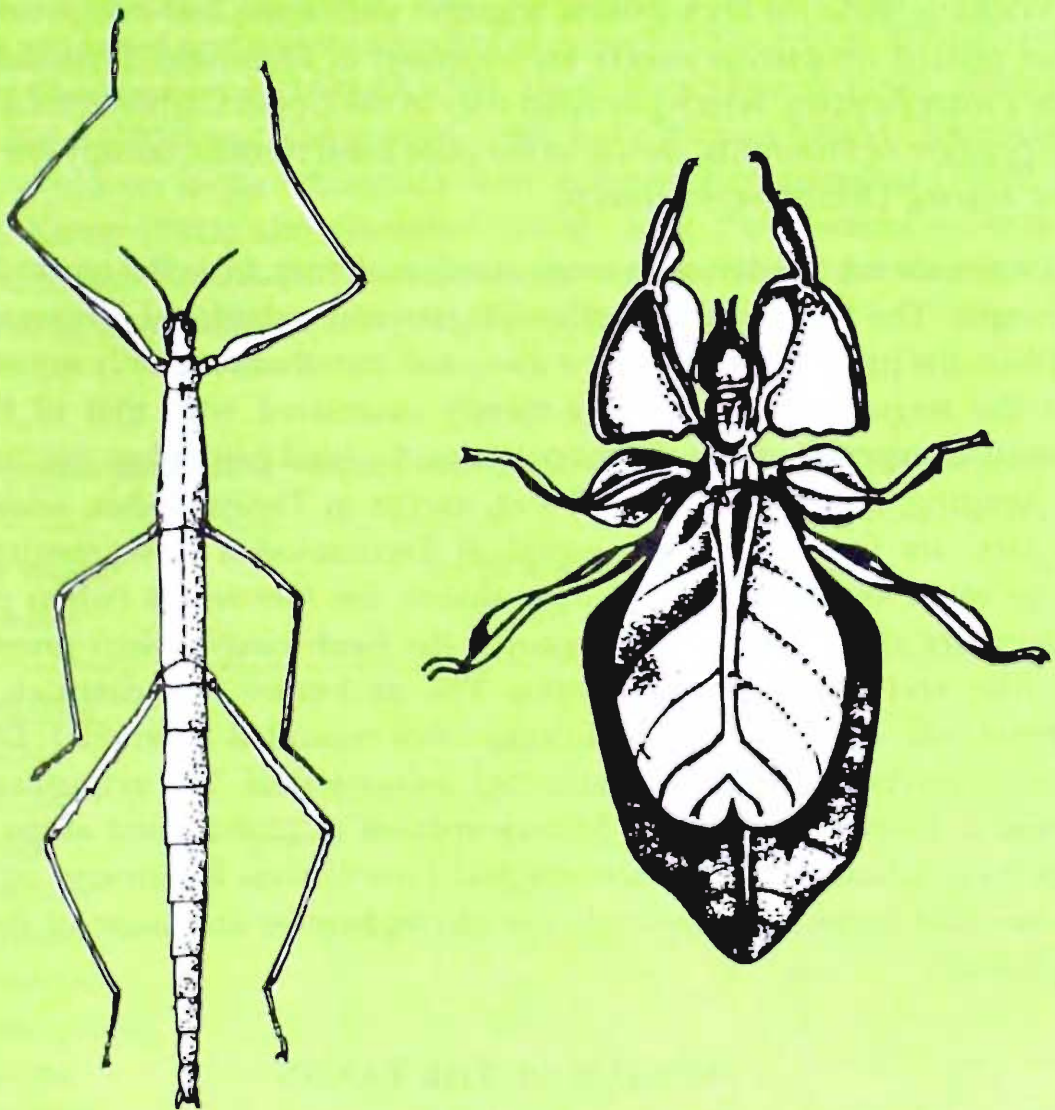
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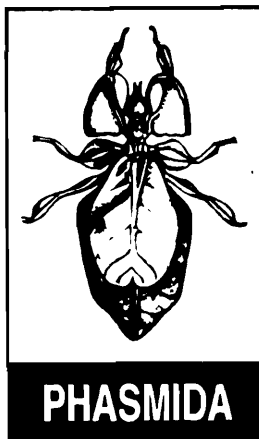
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Faunal Diversity in India : Phasmida

M. S. SHISHODIA

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Walking-sticks, or stick-insects, together with some leaf-insects and a few other related neopteous insects are included in Phasmida. Phasmids arose from Protorthoptera, which persisted only in the Upper Carboniferous Period. The position of Phasmida, owing to the poor fossil records, occupy the ordinal rank among Orthopteroid insects.

Phasmids are moderate to large sized, and vary from 3.0 cm to 33.0 cm in length. The body-form usually elongate and cylindrical, depressed and leaf-like; the prothorax is short, the meso and metathorax usually are elongate, and the tergum of the latter is closely associated with that of the first abdominal segment except in Timematodea; the hind pair of legs not modified for jumping; the coxae are small and, except in Timematodea, wide apart; the tarsi are five segmented, except in Timematodea (3 segmented). The wings often are greatly reduced or absent; the fore-wings (when present) usually are short, leather-like tegmina; the hind-wings (when present) are fan-like and surpassing tegmina. The abdomen has distinct, short, symmetrical, unsegmented cerci (sometimes expanded in female). The male external genitalia are very variable, but asymmetrical. The ovipositor of the female is short and complex. Metamorphosis is gradual and slight. These insects are arboreal or arbusticolous, but a few live on the ground or among grasses and herbs. All phasmids are phytophagous and most of them are nocturnal.

STATUS OF THE TAXON

Global Status

Global phasmids are estimated at about 2,500 species (Kevan, 1982). The majority of species occur in the humid tropics, and a large portions of these are from the Oriental—Australian Region. However, they do occur in drier and in temperate regions. Handlirsch (1930) divided Phasmida into 3 families, *i.e.*, Bacteriidae, Phyllidae and Phasmidae, but Beier (1968) classified it into

two families only *i.e.*, Phyllidae and Phasmatidae. This is also followed by Clark (1975), who divided the family Phyllidae into 8 and Phasmatidae into 11 subfamilies. Kevan (1982) called Phasmida as Phasmatoptera and divided it into 2 suborders : Timematodea and Phasmatodea. The suborder Timematodea contains single family, while Phasmatodea contains 10 families. He raised most of the subfamilies of Clark to family rank. The author has followed Kevan (1982) here.

Indian Status

Indian phasmids, as per records, comprise nearly 146 species. This number is very less in comparison to Global phasmid species (Table 1). The main reason for this may be due to less exploration of forest area where these insects are found and non-availability of experts of the group. Though earlier worker like Westwood (1838-40, 1859, 1864), Wood-Mason (1873, 1875, 1876, 1877), Rehn (1904) and Kirby (1896, 1904) have studied Indian Phasmida but major works on Indian Phasmida were done by Redtenbachar (1908), Carl (1913), Karny (1923) and Guenther (1938). After these works nobody has studied Indian Phasmida. The total number of species and families of Global and Indian phasmids is shown in (Table 1).

Table – 1
Family-wise position of World phasmid species versus Indian phasmid species

Total World families		Total World species	Total Indian species	%
Timematidae		9	–	–
Bacillidae		300	13	4.33
Bacunculidae		300	6	2.0
Phyllidae		20	5	25.0
Necrosciidae		500	44	8.8
Heteronemiidae		100	–	–
Lonchodidae		200	44	22.0
Pachymorphidae		200	29	14.5
Palophidae		10*	–	–
Bacteriidae		123-125	3	2.43
Phasmatidae		500	2	0.4
Total	11	2262-2264	146	6.45

* Exact number may slightly vary.

DISTRIBUTION

Family-wise distribution of number of phasmid species in India is shown in Table 2.

Table - 2

Families		No. of species in							
		N.E. India + West Bengal	Bihar	Orissa	South India	North India	West India	Anda- man Is.	India with unkn- own locality
Bacillidae		3	—	1	7	—	—	1	1
Bacunculidae		2	—	1	2	—	—	—	1
Phyllidae		5	—	—	—	—	—	—	—
Necrosiidae		28	1	—	8	—	—	1	6
Lonchodidae		27	—	—	14	—	—	1	2
Pachymorphidae		13	1	1	6	2	—	1	5
Bacteriidae		2	—	—	1	—	—	—	—
Phasmatidae		2	—	—	—	—	—	—	—
Total	8	82	2	3	38	2	—	4	15

Thus it is clear from this table that most of the species are recorded from North-east India, followed by South India. It is worth mentioning here that no phasmid has been recorded earlier from West India.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

As mentioned earlier, the body-form of Phasmids is generally elongated and twig-like, occasionally shorter, depressed and leaf-like, or rarely of other form. These insects are unusual for the capability possessed by many (if not all) to regenerate to a considerable degree damaged or lost appendages in the instar following an injury or autotomy. Adults can not regenerate since they do not moult, but they retain the facility for autotomy as an escape mechanism. Phasmids are remarkable for the powers of camouflage that result from extraordinary mimicry of plant stems of many kinds and

occasionally of foliage and so forth. These have the habit of entering a state of catalepsis, whereby they become rigid and often feign death. Most of the species can change their colour from instar to instar in order to match their background; some can even change colour without moulting. Various colour-forms varying from brown to green and in all except the green variety a change in the intensity of the colour can be produced quite rapidly by migration of pigment granules under the influence of a hormone. High humidity, low temperature and low light intensities cause darkening, while pallor is induced by the opposite conditions. Under normal influences a rhythmical colour change occurs diurnally (dark at night, light in the day). The thoracic glands are well developed in the family Bacunculidae. *Anisomorpha* and related genera of this family are remarkable that they can squirt out a protective irritant secretions from these thoracic glands for a distance of 30 cm or so.

The members of the family phyllidae are recognisable from other members of the order by the striking resemblance, particularly of females, to green (less commonly brownish), broad-leaved foliage. They are strongly dimorphic sexually, and are broadly expanded and dorso-ventrally flattened. The femora and often the tibiae are very short, shorter than head in females, much longer and hairy in males. The tegmina are leaf-like, broad and relatively long in females, covering much of the abdomen, and smaller in males, leaving much longer hind-wings exposed. The hind-wings of females are reduced or even absent.

The eggs are laid singly in seed-like oothecae, usually scattered randomly. Many species are parthenogenetic, often continuously so, though occasional males occur in such cases. There are about 5 to 8 nymphal stages.

Phasmids are usually not stridulate, but female leaf-insects have stridulatory teeth on the inner surfaces of the bases of the antennae, and some species of other families strike hind and fore-wings together when alarmed.

ENDEMICITY

The genus *Carausius* is predominant in South India, specially in Tamil Nadu. The well-known 'laboratory' stick-insects, *Carausius morosus*, originating in southern India, belongs to the family Lonchodidae. The species of the genera *Clitumnus* and *Cuniculina* are generally abundant in N. E. India. The Table 3 shows the position of endemic species family-wise in India.

Table – 3
Family-wise distribution of endemic speices in India

Families	N. E. India	S. India	Orissa	Andaman Islands
Bacillidae	1	1	1	–
Bacunculidae	–	1	–	–
Phyllidae	1	–	–	–
Necrosciidae	12	6	–	–
Pachymorphidae	11	2	–	1
Lonchodidae	17	13	–	1
Bacteriidae	1	–	–	–
Phasmatidae	1	–	–	–
Total	44	23	1	2

VALUE

Relatively a few species are economically important and some may suddenly become abundant and seriously defoliate trees. There is keen interest, specially in the species of *Phyllium* among amateur naturalist in rearing these insects, and fairly large international exchange occurs. One or two species have become favourite experimental animals to physiologists.

THREATS, CONSERVATION AND FUTURE STUDIES

The habitats and ecological niches for insects, specially phasmids, which are shy in nature, are becoming less and less due to considerable deforestation and cutting of trees for meeting human need. Besides, some amateur naturalists and school/college students are collecting these insects for their hobbies or educational purposes. During the faunistic survey by the Zoological Survey of India, parties, it has been observed that phasmids are rarely available. The specimens of some genus like *Phyllium* are occasionally seen in their natural habitat.

The need to conserve the rare or threatened species of the genera like *Phyllium* must be popularised. A list of rare or endangered species of phasmids together with their distributional map should be prepared for the

common people for their awareness. Collections of these species from their natural habitats should be stopped. There is no active taxonomic expert of the group in India at present. It is, therefore, obvious that expertise on this group is to be developed for explorations, study and inventorisation of this unique insect order.

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Faunal Diversity in India : Dermaptera

G. K. SRIVASTAVA

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053

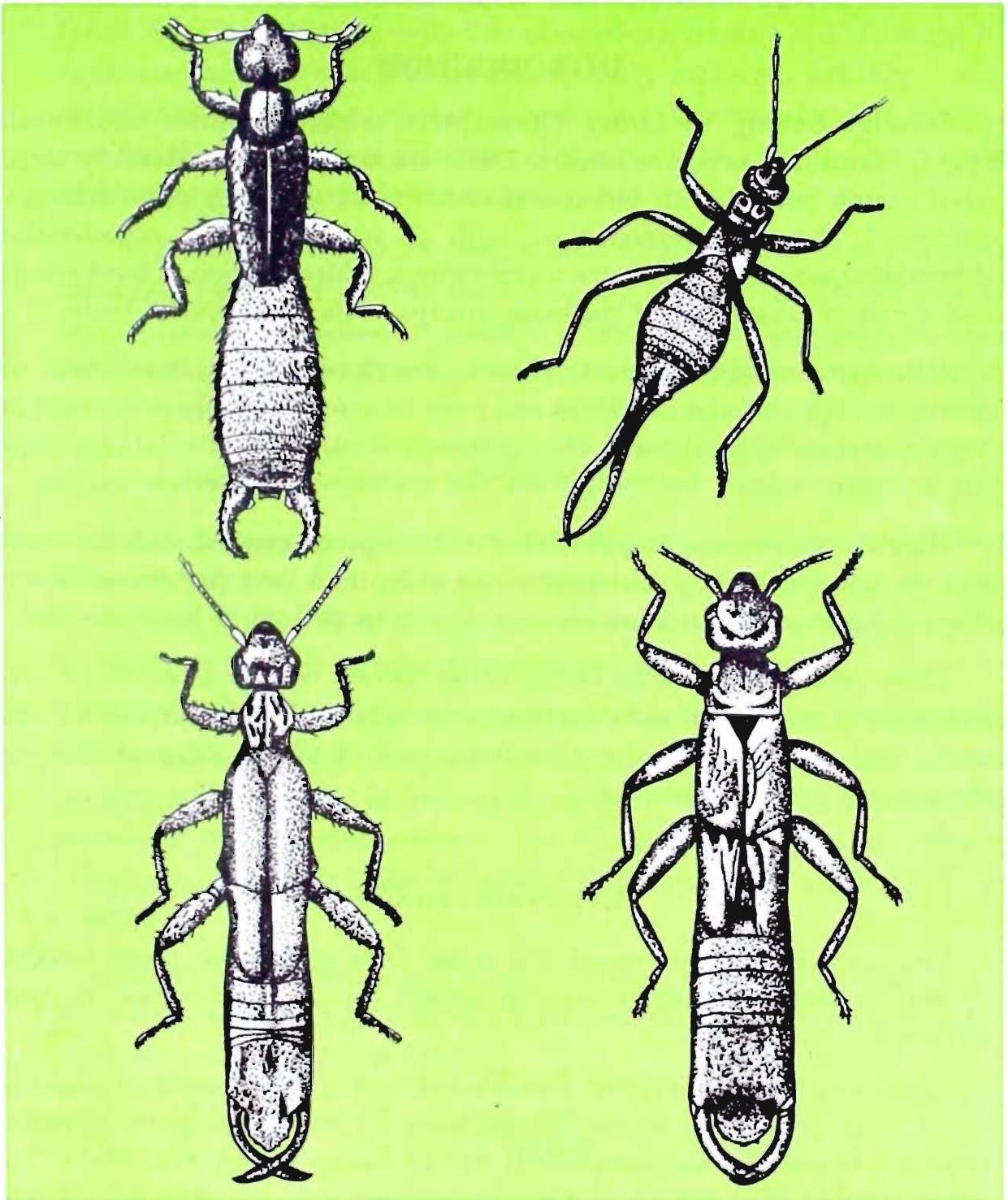


Table 1 showing zoogeographical composition of Dermaptera from the Indian region including Andaman & Nicobar Islands

O R I E N T A L

Family & Subfamilies	Genera	Species	Indian penin- sular	North India including Himalaya & N.E mountains	Sri Lanka	Rest P of area	E	AS	WW
PYGIDICRANIDAE									
Pygidicraninae	2	20	10	7	2	2	—	—	—
Diplatyinae	4	48	23	27	6	6	—	—	—
Echinosomatinae	1	7#	3	3	1	1	—	—	—
Prolabiscinae	1	1	—	1	—	1	—	—	—
ANISOLABIDIDAE									
Platylabininae	1	2	1	1	—	—	—	—	—
Titanolabidinae	1	2	2	—	1	—	—	—	—
Anisolabidinae	8	42	21	21	7	6	2	3	2
Brachylabidinae	3	5	2	1	3	—	—	—	—
Antisolabidinae	1	3	1	—	1	1	—	—	—
Isolaboidinae	1	5	—	5	—	—	—	—	—
LABIDURIDAE									
Allostethinae	2	5	4	1	—	—	—	—	—
Nalinae	1	3	1	3	1	2	1	1	1
Labidurinae	2	14+	3	11	2	4	1	1	1
APACHYIDAE									
Apachyinae	2	2	—	1	1	1	—	—	—
SPONGIPHORIDAE (=LABIIDAE)									
Sparattinae	1	2	2	—	—	—	—	—	—
Irdexinae	1	3	2	1	1	1	—	—	—
Spongiphorinae	2	5	5	3	3	3	1	1	1
Homotaginae	1	2	—	2	—	1	—	—	—
Labiinae	5	30	12	22	7	9	2	2	2
CHELISOCHIDAE									
Chelisocheinae	1	1	—	1	—	1	—	—	—
Chelisochinae	7	29*	9	19	2	12	1	1	1
FORFICULIDAE									
Cosmiellinae	1	7	—	6	—	—	—	—	—
Opisthocosmiinae	11	21	8	14	4	4	—	—	—
Allodahlinae	1	9	—	9	—	3	—	—	—
Anechurinae	4	11	1	9	—	1	8	—	—
Eudohrniinae	3	9	3	9	2	2	—	—	—
Forficulinae	3	32	4	27	2	8	23	2	1
Total	71	320	117	204	46	69	39	11	9

* Including one from Andaman Is. # Including two from Andaman Is. + Including three from Andaman Is. P = Palearctic, E = Ethiopian, AS = Australian, WW = World wide.

shoots and leaf causing damage. *Euborellia stali* (Dohrn) has been observed to bore into the tender pods of Groundnut (*Arachis hypogea*), one of the important oil seed crops of South India and feeds on karnels (Cherian and Basheer, 1940).

In Philippines *Euborellia* sp. has been used to control the population of Asian corn borer *Lostrinia furnacalis* (Guenée). This has proved to be more cost effective than the chemical control. Other species, namely, *Labidura riparia* (Pallas), *Euborellia philippinensis* Srivastava, *Euborellia annulipes* (Lucas), *Nala lividipes* (Dufour) and *Proreus simulans* (Stal) are effective predator on the above corn borer (Sakai, 1995).

Further studies on their life cycle may throw light on their potential as agents of biological control.

CONSERVATION STRATEGIES

There seem to be no study undertaken on the above aspect, in general, like other group of insects.

However, on the basis of field studies and the specimens collected for various species from different parts of India a broad idea about their existence and survival could be given.

The peninsular mountains harbour relicts forms which are concentrated in Southern Uplands and in less numbers in Deccan Lavas (Srivastava, 1988). Such species may be considered as threatened in the light of restricted distribution. Their survival depends mainly on the preservation of limited habitats.

Another area where a large number species are restricted within the Indian limits is North East Himalaya and other hills. Amongst these are outliers of Indo-Chinese and Malayan elements, represented by small number of individuals. There is need to protect such faunal pockets for the survival of species.

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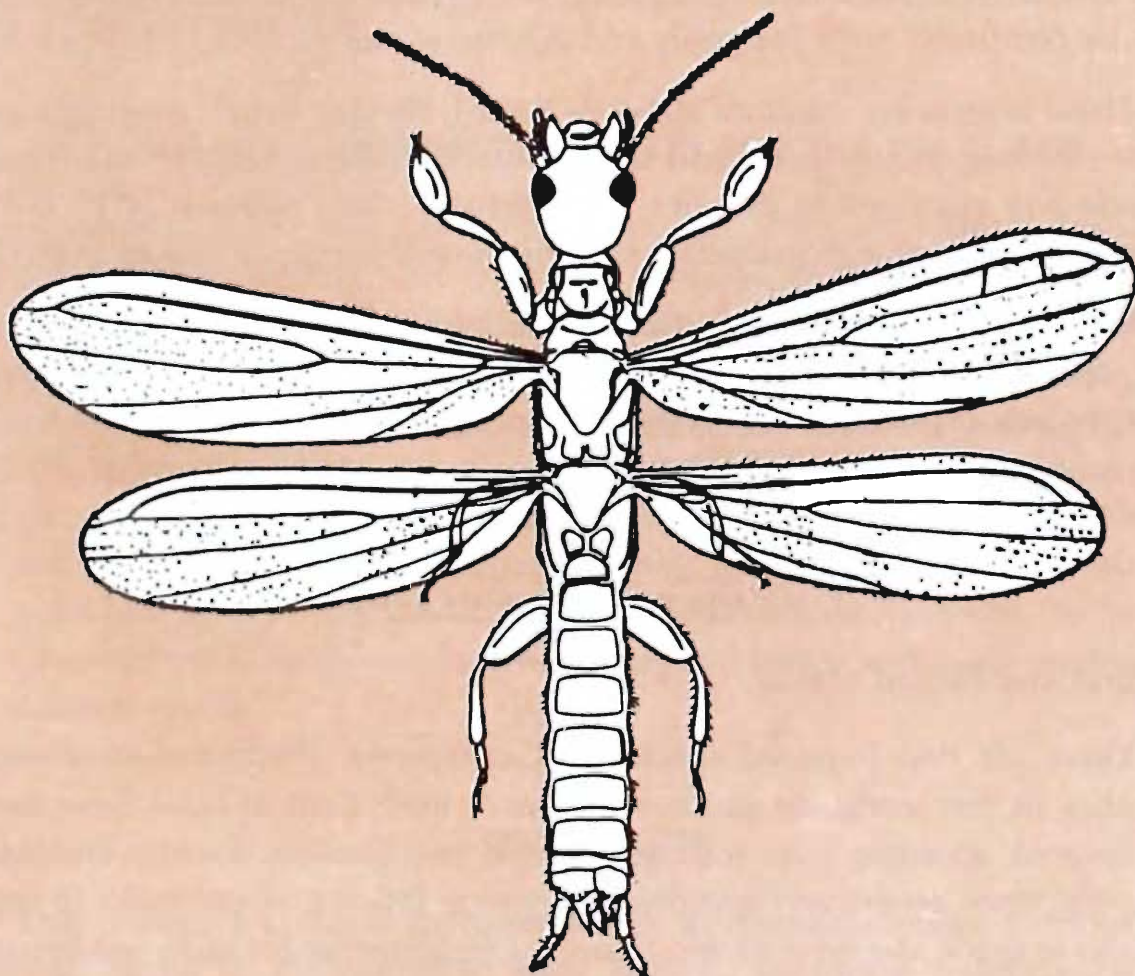
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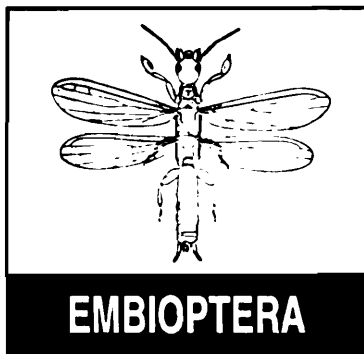
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Faunal Diversity in India : Embioptera

TRIDIB RANJAN MITRA

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Order Embioptera constitutes one of the smallest and interesting group of primitive insects. These insects show interesting combination of primitive and specialized characters. As a result, several authorities believe that these can be compared with Peripatus and Anaspids among other arthropods.

These insects are medium sized (5-2 mm), slender built, campodeiform, with chewing mouth parts and metatarsus of forelegs swollen containing glands and spinuettes. Females are apterous, while males may be either apterous or winged; reproduction by both sexually and parthenogenetically.

These insects inhabit humid places, usually away from light. They live gregariously in the silken tunnel under bark, stone or soil block. They spin with their feet. The tunnel helps them in getting protection from the predators. Some of these insects live in association with termites, social spiders, etc.

STATUS OF THE TAXON

Global and Indian Status

There are two hundred species and subspecies distributed over eight families in the world. In India, so far only thirtythree species have been discovered, spreading over four genera and two families. Family Embiidae contains three genera and seventeen species as follows : *Pseudemibia* (6 spp.) , *Embia* (8 spp.), *Metembia* (3 spp.); family Oligotomidae contains one genera, viz., *Oligostoma* with sixteen species.

DISTRIBUTION

Thirty three species reported so far from India have been recorded from Bihar, Delhi, Goa, Kerala, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal.

Following is synopsis of distribution of the order in five ecosystems of India.

(a) **From the Himalayas :** *Embia major*, *Oligotoma gravelyi*, *O. montana* and *O. himalayensis*;

(b) **From the gangetic plain :** *Embia saundersii* and *E. minor*;

(c) **From Barkuda Island :** *Oligotoma anandalei*;

(d) **From Eastern Ghats :** *Oligotoma pruthii*;

(e) **From Western Ghats :** *Oligotoma ceylonica*, *O. cindica*, *O. dhariwarina*, *O. greeniana*, *O. humbertina*, *O. josephi*, *O. latereillei*, *O. minuculav*, *O. saundersii* and *Pseudembia trundata*.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

These insects occur in all continents, but they are discontinuously distributed. Family Embiidae is mainly confined to India and Africa and some extended to South Europe and middle East. Family Oligotomidae is available in Asia And Australia ; but the genus *Haptoembia* occurs in the Mediterranean and Black Sea. Family Clothidae is visible in the tropical forest of Amazon North America and Trinidad. Family Notoligotomidae occurs in Tropical zone of Asia, Thailand and Australia. Family Embonychidae is distributed only in north Vietnam, family Aniembidae is a new world element and family Austrambiidae is confined to East Australia. In India the species are distributed in five ecological zones and eight states as mentioned earlier.

ENDEMICITY

This primitive group is characterised by its discontinuously distribution pattern; hence its endemicity is high. In India following fourteen out of thirty three species have been recorded as endemic.

Family Embiidae : *Embia major*, *E. minor*, *Pseudembia paradona*, *P. truncata*., *Metembia flava*.

Family Oligotomidae : *Oligotoma anandalei*, *O. gravelyi*, *O. folias*, *O. ceylonica*, *O. indica*, *O. dharwariana*, *O. himalayensis*, *O. josephi*, *O. montana*, *O. pruthii*.

VALUE

Studies on the members of the order Embioptera are very important both in the academic and economic point of view. Moreover, studies on their association with tremite and other arthropods may throw lights on the evolution of commensalism and socialism in insects. These insects live in humid places with vegetation and helps in the formation of humus and improvement of the soil layers.

THREATS

On going developmental work throughout the county is resulting in reducing the habitat of this group since habitat destruction is the main threat for their survival.

CONSERVATION AND FUTURE STUDIES

Habitat conseryation is to be the main effort for the conservation of this insect group. Thorough survey is to be conducted in the Himalayas, NE India, Central India and Eastern and Western Ghats for exploration and study of this insect order. There is every probablity that surveys in these areas may yield some good results including discovery of many new taxa.

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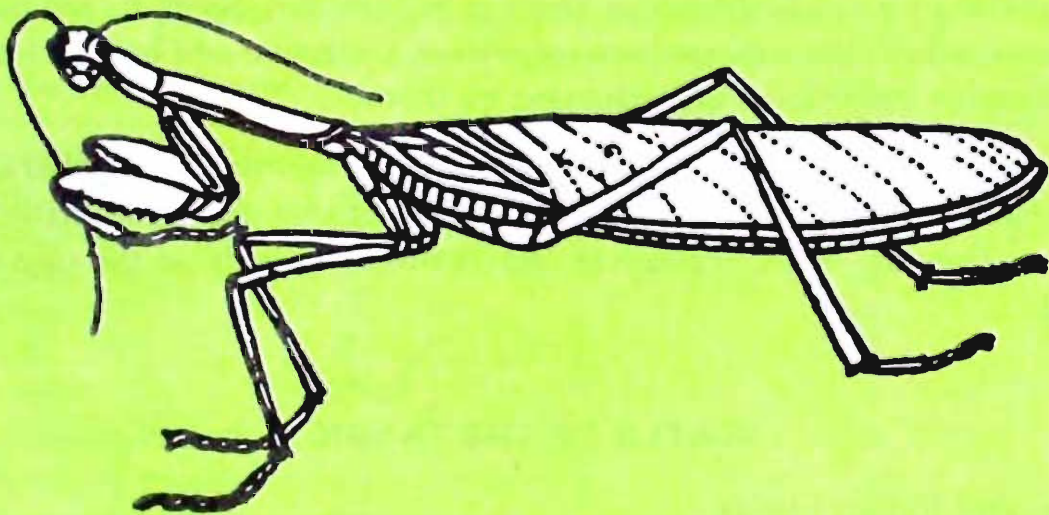
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Faunal Diversity in India : Mantodea

A. K. HAZRA AND T. K. MUKHERJEE

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The insects of this order is popularly known as “Praying mantis”—because of the habit of adults in holding their grasping forelegs in “namaste” posture while waiting for the prey. They are carnivorous insects. Their body is elongated, specially the prothorax and the forelegs are long and spinous for capturing prey. Cannibalism is very frequent among them. Particularly after successful mating. Teritoriality also exhibited by exposure of marks or body or by making sound. Body colour green or pale brown. Nymphs are mostly ant mimic, adult take various forms sfor their protective and both defensive and offensive behaviours are exhibited by them.

Mantids were previously considered to belong to order Dictyophera. But Burmeister (1838) considered them under Mantodea for their distinctive features. They are close to Isoptera and recorded as early as the oligocene period.

STATUS OF THE TAXON

Global and Indian Status

About 432 genera and 2310 species are known from the world. There are 162 species, distributed over 6 families, 19 subfamilies and 68 genera are known from India.

DISTRIBUTION

The mantids occur in all places of the Indian sub-continent from plains to hills ranging in altitude of more than 7000 ft. These insects generally prefer altitude of about 3500 ft to 4500 ft. As mantids are mostly weak fliers, they generally found in herbs and shurbs. But younger forms are usually found in trees. They are mostly found during early part of the day on leaves or open areas on plants where other insects often visit. They are also attracted to light. The mantids are apparently and opted to the different climatic zones of India. In central India most species occur during winter while in northeast

India; they occur in maximum number during monsoon. The influence of south-west monsoon of mantids in western parts of Tamil Nadu and in Kerala is seen in March and April. The valleys below 200 m are probably least preferred habitat. This pattern is however, dependent on the occurrence of tropical rain forests in those altitudinal zones. The species inhabiting arid and semi-arid region of India become active after sun-set to avoid desiccation. The data so far available their most preferred habitat is north east India from where maximum genera and species received (44 genera and 86 species).

The oriental Region shows much habitat diversity and closer faunal affinity with Ethiopian and the Australian Regions rather than with the Neotropical or the Holarctic Regions.

There are 44 genera and 86 species in North-Eastern regions of India while 35 genera and 45 species occur in Southern India. The distribution pattern of genera and species in India, is given in Table 1. This is based on specimens examined as well as records from Literature.

Table - 1
State-wise distribution of mantids in India

State/Union Territory	Genus	Species
Andaman & Nicobars (1)	4	4
Andhra Pradesh (2)	14	16
Arunachal Pradesh (3)	12	20
Assam (4)	22	29
Bihar (5)	14	16
Goa (6)	1	1
Gujarat (7)	4	4
Himachal Pradesh (8)	10	15
Jammu & Kashmir (9)	4	4
Karnataka (10)	22	26
Kerala (11)	15	20
Lakshadweep (12)	1	1
Madhya Pradesh (13)	11	16
Maharashtra (14)	14	17
Manipur (15)	7	10
Meghalaya (16)	17	25
Orissa (17)	10	14
Punjab (18)	3	3
Rajasthan (19)	7	8
Sikkim (20)	12	16
Tamil Nadu (21)	36	44
Tripura (22)	2	2
Uttar Pradesh (23)	29	55
West Bengal (24)	24	35

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Fourteen subfamilies of mantids are common to the oriental and the Ethiopian regions. These are Oxythespinae, Iridopteryginae, Amelinae, Tarachodinae, Liturgusinae, Catiridinae, Thespinae, Acromantinae, Hymenopodinae, Toxoderinae, Empusinae, Belpharodinae, Deroplatinae, and Eremiaphilinae.

Six subfamilies of mantids are common to the oriental and the Neotropical regions, viz. Acromantinae, Amorphoscelinae, Hymenopodinae, Choeradodinae, Liturgusinae, and Thespinae.

Four subfamilies of mantids are common to the oriental and the Palaearctic Regions, viz. Oxythespinae, Iridopteryginae, Amelinae and Empusinae. Only two subfamilies, Amelinae and Thespinae are common between the oriental and the Nearctic Regions.

The mantids subfamilies common to the Australian and the Oriental Regions are Iridopteryginae and Toxoderinae. Many genera are common in the Indo-australian Area, or related genera occur in different parts of the Indo-Australian area. Beier (1964) pointed out that there is a transgradation of certain genera from the Malayan Peninsula and Sunda Archipelago to Eastern India and Sri Lanka subregion is comparatively richer in endemism than the Indian subregion. Similar transgradation is also observed with the fauna of the Palaearctic Region by the presence of several common subfamilies as mentioned above.

Kaltenbach (1982) recorded 20 genera of mantids from the Arabian Peninsula of which 6 are common with India. Among these the desert genus *Eremiaphila* has been recorded from Western India. Similarly the *Blepharopsis* has been recorded from Rajasthan (India), Arabia, Canary Island, North and North-West Africa, West Asia, Iran, Palestine and Afganistan. *Empusa* has a more extended distribution from Andhra Pradesh, Orissa, through Uttar Pradesh and Rajasthan of India to South Arabia, probably Iran and Baluchistan and North Africa. At least 3 genera, viz. *Iris*, *Matis* and *Hierodula* occur in the orient, Ethiopian and the Palaearctic regions.

Hapalopeza and *Nanomantis* are found in West Bengal and South India. These are again known from the Australian region. Some of the common North-Eastern Indian species, viz., *Acromantis gonglus* are also represented in the Palaearctic region. However, there is probably no genus common to India and the Nearctic Region although two subfamilies are common in distribution.

ENDEMICITY

The endemic families are subfamilies of mantids occurring in the Oriental region are metallyticidae, Schizocephalinae, Phyllothelinae and Parathespiniae. Several endemic genera belonging to Hymenopotidae, Amelinae, Iridopterydinae, Toxoderinae, Haaniinae and Deroplatynae are also known. The study reveals that 24 genera and 86 species are endemic to India.

THREATENED AND INTRODUCED SPECIES

The detailed data regarding threatened species in India is not available. However, our field observation reveals that at least 10 genera and 40 species under this order are threatened. There is no record of introduction of any species to India from other countries.

VALUE

The praying mantids are carnivorous insects. They play a vital role in Biological control of insects pests.

The adult mantids consume voraciously both nymphs and adult of grasshopper pests in the paddy fields. Hazra and Mukherjee (1983) observed in the laboratory that the 5th instar nymphs of the praying mantid *Euantissa pulchra* consumed as many as 21.66 nos. Dipterans per day by a single nymph of the mantid. Another important value of this insect was also studied by the same authors that in *E. pulchra* that there occurred a gradual change in colour from black through brown to green. The first and second nymphs were black and very similar to black ants. During these two stages the colour was of protective type for the helpless nymphs. In adult the green colour of the body matched uniquely with green leaves making it difficult to spot out by their enemies and prey.

THREATS

The shrinkage of habitat particularly tropical rain forests areas in the country is the major threat as mantids are predominant in tropical rainforests. Moreover, extensive use of pesticides and insecticides in the crop fields also reduces their numbers very fast.

CONSERVATION STRATEGIES AND FUTURE STUDIES

To protect these beautiful beneficial creatures the tropical rainforests should be protected and also the application of high doses insecticide should be banned near tropical rainforest areas.

The U.S. and European countries are now very keen to collect Oothecae (eggs) from different countries for rearing them in the laboratory. We also can conserve by keeping their germplasm in gene banks.

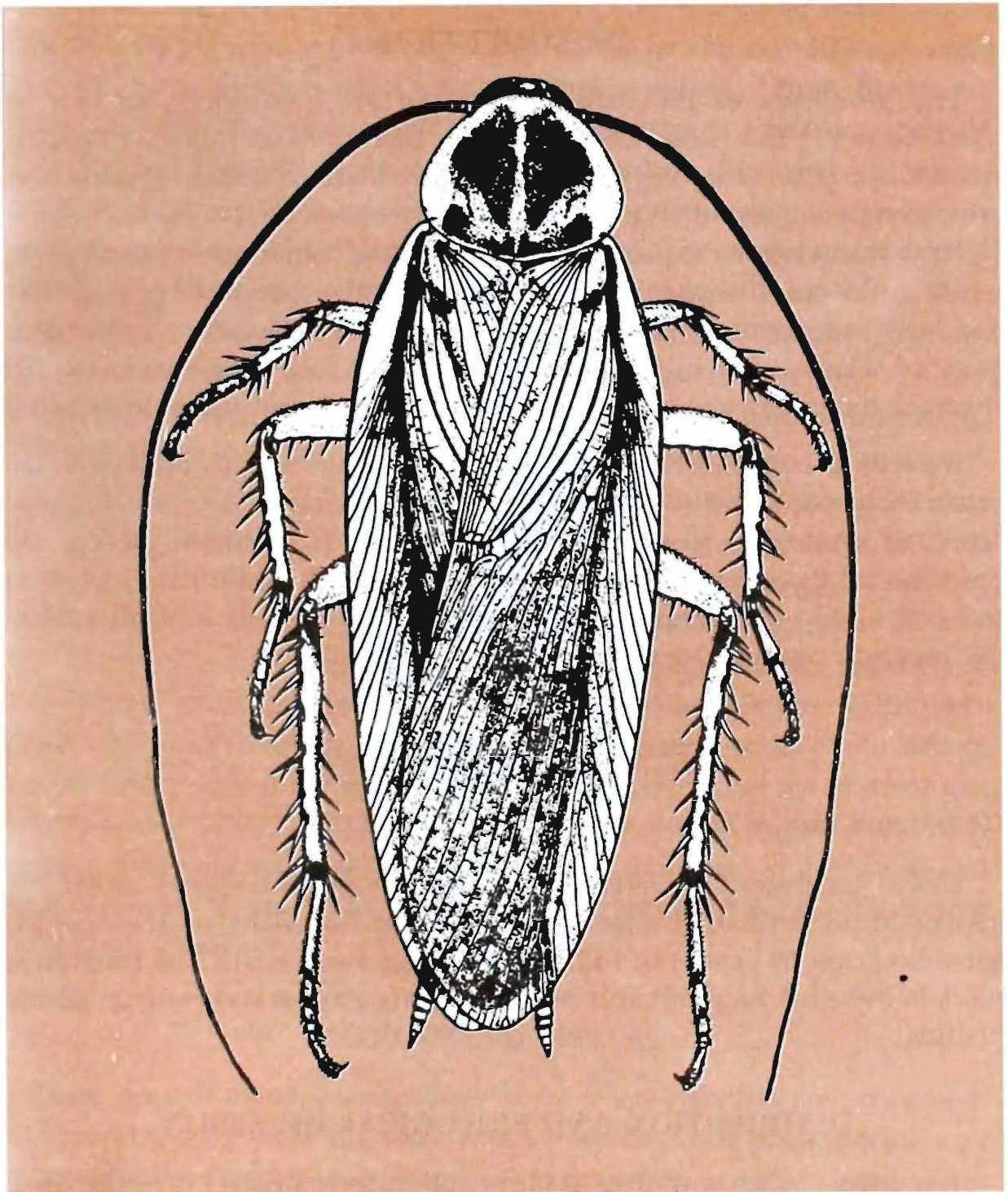
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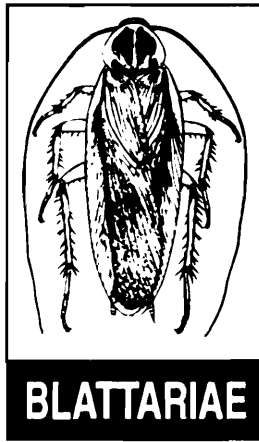
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Faunal Diversity in India : Blattariae

S. K. MANDAL

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700 053





INTRODUCTION

The members of the order Blattariae are commonly known as 'Cockroaches'. The name 'Cockroach' has been derived from the Spanish word 'Cucaracha'. They are brownish black or black in colour. Their bodies are strongly depressed and heads are mostly or completely covered above by large shield known as pronotum. They possess mandibulate mouth parts, variable filiform antennae, legs similar to each other, coxae large and close and tarsi 5 segmented. The wings may be present, reduced or absent; two pairs of wings differ in size and structure; the fore-wings are generally stronger, tough and elytra-like and the hind wings broad and membranous.

It needs to be mentioned here that many workers include blattids in the order Dictyoptera and suborder Blattaria. But Princis (1960; 1962-71) who has done outstanding work on the taxonomy and classification of this group has elevated the suborder Blattaria to order Blattariae and further classified this order into 4 suborders and 28 families. This classification is followed in the present communication.

STATUS OF THE TAXON

Global and Indian Status

Global component of Blattariae comprises about 5,000 species under 398 genera in 28 families. Indian Blattarian diversity includes 186 species, spreading over 58 genera and 12 families under 4 suborders. The taxonomic work in India has been concentrated mainly on common and easily available blattids.

DISTRIBUTION AND BIOLOGICAL DIVERSITY

The order Blattariae is divided into 4 suborders, namely, Polyphagoidea, Blaberoidea, Blattoidea and Epilamproidea. Taxonomy of many families of Blattariae is still in a confused state. There are only a few of taxonomists

who have undertaken the studies on Indian Blattariae and, as a result, knowledge on this group is far from complete. The suborder Polyphagoidea includes 7 families, the Blaberoidea includes 15 families, the Blattoidea includes 2 families and the Epilamproidea includes 4 families. Even from our present limited knowledge, it is clear that blattids have adapted themselves to diverse habitats. For example, some of the species *Blatta orientalis* and *Neostylopyga rhombifolia* are semiaquatic (Shelford, 1909), some are found among fallen leaves, on the surface of the soil, under stones, under bark, in thick grass among low vegetation, debris and inside buildings; some species are cave dwellers and a few are myrmecophilous. Family Blaberidae which includes single Indian species *Calolampira irrorata* occurs in forests of West Bengal, Orissa, Madhya Pradesh and Pondicheri. Family Polyphagidae also includes only a single species, *Polyphaga indica*, occurring in India. Family Derocalymidae includes *Pseudoglomeris glomeris*, *Tricoblatta sericea* and *T. himbertiana*. These house hold pests are distributed in Tamil Nadu, West Bengal, Orissa, Meghalaya, Sikkim, Maharashtra, etc. Family Blattidae includes *Periplaneta americana*, *Homalosilpha ustulata*, *Heberdina concina*, *Neostylopyga rhombifolia*. These are exclusively house hold pests, cosmopolitan in distribution and known to occur both in plains and hilly region. *Paranauphoeta indica* and *P. curcumdata* are also common in India and widely distributed. These are woodland species and usually considered as pests although they do frequently invade summer houses and cottages in autumn. Some species of Epilampridae and Blattellidae, such as, *Symploce biligata*, *Balta acutiventris*, *Theganopteryx parvula* live near water and are reported to be capable of submerging. *Blattella germanica*, so called 'German Cockroach' which seems to be native to certain drier parts of Africa, south of the Sahara, is now most widely distributed. The species under the genera *Salganea* and *Panesthia* are common in India and known to occur both in plains and hilly region mostly under the bark. These are more dominant in Andaman and Nicobar islands, Tamil Nadu, North-East India and West Bengal (Darjeeling and Jalpaiguri districts).

INTRODUCED SPECIES

There are not many introductions as far as cockroaches are concerned. But several species including some well known domestic pests species, e.g., *Blatta orientalis*, *Periplaneta americana*, *Blattella germanica* and *B. himbertiana* are readily distributed through human agency and have become established in different parts of India.

ENDEMICITY

A total of 60 species belonging to the families Ectobidae (7 spp.), Blattellidae (13 spp.), Polyphagidae (1 sp.), Anaplectidae (1 sp.), Panesthideae (13 spp.), Epilampridae (15 spp.) , Archiblattidae (1 sp.) and Blattidae (19 spp.) are known to be endemic to this country.

VALUE

Blattariae are not having any consumptive use in India. But there are eight species of cockroaches which are eaten by tribal people of India. These are *Periplaneta americana*, *Homalosilpha ustulata*, *Neostylopyga rhombifolia*, *Stictolampra plicata*, *Blattella germanica*, *Paranauphoeta circumdata*, *Panesthia angustipennis angustipennis* and *Panesthia angustipennis cognata*.

Recent investigations have shown that some of the cockroaches are potential sources of biomedical compounds. For example, *Blatta orientalis* is used in preparation of Homeopathic medicines, which is used in asthma.

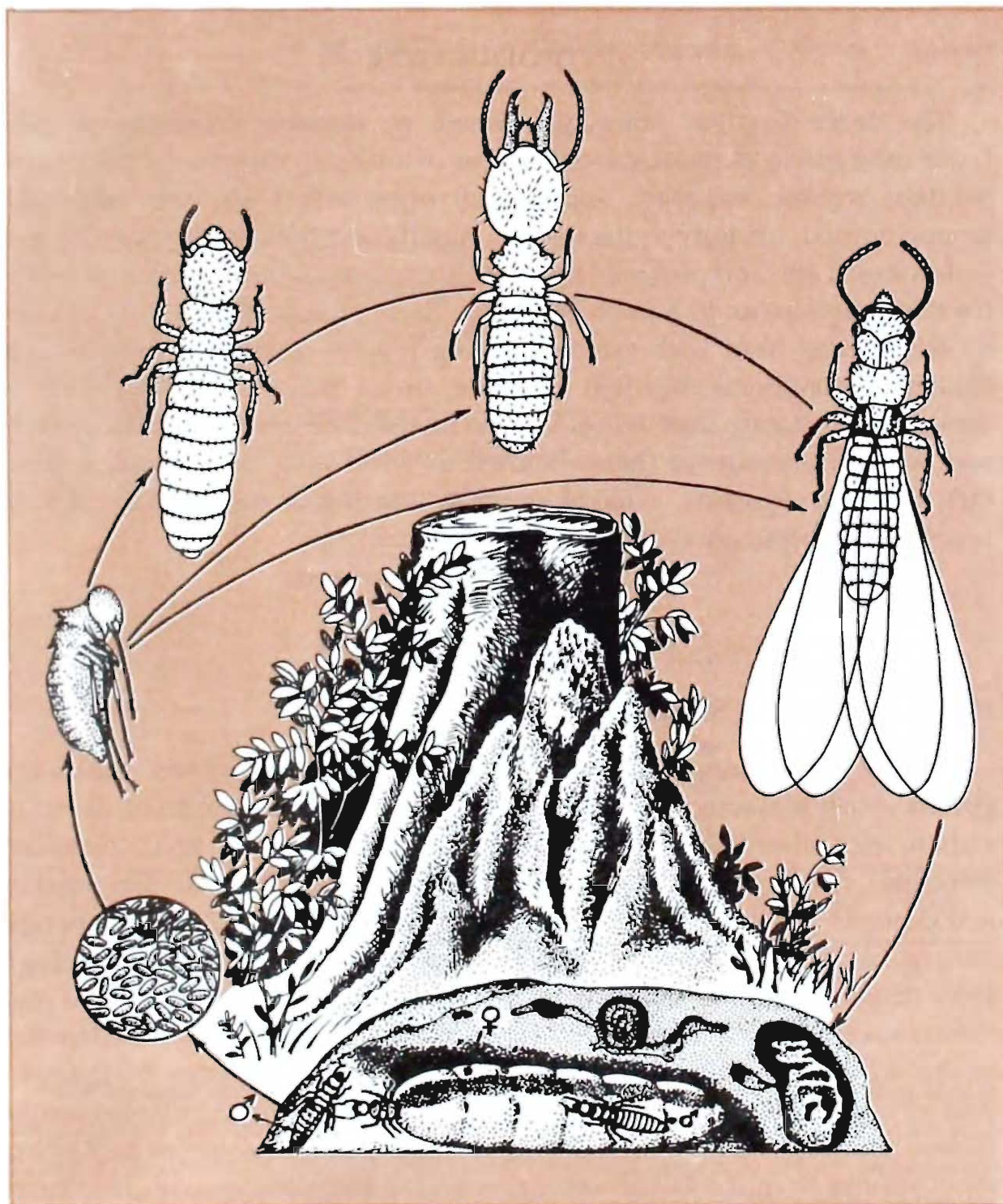
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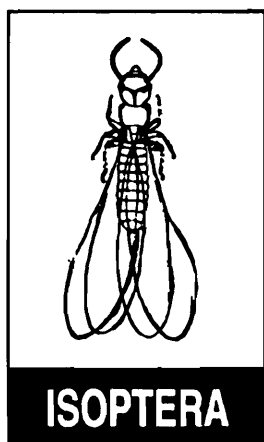
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Faunal Diversity in India : Isoptera

P. K. MAITI AND N. SAHA

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The order Isoptera popularly known as termites constitute a most fascinating group of social insects because of their polymorphic caste systems (soldier, worker, imagoes), supra-social organisation (division of labour among adults), ubiquity in the tropics, superb nest-building ability (mound, carton-nests, etc.), cryptobiotic mode of life in wood and in soil, and lastly, for their interference to human economy. These insects are easily recognised by their broad head with grinding-biting type of mandibles (modified in soldiers), moniliform (beaded) antennae, broad thorax with two pairs of almost similar transparent wings (only in imagos), abdomen with transparent and whitish integument (hence known as white-ant), cerci short or long, tarsi with 3-5 segments, external genitalia wanting or rudimentary in both sexes, metamorphosis slight or absent.

STATUS OF THE TAXON

Global and Indian Status

All the known nine families of Isoptera had been in existence since the period of late Mesozoic. But, they unlike their other insect relatives, failed to radiate into diversified climatic and food niches due to their imperfect structural, developmental and behavioural adaptation. As such, this order as a taxonomic group, is neither hyperdiverse containing numerous species, genera, families, etc., than expectation, except in certain groups nor biologically diverse in all the habitats or geographical areas in the world having numerous species (Table-1). There are four hypodiverse monogeneric families in the world. These are Mastotermitidae with a single species *Mastotermes darwinensis* (Frogatt) in Australia, Serritermitidae with only *Serritermes serrifer* (Bates) in Brazil, Stylotermitidae with a single genus *Stylotermes* containing eight species from the Indian subregion and Indotermitidae with *Indotermes* containing seven species in the Orient. Rest of the families are fairly represented by genera and species, of which the most diverse family is the

Termitidae with 145 genera under four subfamilies. Taxonomic diversity of Isoptera known from India and the world is shown in Table 1.

Table – 1
Taxonomic Diversity of Isoptera

Taxonomic Categories		India		World	
FAMILY	SUBFAMILY	Genus	Species	Genus	Species
Mastotermitidae		–	–	1	
Kalotermitidae		9	40	23	
Termopsidae		1	1	2	
Hodotermitidae	Stolotermitinae	–	–	1	
	Porotermitinae	–	–	1	
	Hodotermitinae	1	2	6	
Stylotermitidae		1	7	1	
Rhinotermitidae	Termitogetonae	–	–	1	
	Psammotermitinae	1	1	2	
	Heterotermitinae	2	8	2	
	Coptotermitinae	1	7	1	
	Rhinotermitinae	3	8	7	
Serritermitidae		–	–	1	
Indotermitidae		1	1	1	
Termitidae	Amitermitinae	8	50	24	
	Termitinae	10	36	57	
	Macrotermitinae	6	48	12	
	Nasutitermitinae	10	44	52	
Total		54	253	195	2000

DISTRIBUTION

The termite fauna of India is not as vast as the country itself. Out of about 2000 species (including 60 fossil species) in the world, about 253 species and subspecies under 54 genera belonging to seven families, are so far known from India (Table-I). This vast landmass is characterised by a great variety of physiography, climate, soil, vegetation, etc., all of which have influenced

termite distribution. Extreme climatic condition is probably the limiting factor. Since termites need a great deal of moisture, they avoid extreme arid as well as cold areas. As such, the species richness gradually decreases towards the temperate higher altitudes of the Himalaya, arid stretches of the Thar desert in the west, but it increases towards the north-eastern borderland.

Termites overcome the adverse environmental conditions by their superb ability of constructing runways and nests. The mound building termites of the genus *Odontotermes* are predominantly found in hot and humid plains of India. Only a single species *O. distans* occurs in a temperate altitude of about 2250 m in the Kumaon Hills. *Heterotermes* inhabits as a house-hold species in the temperate altitudes of the Himalaya to have warmth of house, while two genera, *Archotermopsis* and *Reticulitermes* occur in the wild condition in the same area. *Psammotermes* and *Anacanthotermes* are successfully adapted to the arid climate of the Thar desert. The presence of the Neotropical genera, *Calcaritermes* (only one species in the Great Nicobar) and *Rhynchotermes* (only one species in Manipur) in the faunal elements of India, is of some Zoogeographical interest.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Biological Diversity

Termite diversity refers to the varieties of types or taxa in the order Isoptera or in a given geographical region. A region with a number of different taxonomic units (species, genus, etc.) is said to be biologically diverse (biodiversity) and a taxon if contains more species, genera, families, etc., is known as hyperdiverse (taxonomic diverse). A species, with interpopulation differences where each population get genetically adapted to specific environmental condition is known to be genetically diverse i.e., genetic diversity of a species or variation of genes within a species. In termites, such studies are not at all done, although many a infra specific categories of population under many species can be discernable. To cite an example, *Protrichotermes flavus* (Bagnion and Popoff) primarily a coastal species of the insular landmass of Sri Lanka, Mangalore, Andaman and Nicobar, is represented by some distinct population in different islands, namely Nicobar, Little Andaman, Nancowry, etc., recognized by their morphological characters and is differing from the typical *P. flavus*. These population appear in the process of speciation in different islands being isolated by water gaps.

Species diversity which is more concerned to the taxonomists refer to the varieties of species within a region or in a taxon. *Angulitermes*, for example,

is an endemic genus to the Indian subregion, consisting of about 16 species. Of these, 3 to 4 species restrict itself in each of the five physiographic regions in India. Three species, namely, *Angulitermes acutus*, *A. fletcheri* and *A. obtusus* are closely related and occupy different ecological pockets within the peninsular India. Most of these species show close relationship with *A. acutus* which itself has a number of distinct population each of which indicates its potentiality to be a distinct species in the course of future evolution.

However, certain taxa containing more species, genera, or higher taxa than normal expectation, are called hyperdiverse. Examples include arthropods among animal phyla, insects among arthropods, Coleoptera and Hymenoptera among insects, ants among social insects, rodent among mammals, and so on. The order Isoptera does not fall under this category. Rather termites may be called as hypodiverse, both taxonomically and geographically due to their extrinsic and intrinsic characters, except in some taxonomic units and in some areas. Example include Termitidae among termite families, Termitinae and Nasutitermitinae among subfamilies, *Odontotermes*, *Microcerotermes*, *Nasutitermes*, etc., among the termite genera known from India (Table-1).

Hyperdiversity also occurs in certain habitats or geographical areas in India with respect to termite distribution. The richest concentration of species is found in the tropical rain forests of the Western Ghats in the peninsular and in the north-eastern borderland, as well as in the moist deciduous forest tracts in the foothills of the Himalaya (Table-2).

The study of termite species richness in different forest ecosystems in India reveals that termites are found in abundance in the evergreen forest with hot and humid climate as evidenced in the Nilgiri and the Andamans, and less so in the deciduous forest with hot and dry climate as found in the Chhotanagpur (Table-2). But record of quite a number of species in the Thar desert is probably due to thorough collections made by the experts over the years in the area. The maximum number of genera in the Nilgiri show more potentiality for more richer diversity of termites in the area.

But, these findings remain merely tentative, in considering the collections are not made uniformly and without defining exact boundary of these ecosystems. Species and area relationship are not at all considered.

Table – 2
Taxonomic Diversity of Termites in different Forest Ecosystems in India

	Species/Genus		
1. Tropical wet Evergreen Forest (Nilgiri Hills)	...	...	23/14
2. Tropical moist Deciduous Forest (Nicobar)	...	...	22/10
3. Tropical Dry Deciduous Forest (Chhotanagpur)	...	...	17/9
4. Subtropical Pine Forest (Kumaon Hills)	...	...	20/13
5. Tropical Thorn Forest (Coimbatore)	...	...	23/11
6. Desert Vegetation (Thar Desert)	...	...	22/11
7. Swamp Forest (Sundarbans)	...	...	11/6
8. Insular Andaman Evergreen Forest	...	...	23/11

Special features of Termites

There is unique combination of intrinsic and extrinsic factors affecting the biodiversity of termites. These are (i) termites being soft bodied, fragile social insects with polymorphism and cryptic life, devoid of exoskeleton or metamorphosis, are not capable of radiating in all the climatic zones of the world; (ii) the large majority of termites thrive well under tropical climate and only few have invaded cold climatic zones; (iii) termites depend on such food as cellulose, keeping them away from the other food niches; (iv) termites live in closed nest and galleries with controlled temperature and humidity which restrict their mobility; (v) being social, they virtually restrict themselves in their self made nests except at the time of swarming organized flying individuals and failing to cross even a narrow water gap of 50 km; (vi) they have developed extreme degree of control reproduction that all sterile except one or few reproductive females in the colony; and (vii) termites are most vulnerable to predators than any other animals. All these factors go against to make them taxonomically and biologically diverse.

ENDEMICITY

A total of 170 species of termites is endemic to India which represents roughly two-thirds of the total to 253 species so far known from India (Table-3). Maximum concentration of 73 species occurs in the tropical rainforests in the Western Ghats in the Peninsular physiographic division which is considered as one of the 15 megadiversity provinces of the world.

Other physiographic divisions in India contain almost equal number of species to a total of 20 or so. Maximum number of endemic species belongs to the soil-inhabiting Termitidae (70%), followed by the wood-inhabiting Kalotermitidae and Rhinotermitidae (30%), of which the latter group is under threat due to human interaction with wood.

Table – 3
Endemic Species of Isoptera in different Physiographic divisions in India

Taxonomic Group	H	G	P	NE	I	C	Total
Kalotermitidae	5	2	15	5	3	2	32
Termopsidae	–	–	–	–	–	–	–
Hodotermitidae			1				1
Rhinotermitidae	1	1	3	2	4	1	12
Stylotermitidae	3	1	1	1		1	7
Indotermitidae	–	–	–	–	–	–	–
Termitidae							
Amitermitinae	5	5	16	1	1	4	32
Termitinae	4	4	19	1	2	2	32
Macrotermitinae	1	4	4	3	1	5	18
Nasutitermitinae	4	3	14	6	8	1	36
Total	23	20	73	19	19	16	170

H = Himalayan; G = Gangetic; P = Peninsular; NE = North-east borderland; I = Insular; C = Common to several divisions.

INTRODUCED SPECIES

About 50 introduced species of termites are so far known (42 indentified, 8 unidentified) in the globe. However, only two species have been introduced in India and one species from Indian subregion had been introduced in the neighbouring countries. *Cryptotermes dudleyi* Bank, a species originated from the Oriental region, has been introduced in Lower Bengal and Orissa and *C. bengalensis* Snyder, a native to Africa, is also known to be introduced in the Sundarbans. On the other hand, *Coptotermes heimi* (Wasm.) predominantly found in India and Pakistan, probably has been established in Java.

VALUE

The termites held a vital status as a primary consumer and contribute in many ways in the tropical ecosystems. They are involved in increasing soil fertility by disintegrating wood in its many forms and thereby enhance the plant growth. They affect the vegetation by consuming selected components of living and dead vegetation and, as such, incur enormous economic loss. Termites serve as ideal food to numerous animals like, ants, lizards, birds and ant-eaters including man. The mound building termites of the genus *Odontotermes* support rich fauna as inquilines and guests in their mound playing a co-evolutionary role to increase the biodiversity of the area.

Ecological indicator taxa are not uncommon among termites in India. The occurrence of *Nasutitermes* in an area, is an indicator of rich biodiversity in rain forest and grass-land. Likewise, presence of *Reticulitermes* indicates temperate climatic condition and *Psammotermes* general aridity of the area. By liberating methane, they pollute our environment to a considerable extent. The food of termites includes a wide range of plant material, such as, living and dead wood in various stages of decomposition, herbaceous plants and grasses, plant debris, fungi, dung and soil rich in organic matter (humus). As such, a large proportion of energy sources of the ecosystem is potentially shared by termites, causing economic loss. In this respect termites differ markedly from other soil animals, the majority of which are saprophagous, scavengers, feeding on micro-organisms (fungi, etc.), humus and decomposed plant debris. However, man has changed the status of termites from the role of scavenger to pest due to his pursuit of extensive extension of agriculture, industries and urbanization.

THREATS

The moderate diversity of recent termite fauna of India, is the product of different elements of diversified ecosystems which have maintained considerable degree of stability for long time. Both diversity and stability are now being destroyed at a faster rate by human action. In the process, large number of species are evidently becoming threatened. Particularly threatened are those of wood inhabiting kalotermitids (*Neotermes*, *Glyptotermes*) and rhinotermitids (*Coptotermes*, *Reticulitermes*) inhabiting fragile and temporary niches, like old dead and dying trees, felled logs and termitid species (*Odontotermes* and *Microtermes*) in dung, sand dunes, under stone, garbage and the like. The destruction of the local population of all these species inhabiting such temporary habitats is being caused regularly by rural people

for their economic uses. Large majority of the soil inhabiting, mound-building and humivore species are becoming impoverished from the indiscriminate use of insecticidal chemicals so widely used in agricultural practice in India. The replacement of wooden structure, frame, furniture, etc., in the modern buildings by metal works, is a genuine threat to the house-hold species of the genera *Cryptotermes* and *Heterotermes*. Lastly, the wide scale consumption of termite queens of particularly mound building species by the tribals results into peril of these species of agricultural importance.

CONSERVATION STRATEGIES AND FUTURE STUDIES

The moderate diversity of recent termite fauna of India is decreasing in rapid rate due to destruction of its habitats through human activities as has been referred to earlier. Unfortunately, there is no real estimation of species which are under threat or becoming rare. Obviously, they need conservation for our own survival, since some of them are architect of our landscape and others are harmful. As such, conservation of these insects is a very critical and sensitive problem.

However, our conservation strategies are directed to establish numerous fairly large 'Nature Reserves' to ensure *in-situ* conservation of the diversity and stability of our living resources in general. In reality, these are not adequate for vast magnitude of our insect fauna due to ill management, exploitation, insufficient in number, size, and unsuitable location.

Realizing all these difficulties conservation criteria of species on priority basis can be considered based on the importance of taxonomy, ecology, biology, co-evolution, etc. Primary creteria for conservation of a species should be relatively rare and unique in taxonomic classification in comparison to others. To cite an example. *Archoptermopsis wroughtoni* (Bugnion and Popoff) a sole living representative of Termopsidae occurring in the western Himalaya, is under threat due to ecodisaster in the area. Likewise, ecological role played by some of the mound-building species of *Odontotermes* and co-evolutionary role played by termitophilous beetles in the nests and flagellates in the gut of *Coptotermes*, are unique criteria for conservation. In fact, the species under threat as mentioned in the preceeding section need protection on their own status and merit.

However, there are two opinions, the species destined to extinction within matter of decades need to be saved. Other aim is to give prior attention to species under threat by the time before they are lost. Some may

suggest that the most advanced genera, *Nasutitermes* and *Hospitalitermes* which are so plastic in adaptive changes in human dominated India, need no protection in comparison to other primitive and relict genera.

The detailed study of the status and preparation inventory of the species occurring in abundance in the eastern borderland, the peninsular and the foothills of the Himalaya, is a profitable area of future investigation to get more insight into their strategy of effective conservation.

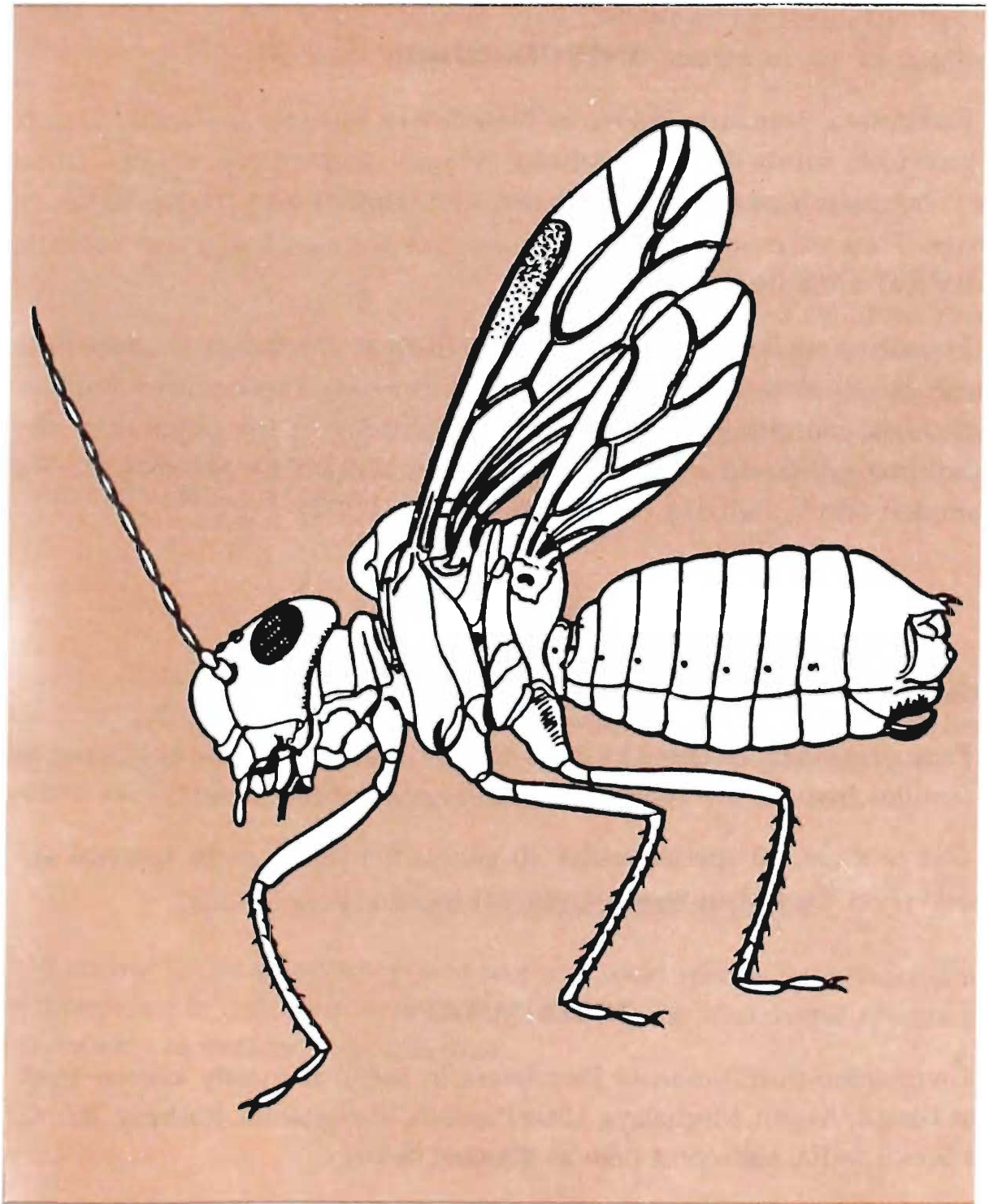
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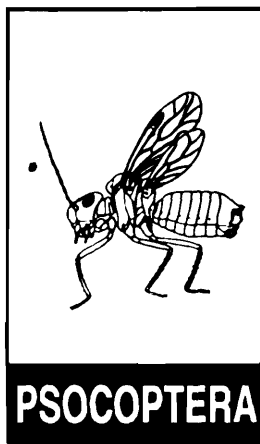
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Faunal Diversity in India : Psocoptera

K. K. RAY

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Psocoptera, popularly known as Book-lice or Psocids, are small, whitish or brownish, soft-bodied, subglobular, winged or apterygote insects. These are commonly found amidst old books and journals and among leaves or foliage. They are economically very important as they damage our valuable books and museum specimens.

In earlier time Burmeister (1839) named them as 'Corrodentia', afterwards Wardle (1937) placed them under order 'Psocoptera'. There exists a number of theories, indicating their origin and phylogeny of the order from the 'Neuropteroid group of insects', as put forward by Sellards (1909), Crampton (1919), Zellasky (1937) and Smithers (1972).

STATUS OF THE TAXON

Global and Indian Status

Psocoptera is represented by 2,500 species under 230 genera belonging to 31 families from all the zoogeographical regions of the world.

Out of these, 90 species under 40 genera belonging to 16 families are known from the Indian zoogeographical regions.

DISTRIBUTION

Geographic distribution of Psocoptera in India, is mostly known from West Bengal, Assam, Meghalaya, Uttar Pradesh, Maharashtra, Kashmir, Kerala and South India, till recent time as detailed below :

McLachlan (1866) reported the first species of Psocoptera from India, *Psocus fraternus* (Psocidae) from Assam along with a few others; Enderlein

(1903) described 7 species from Maharashtra; Banks (1914) recorded 6 species from Assam; Navas (1934) contributed 14 species from Maharashtra; Menon (1938, 1942) recorded 8 species from Maharashtra and Kerala; Datta (1963-1969) published 22 species from Assam, Meghalaya and South India; Thornton & Wong (1966) published 13 species from West Bengal; Badonnel (1981) reported 14 species from West Bengal, Assam and Uttar Pradesh; Ray (1984) provided a record of 43 species from Northeast India belonging to 10 families; Garcia Aldrete (1987) noted 2 species from Kashmir on Lachesillidae; Ray & Srivastava (1992) published a document with 39 species under 15 families from West Bengal.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

As mentioned earlier, Indian Psocoptera includes 90 species under 40 genera and 16 families. These insects prefer fungal and cellulose food deposited in book-binding material, among leaf-litter, in foliage, in the midst of stored cereals, under tree-bark among haystacks, organic debris, in bird-nest, lichens and yeast. They are gregarious in habit and live a colonial life. Eggs are covered under silken web. They have biting-type mouthparts. Food is rasped by single-lobed maxilla (lacinia).

ENDEMICITY

Most of the psocid species reported from Indian zoogeographical regions, are cosmopolitan in distribution, as endemicity is not thoroughly worked out in this country, till recent time. But it may be mentioned that so far 15 species are known to be endemic to India.

THREATENED AND INTRODUCED SPECIES

A review of the literature reveals that no Psocid species is considered to be threatened in India and there is no record of any introduced species in this country as evident from literature.

VALUE

Psocoptera are economically very important, because they damage our valuable books, herbarium and zoological specimens and stored cereals.

Sometimes, they become pest of stored grains. It is also reported that they may disseminate plant diseases by feeding on pathogenic fungi and leaving viable spores deposited elsewhere (New, 1971) and act as vectors of the fringed tapeworm of sheep as reported in North America (Allen, 1959).

THREATS

As long as the flora and silviculture exist, there is no threat for the survival of Psocopteran species. However, much deforestation and pollution in the environment may cause harm to these small insects.

CONSERVATION AND FUTURE STUDIES

Conservation of Psocids in India can be better achieved by afforestation programmes mostly with the help of village communities, by planting various kinds of herbs, shrubs and trees. While pursuing this programme, side by side, people interested for knowing these insects are to be trained under the expertise of Psocidologists, in field collection, preservation and identification of various taxa to enrich our Indian Psocid faunal wealth available from different ecological niches in our country.

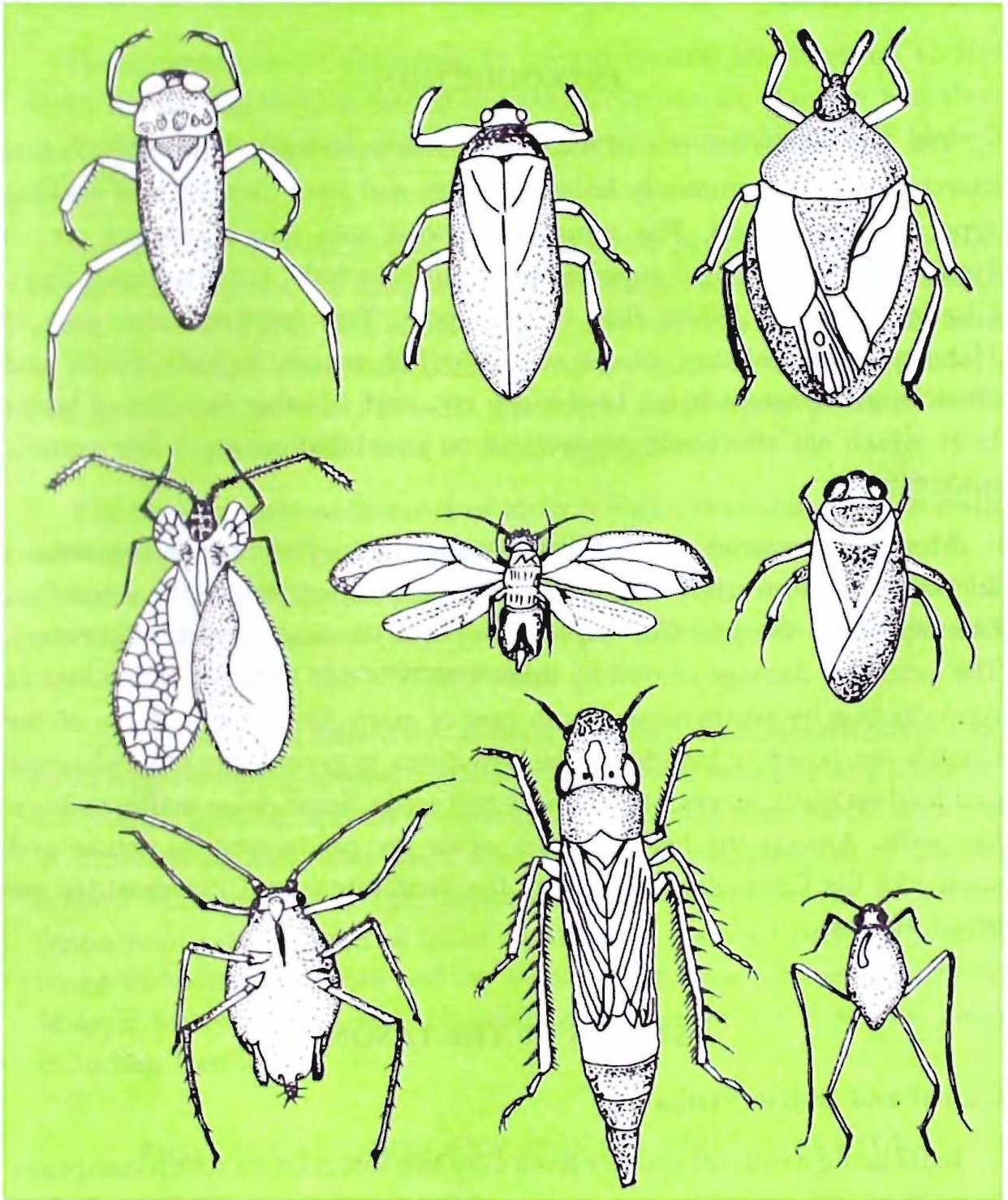
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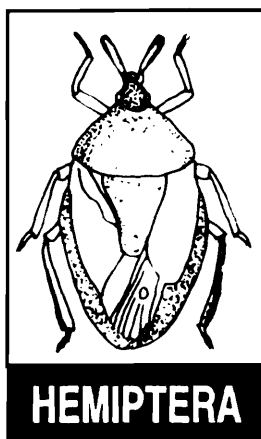
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Faunal Diversity in India : Hemiptera

L. K. GHOSH

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The Hemiptera are one of the largest and most important exopterygote insects. They are commonly known as bugs and have piercing and sucking type of mouth parts. The group is divided into two suborders *viz.*, i) Homoptera containing 8 superfamilies which include Aphids, Mealy bugs, Cicadas, Psyllids, White flies, Leafhoppers, Tree hoppers, etc., and ii) Heteroptera consisting of 14 superfamilies which include Stink and Shieldbugs, Assassin bugs, Lace bugs, etc., and 14 other families of water bugs which are effectively predaceous on zooplanktons and other aquatic microfauna.

Most of the species entail direct or indirect injury to various vegetations and are often destructive, like the Leafhoppers (Cicadellidae), the white flies (Aleyrodidae), the plantlice (Aphididae) and the scale insects (Coccidae). The extensive damage caused by these insects is due to the very fast rate of reproduction by parthenogenesis in case of many Homoptera. Some of the Coccids are, however, beneficial. The Hemiptera, in general, are phytophagous and feed on roots, leaves, stems, fruits and seeds. Some cause malformations like galls. Among the heteropterans, some are predaceous in nature and some like the Cimicidae (Bed bugs), the Triatominae and Polyctenidae are blood suckers.

STATUS OF THE TAXON

Global and Indian Status

India being a tropical country has a very rich insect fauna which comprises more than 80% of the known species of the world fauna. Of these, Indian Hemiptera, one of the largest exopterygote insects, consists of about 6,500 species distributed over 77 families and constitutes a little over 8% of the

hemipterans known from the world. Among 77 families, aquatic and semiaquatic hemipterans cover a little over 200 species belonging to 14 families, the remaining are terrestrial consisting of about 6,300 species belonging to 63 families. The aquatic and semiaquatic habitats harbour a sizeable population of species in Hemiptera.

DISTRIBUTION

Hemipteran insects belonging to certain genera are observed to have restricted distribution, occurring in Eastern Himalayas, Western Himalayas or Peninsular India and often showing their Indó-chinese and Malayan affinities.

Compilation of data reveals that most of the species of North East and North West regions are distributed in Himalayan ranges between altitude about 750 m and 4000 m and only a few from foot hills or lower hilly areas. In the Peninsular India there occurs about one-sixth of the total number of hemipteran species found in India whereas in the Gangetic plains as well as in the Indus plains said fauna is rather negligible.

The biogeographical diversity of India is well reflected in the distribution and abundance of flora and fauna. Aphid-host plant association, as for instance, is a typical example where about 650 aphid species infest 1250 plant species belonging to nearly 700 genera and 75 families against about a total plant species of 45,000 in India.

In spite of the vast differences in floral distribution and faunal composition in different biogeographical regions of India, there is hardly any attempt to analyse the biogeographical peculiarities in respect of abundance, endemism in different regions, host plant association and polyphagism of the soft-bodied homopterans in particular and other hemipterans in general. Discontinuous distribution of fauna and flora is observed between southern range including Sri Lanka and the Eastern Himalayas, Assam, Burma and Malaya. Many workers have observed this phenomenon in several groups including Hemiptera.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURE

A perusal of literature reveals that a great diversity of hemipteran insects is found in the Eastern and Northeastern Himalayas where the Hemiptera

fauna is an admixture of Palaearctic, Chinese and Malayasian fauna. Similar is the case with the Western Himalaya which includes mainly Jammu and Kashmir, Himachal Pradesh and Kumaon and Garhwal ranges of Uttar Pradesh where four phytogeographical zones are observed, *viz.*, tropical, subtropical, temperate and alpine zones. It is seen that subtropical zone is represented chiefly by rich aphid fauna both qualitatively and quantitatively, when compared to the tropical temperate and alpine zones. Here, the subfamily Aphidinae has higher frequency of occurrence than any other subfamilies. It is also observed that many hemipteran species occurring in the above areas are found in similarity with the fauna of Tibet, Afghanistan, Pakistan and Middle East. With the temperate climate and forests of Oak, Pine, Cedar, etc., these areas provided habitat for little known and rare species of Hemiptera. On the other hand, in the Indian Peninsula, Gangetic and Indus plains, diversity of hemipteran fauna is rather poor. The above concept may be explained as follows.

An analysis or regionwise distribution of some hemipteran groups like Aphididae in India reveals that species diversity and abundance are more in hilly terrains which meet with subtropical to warm temperate climate and represents the transition area between the realms of Oriental and Palaearctic. Genera wise break up of the group indicates that out of about 212 genera so far known from India, N. E. and N. W. India represent about 160 and 130 genera respectively whereas Peninsular India, Gangetic plains and Indus plains represent about 130, 60 and 35 genera respectively. Both N. E. and N. W. India represent genera belonging to all the subfamilies of Aphididae (Homoptera). Any representative of the subfamily Anoeciinae is apparently absent in Peninsular India. Likewise, the subfamily Lachninae is apparently absent in Gangetic plains.

It is worthwhile to mention that the genera belonging to subfamilies Aphidinae and Callipterinae are found to occur in all the regions of India and those of Aphidinae are most abundant throughout the country in comparison to other subfamilies. Further, it appears that percentage composition in subfamilies *viz.*, Aphidinae, Greenideinae, Hormaphidinae, Lachninae, Drepanosiphinae and also Pemphiginae recorded in the Himalayan region is apparently high. The Indian Peninsula having the Eastern and Western Ghat and the Vindhya ranges as well as the Gangetic and Indus plains represent rather poor aphid taxa.

Some hemipterans like plant lice exhibit peculiar diversity in the pattern of life cycle also. It is unique and highly adapted for individual species with a view to reproduce successfully, to tide over some adverse conditions and to avail of the maximum chances for survival. It is observed that in nature, sexuales of about 13% of the total number of species have been so far known mostly from the elevations in India. This may be explained by the fact that low temperature, short day length and physiological condition of plants are the factors for production of sexual forms.

It is interesting to note that out of about 650 species of aphids recorded from India, sexual morphs have been recorded for only 120 species and about 530 species are known from parthenogenetic viviparous forms. A majority (115) of species known by sexual forms are distributed in the temperate regions and only 5 species are so far known to produce sexuales in tropical regions of the country. But astonishingly enough, sexual morph (Apterous oviparous females) of Mustard aphid has been discovered (L. K. Ghosh and Rajendran 1988) recently in the Arid and Semiarid Zones (Rajasthan) where general faunal picture in almost all hemipteran groups including Aphids is poor.

The diversity of these phytophagous group of insects depends not on vegetational diversity alone but also on temperature and relative humidity. India, though tropical and subtropical on latitudinal consideration, has great assemblage of arctic to tropical climatic conditions because of its physiography influenced by Himalayan and Peninsular hills, mountains and uplands, and monsoon influenced by wind currents from the Indian ocean. This has led to more diverse and congenial ecological niches and habitats providing situations for many soft-bodied homopterans.

ENDEMICITY

Endemism has been found to be highly correlated with total number of species found in different regions and in different subfamilies of Aphididae in particular. This, however, may not be applicable to all the hemipteran group of Insects. Species diversity and endemism in certain families of hemiptera of economic importance are shown in Table 1.

Table – 1

Showing endemism in some hemipteran families of economic importance

Suborder	Family	Species (N)	Endemic Species (N)	%
Homoptera	Aphididae	650	422	65
	Psyllidae	120	69	57.5
	Cicadellidae	680	306	45
	Membracidae	200	94	47
	Coccoidea (Super family)	667	271	40.6
Heteroptera	Lygaeidae (Aquatic and Semiaquatic bugs)	260	130	50
	14 families	216	43	20

VALUE

The representatives of these hemipteran group of insects have enormous scientific, ecological and economical values. Aquatic bugs are important from the view point of water pollution. Some members of waterbugs destroy fishfry, tadpoles, etc., and are responsible for economic loss to the fish culture. Some members belonging to Cimicidae, Triatominae and Polychtenidae are blood suckers and are reported to carry diseases.

Some heteropterans are predaceous and thus keep check on populations of other insect pests. On the otherhand, there are some beneficial insects in Hemiptera such as the lac insects. India produces the largest quantity of lac in the World. Moreover, there are some more beneficial Hemiptera like wax insects, Cochineal insect and the lantana bug. Also, aquatic Hemiptera are effectively predaceous on zooplanktons and thus, play an important role in the aquatic ecosystem for transformation of energy. Because of their predatory habit, some aquatic bugs are studied for the biological control of mosquito larvae. The *Lethocerus* among water bugs kills even a full grown frog and even a small woodpecker, while some Belostomatids are known to feed on snails, potential vectors of Schistosomiasis.

THREATS AND CONSERVATION STRATEGIES

i) For control of hemipterous pest species, indiscriminate use of chemicals/ insecticides should preferably be stopped. Because in chemical control

schedule some beneficial insects are also killed along with harmful ones. Instead, biological control method should be encouraged so that ecological balance is restored. Uses of pheromones as insect repellent may be used as one of the tools of biological control programme.

ii) Farming the beneficial hemiptera like lac insect is to be implemented on a large scale because it is directly involved in Indian economy.

iii) The human interference in the destruction of habitat through deforestation, urbanisation and agricultural extension should be discouraged through Act, if possible.

iv) Since most of the hemipterans are phytophagous and host specific in many cases, attention should be given to preserve the food plants so that ecological harmony is maintained. Also, where natural forests are severely depleted, the plantation forestry should be initiated.

v) Collection of large number of specimens of a particular species should be discouraged because this practice may bring the population below the threshold of recovery.

vi) Human interference in aquatic ecosystem is gradually causing shrinkage in wetland hemipteran fauna. In near future, it may become a threat to some of the beneficial aquatic bugs. This practice should be resisted and also measures should be taken to control pollution through extensive use of pesticides and industrial effluents.

vii) More public awareness is necessary about the conservation needs of some important hemipteran species, such as lac insects and their host plants.

FUTURE STUDIES

Although a good number of hemipteran species including an appreciable number of endemic ones are on record, the real numbers are likely to be much higher. Many biogeographical areas of the country are yet to be fully explored and also, there are several groups that have not been studied in depth due to lack of either material or expertise. Further, fauna of aquatic habitats have received scanty attention. It is, therefore, expected that in years to come, with extensive and intensive collection of materials round the year and subsequent study could no doubt reveal a greater number of Hemiptera in India.

Since the knowledge on biology of a good number of hemipteran pest species is meagre in India, a serious study on bionomics of such important

species including endemic ones may be taken up in collaboration with different Indian Universities. Further, scientific studies are necessary to establish the population sizes of each species.

Lastly, wetland fauna of Hemiptera is not well explored in India. Sincere efforts may, therefore, be made to study these insects based on the systematic collections of base line data from diverse habitats such as waterfalls, slowmoving rivulets, fastflowing mountain streams, pools & puddles including most of freshly dried river beds. The serious study may reveal interesting results so far as aquatic hemipteran insects are concerned.

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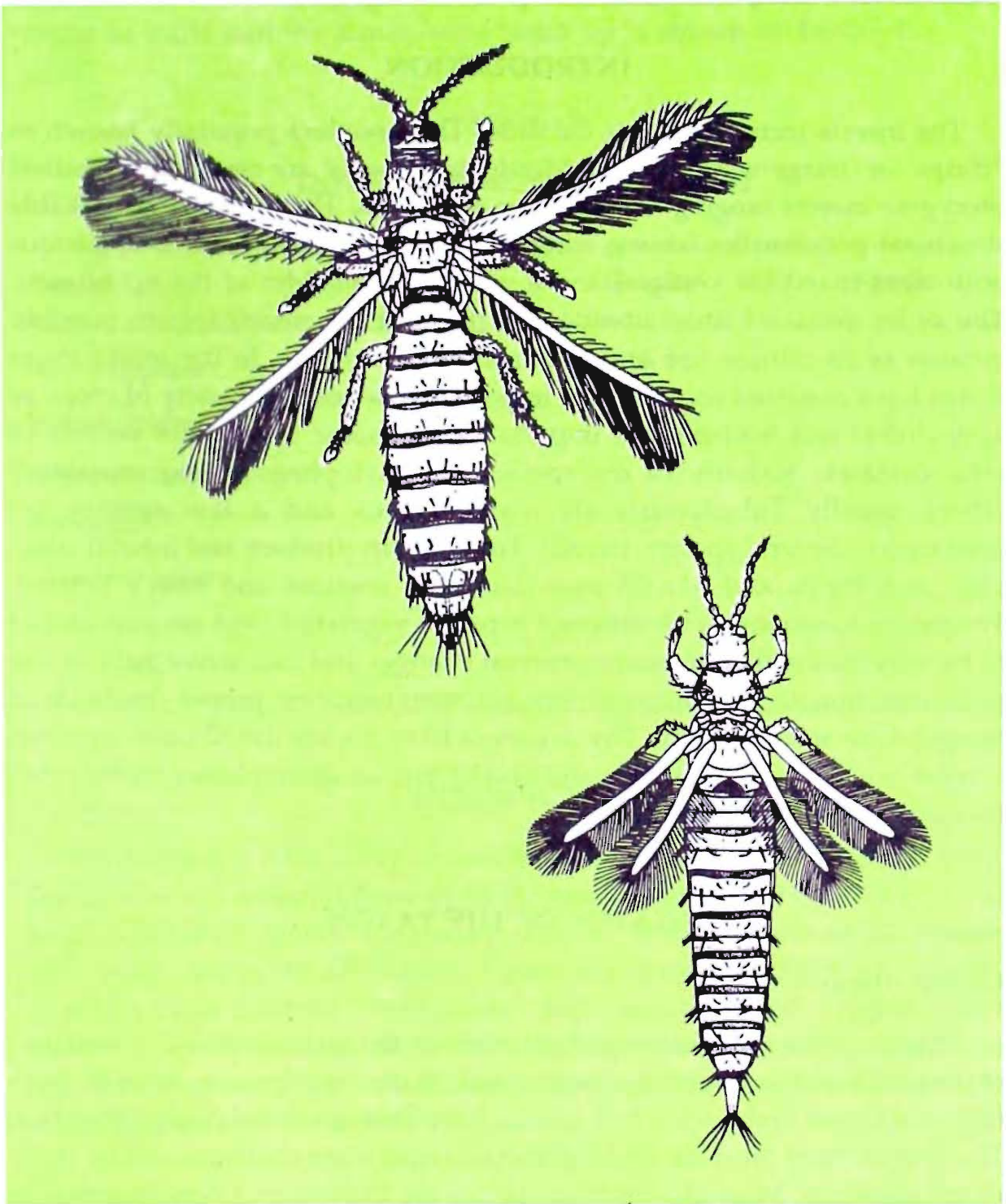
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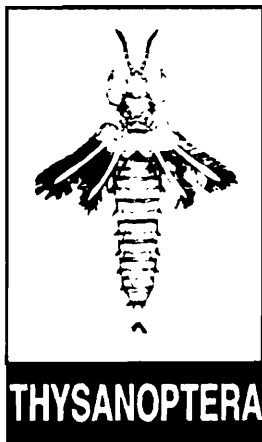
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Faunal Diversity in India : Thysanoptera

S. SEN

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The insects included under the order Thysanoptera popularly known as “thrips” or ‘fringe-wings’ or ‘bladder-footed insects’ are one of the smallest pterygote insects ranging from 0.5 mm to 10 mm. They possess remarkable structural peculiarities having fringe-wings, asymmetrical feeding apparatus with right mandible vestigial and a portrusible bladder at the tip of tarsi. The order received little attention in the past by entomologists possibly because of its minute size and unattractive colouration. In the recent years thrips have assumed considerable importance as pests of variety of crops of agricultural and horticultural importance and some species are vectors of viral diseases. Majority of the species are phytophagous and remaining others usually Tubuliferans are mycophagous and a few species are predaceous. Several species, usually Tubuliferans produce and inhabit plant galls and thrips and remain protected from enemies and heavy rainfall. Thrips are associated with different types of vegetation and are considered to be very susceptible to environmental changes and can thrive only under particular climatic and microclimatic situation requiring proper condition of temperature and humidity. Thysanoptera have a wide distribution by often carried over to a small distance and also by human agency being transported through article of commerce.

STATUS OF THE TAXON

Global Status

Thysanoptera are widespread throughout the globe with an abundance of tropical and subtropical species and many species are known from temperate zone and even a few species have been reported from Antarctica. The species from Nearctic and Palaearctic regions are characterised by more recent elements. Most gall-forming species are tropical and very common in Indo-Malaysia and Australia; others occur in Pacific Islands and Africa are few and also in Europe and America. At present eight families of

Thysanoptera, viz., Uzelothripidae, Merothripidae, Aeolothripidae, Adiheterothripidae, Fauriellidae, Heterothripidae, Thripidae and Phlaeothripidae have been recognised. Approximately 6,000 species are known from the world.

Indian status

Out of eight families of Thysanoptera, five families Merothripidae, Aeolothripidae, Adiheterothripidae, Thripidae and Phlaeothripidae are represented in India. Altogether 693 species under 249 genera are known to occur in India and the family-wise break up is shown in Table – 1.

Table – 1
Diversity of Indian Thysanoptera

Family	Genera	Species
Aeolothripidae	10	18
Merothripidae	1	2
Adiheterothripidae	1	2
Thripidae	100	252
Phlaeothripidae	137	419
Total	249	693

DISTRIBUTION

Thrips have a wide range of distribution throughout the country. Even a few species are reported from up to the snow limit of the Himalayas. A very large number of species are known to occur in some parts of the country, viz., South India, West Bengal, Delhi and parts of Rajasthan, Madhya Pradesh, Uttar Pradesh, Northeastern India and Himachal Pradesh due to intensive survey in these areas from thrips point of view. The distribution record of thrips in india from different geographical, regional and ecological zones is shown in Table – 2.

Table – 2
Family-wise Distribution of Thysanoptera in India

	Aeolothri- pidae		Merothri- pidae		Adihetero thripidae		Thripi- dae		Phlaeo thripidae	
	G.	sp	G.	sp	G.	sp	G.	sp	G.	sp
N-E India	1	1					22	28	42	76
E. India	2	3	1	1			40	60	34	60
Peninsular										
India	5	5	1	1	1	1	57	101	93	180
Eastern Ghat							12	13	44	64
Western Ghat	1	2	1	1			25	49	62	110
N. India	1	4					41	62	29	43
Arid and Semi-Arid zone							8	11	3	6

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Thysanoptera possess remarkable structural diversity stimulated possibly due to fluctuations in habitat and internal environments. Although majority of thrips are phytophagous, a fairly large number of mycophagous Tubuliferans due to fungal feeding have a considerable strong impact on there biology, dispersal patterns, resulting in speciation. Most of the species are unicolourous bright, some bicolourous or tricolourous and others with a variety of shades. Cuticle shows striking patterns of scupltures in different genera and species taking the form of distinct polygonal reticulations, irregular corrugations and transverse striae or granulations. Sexual dimorphism is sometimes characteristic of antennal segments. Forelegs in both sexes show remarkable specialisation in possession of various degree of armature from setal clothing to strong bizarre teeth. Wings often vary inform and four types of wings, *viz.*, macropterous, hemimacropterous, brachypterous and apterous forms are recognised. Sex limited polymorphism and presence of Oedymorous and Gynaecoid males are unique characteristic of the group. In the Oedymorous forms certain parts specially the size, forelegs and antennae are strikingly enlarged while in the Gynaecoid froms they are devoid of such anomalies and their body proportions much reduced and often resemble the females.

ENDEMIC AND EXOTIC SPECIES

Endemic species in India

Endemic species are abundant in Tropical and Ethiopian Regions. Majority of the species recorded from India is also endemic. Altogether 92 genera out of 249 genera and 520 species out of 693 species reorded from India are endemic and endemicity in Indian fauna constitutes about 38% and 74% of genera and species respectively. Family-wise break up of endemic species in India is shown in Table – 3.

Table – 3
Number of endemic genera and species of Thysanoptera in India

	Genera	Speicies
Aeolothripidae	1	14
Merothripidae	—	1
Adiheterothripidae	—	2
Thripidae	37	175
Phlaeothripidae	54	328

Exotic species in India

Apart from the presence of a fairly large number of endemic Indian thrips, there are a number of exotic species comprising Ethiopian, Malayan, Palaearctic, Nearctic and Cosmopolitan species. The regional break up of which is shown in Table – 4.

Table – 4
Number of exotic genera and species in the families reported from India

	Aeolothri- pidae		Merothri- pidae		Thripidae-		Phleo- thripidae	
	G.	sp.	G.	sp.	G.	sp.	G.	sp.
Ethiopian	1	2	1	1	21	25	13	21
Malayan					1	2	15	17
Palaearctic	1	1			11	15	6	6
Neotropical					2	2	1	1
Nearctic			1	1	3	3	7	7
Cosmopolitan	1	1			3	3	2	2

VALUE

Majority of thrips are phytophagous feed on cultivated crops and ornamental plants causing considerable damage and their ability to exploit suitable niches results in their increased damage potential. Although thrips are minute in size they make up by their numbers and their aggregate feeding causes severe damage to young leaves, flowers, buds and fruits.

A number of species usually the Tubuliferans produce plant galls on variety of plants belonging to Gymnosperms, Dicotyledons and also some Monocotyledons. Some species of thrips are known to be vectors of viral diseases. Tomato Spotted Welt Disease and Pea Nut yellow Spotted Disease are transmitted by thrips and Tobacco Streak Virus enters its host plant through feeding punctures in the leaves by thrips. Thrips also cause Toxaemias in plants by toxin in saliva, bacterial and fungal diseases by contact and virus transmitted during feeding. Thrips play a role as natural control agents. A few species of predatory thrips feed on small soft bodied insects, aphid nymphs, psocids, scales, mites other thrips and even their own young ones. In recent times it is known that thrips play a role in pollinating specially where large insects are scarce. Another beneficial effect is their role in weed control. Few species of phytophagous thrips have been exploited to control weeds.

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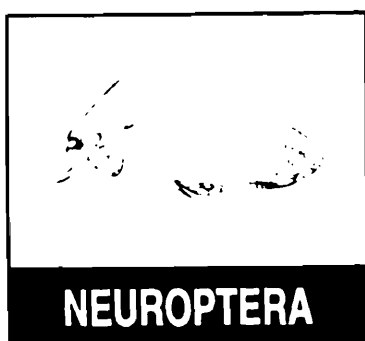
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Faunal Diversity in India : Neuroptera

S. K. GHOSH

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Neuroptera are soft-bodied insects and include a variety of small to large insects. They are readily recognised by the fine net work of veins of generally transparent wings and well developed antennae. The wings are held roof-wise over the back at rest and are generally similar in size, shape and venation. The mouth parts are adapted for chewing, with strong mandibles, maxillae and well developed labium. In majority, the thoracic segments are subequal. Abdomen is 10-segmented with eight abdominal spiracles. The larvae are predacious, aquatic, semiaquatic, arboreal or terrestrial. The pupa is pupa libera.

STATUS OF THE TAXON

The order Neuroptera was erected by Linnaeus (1758). Later it was found that Linnaeus's Neuroptera represented a heterogeneous group being formed of a large number of heterometabolic and holometabolic insects. These insects later were separated into orders of their own, namely, Odonata, Plecoptera, Ephemeroptera, Psocoptera, Mecoptera, Trichoptera, beside true Neuroptera. Popularly, the neuropterans may be called as Dobson flies, Alder flies, Fish flies, Snake flies, Lacewings, Antlions and Owl flies. The name Neuroptera is presently used in two different senses. Some authors divided Neuroptera into three orders namely, Megaloptera, Raphidioptera and Neuroptera (*S. str.*), while others split Neuroptera into two suborders, Megaloptera and Planipennia as conceived in the present paper. These two suborders contain seven superfamilies which include twenty families from all over the world. These families are Corydalidae, Sialidae*, Raphididae (including Inocellidae), Ithonidae*, Coniopterygidae, Dilaridae, Berothidae, Polystoechotidae*, Sisyridae, Mantispidae, Hemerobiidae, Chrysopidae, Psychopsidae*, Osmylidae, Neurorthidae*, Nymphidae*, Myrmeleontidae, Ascalaphidae, Stilbopterygidae* and Nemopteridae. The families marked with asterisk are not represented in India. The taxonomy of the majority of the families of Neuroptera is confused and difficult to study due to large

number of inadequately described taxa. These descriptions lack information required for the determination of the species.

Global Status

Numerically, about 5000 species are known from the whole world of which the family Chrysopidae with about 1350 species (Tjeder, 1966), Myrmeleontidae with more than 1200 species (Richards and Davis, 1977) and Hemerobiidae with about 800 species (Tjeder, 1961) constitute about 67% of the total global neuropteran fauna.

Indian Status

A total of about 335 species under 125 genera and 13 families are known from India. The suborders and family-wise break up are as follows:

Suborder	Family	Genera	Species
Planipennia	Coniopterygidae	7	11
	Dilaridae	3	3
	Berothidae	3	3
	Mantispidae	4	12
	Osmylidae	8	14
	Sisyridae	2	4
	Hemerobiidae	10	22
	Chrysopidae	20	73
	Nemopteridae	4	6
	Myrmeleontidae	40	126
	Ascalaphidae	16	36
Megalloptera	Corydalidae	7	24
	Inocellidae	1	1
Total : 2	13	125	335

DISTRIBUTION

The presence of diverse ecosystems and habitats in India has given scope for rich species diversity. Neuropterans are found in the Himalayan ecosystem, desert ecosystem, terrestrial ecosystem of Peninsular India and

insular ecosystem. Of these, the diversity is more in the Himalayan ecosystem. This may be assessed by the existence of about 128 species of Neuroptera (about 38% of the total Indian neuropteran fauna) from North-East India comprising of nine states, namely, Arunachal Pradesh, Assam, Meghalaya, Manipur, Nagaland, Mizoram, Tripura, West Bengal (Darjeeling) and Sikkim. Due to varied climatic conditions, a wide variety of vegetation are found in North-East India. This includes evergreen and semi-evergreen forests, grasslands and swamps upto an altitude of 900 m., temperate and alpine vegetation. In these places, cereals under terrace cultivation, fruits and beverages are common. Due to wide variety of vegetation, North-East India is important for the insect species richness. In the Peninsular part, the floristics are rather exclusively composed of tropical elements including cereals, pulses, fruits, etc. Such richness of flora evidently invites a large number of insects or mites on which these neuropteran insects predate. Therefore certain areas of Peninsular India are rich in neuropteran diversity. In Desert and Insular ecosystem, the knowledge is far from complete. Only 11 species of Neuroptera from Andaman and Nicobar Islands and 2 species of Neuroptera from Laccadive Islands have so far been reported. A few species have so far been reported from Desert ecosystem. From the existing knowledge, it is too premature to attempt an estimation of species diversity.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Larvae of Neuroptera occupy a wide range of habitat. Some are found only in sand or dust (Myrmeleontidae, Nemopteridae, Ascalaphidae), others arboreal (Chrysopidae, Hemerobiidae, Coniopterygidae) and several are aquatic or semiaquatic (Sialidae, Sisyridae, Osmylidae). Several families of Neuroptera are predacious in habit. The formation of pits by the larvae of antlions (Myrmeleontidae), utilisation of natural depressions for concealment by the larvae of owl flies (Ascalaphidae) or awaiting in the dust on the floor of neglected buildings (Nemopteridae) for predation on other insects are the interesting features of Neuroptera. Besides, some Neuroptera predate on insects of sedentary habits or mites (Chrysopidae, Hemerobiidae and Coniopterygidae). Spongilla flies (Sisyridae) suck the body fluid of sponges and mantispids (Mantispidae) are predacious on the egg sacs of spiders.

Several kinds of strategies are used by neuropteran predators in finding and capturing prey :

(i) **Random searching** : Predators may patrol leaves, stems, etc. and eat immature or adult insects (Chrysopidae, Coniopterygidae, Hemerobiidae).

(ii) **Trapping** : By the formation of a pit, concealing in natural depression or dust as stated above, the predators wait for the prey.

(iii) **Ambush** : They simply wait for prey to reach within striking distance by the raptorial forelegs (Mantispidae of Neuroptera like Mantidae of Dictyoptera).

Distributional diversity :

Some interesting observation may be made on the distribution of genera and species on world basis. In the family Coniopterygidae, the genus *Semidalis* Enderlein occurs in all continents except Australia, while *Spiloconis* Enderlein and *Heteroconis* Enderlein are restricted in distribution to Asia. The genus *Hemerobius* Linn. of the family Hemerobiidae is represented in all major regions of the globe except Australia and Oceania but the genus *Micromus* Rambur has a world-wide distribution. In Chrysopidae, the genera *Chrysopa* Leach, *Chrysoperla* Steinmann, *Mallada* Navas are distributed almost world-wide, while *Ankylopteryx* Brauer, *Brinckochrysa* Tjeder are tropical genera of the old world and *Stigmachrysa* Navas and also *Evanochrysa* Brooks and Barnard are restricted to Indo-Malayasia. Though the family Osmylidae is found in most continents but the genus *Spilosmylus* Kolbe is restricted in distribution to Oriental and Ethiopian regions and *Hyposmylus* MacLachlan and *Heterosmylus* Krüger are represented in Asian continent. The family Myrmeleontidae and Ascalaphidae are most abundant in tropical countries. In the family Ascalaphidae, *Protidricerus* Weele, *Idricerus* MacLachlan, *Hybris* Lefebvre and *Acheron* Lefebvre are restricted to Asian continent as that of the genera *Neoneuromus* Weele, *Protohermes* Weele, *Neochauiodes* Weele and *Acanthacorydalis* Weele of the family Corydalidae. Other interesting genus in the family Ascalaphidae is *Glyptobasis* MacLachlan which is restricted in distribution in Indian subcontinent. The genus *Berotha* Walker (Berothidae) is probably restricted to the Oriental region (Aspöck, 1983) while the genus *Acroberotha* is Oriental and Ethiopian in distribution.

“A remarkable type of distribution is represented by *Micromus timidus* Hagen (Hemerobiidae). It ranges from Western Africa via Seychelles, India and the East Indies to Australia and Oceania and has the widest distribution among the intertropic Neuroptera” (Tjeder, 1966).

ENDEMICITY

The approximate number of the endemic genera and species stands at 13 (10%) and 262 (78%) respectively. The endemicity can probably be explained by the richness of the flora including agri-horticultural plantations. Such

richness of the flora evidently invites a large number of insects and other organisms on which these neuropteran insects predate.

THREATENED SPECIES IN INDIA

The documented data on the threatened species of Neuroptera is not available. Quite a large number of species were not collected after their discovery. Faunistic surveys for the collection of Neuroptera and the taxonomic studies on the group are not satisfactory. Therefore it is difficult to provide any information of the threatened species of Neuroptera.

VALUE

The neuropterans are valuable allies of man. The group includes quite a large number of species which are predacious on different insect pests in their larval and adult stages. These active predators destroy the agri-horticultural pests like aphids, coccids (Hemiptera), thrips (Thysanoptera), moths (Lepidoptera), mites (Acarina), etc. They are thus agents of biological control of pests and may contribute savings in national economy by reducing the pest population if they are properly utilised.

THREATS, CONSERVATION AND FUTURE STUDIES

The occurrence of diverse ecosystems and habitats enriched species diversity in India. But due to habitat alteration, some of the species reported earlier are not found in recent samples. So, intensive surveys have to be undertaken to establish the fact that the species have either been threatened or extinct. Besides, the systematic studies of Neuroptera have not received much attention in India. Therefore, more efforts should be made to identify, inventorise and designate the status of the species. There is a need to gather biological and ecological information of the species to gain better understanding of the systematics. Such studies will provide the baseline data for a conservation strategy. As the neuropterans are entomophagous, the native home of the pests should be located and details of their biology should be studied. Biological control agents like Neuroptera cause no environmental pollution or generally harm to other organisms like insecticide control. On the other hand, they play vital role in reducing insect pest population affecting flora including agri-horticultural plantations and thereby

indirectly contribute savings in the national economy. So, proper attention should be given to conserve and maximise by captive breeding these regulatory forces to reduce the pest population.

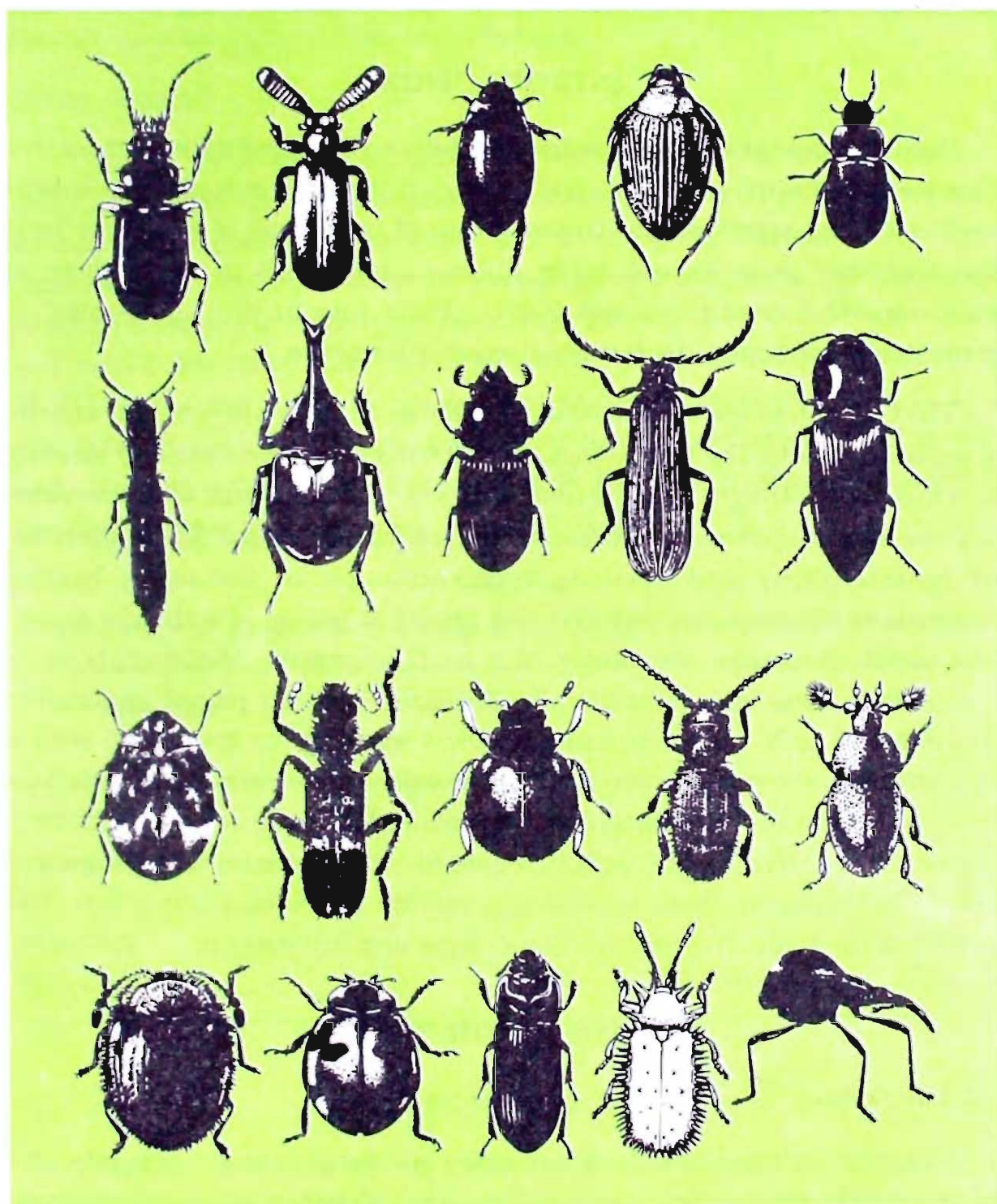
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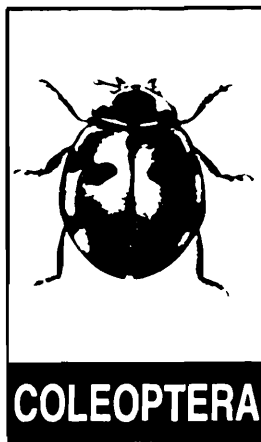
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Faunal Diversity in India : Coleoptera

T. SENGUPTA AND T. K. PAL

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Beetles comprise the insect order Coleoptera (the name derived from two Greek words, meaning a sheath, and a wing). Not only in number of described species beetles represent the largest group of organisms at the order level but also they show exceptionally diverse adaptations to wide range of environmental conditions and habits. Their role in the functioning of ecosystems, especially the terrestrial ones is immense.

The Coleoptera are minute to large (0.6 mm to 15 cm) in size and usually sclerotized insects. The front wings are much thickened, veinless and meeting in a middorsal straight line; the hind wings are membranous, with few veins and the apex folded beneath when at rest, sometimes absent. Mouthparts are of typical biting and chewing type, although in the snout beetles (Curculionidae) these are reduced and placed at the tip of a slender trunk-like snout. Antennae are mostly of 9 to 11 segments. Metamorphosis is complete. Larvae are worm-like; head usually without paired endocarina forming a V or Y, antennae usually with 4 segments or fewer and with a sensorium on the penultimate segment; usually with 3 pairs of thoracic legs but rarely apodus (Scarabaeidae, Curculionidae, etc.), legs with 5 or 6 segments; abdomen usually with 10 segments and sometimes with prominent cerci. The pupae are with appendages and do not form a puparium. The beetles show wide diversity of colour, form and life pattern.

STATUS OF THE TAXON

Global Status

More than one out of every four named species of animal is a beetle. Out of about 8,00,000 described species of insects Coleoptera alone shares about 3,50,000 species belonging to 177 families under 4 suborders. But still it is doubtful whether this number represents one-tenth of those existing today.

So far as the richness of the fauna in the World is concerned the beetles are found in most abundance or with great concentration in the tropical and subtropical parts of both the hemispheres which receive good precipitation and possess substantial vegetative cover. Often the areas within which a particular species occur naturally appear to be interconnected. But the taxa above species level, in many cases, are distributed to disjunct areas interrupted by vast stretches of oceans or seas. These distribution have undergone changes in the remote past through the interaction of positional change of continental masses, climatic and evolutionary changes.

Indian Status

Owing to variation in altitude and latitude and difference in rainfall, India possesses great ecological diversity ranging from tropical and subtropical of plains to temperate and arctic of the Himalaya. All these demonstrated vegetative cover of varied groups, plus a hot hostile desert patch in west of the country. These contribute to a diversified beetle fauna and India holds about 5 per cent of all known species of the world, *i.e.*, about 15,500 species belonging to 104 families under 3 suborders (Table 1). It is estimated that if a good exploration of all habitats for collection of beetles and inventorisation of collections are made, the number of species would at least be doubled to the existing figure of 15,500.

Table – 1
Diversity of Coleoptera (in numbers) in India in contrast to world

Suborders	No. of families		No. of species	
	W	I	W	I
Archostemata	4	—	26	—
Myxophaga	4	1	58	1
				(undescribed)
Adephaga	11	7	34,250	3,000
Polyphaga	158	96	3,16,000	12,500

DISTRIBUTION

A significant feature of the present Indian beetles is the occurrence of Chinese, Burmese and Malayan elements, which are rich in terms of number of species, plus the element of original Gondwanaland that shows affinities

with the existing African element to a certain extent. Beetles are to be found everywhere and in almost all ecosystems where animals can thrive, with the exceptions of arctic snow and the sea-waters. There are many types of habitats in which more or less characteristically specialized beetle representatives are to be seen. Water or atmospheric humidity, favourable temperature gradient and the food (plant life is basic source) are the three basic requirements for the beetles to flourish. The annual rainfall in India exhibits a wide range of variation from less than 150 mm in Thar desert to more than 5000 mm in Khasi hills. India possesses very rich evergreen and subtropical vegetation in Eastern Ghat, Nilgiri hills, Western Ghat, Northern West Bengal, Assam plateau, Eastern and Western Himalaya, etc., and consequently these areas become the major zones of concentration of rich beetle fauna of the country.

Apart from the course of distribution impacted by geographic, climatic and evolutionary changes, the distribution of beetles must have been influenced at a greater rate by the human activities in recent times. Though a realistic estimate become impractical, it is thought that at least 400 species have entered into this country in the last four centuries through various human agencies. These species might have come either as adults, or as immature stages, or as eggs along with plants, fruits, seeds and plant products.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The biological diversity of Coleoptera is enormous as they exploit varied types of foods, reside in widest range of habitats and use diverse methods of locomotion. The taxonomic diversity of this group has already been shown in Table 1.

The diversification within Coleoptera in modes of feeding and digestion is almost as great as that in the food themselves. Many beetles are primarily predacious. The ground beetles (Carabidae), rove beetles (Staphylinidae), predacious diving beetles (Dytiscidae) are good examples of predators. Worms, various tiny insects and their larvae, slugs, snails, and even fishlings and tadpoles become their victim. Some hydrophilid larvae predate on snails and small invertebrates while their adults feed on decomposing vegetation; Histeridae usually predate on wood inhabiting grubs and dung inhabiting maggots; some Staphylinidae, Scydmaenidae, Pselaphidae and Coccinellidae feed on mites, coccids, aphids, etc.; adults of some but larvae of most of the Cleridae are predacious on larvae in dead woods; larvae of fireflies (Lampyridae) prey on snails, slugs, earthworms, caterpillars, etc. Many Silphidae, Anisotomidae and Staphylinidae are scavengers and feed on dried

animal matters, dry insects and museum specimens. A number of beetle families are mould feeders; Nitidulidae are usually mycetophagous or saprophagous; members of Erotylidae, Endomychidae, Corylophidae, Mycetophagidae, Tetratomidae, Melandryidae, etc. feed on fungal spores or soft fungal tissues. Some Anthicidae, Meloidae, Cantharidae, Nitidulidae and Staphylinidae feed on pollen and nectar of flowers. Anobidae, Bosrychidae, Scolytidae, Platypodidae and Lyctidae are xylophagous (wood eating). The adults of Buprestidae, Elateridae, Curculionidae, Chrysomelidae, Cerambycidae are phytophagous, usually feeding on foliage or vegetal parts of plants; many soil dwelling white grubs (Scarabaeidae) feed on roots of plants. A number of beetles distributed to families Curculionidae, Tenebrionidae, Bruchidae, Bostrychidae, Cleridae, Nitidulidae, Silvanidae, Cucujidae, etc. feed on stored grains or grain products. A number of Scarabaeidae are dung or carrion feeders. In a few cavernicolous species (Leiodidae), the larva takes no independent food but gets nourished inside the body of the mother. In some Elateridae, the adult feeding is very restricted and of little biological significance.

The exceptional diversity of food and extensive adaptive biology have made the beetles capable of exploiting diversity of ecological habitats. The chief habitats and their prevalent representative families are as follows :

(i) Under stone, logs and fallen trees :— Carabidae, Tenebrionidae, Staphylinidae, Histeridae, etc.

(ii) Under bark (dying or dead trees) :— Silvanidae, Cucujidae, Elacatidae, Inopelidae, Nitidulidae, Colydiidae, Corylophidae, Cryptophagidae, Erotylidae, Endomychidae, Rhizophagidae, Cerylonidae, Mordellidae, Carabidae, Staphylinidae, Histeridae, etc.

(iii) Tunnels and holes of trees, stumps :—Scolytidae, Bostrychidae, Lyctidae, Platypodidae, Anobiidae, Colydiidae, Carabidae, Elateridae, etc.

(iv) Rotten and decayed wood :—Passalidae, Lucanidae, Anthribidae, Cerambycidae, Rhipiphoridae, Rhipiceridae, Tenebrionidae, Scapidiidae, Rhysodidae, Paussidae, etc.

(v) Shrubs, foliage and small trees :—Chrysomelidae, Cantharidae, Coccinellidae, Curculionidae, Buprestidae, Burchidae, Elateridae, Scarabaeidae, Cleridae, Languriidae, Lathridiidae, Mycetophagidae, etc.

(vi) Flowers :—Anthicidae, Pedilidae, Nitidulidae, Cryptophagidae, Phalacridae, Coccinellidae, Buprestidae, Scarabaeidae, Cerambycidae, Chrysomelidae, etc.

(vii) Vegetation debris :—Staphylinidae, Scarabaeidae, Mycetophagidae, Anthicidae, Scydmaenidae, Ptilidae, Pselaphidae, Tenebrionidae, etc.

(viii) Dung and Carrion :—Scarabaeidae, Staphylinidae, Hydrophilidae, Histeridae, Silphidae, Dermestidae, etc.

(ix) Fungi :—Erotylidae, Nitidulidae, Sphingidae, Tenebrionidae, Scaphidiidae, etc.

(x) Nests of mammals, birds, ants, termites :—Dermestidae, Staphylinidae, Histeridae, Merophysiidae, Cerylonidae, etc.

(xi) Water bodies :—Dytiscidae, Gyrinidae, Hydrophilidae, Haliplidae, Dryopidae, Amphizoidae, etc.

ENDEMICITY AND PLASTICITY

On the basis of available information, India appears to possess about 20 per cent of its beetle species endemic to this country. However, the Coleopteran fauna of the adjoining countries is far less known than that in India. Therefore, it is uncertain whether a large number of species described from India extend their range of distribution to those countries or not. Hence, the endemicity of the Indian species remains to be a matter of controversy till the fauna of the neighbouring countries are significantly explored.

From the view point of dispersal efficiency, that underlies the reason for endemicity to certain extent, beetles may be categorised into five main types. The first of these are the forms in which the females are flightless, and those who do neither have regular phoresy by flying hosts or development in dead timber (found among certain Carabidae, Cerylonidae, Drilidae, Cantharidae, Tenebrionidae, Curculionidae, etc.). The second category comprises the long-lived but rarely flying adults and whose larvae do not develop in dead timber (found among certain Chrysomelidae, Curculionidae, Carabidae, etc.). The third category comprises short-lived but frequently flying and active adults which spread reasonably over distance, excepting wide habitat gaps (found among certain Scarabaeidae, Cantharidae, Cicindelidae, Melyridae, Mordellidae, Oedemeridae, Cerambycidae, etc.). The fourth category comprises long-lived larvae in dead timber and both adults and larvae capable of surviving in sea drifted logs, etc., (found among certain Curculionidae, Cerambycidae). The fifth category comprises small, readily flying beetles, caught up in air currents and drifted to distance as 'aerial plankton' (found among certain Staphylinidae, Nitidulidae, etc.). The species belong to categories one and two entirely and these of three partially have

rather restricted areas of distribution. Moreover, the cave dwelling forms with flightless adults have least capacity of survival outside their specific habitats (found among certain Carabidae, Scydmaenidae, etc.).

It is also believed that the beetles as a group which has shown great adaptability and plasticity in the evolutionary course may be able to adjust changes of human dominated world. As for example, a number of species have established themselves as 'stored pests' or 'agricultural pests' or otherwise 'anthropophilic' by adaptations in course of millienia of stable custom of food storage, agriculture, etc.

VALUE

Most of the beetle species are neither specifically useful or harmful to us, nor are they unique indicator species monitoring the health of the environment in any precise way. Most are in a sense, merely small fibres in the enormous fabric of life in our natural world. However, some of them really have beneficial uses as well as harmful effects to human concerns.

Human interest in Coleoptera can be traced back to ancient history or prehistory. The luminosity of fireflies (Lampyridae), the poisonous properties of certain Chrysomelidae and Carabidae, the brilliant metallic colours of large Buprestidae have all attracted attention of primitive people. The depredations by beetles in food stores and medicinal properties of Cantharidin of Meloidae were not unknown to them.

The economic importance of various beetles are well known. More than 300 species in India are noted as pests of field crops, forest trees, timbers and various stored products. A large number of beetles are detrimental to economic crops or agriculture. They attack various plants of cereals, vegetables and spices (Chrysomelidae, Curculionidae, Elateridae, Meloidae, etc.) ; fruit trees and orchard crops (Curculionidae, Chrysomelidae, Scarabaeidae, Cerambycidae, Tenebrionidae, Buprestidae, etc.). A number of beetles belonging to families Cerambycidae, Chrysomelidae, Curculionidae, Platypodidae, Scolytidae, etc., cause damage to forest trees and timber by infesting them. Some beetles belonging to families Cerambycidae, Lyctidae and Anobiidae are destructive to timber in buildings, packing cases, furniture, etc. The main beetle pests of stored products belong to the families Dermestidae, Bostrychidae, Anobiidae, Trogositide, Cleridae, Nitidulidae, Silvanidae, Cucujidae, Tenebrionidae, Bruchidae, Curculionidae, etc.

On the contrary, the value of Coccinellidae as destroyer of injurious homoptera and mites; of the Carabidae, Staphylinidae and Colydiidae as

destroyer of lepidopterous, dipterous and coleopterous larvae; of many Chrysomelidae as destroyer of injurious plants are realised. Many species (Silphidae, Trogidae, Scarabaeidae, Dermestidae, etc.), scavenging and feeding on dead bodies of animals, serve in sanitation of nature. Many of the beetles (Histeridae and Staphylinidae) found in carrion are largely predatory in larval stages on the dipteran maggots. By combating toxic pollutants produced by larvae of Calliphorine flies they help other beetles in consuming carrion. Trogids feeding on very old carcasses are able to break down keratin from hairs and feathers of vertebrates. Phycocsesids occurring on sea beaches often consume dead fishes. The activity of dung beetles (Scarabaeine and Aphodiine Scarabaeidae, Geotrupidae) is important in the downward transportation of minerals into the soil. The use of Coleoptera as 'material' for various laboratory and experimental investigations is long established.

The activities of dung beetles (Scarabaeine and Aphodiine Scarabaeidae, Geotrupidae) are of considerable ecological importance especially through the return of mineral components into the soil. The adult beetles show strong burrowing modifications and the burrows may be as deep as 2 metres in certain species. They sink the dung to a sufficient depth of the soil. It has been observed that earthworms play a greater role than dung beetles in the disappearance of cow dung patches in the fields, but the dung beetles played an important part in opening up the habitat to the earthworms.

THREATS

The extremely diversified ecosystems which maintained considerable degree of stability have supported immense diversity of beetle fauna. These are now being depleted by human acts and large number of species face extinction. Particularly threatened are those species which are dependent upon old dying and dead trees in natural forests, and those which live in heap of humus on forest floor accumulated over the years since these habitats are not safe from human interference. Apart from the destruction of climax forests in which numerous specialized beetles live, serious threat to the beetle fauna comes from the chemical insecticides so widely used at present in agriculture and public health programmes. Periodic forest fires also contribute to a great loss of population of beetles in terms of quantity and quality.

CONSERVATION AND FUTURE STUDIES

Beetles like all wildlife deserve conservation. As ecological indicator beetles are especially valuable as they have intimate and specific biological links

with extremely diverse range of other organisms in the ecosystem. Further, conservation of relict beetle population *in situ*, is extremely essential as ecological information of various fossil fauna and their lines of evolution could be interpreted from study of these relict species.

The survival of the present diversity of beetle fauna of the world can only be assured by the establishment of numerous and fairly large nature reserves in all parts of the world, and by safeguarding their long term inviolability against the pressing claims of economic and social development plans. Virtually, the conservation of some less wide-spread beetles in their existing habitats are threatened by the introduction of various nonindigenous predators or fishes into pools where they have not previously occurred. Another type of threat arises from the silvicultural measures instigated by botanists eager to promote mass regeneration of favoured species of woody plants, or to protect existing ones against fungal infection or insect damage. There is no doubt that the floral constitution of an ecosystem is liable to be greatly influenced by the activities of its animals and vice versa. However, people in the forestry sector hardly appreciate the consideration and accommodate it into actions. It can no way be ignored, if consideration for beetles receive due attention. In a natural forest old trees in suitable condition provide habitat for many beetle species completely dependent on them. Trees of this type either standing or fallen, should be given special consideration in relation to plans for conservation.

Many beetles are extremely sensitive to various chemical insecticides. It is necessary that an important reserve should be surrounded by sufficient 'buffer' area which is to be kept free from application of chemicals. Because, the reserves close to agricultural fields are likely to receive windblown spray or dust material from adjacent fields. Further, insecticides should never be applied in a reserve, even to protect its desirable trees species from the destruction by insects.

It is believed that complete inventory of the beetle species of a particular habitat (or protected nature reserve) would permit to draw more information about it than would a similar list for many other kind of organisms. Considering all the aspects presented here, it is but essential for the workers engaged in the study of biodiversity to (i) carry out extensive surveys and inventories of the collection; (ii) develop plans for managing the species diversity (and populations) steadily; (iii) assess long-term effect of traditional methods of management and exploitation of forest produces as well as effect of moderated ecosystems, agrophysiological changes, and changes of cultural

practices on the fauna; (iv) undertake study on environmental as well as genetic variations; (v) analyse the relationship between populations and communities and identify the role of a species in the food web.

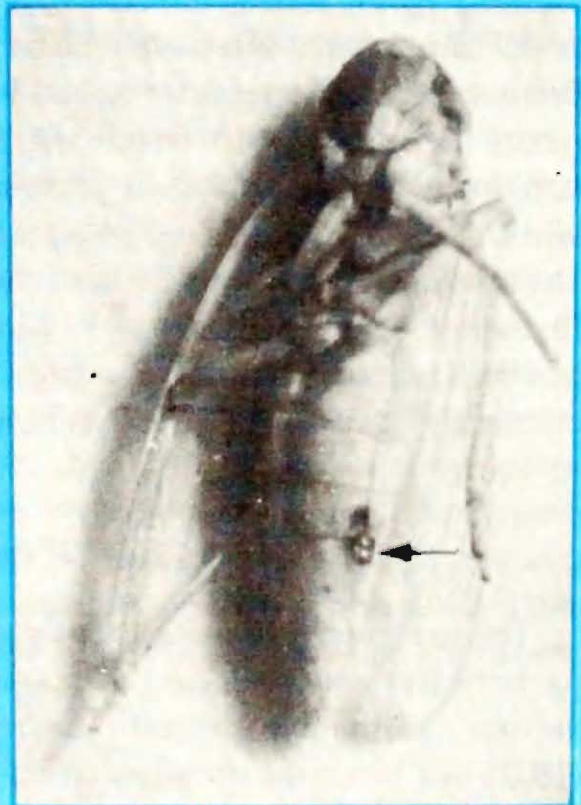
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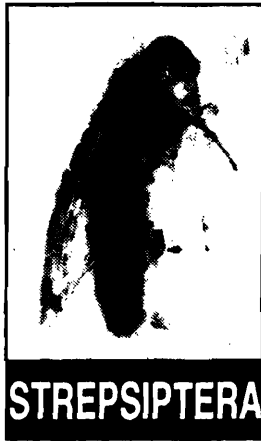
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Faunal Diversity in India : Strepsiptera

P. K. CHAUDHURI

*Department of Zoology University of Burdwan, Burdwan 713 104,
West Bengal*





INTRODUCTION

The strepsiptera commonly called as "twisted winged insects" or "stylops" are entomophagous parasitoids of cosmopolitan distribution. Because of many unusual features of biology and striking structural modifications, they have been a favourite subject for philosophical speculation to entomologists since the early part of nineteenth century. They exhibit extreme sexual dimorphism in the form of an adult male which is free-living and a neotenic female being permanently endoparasitic in the host except in the family Mengenillidae where the female is also free-living. Strepsiptera are reported to parasitize 35 families of 7 orders but their principal hosts are proved to be Hymenoptera and Auchenorrhynchan Hemiptera. Other hosts belong to the orders Thysanura, Dictyoptera, Diptera, Lepidoptera and Orthoptera. Recently, a first stage strepsipteron larva or triungulin belonging to genus *Xenos* Rossi or *Pseudoxenos* Saunders has been noticed in the abdominal cavity of a caddis fly, *Oxyethia janella* (Manuel & Bohart).

STATUS OF THE TAXON

The first record of male strepsipteron insect motilal *Xenos vesparum* Rossi parasitic in *Polistes gallicus* Lat. was made by Peter Rossi (1793). Later, *Stylops melittae* Kirby, a parasite of *Andrena nigroaenea* was described by Kirby (1802) but he could not associate it with *Xenos vesparum* until 1813.

Global Status

So far more than 554 species of strepsiptera have been described from different parts of the world (Kathiarithamby, 1993). Approximately 73 species have been made known from the Neotropics, 169 from Australian, 111 from the Oriental, 94 from Afrotropical, 73 from the Palaearctic and 64 species from the Nearctic regions. Uptil now, 41 genera of strepsiptera have been made known worldwide, out of which 20 genera were reported from the Orient.

Indian Status

There is very little information on record about Indian representatives of the extremely interesting group of insects. As far as the author is aware, only two species are described definitely from the Indian region. One is *Pyrilloxenos compactus* Pierce from Bihar as a parasite on species of Hemiptera belonging to the families Fulgoridae and Jassidae. The other *Tachytixenos indicus* Pierce parasitizing a wasp, *Techytes* from South India. Leproy in his book, "Indian Insect Life" (1909) made a mention of a *Xenos* without mentioning what species it was. He simply quoted Horne that the wasp, *Polistes hebraeus* was the host of a *Xenos*. Nurse (1909) also obtained a number of stylotized wasps of the genus *Techytes* from Deesa (India). Subramanian (1922) erroneously identified *Pyrilloxenos compactus* as a new species which later became synonym with *Halictophagus indicus*, a new species described by Bohart (1943) parasitizing mango jassids in Mysore. Subramanian (1927) reported another strepsipteron, *Halictophagus* (*Indoxenos*) *membraciphaga* from a membracid bug, *Otinotus pallescens* Dist. from Sasalu (Karnataka) followed by one more species, *Tridactylophagus mysorensis* in 1932 parasitizing *Tridactylus* sp. Bohart (1943) revised the generic status of *Pyrilloxenos compactus* Pierce to *Halictophagus* and described one species, *Halictophagus indicus*. Since then there was not much progress until Baliga (1967) described *Corioxenos raoi* parasitizing *Antestiopsis cruciata* (Pentatomidae). Chaudhuri et al. (1978) recorded *Parastylops plantipes* from Pasighat (Arunachal). In subsequent years, Chaudhuri et al. (1978-1983) added 6 more species of genera, *Triozcera* Pierce, *Halictophagus* Dale, *Tridactylophagus* Subramanian, *Myrmecolax* Westwood and *Lychnolax* Bohart to the directory of Indian strepsiptera. During the recent years 8 more species belonging to genera, *Dundoxenos carvalho*, *Elenchus* Curtis, *Halictophagus*, *Tridactylophagus* and *Myrmecolax* have been made known from India (Mazumdar & Chaudhuri 1997, 1998) raising the number of species to 18 under 8 genera from this subcontinent.

DISTRIBUTION

These insects have been recorded from all the major zoogeographical regions viz., Afrotropical, Australasian, Nearctic, Neotropical, Palaearctic and Oriental.

Owing to the endoparasitic life, strepsipteron is not easily noticed and remains an enigma to the entomologists. The families that are widespread in distribution are Corioxenidae, Elenchidae, Halictophagidae and Stylopidae. However, the remaining families are characterised by a discontinuous distribution or extremely limited distribution (Kathirithamby, 1989). The distribution of various genera is restricted to the distribution of the hosts

although in most cases, the hosts are more widely distributed than the parasites in all the zoogeographical regions. The maximum number of strepsiptera was recorded from Australia followed by the Oriental. Although only 18 species have so far been recorded from the Indian region, it may be emphasized that this region may be rich in strepsipteran species which remains very ill explored.

The following outline distribution and host relationship of the Indian genera have been made on the basis of previous reports and investigation made by the author during the past years :

Table – 1
Distribution of host and parasitic genera

Host genus	Distribution	Parasitic genus
<i>Antestiopsis</i> sp. (Hemiptera)	India (Mysore)	<i>Corioxenous</i> Blair
<i>Aethus</i> sp. (Cydnidae)	Africa and India (Maithon, Burdwan)	<i>Dundoxenous</i> Carvalho
Cydnidae (Hemiptera)	India (Raniganj & Burdwan)	<i>Triozocera</i> Pierce
<i>Javesella</i> sp. <i>Nephotettix</i> sp. <i>Nilaparvata</i> sp. (Hemiptera)	Japan, Malaysia, Philippines, Thailand & India (Burdwan & Malda)	<i>Elenchus</i> Curtis
<i>Pyrilla</i> sp. (Lepidoptera)		
<i>Otinotus</i> sp.		
<i>Halictus</i> sp. <i>Tettigonia</i> sp. (Orthoptera)	Australia & India (Burdwan)	<i>Halictophagus</i> Dale
<i>Cicadella</i> sp. <i>Idiocercus</i> sp. (Hemiptera)		
<i>Tridactylus</i> sp. <i>Gryllus</i> sp. (Orthoptera)	Sri Lanka, China, Philippines & India (Asansol, Burdwan, Calcutta, Chinsurah, Maithon, Malda, Muzaffarpur, Mysore, Raniganj & Taki)	<i>Tridactylophagus</i> Subramanian

Host genus	Distribution	Parasitic genus
Unknown	Borneo, Laos, Hong Kong, Philippines & India (Burdwan & Pasighat)	<i>Lychnocolax</i> Bohart
<i>Gryllus</i> sp. <i>Gryllotalpa</i> sp. <i>Tettigonia</i> sp. (Orthoptera)	-do-	<i>Myrmecolax</i> Westwood

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The knowledge of biology of these curious insects is meagre. There are 1-7 larval instars in strepsiptera. The distinction of larval instars is determined by the increment of larval size. In most cases (e.g, Halictophagidae), development comprises of six instars and pupa before eclosion to imagines. The first instar larvae (triungulin) parasitizes second to fourth instar nymphs of the host. On entering the nymphal host, it moults to an apodous second larva and remain endoparasitic until fourth instar. In all the families (except Mangelinillidae) at the end of fourth instar, the male extrudes its head out of prothorax and pupates while the female extrudes the head, pro- and mesothorax and becomes a neotenic female. In Mangelinillidae the male and female larvae emerge at the end of last instar from the host to pupate externally. The freeliving adult male emerges at the end of pupation while the female remains endoparasitic in the host. The duration of each of the life stages as revealed in experiment with *H. australiensis* happens to be 1 day for the first instar and 5 days for the second instar. Male requires 2-14 days for the third, 5-13 days for the fourth, 5-13 for the fifth and 5-22 for the sixth instar. Whereas the female takes 7-15 days for the third, 5-14 days for the fourth, 3-12 days for the fifth and 1-18 days for the sixth instar larvae. The pupal stage lasts for 10-12 days. Average time from infection to protrusion requires 23-41 days in male parasitoid while in the female it takes 23-36 days. The life cycle requires 20-23 days in *Elenchus* and 46-59 days in *Stichotrema* (Young 1987, Gu Xiu-Hui, 1990) and 23-41 days in *Halictophagus australiensis*. The larval development of both the sexes appears to be dependent on several biotic factors which need investigation. The insects generally emerge in the morning and fly rapidly for an hour. Life span is extremely short but in humid condition, they survive little longer.

Habitat diversity

The adult male (particularly of the families Corioxenidae and Myrmecolacidae) and female of Mangelinillidae are free-living and are attracted

to light. Alternately, they may be had through rearing from the host or by chance caught in sweep nets, malaise or truck traps. In all known families except Mengenillae, the sexually mature female is "larviform" and lacks diagnostic characters. The externally visible feature like cephalothorax extrudes through 4-6th abdominal segments from the adult hosts. The more interesting side of the phenomenon of extrusion concerns the male. In Delphacids which are mainly brachypterous, the male strepsipteran pupa always extrudes and the free-living male emerges from the fifth instar nymphs in delphacids. In most macropterous the male extrudes and emerges from both fifth instar and adult hosts. The extrusion of male takes place through 4-5th abdominal segments of the host. *Nilaparvata lugens* with *Elenchus* male pupae often appears in the light traps. A good number of insects serve as hosts of strepsipteran parasites, some of them are said to be Lepismatidae (Thysanura); Blattellidae and Mantidae (Dictyoptera); Gryllidae, Gryllotalpidae, Tettigoniidae, Tridactylidae (Orthoptera); Cercopidae, Cicadellidae, Membracidae, Delphacidae, Dictyophoridae, Eurobrachyidae, Ricaniidae, Flatidae, Fulgoridae, Jassidae, Tettigometridae, Coreidae, Cydnidae and Lygaeidae (Hemiptera), Andrenidae and formicidae (Hymenoptera).

Usually one strepsipteran parasitoid parasitizes one host but more than one with any combination of sexes become involved. If there are two males or a male and a female strepsiptera, the male emerges first bearing an empty puparium which gets fungal infected and kills the host along with the remaining male or females in it (Kathirithamby, 1989). Strepsiptera have also been reported to be parasitized by Hymenoptera and Nematoda (Kinzelbach, 1971.).

There are reports of the Eurybrachyids (*Platybrachus*) to be parasitized by two strepsipteran members of *Halictophagus* and *Deinelenchus*. It is a case of multiparasitism of two strepsipteran parasitoids which may be considered as a deviation from the general rule of one parasitoid and one host relationship. Multiparasitism involves parasitoids belonging to different orders.

The species of strepsiptera are not absolutely host specific. Specificity may therefore extend over a genus or even a family. As for examples, members of *Halictophagus* attack the hosts of Fulgoridae, Cicadellidae, Membracidae and Cercopidae (Hemiptera) while the closely related *Tridactylophagus* parasitizes only Gryllidae (Orthoptera). The specificity appears to be high in Hymenoptera while it is not so in Hemiptera (Rick, 1970). Myrmecolacids parasitize hosts of two different orders, the male parasitizes Hymenoptera and the female, Orthoptera. Infection of mixed species occur in low frequencies in strepsiptera as in other parasitoids and parasitic castrators of Crustacea.

ENDEMICITY

Of the eighteen species described from India 15 species may at this moment be considered as endemic in India. These are : *Corioxenos raoi* , *Halictophagus acerbus*, *H. compactus*, *H. indicus*, *H. membraciphaga*, *H. tenebrosus*; *Tridactylophagus aduncus*, *T. carinatus*, *T. kifunei*, *T. maculatus*, *T. mysorensis*; *Lychnocolax similis*; *Myrmecolax pierci*, *M. plantipes* and *Trizocera pugipenis*. The remaining three were previously reported from other countries enjoy distribution in India. These are (i) *Dundoxenox kinzelbachi* described by Luna de Carvalho (1985) from Republic of Cape Verde; (ii) *Elenchus japonicus* described by Esaki and Hashimoto (1931) from Japan and (iii) *Halictophagus australiensis* described first by Perkins (1905) from Australia.

VALUE

The insects harbouring the strepsipteran parasites undergo "castration" which is attributed to as "stylopization" Species are known to attack members of the various insect orders. Some of them are economic pests. For example, *Nilaparvata lugens* Stal and *Sogatella furcifera* Horvath (Homoptera : Delphacidae), which spread virus diseases and cause "hopper burn" in rice in South and Southeast Asia, are parasitized by *Elenchus* sp.; *Javesella pellucida* (F.) (Homoptera : Delphacidae), a vector of a virus disease in oats in the Palaearctic region, is parasitized by *Elenchus tenuicornis* (Kirby) ; *Nephotettix* sp. (Homoptera : Cicadellidae), a vector of a virus disease in rice in South and East Asia, is parasitized by *Halictophagus* sp.; fruit flies (Diptera : Tephritidae) that damage fruits in Australia and Southeast Asia are parasitized by *Dipterophagus daci* Drew and Allwood; *Segestes decoratus* Redtenbacher. *Sexava nubila* (Stal) and *Segestidae novaeguineae* (Brancsik) (Orthoptera : Tettigoniidae), causing severe defoliation of coconuts, oil palm and *Pandanus* spp. in Papua New Guinea, are parasitized by *Stichotrema dallatorreanum* Hofeneder; and *Antestia* (Heteroptera; Pentatomidae), a pest of coffee in Africa, is parasitized by *Corioxenos antestiae* Blair. The effect of stylopization on beneficial pollinators and predators is difficult to evaluate. The degree of parasitization is usually low rarely exceeding 50%. The situation is more definite in case of leafhoppers. Halictophagids are definite factor in the control of sugarcane leafhoppers of genus *Pyrilla* and planthoppers, *Nilaparvata* and *Cicadella* in this country.

Stylopization causes reduction of reproductive potentiality of the host. Sex conversion is found to occur in Hymenoptera due to stylopization which may also cause considerable reduction of external genitalia of the host.

FUTURE STUDIES

Strepsiptera exerts some control of the population level of the host. The rate of parasitism by strepsipteran insect varies according to the season of the year. There is ample scope for studying the bio-control aspects of the crop pest by Strepsiptera. Therefore exploration of the fields and the various types of insect host must be made to find out the species of strepsiptera infecting them. There are certain biotic factors which are assumed to play major role in the parasite population. The stability of the host population, migration, presence of other parasites and cropping pattern might determine the percentage parasitization in the rice field ecosystem. However, the method may not be free from errors but on the other hand is advantageous while considering observations of the large number of hosts. The protrusion provides a much reliable and quicker method than dissecting the host individually for parasitism. However, it is too premature to conclude the effectiveness of *H. australiensis* in controlling the population of *C. spectra*. Several factors require to be taken into consideration before drawing a meaningful conclusion.

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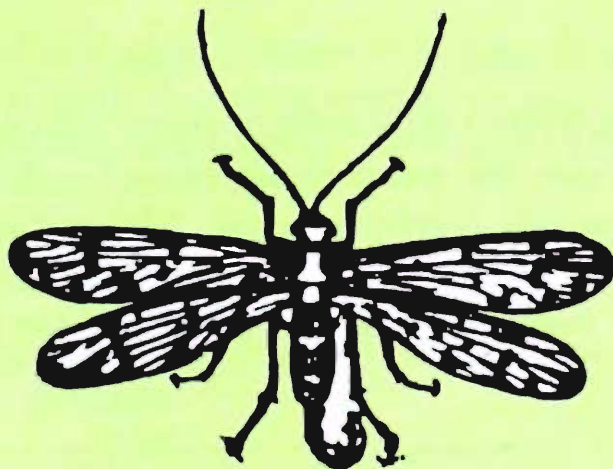
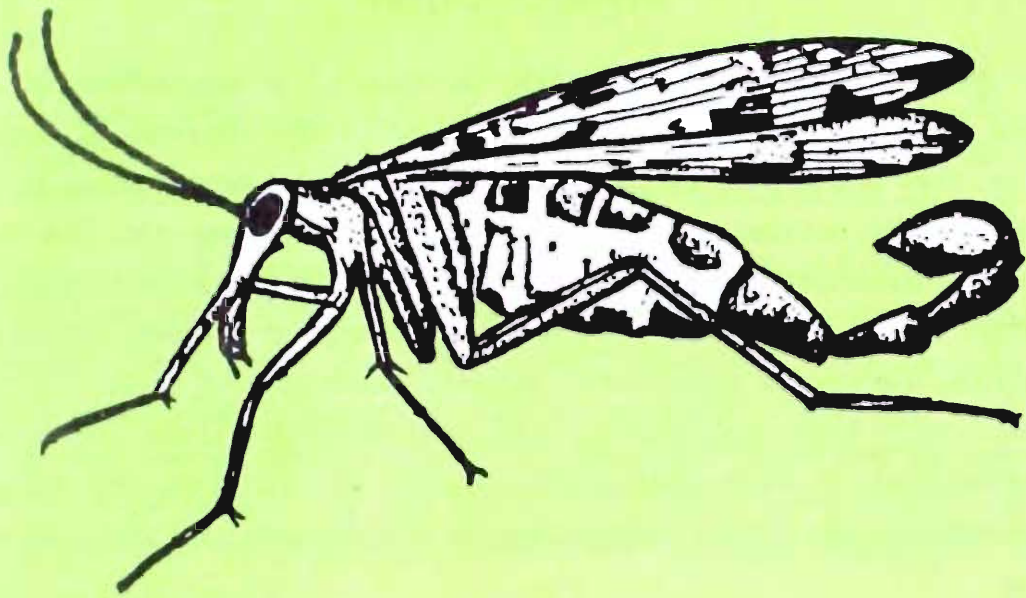
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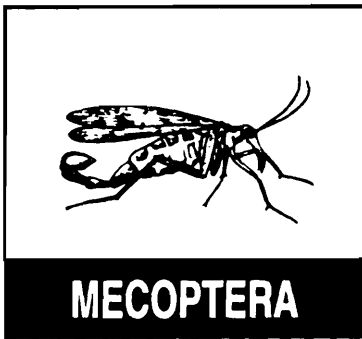
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Faunal Diversity in India : Mecoptera

M. PRASAD

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Mecopteran insects are commonly known as scorpionflies. In males terminal abdominal segments are upturned in the manner of scorpion; therefore, they are known as scorpionflies. Adults are omnivorous and feed on small insects, nector, pollens, petals, fruits and mosses, etc. The winged forms are more active fliers and females lay eggs on ground either singly or in clusters of hundred or more, Larvae are found in mosses, rotten wood and humus. Mecoptera represents relatively much smaller insect orders and is rather scanty both qualitatively and quantitatively. There are relatively more palaearctic in their distribution, though two families, *viz.*, Bittacidae and Panorpidae are more cosmopolitan in distribution and are very scanty in India.

STATUS OF THE TAXON

Global Status

Mecoptera is relatively a small order of insects with a little more than 350 species reported from the world under seven families, *viz.*, Bittacidae, Boreidae, Panorpidae, Notiothanmidae, Meropidae, Choristidae and Nonnocharistidae belonging to two suborders Protomecoptera and Eumecoptera. The families Panorpidae and Bittacidae are relatively more common.

Indian Status

Altogether 15 species of Mecoptera belonging to 3 genera under two families are recorded from India, the details of which are shown in Table 1. The table shows that Indian Mecoptera represents only 4.28 per cent of world Mecoptera in number of species. The main reason of this may be due to less exploration as well as non-availability of experts of this group.

Table – 1

Family-wise position of Indian Mecoptera Versus world species

Indian Family	Indian	Indian Genus	Indian Species	World Species%
Bittacidae		Bittacus	2	
Panorpidae		Panorpa	7	
		Neopanorpa	6	
Total	2	3	15	350 4.28

Initial work on Indian Mecoptera was after Needham (1909) who worked out the Mecoptera collection present in Indian Museum as Neuroptera collection. Cheng Fung Ying (1952, 1954) described 3 new species one of which was from Darjeeling, India. This was included in his main work “Fauna of Formosa” Subsequently Penny (1970) described a new species under genus *Bittacus* (*B. taraiensis*) of the family Bittacidae. Contribution of Indian Mecoptera also included one family Panorpidae (Panorpa-7 species, Neopanorpa-6 species).

DISTRIBUTION

Out of 15 species of Mecoptera known from India 13 species are recorded from Eastern India, while two more species are reported one each from Pantnagar, Uttar Pradesh and Bombay, Maharashtra (Table 2).

Table – 2

Distribution of species in India

State/Regions of India	No. of species
Eastern India (Assam, Meghalaya, Sikkim and West Bengal)	13
Maharashtra	1
Uttar Pradesh	1

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Suborder Eumecoptera of order Mecoptera is represented world over by 5 families, of which Indian representatives are grouped under two families, viz., Bittacidae and Panorpidae. Members of the family Bittacidae, relatively, commonly occurring Mecoptera are cosmopolitan in distribution—except the northern portion of Holarctic region. The members of the genus *Bittacus* are very slender tipula-like insects having prehensile tarsi and very prominent bulbous swelling of male abdominal end. Panorpidae is another family having relatively more Indian representation. These have 40-50 segmented, more or less filiform antennae, claws pectinate, terminal abdomen of male not with conspicuous bulbous swelling, in contrast to Bittacidae.

ENDEMICITY

Very Little is known so far about the Mecoptera fauna of India. Therefore, an accurate assessment of their endemicity and number of endangered species in India is not feasible.

VALUE

There is no definite record of economic importance of the members of this order. Both larvae and adults of the family Panorpidae are carnivorous but the extent to which members of this family prey upon living, uninjured insects or other animals is not known. Members of *Bittacus* remain suspended on grass or twigs by its fore legs and prey upon small dipterans whereas members of the genus *Boreus* live among mosses or beneath stones in autums or early winter, appearing occassionally on the surface of snow. Sometimes they are observed feeding upon vegetable matter.

CONSERVATION STRATEGIES AND FUTURE STUDIES

In the last decade some public awareness of insect conservation in India has been persistently felt and consequently, scorpionflies have also been considered worth preserving in the country. In India there are some species of Mecoptera, which also need their protection as far as possible. This has to be taken with various other national programmes aimed at conserving all the vertebrate and invertebrate fauna. The Government of India is presently

running various nature conservation programmes and the results are highly relevant since the protection of habitats, *i.e.* , forests, lakes, rivers, mountains and their cascades, etc., from destruction has undoubtedly promoting the conservation of scorpionflies. A list of rare of endangered species of Mecoptera together with distributional map should be prepared for the common people for their awareness. Collection of these species from their natural habitats should be stopped.

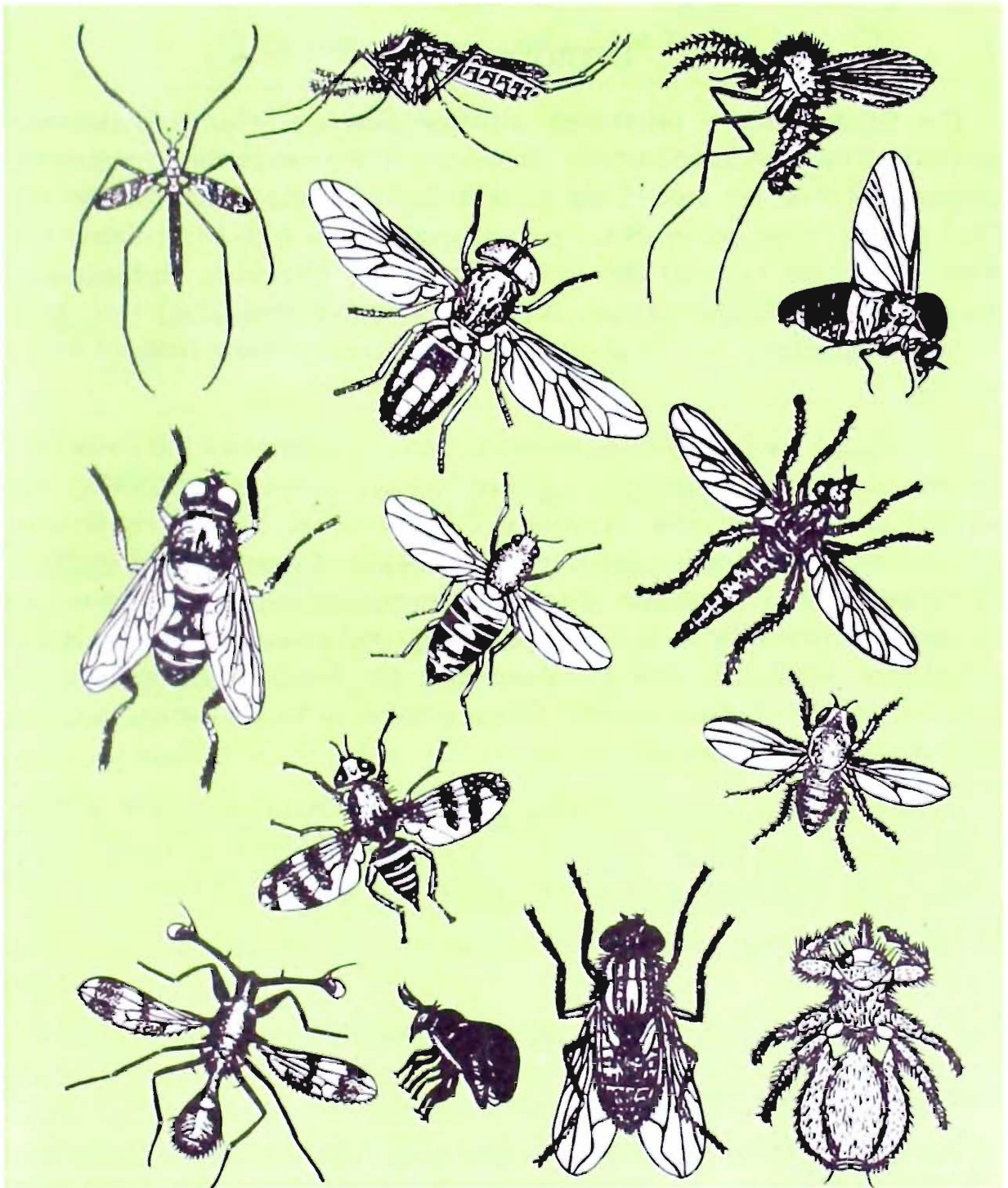
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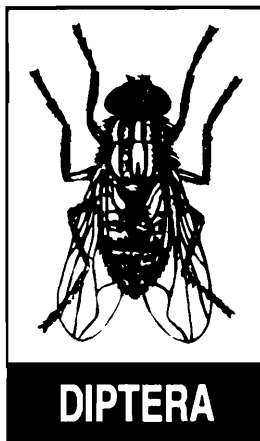
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Faunal Diversity in India : Diptera

M. DATTA

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The Diptera (name originated with the Greek scholar Aristotle and adopted by the Swedish naturalist Linnaeus in 1744) comprising mosquitoes, midges and flies, are among the most highly specialized members of the Class Insecta. They are generally two-winged insects with two halteres but there are some (among Tipulidae, Sciaridae, Phoridae, Ephydriidae, Sphaeroceridae, Hippoboscidae, Nycteribiidae and Streblidae) that have partially or entirely lost their wings, usually leaving their halteres intact behind.

The Diptera are fairly homogeneous in general appearance but some flies may be mistaken for some other kinds of insects of no near relationship, *e.g.* Bombyliidae, Stratiomyidae, Syrphidae, Conopidae, etc., frequenting flowers as mimics of bees and wasps (Hymenoptera), and again Hippoboscidae, Nycteribiidae and Streblidae that are parasitic on birds and mammals appearing at first sight to be lice (Mallophaga and Anoplura). Whereas the Celyphidae dwelling in the grassland look like beetles (Coleoptera), the Sepsidae and the Sphaeroceridae that are liable to be on dungs, are like winged ants (Hymenoptera).

Indeed, no other insects present so great a diversity of habits and habitats as the Diptera, and this is the reason why general biologists, parasitologists, medical and veterinary doctors, and others pay serious attention to these insects.

STATUS OF THE TAXON

Global and Indian Status

The Diptera occur almost everywhere from high mountains to the sea, and from the hot desert to the cold ice-water at the opposite extreme, and all these cause them to flourish extremely well with more than hundred thousand species belonging to some 130 families spread all over the world.

India, however, holds only 6% of the species under 1,075 genera of 157 subfamilies that pertain to 87 families so far known (Table 1), with the major concentration of the species both qualitatively and quantitatively all along the Himalayan belt where expectedly the number of species still remaining undiscovered is equal to that known till today from the entire country. India harbours 12% as an estimated figure of the world species, of which at least 6% still await discovery.

Table – 1
Diversity of Diptera (in nos.) in India

Suborders	families (n)	genera (n)	species (n)
Nematocera	22	245	2,759
Brachycera	15	198	1,156
Cyclorrhapha	50	632	2,178
Total	87	1,075	6,093

BIOLOGICAL DIVERSITY AND DISTRIBUTION

There are 3 suborders : Nematocera, Brachycera and Cyclorrhapha in the Order Diptera. The Nematocera contain 22 families; the Brachycera 15 families and the Cyclorrhapha 50 families. The aquatic Diptera (based on the larval habit) mainly belong to the Nematocera with 14 families : Tipulidae, Tanyderidae, Psychodidae, Ptychopteridae, Nymphomyiidae, Blephariceridae, Deuterophlebiidae, Dixidae, Chaoboridae, Culicidae, Thaumaleidae, Ceratopogonidae, Chironomidae and Simuliidae; to the Brachycera with only 4 families : Stratiomyidae, Tabanidae, Empididae and Dolichopodidae; and to the Cyclorrhapha with at least 6 families : Syrphidae, Sciomyzidae, Ephydriidae, Canaceidae, Scathophagidae and Muscidae. The ratio to which the aquatic Nematocera, Brachycera and Cyclorrhapha stand, figures nearly to 11 : 3 : 1.

The dipterous species leading aquatic life (partially) both in fresh and brackish water (ratio 9 : 1) constitute 25% of the fauna hitherto known in India, and account for 70% inhabiting stagnant (lentic) water, *viz.*, plainland rivers, lakes, ponds, pools, ditches, etc., 20% in torrential (lotic) water, *viz.*, mountain rivers, lakes, cascades, streams, trickles, etc., and 10% in brackish water, *viz.*, seas, estuaries, salt-lakes, etc.

As regards feeding by Diptera, species living in or on animals including humans, account for about 25% ; and in or on plants for about 15%; and the remainder are absolutely saprophagous, subsisting on decaying organic matter. Indeed, the synanthropous flies fall in this group.

The adaptive radiation exhibited by Diptera leads them to four general directions : over the earth's surface, above the surface on to plants and animals, beneath the earth's surface and in or close to water.

Generally speaking, all adult Diptera are terrestrial but some go to water usually for certain special purpose, *viz.*, oviposition. Dancing by adults in swarms in the air, especially for mating, is performed by the Trichoceridae mainly during the winter at high altitudes, by the Chironomidae mainly in the vicinity of water, and by the species of *Empis*, *Hilara* and *Rhamphomyia* (Empididae) about forests. Likewise, the Platypezidae, Nymphomyiidae, Anisopodidae, Dixidae and males of the Blephariceridae, Lonchaeidae, Milichiidae, Fanniidae and some Muscidae become on the wing in the wooded areas. The Simuliidae, while particularly attacking their hosts, often swarm enormously. The Bibionidae also often appear in the air in great numbers. Some other flies may also be observed to swarm in the air during mating.

The great majority of Diptera habitually long for flowers and spend much of their time mainly feeding on nectar, whereas others do visit for the time being. The phytophagous habit of adult Diptera is extremely rare and is limited only to feeding on nectar by most species or on plant-sap by *Forcipomyia* (Ceratopogonidae), Aulacigastridae, a few Agromyzidae and Drosophilidae, etc. or on pollens by most species of the Bombyliidae, Stratiomyidae, Syrphidae, Pipunculidae, etc. Plants are also used as selective ovipositing arena by some flies, of which Cecidomyiidae, Stratiomyidae, Tabanidae, Syrphidae, Tephritidae, Chamaemyiidae, Agromyzidae, Chloropidae, Muscidae (Atherigonini), etc. are notable.

Of the zoophagous adult Diptera, females of most Phlebotomidae, Culicidae, Simuliidae and Tabanidae, and some Ceratopogonidae and both sexes of *Stygeromyia*, *Stomoxys*, *Lyperosia*, *Haematobia* and some Muscinae (Muscidae), *Carnus* (Carnidae), Hippoboscidae, Nycteribiidae and Streblidae feed on blood of warm-blooded vertebrates including man, and a few of them are incriminated as carriers of dreaded diseases, *viz.*, malaria, trypanosomiasis, leishmaniasis, filariasis, dengue fever, encephalitis and several other viral infections of man and animals.

Besides, the predatory habit of adult Diptera is rather surprisingly high and interesting. Small midges like *Atrichopogon*, *Forcipomyia*, *Palpomyia*, etc. (Ceratopogonidae) feed on moths, caterpillars, dragonflies or other smaller

insects. Females of the Blephariceridae are predacious upon small slow-flying Diptera (e.g. Chironomidae). The Asilidae are far more daring in preying upon bees, beetles, butterflies, moths or any Diptera. Some species of the Rhagionidae, Empididae, Dolichopodidae, Scathophagidae and Muscidae, however, prey upon small soft-bodied insects. The Dryomyzidae live on barnacles, whereas the Sciomyzidae on slugs and snails. The Rhinophoridae are known to prey upon termites.

Apart from parasitic and predacious habits, certain species of *Siphunculina* and *Hippelates* (Chloropidae) transmit conjunctivitis and other eye-diseases of man by getting into eyes.

There are several dipterous flies, such as, Acroceridae, Bombyliidae, Pipunculidae, Conopidae, Pyrgotidae, Gasterophilidae, Oestridae, etc. that are in the habit of ovipositing on other specific kinds of insects or vertebrates for the purpose of inflicting parasitization.

The adult dipterous species that frequent dead or decaying plant or animal tissues are usually saprophagous and belong to the filth-inhabiting Diptera (e.g. Muscidae, Calliphoridae, Sarcophagidae, etc.) Some of them live in or near human inhabitations (synanthropous species) and are liable to convey pathogenic organisms from filth to food.

A phenomenon of co-existence of certain Diptera asinquilines in the nests of other insects or of birds and mammals, mostly for beneficial effect to them, is remarkable. In some instances, adults become apterous or so in order to lead subterranean life. Some Phoridae (e.g. *Rhynchomicropteron*, *Megaselia*, *Puliciphora*, etc.) inhabit the nests of ants and a large number of them are associated with termites. A few species of the Milichiidae and Sphaeroceridae are also known to live with ants, and the latter with scarabeid beetles too. The Heleomyzidae live in the nests of birds and mammals, and the only known Indian species *Carnus hemapterus* Nitzsch (Carnidae) exclusively inhabit the birds' nests. Some species of the Sphaeroceridae also live in the nests of small mammals like rodents or in cow houses. Again, larvae of *Microdon* and *Volucella* (Syrphidae) live in the nests of ants and termites, and aculeate Hymenoptera respectively, as scavengers.

Adults of Diptera that occur in or on water are far fewer than those encountered on land. Indeed, some Chironomidae, Tipulidae, Empididae, Dolichopodidae, etc. spend much of their time floating or walking on water and some (e.g. Simuliidae, Blephariceridae, Deuterophlebiidae, Thaumaleidae, Culicidae, Chironomidae, etc.) come in contact with water during oviposition or emergence from pupae submerged in water. However, a few species of

the Nymphomyiidae remain under water for a longer period for the purpose of oviposition.

Dipterous larvae are exceedingly ahead of adults in diversity. The habitats of larvae are usually very different from those of adults. They live in water, in rotting vegetable or animal matter or soil and inside living plant tissue or bodies of other animals. Larvae of the Bibionidae living in relatively dry soil are terrestrial in the true sense.

The great majority of the Cecidomyiidae, Psilidae, Tephritidae, Lonchaeidae, Agromyzidae, and Chloropidae are phytophagous. The majority of the Agromyzidae, some Tephritidae (e.g. Trypetinae) and a few Drosophilidae (e.g. *Scaptomyza*) are miners in different parts of plants, predominantly in leaves, while most of the Cecidomyiidae (e.g. Cecidomyiinae), some Tephritidae (e.g. some Tephritinae and Trypetinae) and a few Lonchaeidae make galls. A few are also known as stem- or root-borers or feeders. There are, however, several mycophagous Diptera but most notable ones are the Mycetophilidae, Sciaridae and Platypezidae.

The great majority of dipterous larvae (e.g. Culicidae, Simuliidae, some Cecidomyiidae, Coenomyiidae, Rachiceridae, Solvidae, Stratiomyidae, Tabanidae, Rhagionidae, Therevidae, Scenopinidae, Asilidae, Syrphidae, Chloropidae, Ephydriidae, Muscidae, etc.) take preferably larvae or adults of insects and worms as their food. The Blephariceridae feed on flagellates, whereas the Sciomyzidae on pulmonate snails, slugs, etc. in their aquatic habitat. The parasitic larvae living externally or internally belong mainly to the Nemestrinidae (e.g. *Hirmoneura* and *Nycterimyia*), Acroceridae, Bombyliidae (mostly), Phoridae (a few), Pipunculidae, Conopidae, Pyrgotidae, Sciomyzidae (some), Muscidae (e.g. *Passeromyia*, etc.), Calliphoridae (among Calliphorinae and Chrysomyinae), Sarcophagidae (a few), Rhinophoridae (*Termitoloemus*), Tachinidae (mostly), Gasterophilidae and Oestridae.

Indeed, larvae of some Diptera (e.g. a species of the Phoridae and Syrphidae each, a few Calliphoridae and Sarcophagidae, and all of the Gasterophilidae and Oestridae) that are saprophagous in habit, cause myiasis in man and animals.

Aquatic habits are best developed among the nematoceros Diptera and among brachyceros Stratiomyidae, Tabanidae, Empididae and Dolichopodidae. Several species of the cyclorrhaphous Sciomyzidae, Ephydriidae and Canaceidae and a few species of the Muscidae (e.g. *Limnophora*, etc.) and of the Scathophagidae have adapted well to water. Some (e.g. Simuliidae, Blephariceridae, Deuterophlebiidae, Thaumaleidae, Nymphomyiidae, Culicidae, Dixidae, Chaoboridae, Tanyderidae, most

Chironomidae and some Ceratopogonidae, etc.) are strictly aquatic and need not come in contact with soil for pupation but some others (e.g. some Tipulidae, Ceratopogonidae, Ptychopteridae, Stratiomyidae, Tabanidae, etc.) come to pupate in wet soil bordering water-bodies or in rotten organic matter.

Dipterous larvae occurring in the aquatic habitat remain either freely suspended (e.g. Culicidae, Chaoboridae, Dixidae, some Chironomidae and a few Ceratopogonidae) or attached to some substrata submerged in water (e.g. Simuliidae, Blephariceridae, Deuterophlebiidae, etc.) or buried in mud, sand, etc. (e.g. some Tipulidae, Stratiomyidae, Tabanidae, Empididae, Dolichopodidae, a few Muscidae, Scathophagidae, etc.).

Larvae or pupae attached to some substrata are adapted to torrential water, whereas others that remain exposed or buried, inhabit standing or stagnant water. Larvae of the Culicidae, Dixidae, Tanyderidae and some Chaoboridae generally occur in small shallow water-bodies and those of the Chironomidae, Ceratopogonidae and Chaoboridae capable of swimming, can live in large water-bodies. However, the Chironomidae inhabit most kinds of aquatic eco-system because of their wide range of tolerance.

Dipterous pupae are mostly terrestrial (e.g. nearly all of phytophagous and zoophagous and/or endoparasitic species).

Of course, speciation to a great number of Diptera is the consequence of this ecological amplitude only.

ENDEMIC AND EXOTIC SPECIES

The dipterous fauna in India is the vast assemblage of curious elements comprising both endemic and exotic units. It appears to own 35% endemic species; most of them are nematocera that are generally of weak vigour and sluggish nature. Indeed, much more species are widespread. It is estimated that species amounting to 25% have intruded and established themselves in India from abroad but it remains unresolved for others that are in effect either of immigration or of emigration or of both under pressing circumstances. As for examples, all species of the Gasterophilidae and Oestridae have certainly been imported with their hosts. Likewise, several pest and parasitic species (among Culicidae, Ceratopogonidae, Simuliidae, Phlebotomidae, Hippoboscidae, Nycteribiidae, Streblidae, etc.) to animals and those (among Tephritidae, Drosophilidae, Agromyzidae, etc.) to plants, have made their way to India mainly either by carriages or by birds and other animals or by imported fruitage and vegetables.

Moreover, rushing waters of rivers, streams, etc. carry the immature stages of so-called aquatic species from neighbouring countries to India.

VALUE

All Diptera together in intimate association with other animals and variegated flora interact with each other in order to maintain the equilibrium of Nature in the region. Flower-visitors (invariably Stratiomyidae, Syrphidae, Bombyliidae, Conopidae, Calliphoridae and Tachinidae) help plants perpetuate through pollination. Larvae of the Sciaridae, Cecidomyiidae, Tephritidae, Agromyzidae, Muscidae, etc. that eat up especially useful plants, are depredated by dipterous and other insect larvae. Larvae of mosquitoes, midges and flies that annoy man and livestock, are devoured by those of Diptera and other insects. Many saprophagous species (of the Bibionidae, Phoridae, Sepsidae, Milichiidae, Scathophagidae, Calliphoridae, etc.) clean up dirty organic matter as scavengers. The Chironomidae not only serve as fish-food but also help in indicating the level of pollution of water where they inhabit. Snails, slugs, etc. that act as primary and secondary hosts of several helminth diseases, are eaten up by the Sciomyzidae. Several other insects (*e.g.* Orthoptera, Homoptera, Heteroptera, Coleoptera, etc.) that are especially detrimental to agriculture and horticulture, are destroyed either by depredation (*e.g.* Cecidomyiidae, Bombyliidae, Syrphidae, Chamaemyiidae, etc.) or by means of parasitization (*e.g.* Acroceridae, Bombyliidae, Pipunculidae, Conopidae, Tachinidae, etc.). Humanity should, therefore, be concerned about preserving them.

THREATS AND CONSERVATION

The main threats to the insect life as to humans are (i) pollution, both air and water, and (ii) destruction of habitats. Air pollution mainly affects the adult life, whereas water pollution mainly acts upon the larval life. Destruction of habitats by way of deforestation and abolition of water-bodies including torrential water-sources in hills, etc., due to increased human inhabitation causes insects either to displace if the magnitude of their tolerance is high or to destroy if their frequency of tolerance is extremely low. If the level of destruction by now goes to 2% upon these causes, it may eventually stand to double by the turn of this century. Therefore, conservation by desisting human interference appears earnestly desirable.

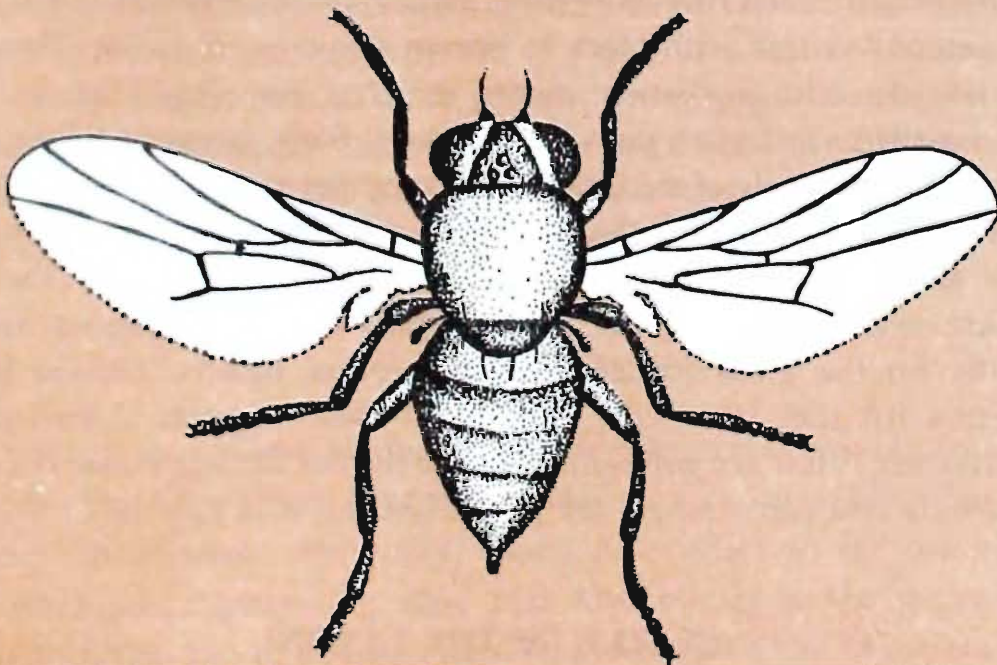
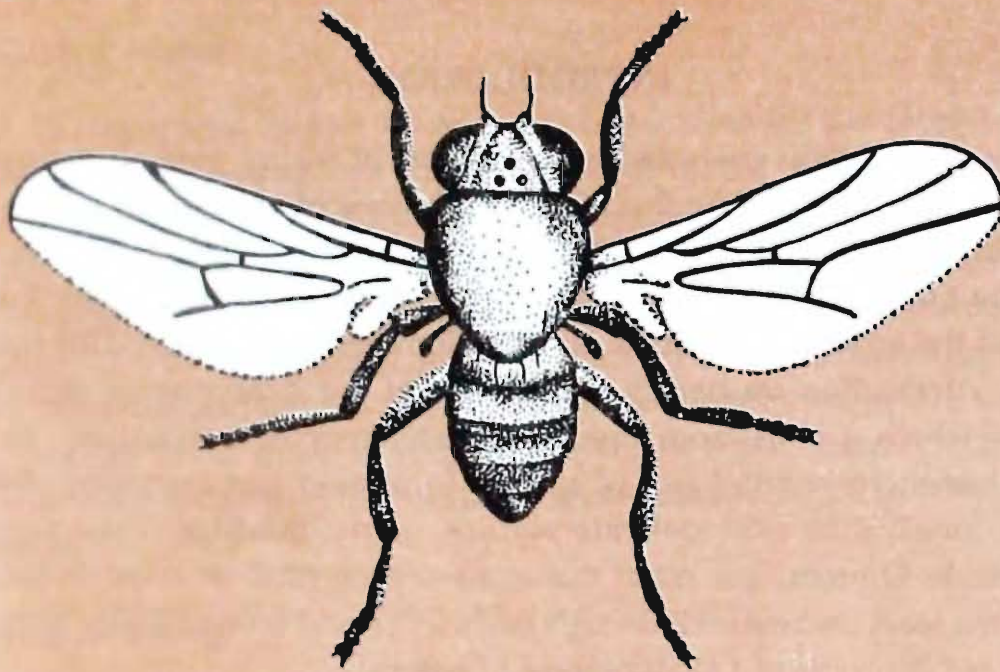
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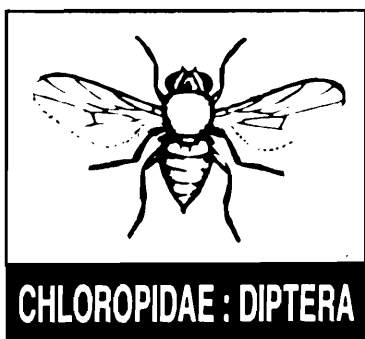
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Faunal Diversity in India : Chloropidae (Diptera)

P. T. CHERIAN

*Zoological Survey of India, Southern Regional Station
100 Santhome High Road, Chennai-600 028*





INTRODUCTION

The audit of biodiversity today is far short of reality. It is all the more so of a species rich group like the Dipterans represented in India which in all probability is home for 8-10% of the total number of species on the earth. The alpha taxonomy of hardly 10 of the 98 Dipteran families reported from India and the adjacent countries, is today somewhat adequate. This includes detailed information on hardly one or two of the Acalypterate families, in many of which a shift from predatory behaviour or scavenging to plant feeding has increased the rate of species formation and evolution. Because of their small size and delicate nature many families, especially the Acalypterate Diptera, are often not even represented in most collections. Among the least understood, though fairly large and economically important families is Chloropidae (Acalypterate : Diptera).

The Chloropids, commonly called "grass flies" or "green-eyed flies", are small to medium-sized flies (0.5-7mm), rather smooth, predominantly black, but sometimes yellow with black to brown stripes or maculae. They occur almost anywhere in grasslands, moors, marshes, low vegetation in forests, graminous plants and even on window panes. Some frequent flowers and a few, such as, the eye-fly of the Orient (*Siphunculina*) and eye-gnats (*Hippelates*) of the New World are attracted to body and eye secretions of man and animals and are important as vectors of certain eye diseases. Their food habits are varied. Many larvae of chloropids are saprophagous and feed especially on the grass from damage by other insects. Others like the destructive frit flies (*Oscinella*) and wheat-stem maggots (*Meromyza*) are phytophagous. A few are gall formers, some devour the egg masses of spiders and mantids and some others are predacious on root aphids.

STATUS OF THE TAXON

The genera and species of Chloropidae were earlier included under the genus *Musca* in family Muscidae (*Sen. lat.*), including the first Chloropid

species *Musca frit* Fallén (1820) separated several genera and species and treated them under the family Oscinides. Later workers used the family name Chloropidae. Through the years a little fewer than 300 genera were proposed. Through the contributions of Sabrosky (1941, 1964) the number of genera and subgenera were reduced to 200. Chloropidae has traditionally been divided into two subfamilies, Chloropinae and Oscinellinae of which the first has long been accepted under its present name. The second has passed under several names and is now recognized under three subfamilies, Siphonellopsinae, Rhodesiellinae and Oscinellinae.

Global Status

Chloropidae has so far been reported from all the faunal realms of the world though they are more abundant in the Afrotropical, Oriental and Palaearctic Regions. About 2150 species under 157 genera have so far been reported from the world. Many of the earlier description are very inadequate. We know practically nothing about the biology and immature stages of more than 98% of the nominal species. Many of the continental and island forest ecosystems still remain unexplored, let alone the canopy fauna but for a few attempts being made in recent years in the Amazonian forests. Hence what is known today may presumably represent hardly 25 to 30% of the world's total.

Indian Status

So far 455 species under 75 genera of Chloropidae have been reported from the Oriental Region. Of these, 155 species under 57 genera have been recorded from India and adjacent countries. These include 44 new species and many new records reported in part 1 of a fauna volume on the group in press. About 60% of these species, including 40% comprising new taxa, were recorded by the author. Another approximately 250 species (including many new) from India and adjacent countries are under various stages of study by the author and are to be published in part 2 of the fauna series.

DISTRIBUTION

A comprehensive analysis of the distribution of this family in India must await the completion of studies under way on the subfamilies Oscinellinae and Chloropinae. However, based on studies so far completed on the subfamilies Siphonellopsinae and Rhodesiellinae the general pattern of distribution can to a large extent be assessed. Of the 19 genera belonging to the last two subfamilies so far known from the world, 16 genera and 126

species are represented in the Oriental Region of which all the 16 genera and 81 species have been reported from India. As for the species rich subfamilies Oscinellinae and Chloropinae it can be presumed, on the basis of data available including unpublished records, that about 20% of the species so far reported from the world are found in India. But in the ultimate analysis this high percentage may be far removed from reality since concerted efforts through nearly three decades have been made to collect and study the Indian fauna whereas no comparable efforts were put in on a global basis.

As for the distribution of the group in India, there is a great concentration of genera and species in the Indian part of the Eastern Himalaya, followed by the Western Ghats, Eastern Ghats and Plains of India in that order.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Chloropidae is a specious family of small flies occupying varied habitats. Some of the species are rather wide-spread and occur in large numbers while many are rather rare. The larvae are mainly phytophagous or saprophagous, sometimes carnivorous and rarely exoparasitic. Some phytophagous species are known pests of cereals like rice, barley and wheat. Some carnivorous species are predators of root aphids and egg masses of poisonous spiders. The adult flies have functional mouth parts and feed also on honey dew. The 'eye flies' and 'eye gnats' annoy man and animals by feeding on wounds or external body openings and are of medicinal importance as vectors of certain eye diseases.

ENDEMICITY

A high level of endemism is discernable in the family represented in India. While subfamily Siphonellopsinae is hitherto known by only one species endemic to India, subfamily Rhodesiellinae is represented by a large number of genera and species which are Indian endemics. All the three tribes and 9 of the 11 genera of this subfamily reported from the world are represented in India. This includes 3 genera, *Pseudonomba*, *Bharathella* and *Ammonella* and a new genus (in press) which have their range of distribution restricted to Indian limits. Besides, 55 of the 76 species known of the tribe Rhodesiellini from India, 3 of the 4 species of tribe Scoliophthalmini and 3 of the 4 species of tribe Stenoscini known from India are endemic to this country. Thus of a total of 126 species which include many new taxa (in press) belonging to the above 2 subfamilies recorded from the Oriental Region, 62 representing 49.2%

of the species and 25% of the 16 genera are Indian endemics. On the basis of data so far available on the remaining 2 subfamilies, it is apparent that a comparably high level of endemism is noticeable in India in these taxa also.

The extraordinarily high level of endemism observed in this group in India calls for dilution with the remark that many of the new taxa studied from India in recent years may in all probability be available in the rest of the Oriental Region and the areas beyond, which may become evident on intensive exploration on a regional and global basis. Thus in the ultimate analysis the high percentage of endemism observed in this family in India may come down to half or even less of what is estimated today. In spite of all these, it is evident that endemism in this group is remarkably high in India.

THREATENED AND INTRODUCED SPECIES

Since the majority of species, especially those reported in recent years from India, have been recorded only once and no attempts could be made in later years to make collections from the type localities of many species, it is not feasible at this stage to evaluate and assign the Indian taxa to the various IUCN categories. At least in a few instances attempts at collecting topotypes in later years have not been usually fruitful. This calls for concerted efforts at intensive explorations to assess the present day status of many of the known taxa.

There is no record of any purposeful and concerted effort for introducing any of the known species of this family into India, since none of the species is known to play any vital role in the biological control of pest species. There might have been accidental introductions of species of genera like *Siphunculina*, which are associated with man, through ships visiting Indian ports or people crossing the Indian borders.

VALUE

As mentioned earlier, the larvae of some of the phytophagous species cause severe damage to crops like rice, wheat, barley, etc., especially in the far eastern countries and Europe. There is no major report of any damage these flies cause to the cereals in India. Though eye flies are said to aid in the spread of eye diseases in the Orient, including India, yet the exact role they play and the extent of their impact on the spread of the diseases have not so far been assessed. A few of the species visiting flowers may aid in pollination.

Though some species are known to be predators of root aphids, the role they play in controlling them still needs assessment. Since the biology and information on the immature stages of hardly 1% of the nominal species reported from India is hitherto known, their role in nature have not been evaluated or quantified. But the potential involved in such a large quantum of germplasm represented by a species group of insects can neither be evaluated or estimated on the basis of our limited understanding of the values of biodiversity today.

THREATS

The loss of biodiversity of the group the world over, and especially in India, is ecologically and socially excessive. The exact rate of loss is rather unknown. Though the family is widely distributed in India, yet the majority of the species and genera are found in the forest ecosystems. Habitat loss has been and is resulting in a contraction of species distribution and many species are accordingly suffering from genetic erosion *i. e.* the loss of considerable part of the genetic variation and variability within their populations. Developmental pressure and the resultant habitat loss, as happens today all over India, is causing serious threat to many of the insect groups, including this family of flies. Atleast 50% of the species of the group in India remain unnamed. Many are travelling the road to extinction even before their existence is known. Indiscriminate use of pesticides, deforestation, inundation of forest land by the coming up of hydel and irrigation reservoirs, conversion of forest land into monoculture plantations and other developmental processes are all depleting the distribution and abundance of many of the species of this group.

CONSERVATION STRATEGIES AND FUTURE STUDIES

'Save the whale' has a convincing ring, but 'save the snail' ? Attempts to argue the case for the conservation of invertebrates are often met with derision. Yet we ignore them at our peril. For every species of higher form of life disappearing, there are thousands of invertebrates that travel the road to extinction.

The needs of insects do not always coincide with those of vertebrates. Since the requirements of most of the insect species are rather limited and many of them inhabit small ecological niches, it is not safe to assume that protection of large areas for the conservation of vertebrates will automatically

safeguard the diversity of lower forms of life also. Because of their diversity and germplasm potential besides the role they play in the maintenance of any viable ecosystem, conservation of this group, as other insect groups, should receive the importance it deserves.

Since the alpha taxonomy of more than 50% of the Indian taxa of this family is yet to be revealed, concerted efforts at intensive exploration of various ecosystems is the need of the hour. Besides, no attempt has been made in India in the past to study the canopy fauna which may represent more than 30% of our species. The biology of 99% of the species so far named remains unattended and this is an area having a busy future. Inter and intraspecies interactions of many of the species of this family and their roles in nature still remain areas of relative darkness.

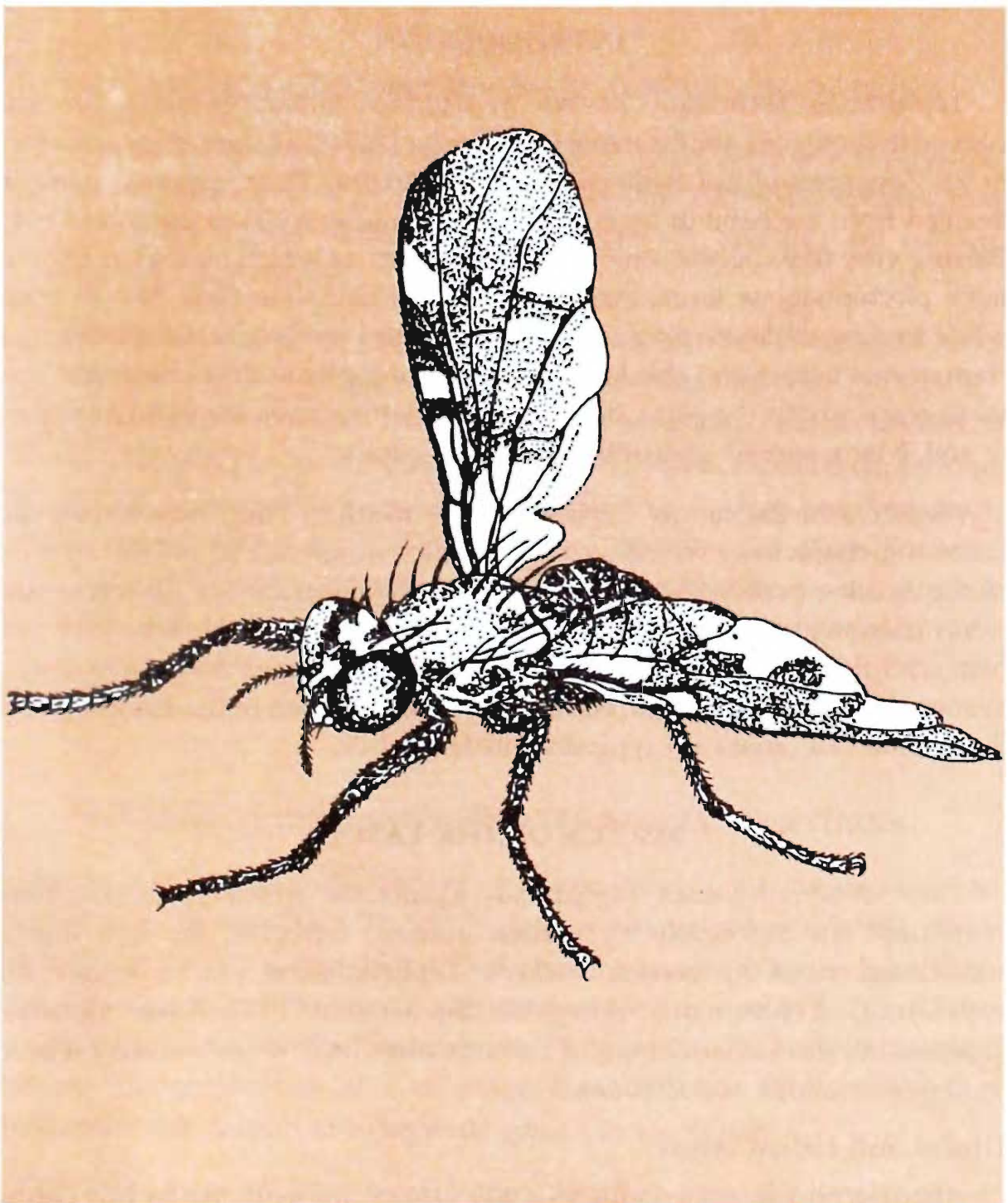
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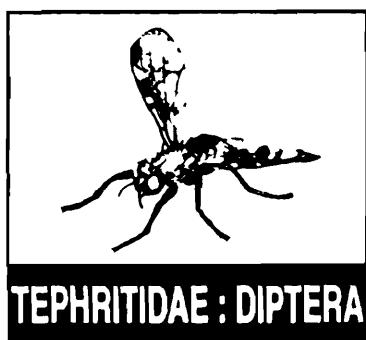
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Faunal Diversity in India : Tephritidae (Diptera)

C. RADHAKRISHNAN

*Zoological Survey of India, Western Ghats Field Research Station
Calicut – 673 002*





INTRODUCTION

Tephritidae, commonly known as fruitflies (although geneticists and some entomologists use the name fruitflies for Drosophilidae) are represented in all Zoogeographical Regions except Antarctica. Their common name is derived from the habit of many species breeding in fruits of different kinds. Barring very few species, almost all the fruitflies, of which biology is known, have phytophagous larval stages. The larvae complete their development while feeding in developing ovaries of fruits and seeds or while mining leaf, stem or root tissues and also forming galls in host plants. Pupation sometimes takes place within the plant, but usually the larvae leave the plant to pupate in soil. Many species of fruitflies are host specific.

Members of the family Tephritidae are medium sized flies having the following characters : well developed inferior fronto-orbital bristles in most of the species; post-vertical (post-ocellar) bristles parallel or divergent and never cruciate; wings typically marked in patterns, with the subcostal vein bent sharply upward at nearly a right angle before apex and weakened or evanescent beyond the bend; costa with a break at apex of the sub costa and the cubital cell (anal cell) typically lobate at apex.

STATUS OF THE TAXON

Three different names Tephritidae, Trypetidae and Trypaneidae have been used for the family by various authors; however, the first one is considered valid by recent workers. Tephritidae is placed under the superfamily Tephritoidea alongwith the families Pyrgotidae, Otitidae, Platystomatidae, Richardiidae and Tachiniscidae. Tephritidae is closely related to Platystomatidae and Otitidae.

Global and Indian status

About 4000 species arranged in 500 genera are included in the family Tephritidae of which about 839 species are known from the Oriental Region which include about 320 species from the Indian subcontinent.

So far 201 species of fruitflies are known (Kapoor, 1993; Radhakrishnan, 1993) from various parts of India. These are included based on White & Elron-Harris (1992) in 3 subfamilies, 11 tribes and 75 genera.

The subfamily Dacinae (tribes : Dacini and Ceratitini) is known by 68 species under 14 genera the subfamily Trypetinae (tribes : Acanthonevrini, Adramini, Euphrantini and Trypetini) by 67 species under 32 genera and the sub-family Tephritinae (tribes : Myopitini, Tephrellini, Terellini and Tephritini) by 66 species under 29 genera.

GEOGRAPHICAL DISTRIBUTION OF THE TAXON IN INDIA

Most fruitflies have a limited natural distribution probably due to physical, climatic, vegetational and host-specificity factors. However, species that infest a variety of vegetables and fruits (non-host specific) are usually widespread in distribution.

About 40 species of Tephritidae are known from West Bengal, 35 from Uttar Pradesh, 30 from Tamil Nadu, 20 from Bihar, 19 from Arunachal Pradesh, 15 from Himachal Pradesh, 13 from Karnataka, 11 from Sikkim, 7 each from Kerala, Punjab, Meghalaya and Maharashtra, 6 each from Jammu and Kashmir, Orissa and Assam, 3 each from Madhya Pradesh and Andaman, 2 from Gujarat and 1 each from Haryana, Rajasthan, Andhra Pradesh, Nagaland and Lakshadweep. Some of the species overlap in distribution over many of the states. The number of species known so far from each state is far from satisfactory as proper survey and documentation of the family has not been carried out in many of the states.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

One of the characteristic features of the fruitflies is the long extendible ovipositor of the females with which eggs are deposited within the plant part in which the larvae grow. Some Tephritids are known to use a pheromone to mark fruit in which they have oviposited which function as a signal to let the other members of the same species know that the fruit is already attacked. The production of such oviposition deterrent or host marking pheromones are suspected to be wide-spread in the family.

Generally, there are three larval instars, although some flower associated species complete the first instar prior to emergence from the egg.

About half of all species of fruitflies are associated with flowers including all species of the subfamily Tephritinae. Some of the Cucurbitaceae associated species of *Bactrocera* and *Dacus* are either exclusively or occasionally associated with flowers rather than fruit and in some cases specifically the male flowers. Many Tephritinae induce gall formation including root galls, stem galls and galls hidden within flower heads. The larvae of some Trypetinae develop in leaf mines and many ceratitini develop in bamboo shoots. Some species have unusual larval habits developing in deadwood, galls of sawfly and termite galleries.

Most fruit infesters drop to the ground and pupariate in soil while most flower breeding Tephritinae pupariate within the host tissue.

The number of eggs laid and duration of each life cycle vary from species to species. In fruit associated Tephritidae depending on the species, number of eggs laid can be from 50 to as many as 1500. The life-cycle stage for egg vary from 1 to 20 days, for larvae from 4 to 37 days (some over wintering), for pupae from 6 to 30 days (some over wintering) and for adults from 1 to 11 months.

Soon after emergence, the adults of most species require a protein source to permit egg maturation and the plant surface bacteria serve as very important source of nutrients.

Most fruit associated Tephritids get attracted to substances which give out ammonia.

Many Tephritids exhibit a pattern of lek behaviour in which congregating males defend territories while waiting for receptive females. Mating displays involve the use of wing pattern and movement, sometimes acoustic signals and presentation of nuptial gift of dried secretion from the mouth parts.

Temperate species with a narrow host range are usually univoltine while tropical pest species are typically multivoltine. About 35% of the world species attack soft fruits including many economically important commercial fruits. Besides, about 40% of species develop in the flowers of Asteraceae. Most of the remaining species are associated with the flowers of other families or mine in leaf, stem or root tissues during their development. Very few species are non-phytophagous, a typical example being that of *Termitorioxaxa termitoxena* (Bezzi) reared from the termite galleries in Australia.

ENDEMICITY

About 91.5% of the Indian fruitflies are Oriental in distribution. The Palaearctic element is represented by 5.5%, the Ethiopian by 1%, Nearctic

and Neotropical by 0.5%. The remaining 1.5% is cosmopolitan in Zoogeographical distribution.

Out of the 201 species reported from India, 93 species are endemic which means that about 46.2% of the known Indian species are restricted to the limits of India in distribution. However, out of the 75 genera reported from India, only the genus, *Indophranta* is so far known to be endemic to the country.

THREATENED AND INTRODUCED SPECIES IN INDIA

None of the species of Tephritidae are threatened in India.

Procecidochares utilis, a species of the subfamily Tephritinae belonging to the Neotropical Region was released in the Darjeeling district of West Bengal, Assam, Tamil Nadu and Uttar Pradesh in India in 1963 for the control of the obnoxious weed *Eupatorium trapezoideum*. The larvae of the fly form galls on the stems particularly destroying the terminal portion of the weed thereby preventing the weed from growing and spreading further. Though introduction of the fly in Hawaii has resulted in a grand success in eradication of the crofton weed, in India the fly inspite of establishing itself sufficiently well has not been effective in the control of the weed.

VALUE

The value of the family Tephritidae lies in the habit of its phytophagous larvae that causes some kind of damage or the other while developing in the host plants.

Of the approximately more than 130 families of Diptera, Tephritidae cause by far the most extensive damage to plants. Many of the fruitflies (*Bactrocera* and *Ceratitis*) are serious pests of economic fruits and vegetables while some of the cecidogenous members (*Procecidochares*, *Urophora*, *Eutreta* and *Tephritis*) are beneficial in the biocontrol of weeds.

The fruitflies have long been considered primarily as pests of many commercial fruits and vegetable crops. Only rather recently have the beneficial members of the family received recognition as agents in the biocontrol of weeds. The cecidogenous members of the family form the majority of such beneficial or potentially beneficial species and most of the tephritids involved are members of the subfamily Tephritinae. About 200 species have been recorded over the world as gall formers, thus ranking the Tephritidae as the second most important cecidogenous family of Diptera after cecidomyiidae.

Based on taxonomic considerations it is estimated that eventually 300-400 species will be found to be cecidogenous. About 20 species of Tephritidae have been used as biocontrol agents of adventive weeds over the world.

Out of the 201 species known from India, a few have become a matter of concern as pests of fruits and vegetables. They are *Bactrocera* (*Zeugodacus*) *cucurbitae*, *B. (Z.) tau*, *B. (B.) zonata*, *B. (B.) dorsalis*, *B. (Hemigymnodacus) diversa*, *Dacus* (*Didacus*) *ciliatus*, *Carpomyia vesuviana* and *Acanthophilus helianthi*. Species under the genera *Bactrocera* and *Dacus* are pests of Cucurbitaceous plants (melon, gourd, cucumber, pumpkin, etc.), tomato, chilly, brinjal, pepper, papaya, ber, pear, peach, custard apple, jackfruit, apple, guava, mango and several citrus fruits. *Carpomyia vesuviana* causes considerable damage to the fruit of ber and *Acanthophilus helianthi* to the seed bearing flower head of Safflower, Sunflower and Cornflower crops.

Most of the beneficial species belong to the genera *Acinia*, *Ceratitella*, *Chaetorellia*, *Euaresta*, *Xanthochaeta*, *Procecidochares*, *Tephritis*, *Tetreuaresta*, *Urophora* and *Xanthaciura*. Some of the species considered for use in weed control and in the natural regulation of some weeds are of the genera *Eurosta*, *Oxyna*, *Dioxyna*, *Ensina*, *Sphenella*, *Eutreta*, *Eupthraanta*, *Terellia*, *Toxotrypana*, *Trupanea*, *Zonosemata* and *Orellia*.

In India, the fruitfly, *Ensina sonchi* is found to attack the sow-thistle weed, *Sonchus arvensis* and the Canada thistle, *Cirsium arvense*. *Dioxyna sororcula* considered a pest of ornamental plants has been found to attack the cobbler's peg weed, *Bidens biternata*. Similarly, *Tephritis cardualis* is reported to breed in the flower heads of the thistle *Carduus edelbergi* in Pakistan and possibly Northern India. *Tephritis heiseri*, *Terralia serratulae* and *Urophora stylata* are also known to attack the flower heads of various thistles.

Extracts of the tephritid galls produced by *Paratephritis transitoria* on *Cacalia hastata* are widely used for tannery in the former U.S.S.R.

THREATS

As such no problems or threats can be attributed to the survival of the Taxon. The larvae and pupae of the fruit associated Tephritidae are prone to the attack of a variety of parasitic Hymenoptera particularly of the superfamilies Ichneumeonoidea and Chalcidoidea. The adults of some species of *Bactrocera* are parasitised by *Stylops* and tephritid puparia in soil are subject to attack by a variety of predators. Though rates of parasitism in some of the cases are as high as 90%, 0-30% levels of parasitism are more typical. However, birds and rodents eat sufficient attacked fruits to account

for a far higher level of larval mortality. Puparia in soil are highly vulnerable to predators and parasitoids. 38% of mortality has been due to ants. Ground dwelling Coleoptera (Carabidae, Staphylinidae), Neuroptera (Chrysopidae) and Hemiptera (Pentatomidae) are also predators.

CONSERVATION STRATEGIES AND FUTURE STUDIES

Since no major problems or threats are posed on the survival of the taxon, no conservation strategies are suggested. However, future studies are required particularly in view of the economic importance of the taxon being both of harmful and beneficial nature. Much more information than what is available is required on the taxonomy and biology of the pest species occurring in India for formulating proper control measures especially while considering further expansion of National land area for horticulture. Knowledge of host plants and detailed information on Zoogeography is essential not only for the control of pest species but also for quarantine purposes. No serious study has been conducted in assessing the beneficial aspects of many of the Cecidogenous species in India. A proper study in this direction is likely to yield very valuable information on potential species that can be employed in the biocontrol of weeds.

It is generally accepted that about 8-12 percent of the world species of most of the Acalyptrate Diptera are represented in India. Judging from this, approximately 400 species of Tephritidae can be expected in India where as only 201 species are recorded so far which indicates that as yet the information available on the fruitfly fauna occurring in India is far from complete.

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Faunal Diversity in India : Lepidoptera

D. K. MONDAL

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Lepidoptera, one of the highly specialised insect orders, includes scale-winged insects of the holometabolous endopterygote series. This includes butterflies and moths that show total metamorphosis and pass through egg, larva, pupa and adult stages. All these stages have characteristic features in structure, habit and habitat so as to readily differentiate butterflies from moths.

Lepidoptera is a large and well known group with cosmopolitan distribution of which India is no exception. The members are of great value both for conservation and for environmental planning in local scale. Individuals have a great potential for inclusion in the faunistic analysis and environmental monitoring. This is particularly true for the butterflies due to the colour and pattern of their wings, variegated food plants, wide range of habitats, abundant local and weedy species along with diverse forms, etc.

STATUS OF THE TAXON

Global and Indian Status

Hampson (1918) estimated as many as 89 families and subfamilies of Lepidoptera, while Hamlyn (1969) reported about 1,40,000 species comprising 13,000 butterflies and 1,27,000 moths from world. A recent estimate shows the occurrence of about 1,42,500 species of Lepidoptera from the globe.

Recent estimate of diversity within Lepidoptera from the Indian Subregion reveals that the group comprises over 15,000 species and many more subspecies distributed over 84 families and 18 superfamilies.

DISTRIBUTION

On the basis of eco-faunistic surveys made at different localities of India by various workers including those of the Zoological Survey of India, it has

been revealed that the niches and habitats of Lepidoptera sprawl from the mountains to the mangrove ecosystems and also the major insular belts like the Andaman and Nicobar and the Lakshadweep groups of islands. Though India principally falls in the jurisdiction of the tropical biome, the country nevertheless shows large faunistic affinities with the equatorial, temperate and even, to certain extent, arctic parts of the globe. Such a distributional pattern of Lepidoptera is necessary to be considered to define the geographical units for conservation. Maximum degree of faunistic stagnation is found in the East Himalaya particularly along the Myanmar border, while in other areas like the West Himalaya, southern and insular parts of India, the number of lepidopteran species is proportionately less. Many more species are, however, yet to be explored from the remote corners of plains, arid and wastelands and forest covers in different areas from east to west and north to south of India.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Out of 84 families and 18 superfamilies of Lepidoptera available in Indian Subregion the butterflies belong to five major families, viz., Papilionidae, Pieridae, Nymphalidae, Lycaenidae and Hesperidae under two superfamilies, viz., Papilionoidea (including the first four families) and Hesperioidea (including the last family) and constitute about 10% of the total faunal species. The largest representative families of butterflies and moths from India are Nymphalidae (450 species) and Noctuidae (1,500 species) respectively, while only a few families of moths like Castniidae, Neopseustidae, etc., are very poorly known from the country. The largest known tropical Lepidoptera is the Atlas moth, *Attacus atlas* (Linn.) with an expanse of 250 mm and the smallest are the members of Nepticulidae, one of the microlepidopteran families of wide distribution. Likewise, the largest Indian butterfly is the Common Birdwing, *Troides helena* (Linn.) with a maximum expanse of 190 mm and the smallest, the Grass Jewel, *Freyeria trochilus putli* (Kollar) with a minimum expanse of 15 mm. The butterflies are diurnal in habit and the moths, nocturnal. But there is exception to this rule. For instance, some shade-loving butterflies like the Evening Brown, *Melanitis leda* (Linn.) are crepuscular, while the brightly coloured moths belonging to Zygaenidae, Agaristidae, Amatiidae, Hypsiidae, etc., are day-flying. Very roughly, some 20-30% if not less, of lepidopterans, still need discovery.

ENDEMIC AND THREATENED SPECIES

Due to paucity of knowledge it is rather extremely difficult to assess endemism in Lepidoptera in India. Nevertheless, the analysis of distribution of the rare and threatened butterflies shows that there are some endemic species in the country. For instance, in Papilionidae there are five in North West India, one, i. e., *Princeps mayo*, in the Andaman Islands and three in South India. Similarly, in other families, there may be a few more such species, too. As to the threatened populations, about 30-40% of butterfly species are known from India, of which quite a few belonging to different families and specially Papilionidae are highly endangered. A total of 123 species of butterfly distributed over four most important families, viz., Nymphalidae (58), Pieridae (6), Papilionidae (16) and Lycaenidae (43) are considered as endangered in India. There is, however, no up-to-date mention of threats of moths in literature, as no record of import or export of listed species, as per CITES, is available.

VALUE

Lepidoptera and particularly the butterflies are immensely beautiful creatures ranging from the delicate Blues of meadows to the large and richly coloured Birdwings of tropical forests in India and elsewhere of the globe. The most beautiful butterfly ever known from India is *Princeps polyctor ganesa* with metallic blue and green tinges, occurring in the East Himalaya. Some moths are also no less significant in depicting the fabulous pattern of colouration. A few may be worth to be mentioned here as *Erasmia pulchella*, a metallic blue-green species of the East Himalaya, large and long whitetailed *Nyctalemon patroclus* from the Indo-Malay-Papuan region, etc. In addition to such aesthetic significance, the group also has other values ; for instance, scientifically without knowing the taxonomy of Lepidoptera it is sheerly impossible to highlight information and help implement in the applied area of faunistic analysis and environmental monitoring. In brief, the direct and indirect use of taxonomic concept are rather universal and the task of protection of wild fauna and flora depends largely on biologists, conservationists, individual campaigners and in the last but not to the least on the politicians and legislators as well. It may further be stated that lepidopterists are encouraged to follow their interests by means other than collecting, such as colour photography. Over-collecting could be a danger to

a small colony of the group, but there is no harm in taking small numbers and to make a proper study, it is necessary to collect only a few representative samples. Ecologically, the adults are useful to plants as pollinators, as observed mainly amongst the butterflies. Besides, for the sake of maintaining nature's balance, overproduction of broods is controlled by predators. The caterpillars may be sporadic or random plant-feeders or pests which, in turn, are important food for their enemies or otherwise. Thus, predation and parasitism are high at all stages of development and only a small proportion survive to adulthood. The cockroaches feed upon the eggs, birds on the larvae, and the birds, lizards, mantids and spiders on the adults. The eggs and larvae of many species are also attacked by parasitic Diptera or Hymenoptera. Naturally, for protection against such enemies, devices like mimicry, protective resemblance, etc. are adopted by the group. From the viewpoint of economic importance the members are both injurious and beneficial. The butterflies do little harm or good to mankind, though only a few are known to be pests on lime and cardamon plantations; on the other hand, some of them belonging to the Lycaenidae effect biological control on aphids, coccids, etc. causing serious damage to the kitchen gardens. Of the beneficial moths, notable are the species of Bombycidae and Saturniidae producing commercial silk; the sericulture industry flourishes entirely on these silk moths. Otherwise, the moths of other families are highly injurious to crops and other plant products, stored grains, etc. Mimetic and symbiotic phoresis are observed amongst certain butterflies. No lepidopteran species has yet been identified as a keystone species from any of the Indian ecosystems.

Since time immemorial, man has been adoring Lepidoptera, particularly butterflies, more for their virtues than vices. The most rewarding pleasure is to observe them flying amidst forests, atop hills and in gardens and orchards or to see them in dry and pinned condition in museum repositories. Their fabulous patterns, designs and texture together with acting as principal agent in effecting pollination of the flowering plants really exert tremendous influence on mankind all over the globe.

THREATS

In many parts of India, notably in the East Himalayan belt, the Lepidoptera with special reference to the butterflies are becoming scarcer to an approximate estimate of 30-40%. The change of habitat by taking land for building, ploughing up meadowland and chalk towns, cutting down hedges and moving verges cause much more harm than insecticides and herbicides,

though there is little doubt that the use of chemicals in agriculture has a harmful effect. Other levels of destruction of the delicate and fragile ecosystems in India include commercial exploitation, industrialisation, etc. Thus, trade in butterflies is a flourishing business in which the smugglers earn huge sum of money through exports. Industrial effluents and smokes are serious threats to wildlife while accelerating demands of charcoal and wood, high level of human population, etc. cause depletion of their population.

CONSERVATION AND FUTURE STUDIES

The CITES (Convention of International Trade in Endangered Species) of wild fauna and flora controls and monitors import and export of listed species. Appendix I contains no insects and Appendix II contains only some species of the Papilionid butterflies. But National Legislation to protect the butterflies has been enacted. Certain species are protected by law in India under the Revised List of Schedules to the Wild Life (Protection) Act, 1972, as amended up to 1986. Accordingly, under Schedule I altogether 114 Indian species and subspecies in four families, *viz.*, Papilionidae, Pieridae, Nymphalidae and Lycaenidae, have been included; under Schedule II, 306 species and subspecies in the foregone families plus Hesperidae and under Schedule IV, 19 species and subspecies in all the families minus Papilionidae included. As the threats to such species become more intense, it is the need of the hour for careful management studies of the group particularly related to the endangered species in India.

Several suggestive measures are suggested as follows for future conservation of Lepidoptera in nature :

1. The human interference in habitat destruction through deforestation, urbanisation, agricultural extension, etc. should be resisted and measures must be taken to control pollution through industrial effluents and extensive use of pesticides as well.
2. Where natural forests are severely depleted, the plantation forestry should be initiated as a conservation toll. More attention should be paid to the food-plants on which the Lepidoptera thrives.
3. Farming of Lepidoptera, particularly the butterflies, should be implemented on a large scale so that the recolonization of the depleted areas with the fauna facing extinction may be possible.
4. Ranching of the group to meet the demands in trade may be used.

5. The biology of threatened, rare and endemic species should be studied as authentically as possible so as to establish the population size of each such species.

6. Preventive measures should be taken to avoid over-collection of specimens of a given species for scientific studies so as to prevent the population from bringing below the threshold of recovery.

7. More public awareness should be stressed for the sake of better conservation needs of Lepidoptera coupled with the requirement of effective implementation of legislation.

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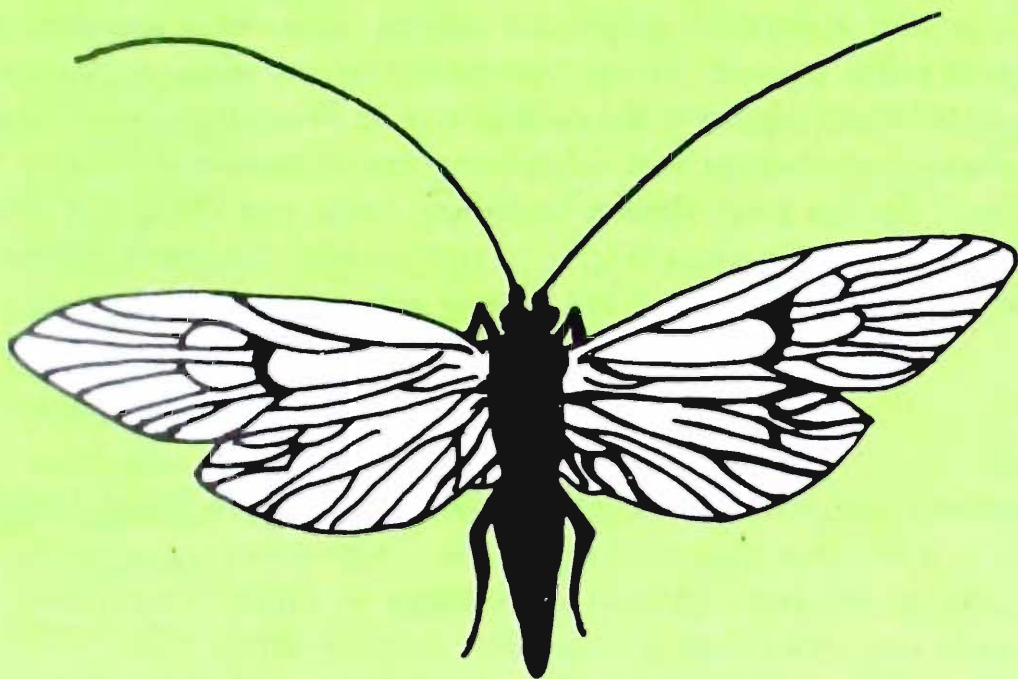
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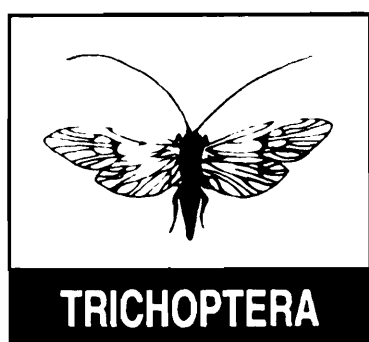
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Faunal Diversity in India : Trichoptera

S. K. GHOSH

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Trichoptera or hairy winged insects are popularly called as caddis flies and their larvae as the caddis worms because of the ability of the latter to construct and line with silk the cases in which they live. The trichopterans are moth-like insects. They are small to moderate in size with setaceous antennae and mandibles may be absent or vestigial. Maxillae with single small lobe and elongated palpi and labium with large mentum and 3 segmented palps present. Wings are membranous, more or less densely hairy and held roof-like over the back in repose. Forewings are elongate but the hindwings are broader with folded anal area. Crossveins are very few in the wings. Legs are long, slender with long coxae and tibiae and provided with both apical and preapical spurs. Tarsi are with 5-segments. Larvae are more or less eruciform. Pupae are exarate and decticus.

STATUS OF THE TAXON

Linnaeus (1758) while erecting the order Neuroptera included Trichoptera in it along with other groups of insects. So, Trichoptera was considered for a longtime in the heterogenous assemblage of order Neuroptera. Later, Trichoptera was considered as a separate order. Kolenati (1848) subdivided the order into two main subdivisions, namely, Inaequipalpia and Aequipalpia on the basis of relative number of joints in the maxillary palpi in male and female. Martynov (1924) divided Trichoptera into two suborders on the basis of the form and habits of the larvae and partly on structures in adult insects. The ultrascientific school, however, has divided these suborders into several superfamilies. Weaver (1983) classified Annulipalpia into two infraorders, Curvipalpia and Spicipalpia and included two superfamilies, namely, Hydropsychoidea and Phylopotamoidea in the former and Rhycophiloidea and Hydroptiloidea in the latter. He also divided Integrepalpia into two infraorders of which Plenitentoria contained superfamilies Limnephiloidea and Phryganoidea, whereas Brevitentoria included two superfamilies, Leptoceroidea and Phryganoidea.

Global Status

Numerically about 7000 species in 38 families are known from the whole world.

Indian Status

Amongst a total of 38 families from the whole world, 19 families have so far been recorded from India. Though family Arctopsychidae is not generally accepted as a distinct family and is considered as a subfamily of the family Hydropsychidae but in the following table the status has been restored. The approximate number of genera and species hitherto known from India are given as follows :

Families	No. of genera	No. of species
1. Molannidae	2	8
2. Hydropsychidae	16	60
3. Polycentropidae	5	24
4. Stenopsychidae	1	13
5. Calamoceratidae	2	5
6. Phryganeidae	3	4
7. Philopotamidae	3	47
8. Hydroptilidae	8	65
9. Leptoceridae	14	201
10. Sericoamatidae	13	36
11. Limnephilidae	20	52
12. Economidae	1	6
13. Psychomyidae	6	31
14. Xiphocentronidae	6	46
15. Rhyacophilidae	4	176
16. Glossosomatidae	4	19
17. Odontoceridae	1	1
18. Arctopsychidae	2	9
19. Hydrobiosidae	1	9
Total : 19	112	812

DISTRIBUTION

There is a scope for rich species diversity in the diverse ecosystems of India. Trichoptera are generally aquatic in immature stages and occur in lakes, ponds, pools, rivers, streams etc. and the adults are entirely terrestrial. Our knowledge on Indian Trichoptera is far from complete. So, it is difficult to estimate the species diversity. From the available data, it may be mentioned that the trichopterans are very rich in species diversity in the Himalayan ecosystems and terrestrial ecosystem of Peninsular India. Our knowledge on this group in the desert ecosystem and insular ecosystem is fragmentary. The qualities of substrate, water temperature, types of vegetation and water current strongly influence the distribution of the species. Any change in the biotic environment may support different fauna.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Majority of the caddis flies are weak fliers but some may fly great distance. In day time, the adults generally conceal themselves on vegetation, under bridges, etc. On the contrary, larvae are conspicuous in diverse aquatic habitats. When the adults live without sustenance or lapping up liquids, the larvae feed on algae, organic particles, invertebrates, etc. Larvae may be free living (Rhyacophilidae), net spinning (Hydropsychidae, Philopotamidae, Psychomyidae) and some inhabit in cases (majority of caddis flies larvae). Diversity is more in case bearing forms. Some are saddle case makers (Glossosomatidae) or purse case makers (Hydroptilidae). Larval cases of the species of some families are in the form of elongate tubes. Free living forms may take shelter beneath the submerged stones or debris or may spin nets, while the case bearing forms take shelter on sand, silt bottoms, stones, logs, etc.

ENDEMICITY

The available data is not sufficient to estimate correctly the extent of endemism. But from the data hitherto available, it may be mentioned that more than 80% species are endemic in India. It is also difficult to provide any information on the threatened species as the faunistic surveys and taxonomic studies are not satisfactory.

VALUE

Because of the broad trophic habits of the larvae, they take an important part in the energy transfer at several levels in aquatic ecosystem and are therefore significant in the nutrition and management of fish and other aquatic vertebrates. Most larvae eat plant materials in one form or other, as for example, algae specially diatoms on rocks or decaying vascular plant tissue. So, they effectively control the growth of water weeds. Though this group is generally not recognised as insects of economic importance but they play the important role in fresh water ecology.

THREATS, CONSERVATION AND FUTURE STUDIES

Trichoptera has not been taxonomically well-worked out group in India and possibly there is no analytical data regarding the status of the species. Gaps still exist on the distribution of species in India. As the status is not known it is not possible to indicate the names of the species threatened with extinction. The expertise available in the country is far less than required to deal with the number of species occurring in India. Efforts should be made to develop expertise in the group and also to explore fauna from diverse ecosystems in India. Particular emphasis should be given on identification, classification, status designation and biogeography. These information will provide the base-line data for a conservation strategy.

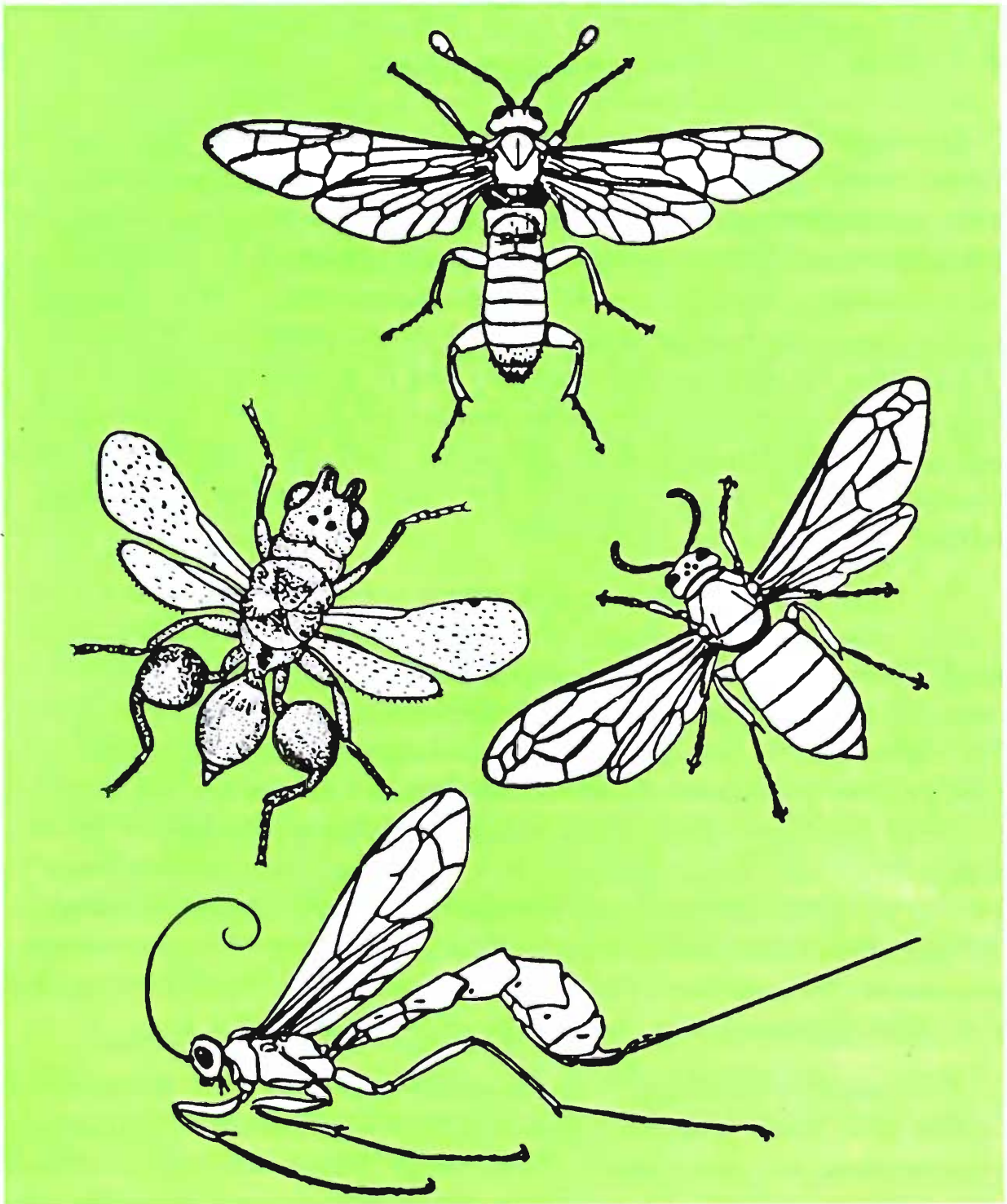
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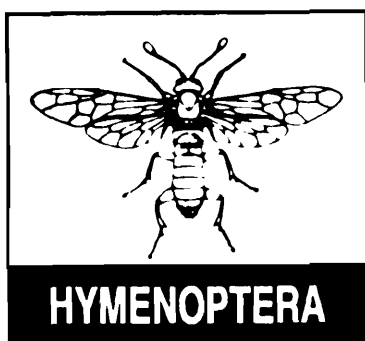
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Faunal Diversity in India : Hymenoptera

J. K. JONATHAN

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The order Hymenoptera evolved during Jurassic period in Mesozoic era, about 155 million years ago. This order is listed as third in point of size, but it has been little studied as compared to beetles (Coleoptera) and moths and butterflies (Lepidoptera). If all the unnamed species of hymenoptera are once thoroughly studied, it would be surpassing these orders. The order exhibits instinctive behaviour in its highest state of perfection. The members of this order are economically, medically and biologically important. In the class Insecta, the order Hymenoptera stands out for its greater bio-diversity, utilizing the environment fully and at the same time controlling other Insects. This seems to be caused by the highly specialized morphological features which gave rise to the order.

The body of the members of this order is covered by a hard and strong cuticle, except the mobile joints, which are covered by soft membrane. The head, which bears the main sense organs, strong mandibles, slightly movable accessory palps, tongue and mouth parts, moves independently of the thorax. The thorax has six strong appendages and four membraneous wings, the hind pair being somewhat smaller. Hind wings are held to the fore wings by a row of tiny hooks on the front margin which catch in a fold of the fore wings. They are strong fliers, though the wings are not very large in proportion to the size of the body. The females of some species are wingless. The abdomen is also covered with chitinous plates but is capable of some movement. The members of this order have true sting. The sting is usually the modified ovipositor of the females; males are without a sting.

The order Hymenoptera is so specialized and diversified that the members of this order show greater adaptation to their environment. The primitive Hymenoptera are phytophagous. Their larvae feed mainly on plant food externally or internally such as Sawflies. Some phytophagous forms lay eggs inside plant tissue and form galls, their larvae draw nourishment from the plant tissue inside the gall (Cynipidae). The second category is social

Hymenoptera. All the ants, wasps and bees form their own colonies leading a complex, social and co-operative life. The third diversified group of Hymenoptera includes Entomophagous insects—Parasites and Predators.

STATUS OF THE TAXON

Global and Indian Status

The order Hymenoptera, with about 1,20,000 known species, ranks third among the five major orders of class Insecta. However, it is estimated that there are actually 2,00,000 species. Of these about 20,000 species belong to superfamily Apoidea (Bees) and 60,000 species belong to 1,250 genera of 26 subfamilies of parasitic family Ichneumonidae. The Chalcidoids is said to be much bigger group than these two, besides several thousand species under Aculeate Hymenoptera (Superfamilies : Bethyloidea, Scoliidea, Formicoidea, Vespoidea, Sphecoidea, etc.).

It is estimated that about 10,000 species of Hymenoptera are found in India, which is about 8.3% of the total species of Hymenoptera in the world fauna. India is unique as far as its bio-diversity is concerned. Varied climatic conditions from the high Himalayas to plains, deserts, east and west coastal climates and mangroves allow various species to thrive abundantly.

DISTRIBUTION

The members of order Hymenoptera are widely distributed in all the ecosystems of India. As already stated, the members of this order show great diversity in their morphological characters, acquired according to the habitat they live in. The distribution data demonstrates very clearly that the affinities of the Indian taxa are entirely with the taxa of Oriental Region. However, the taxa distributed along the Himalayan region show affinities with the taxa of Palaearctic Region. The taxa of South India show greater affinities with Sri Lankan taxa and the taxa of Andaman and Nicobar Islands are related to Indonesian taxa.

It is of great interest that more than 60% of the taxa are distributed in the Himalayan region from Kashmir in North-West to Nagaland in North-East, about 20% in the hilly regions of Eastern and Western ghats and remaining 20% in the plains of Central and North India.

This shows that there is a quantitative abundance of some species of bees, wasps, ants and some parasitic species of crop pests in the plains, whereas,

there is greater biodiversity of species in the hills where there is an abundance of variety of fauna and flora. There is no consolidated account of distribution of species of Hymenoptera of India available to the author, however, on the basis of surveys conducted by the Zoological Survey of India, more taxa were recorded from the hilly and densely forested areas of India. The species in the plains are also abundant during certain seasons but number of taxa are less, representing largely common species.

It is estimated that approximately more than 25% of the Indian Hymenopteran diversity still awaits discovery, *e.g.*, in the family Ichneumonidae (Parasitic Hymenoptera), of the 1200 species/subspecies known, about 250 species (20%) have been discovered by Jonathan *et al.* during the last 15 years.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The order Hymenoptera, is diversified on the basis of food and feeding habits, social behaviour and adaptation to the environment. The order is divided into two suborders, namely, (a) Symphyta and (b) Apocrita. In Symphyta the abdomen is broadly attached to the thorax, with no marked constriction between thorax and abdomen whereas in Apocrita the abdomen is attached to the thorax with a narrow segment called pedicel.

(A) SUBORDER SYMPHYTA

The suborder Symphyta is divided into 4 superfamilies, *viz.*, Siricoidea, Xyeloidea, Cephoidea and Tenthredinoidea.

Superfamily I — SIRICOIDEA

This superfamily is known by two families, *viz.*, Siricidae and Orussidae. The family Siricidae is known by 85 species belonging to 9 genera in the world. In India, only 5 species have been recorded. The members of family Orussidae seem to be ectoparasitoids on Buprestid larvae. Excepting the ovipositor and veins in the wings, they resemble Siricidae and they will probably form a link between Symphyta and Apocrita. The Orussidae is known by 66 species belonging to 14 genera from the world, and only 3 species are known from India.

Superfamily II — XYELOIDEA

This superfamily includes one family Xyelidae. The family xyelidae is represented by 15 species under 5 genera from the world. Of these 2 species are known from India only.

Superfamily III — CEPHOIDEA

This superfamily is represented by a single family Cephidae having about 100 species under 13 genera in the world fauna. Only 5 species have been recorded under this family from India.

Superfamily IV — TENTHREDINOIDEA

The superfamily Tenthredinoidea includes 6 families, *viz.*, Argidae, Cimbicidae, Diprionidae, Tenthredinidae, Blasticotomidae and Pergidae. The last two families are not recorded from India. The Tenthredinoidea is known from India by nearly 200 species, whereas over 2000 species were recorded from the world.

(B) Suborder — APOCRITA

The suborder Apocrita is divided into two divisions, *viz.*, Aculeata and Parasitica.

Division (I) Aculeata is represented by six superfamilies, *viz.*, Bethyloidea, Scolioidea, Formicoidea, Pompiloidea, Vespoidea, Sphecoidea and Apoidea.

Superfamily V — BETHYLOIDEA

The superfamily Bethyloidea includes 5 families, *viz.*, Scelogibbidae, Dryinidae, Chrysididae, Bethylidae and Cleptidae. This superfamily is known by more than 200 species in India and over 1500 species in the world fauna.

Superfamily VI — SCOLIOIDEA

The superfamily Scolioidea is represented by 4 families, *viz.*, Scoliidae, Tiphiidae, Mutillidae and Sapygidae. In India, the superfamily is represented by 500 species, whereas in the world by over 1250 species.

Superfamily VII — FORMICOIDEA

The superfamily Formicoidea includes a single family, Formicidae. The family Formicidae is one of largest families of Hymenoptera.

This family is known by over 500 species in India. In the world fauna there are more than 2500 species.

Superfamily VIII — POMPILOIDEA

The superfamily Pompiloidea is represented by two families, *viz.*, Pompilidae and Rhopalosomatidae. Pompilidae is a moderately large family and Rhopalosomatidae is a small family with a few species known from the world. Pompilidae is known by 150 species under 33 genera from India.

Superfamily IX — VESPOIDEA

This superfamily includes 3 families, *viz.*, Masaridae, Eumenidae and Vespidae. These families are represented in India by about 225 species under 25 genera, and in the world by over 600 species.

Superfamily X — SPHECOIDEA

This superfamily is represented by a single family Sphecidae. The family Sphecidae is further divided into 9 subfamilies. This is a moderately large family, more than 1500 species are known from the world and 450 species from India, but this is only a fraction of those awaiting discovery.

Superfamily XI — APOIDEA

Included in this superfamily are the social and solitary bees. The truly social species, which have evolved worker caste, are confined to Helictidae and Apidae, the great majority of forms being solitary. The Apoidea is divided into several small and large families, the important ones are Apidae, Colletidae, Andrenidae, Halictidae, Megachilidae, Anthophoridae, Xylocopidae, Bombyliidae, Bremidae, Ceratinidae and Nomidae. In India, this superfamily is represented by about 450 species, which is only a fraction of those undiscovered species.

Division (II) Parasitica is represented by 6 superfamilies, *viz.*, Trigonoloidea, Ichneumonoidea, Evanioidea, Cynipoidea, Chalcidoidea and Proctotrupoidea.

Superfamily XI — TRIGONALOIDEA

This superfamily includes family Trigonalidae, which is a small family of rare but widely distributed species. The number of species in India and world over are not correctly known.

Superfamily XII — ICHNEUMONOIDEA

This superfamily includes two main families, *viz.*, Ichneumonidae and Braconidae. The family Ichneumonidae is represented in India by 1200 species and subspecies under 337 genera and 23 subfamilies. The family Braconidae has 17 subfamilies and includes 250 species from India, whereas there are over 7000 species in the world fauna.

Superfamily XIII — EVANIOIDEA

Evanioidea includes 3 families, *viz.*, Evaniidae, Gasteruptidae and Aulacidae. There are about 50 species under these families from India and about 350 species are reported from the world.

Superfamily XIV — CYNIPOIDEA

Cynipoidea includes 4 families, *viz.*, Ibaliidae, Liopteridae, Figitidae and Cynipide. Cynipoids are of great interest as the various species are either gall-makers of parasites. In this superfamily about 1600 species are included. There are about 50 unconfirmed species from India under this superfamily.

Superfamily XV — CHALCIDOIDEA

This is one of the largest superfamilies of the order Hymenoptera. This superfamily includes 11 families, *viz.*, Agaontidae, Chalcididae, Encyrtidae, Eulophidae, Eupelmidae, Eurytomidae, Mymaridae, Perilampidae, Pteromalidae, Torymidae and Trichogrammatidae. In India this superfamily is known by over 100 species, whereas over 30,000 species are recorded from the world fauna.

Superfamily XVI — PROCTOTRUPOIDEA

This superfamily includes 7 families, *viz.*, Proctotrupidae, Roproniidae, Heloridae, Diapriidae, Ceraphronidae, Scelionidae and Platygasteridae. This superfamily is poorly known from India, about 100 species are recorded from India and about 2000 species are known to occur in the world.

ENDEMIC AND INTRODUCED SPECIES

There is a high degree of endemism of species in the order Hymenoptera in India. Most of the species recorded in India and adjacent countries are not recorded from other geographical regions. A total of about 90% species are endemic to India and remaining 10% are either introduced from other far-off geographic regions or have entered into Indian region, where Oriental and Palaearctic fauna are intermixing in the Himalayan region. The correct number of threatened or endangered species is not exactly known. However, it is evident that some species which were common in certain areas are not recorded in recent times.

VALUE

Most members of the family Apidae (*e.g.*, *Megapis dorsata*, *Apis indica* and several other species of solitary bees) are plant pollinators, and abundance of fauna and flora of a particular area largely depends on the activities of these bees. Therefore, these bees are known as "indicator species." There are

several species of Hymenoptera which are predators and parasites, and any increase or decrease in their population is an indicator of the population of noxious (harmful) species. These noxious or pests species usually belong to other insect order. However, some species of Hymenoptera are also harmful or considered pests species of forests and crops. The members of families Siricidae and Tenthredinidae lay their eggs in the soft plant tissues, stem, leaf or fruit, and produce galls for the purpose of providing shelter and nutrient to their off spring. To check their undue increase, they have natural hymenopteran enemies. For example, *Rhyssa persuasoria himalayensis*, a well known Ichneumonid parasite, has been successfully utilized in the control of conifer infesting siricid pest—*Sirex imperialis*. All such Hymenopteran species are considered 'indicator species' because their absence or abundance is considered as an indicator on which the existence of host-plant, pest, predators or parasite depends.

This order includes many economically important species : the parasites of noxious species of insects, efficient plant pollinators and the only honey producers. There are a few pest species, usually ants and sawflies.

Beneficial Hymenopterans

Honey producers : Of the many species of insects, only two, the silkworms and the honey bees have been domesticated. The honey produced by honey bees is a wholesome food for man from time immemorial. The honey bees also produce bee wax which is extensively used in industry and medicine. Moreover, bee-poison, *i.e.*, posion from the sting of honey bee is used in various ailments in human beings.

Pollinators : In the higher plants sexual reproduction is made possible by the process known as *Pollination*. The pollination depends mainly upon the visits of these insects to carry the pollen from one flower to another. More than 100 species of bees are recognised as pollinators.

Parasites and Predators : There is no doubt that the greatest single factor in keeping the plant feeding insects from overwhelming the rest of the world is that they are fed upon by other insects. The predatory hymenopteran larvae consume more than one individual in order to reach the adult stage, on the other hand parasitic hymenopteran larval stage develops at the expense of a single individual (host). By their parasitic and predatory habits they destroy large number of agricultural and forests pests and thus constitutes one of the major forces for preventing the undue increase of noxious species. In other words, these insects help in biological control of insect pests.

Destructive Hymenoptera

There are a few insects which have proved themselves more persistently exasperating to human being. Every one is familiar with the fact that when ants have invaded houses, the ant workers will be found crawling over every food that is their liking, bits of which they cut off and carry to their nests. The sawflies (family Tenthredinidae) and horn tails (family Siricidae) are the outstanding pests of coniferous trees. They periodically defoliate these trees in hills. Sawflies of various species attack a wide range of trees and shrubs and even grasses. In all cases, the larvae devour the foliage.

THREATS

The evils of human activities, specially during the past few decades have caused deliberate damage to the environment and the biosphere. Human activities have annihilated many of the habitats, which lead to the decline in the population of certain species. There are other reasons such as urbanisation, agricultural conversion, loss of host, over collecting and pesticides, which are responsible for the very existence of large number of species of this economically important order Hymenoptera.

CONSERVATION

It is understood now that with the ever-increasing loss of the habitats resulting from forestry, agriculture, industrial, urban and other developmental programmes, the collection of insect fauna should be considered in the interest of conservation of the insect fauna, particularly Hymenoptera. It is expected that entomologists should try to observe the following :

1. No more specimens than required should be killed.
2. Common species should not be killed ; specimens should be examined alive and released in the same habitat.
3. Supposed or actual parasites and predators should not be destroyed.
4. When collecting, never collect whatever is available, leave as many as possible to allow the population to recover.
5. For commercial purposes, insects should be either bred or obtained from old collections.
6. Collectors should attempt to break new grounds rather than collect a local or rare species from a well known and perhaps over worked area.
7. Unwanted specimens shouldn't be fed to birds or animals.

8. If a trap used to collect specimens, is found to be catching rare or local common species, it should be resisted.
9. When collecting on nature reserves, supply a list of species collected to the appropriate authority.
10. Do as little damage to the environment as possible, protect vegetation and rare plant species.
11. Overturned stones and logs should be replaced in their original positions.
12. Breeding from a fertilised female or pairing in captivity is preferable to taking a series of specimens to the field.
13. Unwanted species that have been reared should be released in the original locality, not just anywhere.
14. Germplasm of economically important species need to be preserved. There are many strains of honeybees, and there is great variation within the strains for characteristics such as honey production and disease resistance.

FUTURE STUDIES

1. For collector the awareness of the need for conservation is required.
2. A responsible attitude towards collecting by all entomologists will make collecting respectable.
3. Dynamic preservation of species populations and 'habitats'
4. Thoughtless or selfish behaviour of a collector reflects upon the credibility of all collectors, and is consequently damaging in entomology.
5. Code for Insect collecting is to be taken in conjunction with lists of schedule of Rare and Endangered species.
6. Status of the species should be known.
7. Entomologists and conservationists need each other to resist the many strong forces which are opposed to the interests of both.

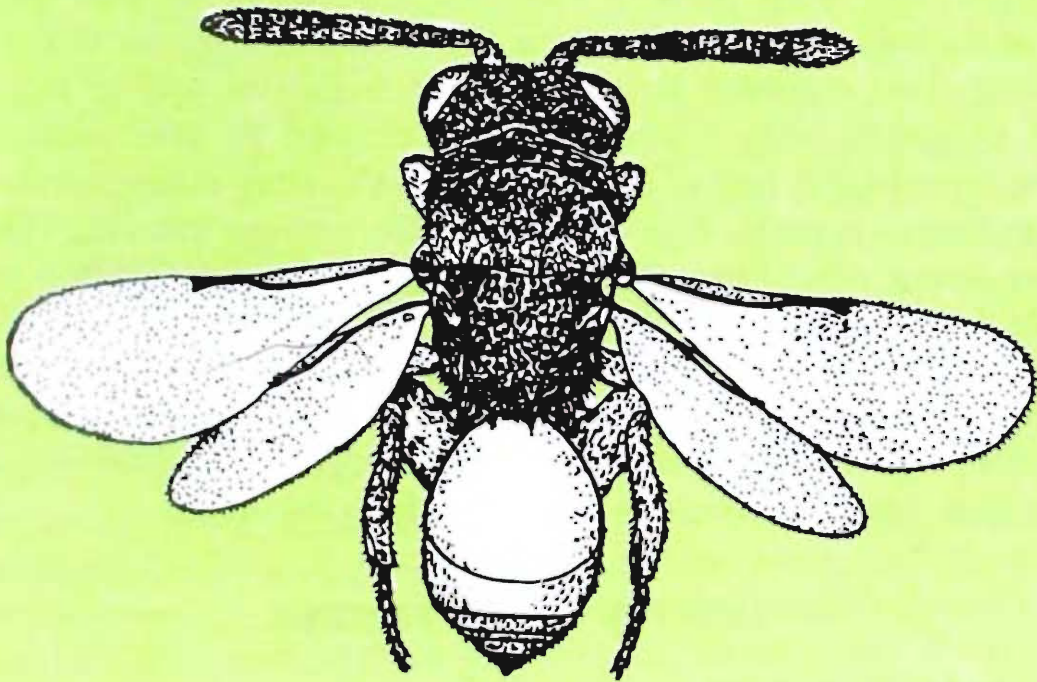
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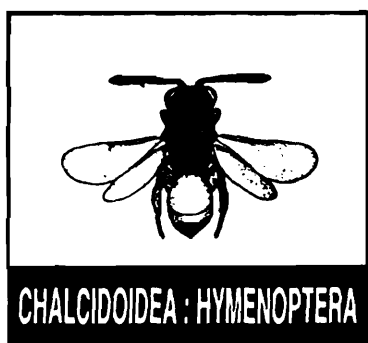
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Faunal Diversity in India : Chalcidoidea (Hymenoptera)

P. M. SURESHAN

*Zoological Survey of India, Western Ghats Field Research Station
Calicut – 673 002*





INTRODUCTION

The superfamily Chalcidoidea, commonly called the Chalcidoid wasps or briefly chalcids is one of the largest groups of Parasitic Hymenoptera. They are taxonomically the most difficult, ecologically most complex and economically perhaps the most important group of insects. Most members of the group are parasitic, attacking major insect orders many of which are agricultural and forest pests of economic importance. By their parasitic mode of life they destroy populations of potential pest species in the field, regulating their numbers, thus playing an important role in biological control of serious pests. Chalcids are characterised by their minute size, ranging between 0.18 mm to almost 25 mm and readily distinguished from other groups of parasitic Hymenoptera by the reduced forewing venation without closed cells. From Proctotrupeoidea, a closely resembling group, chalcids differ in the nature of pronotum which never touches tegulae, due to the presence of a sclerite called propectus. The other distinguishing characters of the group are geniculate antennae with 13 or fewer segments, biarticulate trochanters, sclerotised abdominal segments and the ovipositor issuing from the ventral surface far anteriorly to the anus.

STATUS OF THE TAXON

Global and Indian Status

The number, definition and limits of Chalcidoid families have always been in a state of flux since the beginning of 1800's. According to the recent classification by Boucek (1988) the superfamily is divided into 21 families to accommodate about 2000 genera and 19,000 described species.

Members of 19 families of Chalcidoidea are known from India. Among these Encyrtidae, Chalcididae, Eurytomidae, Aphelinidae, Trichogrammatidae and Agaonidae are well documented from the region. The families Tanaostigmatidae, Tetracampidae, Eulophidae, Pteromalidae, Perilampidae etc. are less studied from this part of the Oriental Region. The approximate number of valid genera and species of Indian Chalcidoidea is 528 and 1695

respectively. This forms only 27 % and 9 % respectively of the world genera and species. These figures are approximate and may go still high if the scattered publications on various families like Encyrtidae, Aphelinidae, Trichogrammatidae etc. are scrutinised.

DISTRIBUTION

Eventhough chalcids have a wider distribution, they are poorly known from the colder parts of the country. The reason for the less common occurrence of chalcids at high altitudes may be attributed to the less availability of the host insects which in turn may be due to the decreased floral diversity. Low temperature may also be a limiting factor for the nonabundance of these insects in these areas. The members of the families Trichogrammatidae, Mymaridae and Aphelinidae reached higher altitudes and this can be due to the probable wind dispersal by virtue of their smaller size. The families Chalcididae, Encyrtidae, Eurytomidae, Pteromalidae, Eupelmidae, Eulophidae, Aphelinidae and Trichogrammatidae, enjoy a wider distribution while Leucospidae, Tetracampidae, Eucharitidae, Perilampidae etc. appear less frequently in collections. Members of the family Agaonidae are widely distributed and are always associated with fig plants. Chalcids can be always collected in plenty around cultivated fields probably due to the presence of the insect pests in large numbers. Like all other animal groups species diversity of Chalcidoidea is also very high in tropical forest ecosystems though represented in low population densities. The Chalcid fauna of the peninsular part is better known in India.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Chalcids show fascinating diversity in biology exhibiting both entomophagy and phytophagy. Adults are free living, feeding on nectar, honey dew and in some cases little water. The females (parasitic forms) insert the eggs into the body of the host with help of needle like ovipositor. The eggs develop inside the body of the host and the ensuing larva consume host tissue, pupate and emerge out as the adult. The term parasitoid is used to describe them as only the larval stages of Chalcidoidea are parasitic and they kill and consume the host during the development. Chalcids attack a wide range of hosts that include 12 orders of insects and 2 of Arachnida. They attack the hosts in their various stages of development like eggs larvae, pupae or even adult.

The phytophagous species either cause galls on plants or are seed eaters. Some species feed on gall tissue but does not cause galls and are called inquilines as they co-exist with the gall causers. Members of Agaonidae

(wasps) are obligatory phytophagous and develop inside the syconia of figs. They pollinate figs and cannot survive without figs and vice-versa. Some members of the family Eurytomidae and Torymidae exhibit both entomophagy and phytophagy.

In host selection parasitic Chalcidoidea are either specialists, generalists or opportunists. Mymaridae and Trichogrammatidae are specialists being strictly internal parasites of insect eggs. Other examples of specialists can be found in Eucharitidae, parasitising ant larvae and pupae, Leucospidae parasitising bees and wasps and Tanaostigmatidae feeding on plant tissues. Chalcids are either solitary (one individual develops in a host) or gregarious. They are either monophagous, oligophagous or Polyphagous. They are primary (attacking only a phytophagous species), secondary or hyperparasitic (attacking a host already attacked by another primary parasite). Hyperparasitism may reach even tertiary or quarternary levels in some species. Chalcids are either ectoparasitic or endoparasitic.

Chalcids show several interesting behavioural patterns in their biology. Some Pteromalids oviposit into the body of the adult beetles and some species build straw like tubes on host's body to suck their body fluids. Eucharitids, parasitic on ants lay their eggs on the leaves and the emerging first instar larva (planidium) jumps and attack the ant when it passes by. The larvae complete development inside the ant's nest by attaching on the body of the ant larvae. One species of chalcid parasitic on ant lion larvae provokes the host into grabbing the parasite's legs with mandibles, at which time the parasite oviposits into the membrane between the larva's head and thorax. Some members of Eulophidae and Trichogrammatidae even dive into water in search of their host. The attacked host is often immediately prevented from further growth and feeding or in some cases the parasite larvae co-exist with the feeding host for some time. The former are called indiobionts and the latter koinobionts. Some members of family Aphelinidae show a very complex behavioural pattern known as adelphoparasitism, where males develop as parasites of females of their own species (obligate adelphoparasitism or autoparasitism) or of females of different species (facultative adelphoparasitism).

Sexual dimorphism is prominent in chalcids and sex ratio varies very much and in some species males are very rare. As generally in hymenoptera the males are haploid and females diploid. After copulation sperms are kept in spermathecae and the females lay either fertilised or unfertilised eggs, the former become females and the latter males (arrhenotoky). Thelytoky (female parthenogenesis) is also found in some species.

ENDEMICITY

An analysis of the available data clearly indicates that Chalcidoidea exhibits a very low level of endemism at generic level in India. Among the various families, Encyrtidae and Agaonidae shows high level of endemism at generic level followed by Pteromalidae, Eurytomidae, Eulophidae, Aphelinidae, Eucharitidae etc. The families Leucospidae, Ormyridae, Perilampidae, Torymidae, Signiphoridae and Tetracampidae contain no endemic genera. At the species level, the range of endemism varies between 40 (Chalcididae) to 100% (Tetracampidae and Tanostigmatidae) among different families. Second to the Oriental species Palearctic elements dominate in Indian fauna, followed by Australian and Ethiopian. Nearctic and Neotropical species are very poorly represented in India.

THREATENED AND INTRODUCED SPECIES

No species has so far been recorded extinct or any taxon categorised under the IUCN red data book. Several species of chalcids were however, introduced by man in different parts of the world. Species introductions mainly occurred in search of natural enemies for biocontrol programmes. Several species of *Trichogramma* (Trichogrammatidae) were introduced in different parts of India in biocontrol programmes against sugarcane and cotton pests. Several species of Encyrtidae also reached different parts of the country as coccid and mealybug parasites. Introduced species are also found in the families Aphelinidae, Eulophidae and Pteromalidae due to their greater utilisation in biocontrol programmes. Species introductions may also occur along with the dispersal of pest affected plant materials like fruits and seeds which are parasitised by chalcids.

VALUE

Chalcids play a significant role in the ecosystem as effective biocontrol agents and key stone species helping to maintain high diversity in other organisms and are directly beneficial to man in economic terms.

Chalcids as Biocontrol Agents

A large number of parasitic chalcids are proved to be of great value in biological control programmes. Most experiments and studies have been devoted to the egg parasite *Trichogramma* whose host range includes more than 150 species of insects. The species *Trichogramma chilonis* was effectively utilised in the biocontrol of sugarcane borers in Karnataka, Tamil Nadu and Gujarat. *Trichospilus pupivorus* (Eulophidae) has been proved a very effective

control agent against the coconut black-headed caterpillar *Nephantis serinopa* in different parts of South India. Many prospective parasites of scale insects are found in the family Aphelinidae. In the family Encyrtidae there are several effective parasites of coccids. Two species of encyrtids have been successfully used against two severe pests of agriculture in Africa, the Casava mealy bug and the mango mealy bug. Release of *Tetrastichus hagenowii* (Eulophidae) proved effective in the control of cockroaches in USA and *Pteromalus puparum* (Pteromalidae) controlled *Pieris brassicae* (Cabbage butterfly) in Australia and New Zealand. An analysis of the literature dealing with the biological control programmes will reveal that no fewer than 16 % of references goes to chalcids and within the group the families Aphelinidae, Trichogrammatidae and Encyrtidae are most important. According to the summary given by Noyes (1985) in the utilisation of various parasites in biocontrol programmes a total of 406 species of chalcids involved in 1101 introductions achieved 233 instances of control of which 119 were of full economic control. The Chalcidoidea possesses a biocontrol index of 1657 which is next to the total of Hymenoptera Parasitica. In terms of numbers of introductions also chalcids come next to Hymenoptera Parasitica (1105 against 2053).

Chalcids as Key Stone Species

Fig wasps (Agaonidae) being the sole pollinators of fig plants act as key stone mutualists in nature. The fig plants can only be pollinated by these wasps and their existence in the nature depends only upon them and vice versa. Other chalcids play a major role in the balance of terrestrial ecosystems through their ability to control populations of phytophagous insects. By checking the populations of herbivorous insects chalcids not only maintain high species diversity in them but also prevent the herbivorous insects from decimating their plant hosts.

Chalcids as Minor Pests

Phytophagous chalcids may assume another type of economic importance of man. Since they are gall inducers and seed eaters they become minor pests. Due to the formation of galls the plant stem become lignified and brittle, snapping easily in the wind. Seed eaters and fruit breeders cause damage to seeds and fruits.

THREATS

The major threats faced by chalcids for survival are habitat destruction, excessive use of pesticides and pollution. Severe habitat destruction emanating from faulty agricultural practices and urbanisation lead to the loss of floral diversity which in turn affect chalcid population. Uncontrolled use of non selective pesticides will extirpate parasitoid populations from agroecosystems.

Secondary enemies or hyperparasites can disrupt the activity of chalcid parasites in nature. In general chalcids are also prone to species extinctions due to various factors.

CONSERVATION STRATEGIES AND FUTURE STUDIES

The importance of chalcids in nature makes urgent conservation measures imperative. As most of the decline in chalcid fauna is due to loss of floral diversity, large scale destruction of natural habitats (deforestation, monoculture) should be controlled. Increasing the adjacent vegetational diversity around cultivated fields will enhance the beneficial activity of Chalcidoid parasites. Minimising of the use of destructive pesticides is also very essential in order to boost the activity of useful parasitoids. The Integrated Pest Management strategies (IPM) adopted recently in the field of pest control may be of some help in protecting these useful insects in nature.

Chalcidoids being numerically rich, basic taxonomic research in the group has to be promoted much in order to utilise the beneficial species in biocontrol programmes. Detailed studies on the life history, ecology, behaviour, phylogeny or any other facet of chalcid life will be highly rewarding in entomological science.

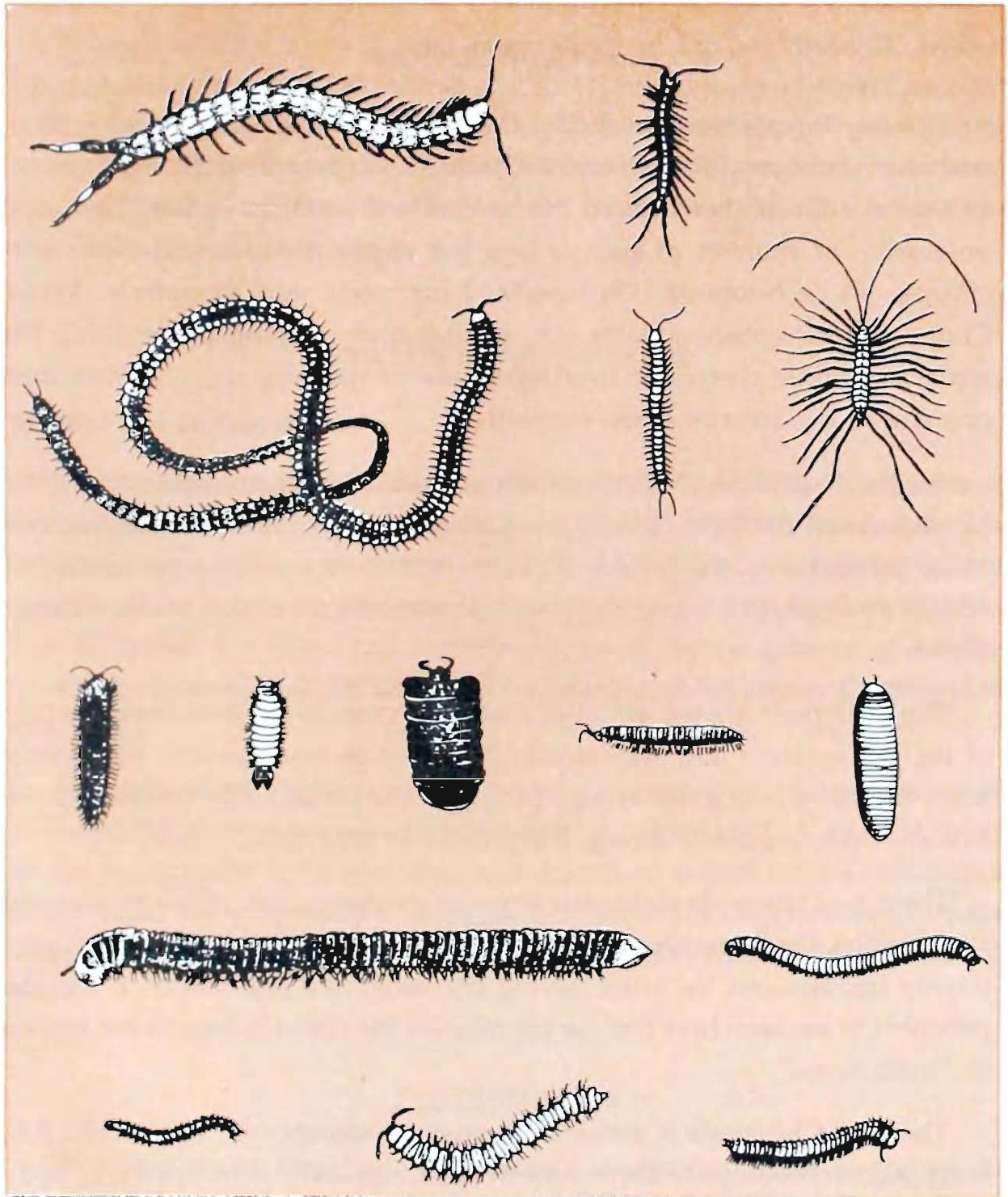
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Faunal Diversity in India : Myriapoda

VINOD KHANNA

Zoological Survey of India, Dehra Dun-248195 (U.P.)





INTRODUCTION

The myriapods are wormlike (Myriads= numberless ; pedes= feet), multisegmented, multilegged and tracheate (*i.e.*, air breathing through trachea) terrestrial arthropods which on the basis of segmentation of their body and possession of number of pair of legs per segment are divided into four classes, *viz.*, Chilopoda, Diplopoda, Pauropoda and Symphyla. While Chilopods are opisthogoneate (*i.e.*, genital duct opening posteriorly), the remaining three classes of myriapods are progoneate (*i.e.*, genital duct opening in the anterior body segments).

All the four classes were formerly included under a single super class Myriapoda on the basis of their possessing many legs and body having two major subdivisions, the head and the trunk ; but they are now recognised as widely divergent phylogenetically so as to merit them ranking under separate classes.

The Chilopods are the group of multilegged animals which bear one pair of leg per segment and are commonly known as “centipedes” Diplopods, however, have two pairs of legs per segment, presumably formed by the fusion of two segments during the process of evolution.

The class Diplopoda is divided into two subclasses, *viz.*, Chilognatha and Pselognatha, the former having six orders of all living diplopods, comprising twenty families and the latter having one order and one family. It may be pertinent to mention here that the members of the class Diplopoda are known as “millipedes.”

The class Chilopoda is divisible into two subclasses, *viz.*, Epimorpha (*i.e.*, body segments complete at the time of hatching) and Anamorpha (*i.e.*, body segments complete only after hatching).

Until recently, four orders of the class Chilopoda were known, *viz.*, Scolopendromorpha, Geophilomorpha, Lithobiomorpha and Scutigermorpha. Shear and Bonamo (1988) have recently described Devanobiomorpha, a fifth and a new order of fossil Centipedes from Middle Devonian (Cat Skill Delta) sediments, near Gilboa, New York, U.S.A. and assigned it as a sister group of the orders Scolopendromorpha+Geophilomorpha (= Epimorpha).

Though Myriapoda is a very large group of land arthropods, with a number of species under each class and order, yet no comprehensive account of species diversity is available in India. Of late, the most well worked out group under this category of animals is the Order Scolopendromorpha, and hence the status report on the biodiversity conservation is restricted here to the Order Scolopendromorpha only.

STATUS OF THE TAXON

Global and Indian Status

The Scolopendrid centipedes are known globally by about six hundred odd species, of which India alone supports roughly 15-18% species, as per available information. The order Scolopendromorpha contains seventeen genera under family Scolopendridae and eight genera under Cryptopidae, but in India, we have the representation of seven genera of family Scolopendridae (*i.e.*, about 40%) and two genera of the family Cryptopidae (*i.e.*, 25%).

Roughly about 15-25% of the present number, so far as the order Scolopendromorpha is concerned, needs to be discovered. A good number of species remains to be identified and placed on record for the centipedes of the order Geophilomorpha. Lithobiomorpha and Scutigermorpha under class Chilopoda and whole of the group of class Diplopoda is unknown till date.

DISTRIBUTION

Distribution of centepeds in different regions of India is shown in Table 1.

Table – 1

Distribution of Centepedes in India

Region	No. of Species
Western Himalaya (Uttar Pradesh)	20
North-West Himalaya	
(Himachal Pradesh and Jammu & Kashmir)	- 14
North-East India	24
Indo-Gangetic plains	
Uttar Pradesh (Plains)	9
Uttar Pradesh (Terai)	7
Haryana	4
Decan plateau	48
Coastal plains	13
Deserts	6
Andaman & Nicobar Islands	17

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The Order Scolopendromorpha is further subdivided into two families, viz., Scolopendridae, the members of which have four ocelli on each side of the cephalic plate, below the base of antennae and Cryptopidae, whose members are blind and mostly cavernicolous.

While majority of the species are classified as Oriental element, only a small percentage of Indian species comprise Palaearctic, Nearctic, Ethiopian, Circumtropical and Cosmopolitan elements.

ENDEMIC AND THREATENED SPECIES

Under the Oriental element (92 species/83%), roughly 60 species (65%) are endemic to India and neighbouring countries like Pakistan, Bangladesh, Nepal and Srilanka. Only a very small percentage of Oriental element represents the Indo-Malayan (14%) or Indo-Malayan extending to Australian region (3%).

None of the species can, at present, be categorised as endangered but species like *Scolopendra hardwicki*, *S. subspinipes* and *Ethmostigmus pygomegas*

are extremely rare and can be threatened by the continuous degradation and destruction of their habitats.

INTRODUCED SPECIES

Since the myriapods are soil arthropods, always associated with nursery plants, agricultural crops and vegetables, the chances of their being transported/introduced from outside, can not be ruled out. The species of the genus *Digitipes* is of congo origin and recorded from Deccan only. This is probably one of the examples of introduced species since it has not established elsewhere in India. Similarly many of the species described/recorded are based on solitary specimen, which raises doubts about their establishment in India.

VALUE

The scolopendrid centipedes are of economic importance, despite the fact that they are poisonous and their bite is not only painful but causes diseases like Oedaema, Lymphangites with inflammation of skins and subcutaneous tissues or ulceration. In most cases, a localised necrosis may also take place or sometimes even death is reported, if it bites an infant. At the same time, they are beneficial also on account of these being predators on many species of pest of crops. While millipedes cause damage to the crops only under forced conditions of drought, both centipedes and millipedes have a definite role in soil fertility, like earthworms, by ingesting the humus followed by defaecation, with more nitrogen contents returned in purified form to the soil. They also help in the decomposition and disintegration of humus for the fertility of soil.

Humanity should definitely be concerned about preserving this taxon, primarily for its faunal value, secondly for its economic, agricultural and medicinal value and thirdly, for much more is yet to be known about this creature.

THREATS

With ever increasing human population, ever growing industrial development, deforestation and other factors like habitat destruction, the depletion of the fauna and faunal resources including myriapods is inevitable.

CONSERVATION STRATEGIES AND FUTURE ACTION

Let the forests be for the wild and wilderness for the creatures of nature to strive in their serenity. Though no measure seems to have been taken in the past, with specific purpose in mind, to protect this taxon, environmentalist's movement in the direction of afforestation and conservation of fauna and faunal resources should be taken up more seriously by one and all. More and more conservation areas should be identified for protection and biodiversity conservation by declaring these as National Parks and Biosphere Reserves.

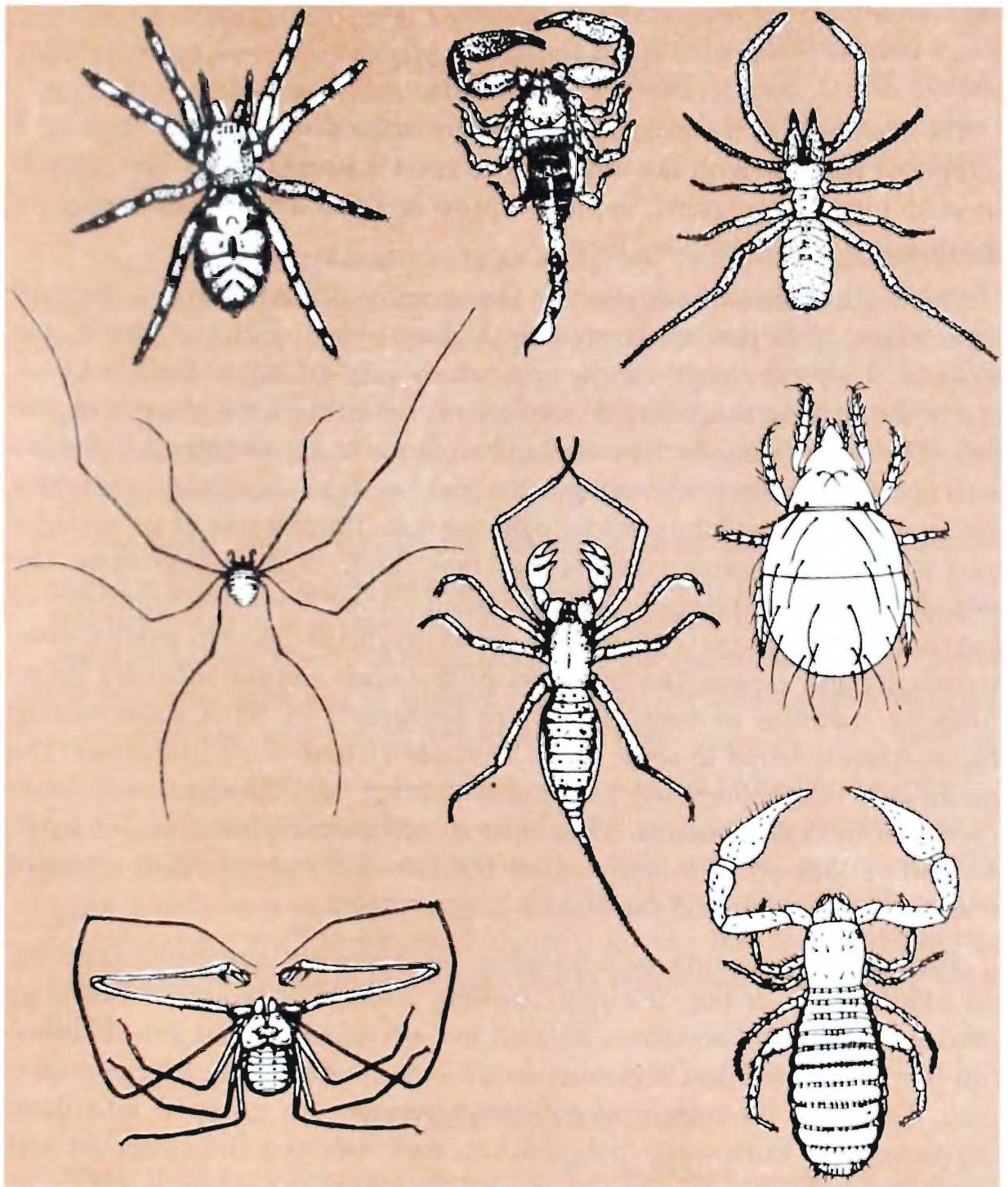
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Faunal Diversity in India : Arachnida

A. K. SANYAL AND S. K. TANDON

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The members of the class Arachnida are arthropods, characterised by a number of features with the exception of some ticks and mites. The body is divided into two regions, cephalothorax or prosoma and abdomen or opisthosoma and antennae absent.

The cephalothorax consists of six somites, each having a pair of appendages. This part is covered by a dorsal hard chitinous shield, the carapace. They have eight simple eyes which vary greatly in their position. One of the striking characteristic features of Arachnida is the absence of true jaws. The prey is crushed by the cephalothoracic appendages. Of the six pairs of cephalothoracic appendages, the first two pairs are used for capturing and crushing prey and the last four pairs are legs. The first pair of appendages are called the chelicerae consisting of two, rarely of three segments. The second pair of appendages are the pedipalp. Arachnids have four pairs of legs each having seven segments, *viz.*, coxa, trochanter, femur, patella, tibia, metatarsus and tarsus. The members of this class respire either by book-lungs or tracheae or both. Sexes are separate and remarkable sexual dimorphism is found in some cases. They are viviparous or oviparous. The young ones resembling their parents are hatched from the egg but undergo a series of successive moults. The arachnids are generally terrestrial in habit. An outline idea about morphological features of the members of different arachnid orders reported from India is given below.

The order Scorpionida includes scorpions. These are considered as one of the oldest forms of life. The most striking features of scorpions are large sized pedipalps and abdomen divided into seven segmented pre-abdomen and five segmented post-abdomen or tail—the cauda having a large poison sting. Based on the nature of habitats scorpions are grouped into three categories, *viz.*, burrowing (pelophilous), rock dwelling (lithophilous) and arboreal.

The members of the order Pedipalpida are commonly called as “whip-scorpions” In their general forms, they show resemblances to scorpions but

can be easily differentiated by the form of the pedipalps of the first pair of legs and of post-abdomen. There are both tailed and tailless forms of whip-scorpions.

The members of the order Solifugae or Solpugida are known as 'false-spiders' or 'wind-scorpions'. They include a moderately large group of primitive forms of arachnids. These arachnids are nocturnal, exclusively predatory and carnivorous. The solifugae are principally desert forms but they also live in forests.

The members of the order Opiliones or Phalangida are commonly known as "Harvestmen". They can be recognised by their long and slender legs and segmented abdomen which is joined to the cephalothorax across the whole breadth and not by a narrow pedicel as in spiders. These arachnids are named as harvestmen because they are generally seen in the field during harvest time.

The 'pseudoscorpions' or 'false-scorpions' are small, dorsoventrally flattened arachnids. They are found in dark, damp places, underneath the bark of tree, under logs or stones, rotten wood and leaves, in poultry houses and the nest of birds. They resemble scorpions in the general form of their pedipalps and body but the hind part of the abdomen is not narrow as in scorpions. The six segmented pedipalps are enormously developed which serve as prehensile organs to capture and kill the prey.

The order Acari includes the mites and ticks and forms an important group under the class Arachnida. The size of mites range from 1.5-16 mm. The ticks vary in size from 1.7-12.7 mm. Engorged individuals of tick may attain 20-30 mm. The mites occur in soil, organic debris, arable land, pastures, salt and fresh water and all types of vegetation. The ticks are external parasites of invertebrates and vertebrates including man.

The members of the order Araneae are commonly known as spiders. All spiders are carnivorous. They feed usually on insects, sometimes on other spiders. The spiders are well-known for their webs or snares of different types which help in hunting prey. The social behaviour is unique among spiders which are mainly cannibals. It is known that most spiders have a pair of poison glands in the cephalothorax which contain venom to kill their prey.

STATUS OF THE TAXON

The class Arachnida was erected by Chevalier De Lamarck, the great French philosophical biologist, in 1815, when he split Linne's heterogeneous group

Insecta into three classes. Lamark's class Arachnida included scorpions, spiders and mites together with the Myriapoda and Thysanura. The Thysanura and Myriapoda are now treated as separate classes.

The living members of Arachnida are grouped into nine orders, *viz.*, Scorpionida, Pedipalpida, Microthelyphonida, Solifugae, Ricinulei, Opiliones, Pseudoscorpionida, Acari and Araneae. The orders Microthelyphonida and Ricinulei are not recorded so far from India.

The earliest record of arachnid from India was made as far back as 1758 when Linnaeus described ticks from India. After about a century in 1868 Peal discovered red-spider mite on tea in Assam. Nearly 30,000 species of Acari under 1,700 genera are known from the world (Krantz, 1978). A total number of 2079 species distributed over 631 genera and 205 families of mites and 107 species under 12 genera and 2 families of ticks are known from India.

The spiders are very common all over India. The studies on Indian spider was initiated by Blackwall (1864) and later gained momentum through the works of Tikader (1960-1987). A total of 1035 species belonging to 240 genera under 46 families are known from India.

The Indian subcontinent is rich in variety as well as in abundance of Opiliones. But in India only a few attempts have so far been made to explore this group. Roewer in 1929 made some studies on Indian harvestmen and described nearly 167 species under 40 genera of the subfamily Gagrellinae of the family Phalangodidae.

The members of the order Scorpionida, Pedipalpida and Solifugae were studied in our country for the first time by Pocock about a century ago (1900). Later Birula (1913-1928), Handerson (1913), Hirst (1915) and Mani (1959) studied these arachnids. In recent times Tikader and Bastawade (1983) have made very comprehensive study of Indian scorpions. At present a total of 104 species and subspecies distributed in 27 genera and 5 families are known from this country. The pedipalps are found throughout the country. But after Pocock no comprehensive study was done and there is a need for a wide revisionary work. They are so far known by 25 species distributed over 10 genera and 4 families.

The Indian forms of false-spiders are so far represented by 15 species distributed over 3 genera and 2 families. After Pocock, till today, unfortunately no attempt has been made to explore this group in India.

The Indian pseudoscorpions were first taken up for extensive study by Murthy and Ananthakrishnan (1977). More than 100 species distributed over 47 genera and 13 families are so far known from India.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The range of biological diversity in the class Arachnida is very wide. The class has been separated from other arthropod classes on the basis of its diversity in morphological features, habit and habitats. The major orders, viz., Acari, Araneae, Opiliones, Scrpionida and pseudoscorpionida have been divided into a number of families, subfamilies, genera, species and subspecies. The diversity in other two orders, pedipalpida and solifugae is not remarkable due to the fact that these groups have not yet been thoroughly studied in India (Table 1).

The diversity in habitat preference is well-marked in the Arachnida. The members are found to live in almost all possible habitats. They may be plant associates, soil associates, storage associates, nest associates, water associates, etc. Maximum number of genera and species are found to occur in association with plants.

Table – 1
Number of arachnid taxa and species endemic to India and discovered as new to science from India

Order	No. of Families	No. of Genera	No. of Species	No. of Endemic species	No. of new species from India
Scorpionida	5	27	104	70	70
Pedipalpida	4	10	25	21	21
Solpugida	2	3	15	12	12
Opiliones	1	40	167	65	68
Pseudoscorpionida	13	47	100	49	49
Acari	207	643	2186	984	
Cryptostigmata	72	174	407	193	193
Mesostigmata	43	124	395	175	175
Prostigmata	60	261	1125	548	554
Astigmata	30	72	152	25	25
Metastigmata	2	12	107	26	28
Araneae	46	240	1035	455	478

ENDEMICITY

From the foregoing account it would be clear that though there is great diversity in the Arachnida, the fauna of majority of the states of this subcontinent still remain unexplored (except acari, spiders, scorpions and pseudoscorpions) and whatever distributional data available are insufficient. However, the data so far available indicate that the Indian arachnid fauna include a number of endemic taxa as shown in Table 1. The Table shows that nearly 50% of the total species known from India and nearly all the species discovered as new to science from India are endemic to this country.

INTRODUCED SPECIES

Though there is no record that arachnid species has been introduced in India, there is every possibility of introduction during transportation of material from outside India. The discontinuous or restricted distribution of many genera/species or description or record of species based on solitary specimen support the possibility of introduction of species in India.

VALUE

The arachnids are of little economic importance except spiders which are highly beneficial and acarines which are harmful as well as beneficial. The majority of scorpions are neither beneficial nor harmful to human beings. Only a few species are known to give painful stings causing swelling and sometimes fever. The whip-scorpions, false-spiders and pseudoscorpions are of no economic importance. However, they play an important role in maintaining ecological balance. The harvestmen are primarily carnivorous and usually feed on dead animal tissues. In view of their habits they are considered to be an agent in biological control of insects. The spiders are considered to be one of the best friends of mankind, because they feed insects which are generally harmful to man and domestic animals. They play a significant role as predator in controlling pests of cotton, apple, banana and rice. Spider silk is also of immense economic importance as reticles of a variety of optical devices. Silk webs are used to stop bleeding, to control recurring fever and as antipyretic agent. This group of arachnids have recently gained attention of scientists as a possible source of homeopathic and allopathic medicines. Spider silk and venom are used in preparation of several drugs. There is a belief that spiders are venomous and their bites are dangerous. But except the black-widow spider or large spiders like tarantula, others are practically harmless.

Mites and ticks are of immense economic importance. The phytophagous mites damage plants by desapping, causing reduction of growth and yield. Some are vectors of plant and viral diseases, while others cause malformations and deformations of plants. A good number of mites infest stored food grains in granaries. The parasitic mites and ticks attack domestic animals, apiary and poultry, causing either direct injuries due to blood sucking or heavy mortality by acting as vectors of viral, bacterial, rickettsial and protozoan diseases. The ticks are also known to cause viral diseases in human beings. Some aquatic mites live as ectoparasites of fish and other aquatic animals. The mites are also responsible for causing respiratory diseases and dermatitis in human beings.

Not all the mites are our enemies. There are many who are our friends too. Some species of mites who are known as efficient and useful predators of the plant feeding mites can successfully suppress the population of pest mites below economic injury levels. Some water mites are also known to feed upon mosquito larvae and thus check their population. Soil mites play a vital role in humification of organic matter resulting in the increase of soil fertility.

THREATS

Indiscriminate use of pollutants and destruction of habitats particularly the species-rich tropical rain forests threaten the survival of numerous arachnid species as well as all the other animals especially insects inhabiting those areas. The loss of insect population ultimately endangers the survival of spiders in nature. The economically important mites are also in problem of survival due to habitat destruction. Similarly, the other Indian arachnids which play partly in maintenance of ecological balance are also in problem due to shrinkage of their habitat.

CONSERVATION STRATEGIES AND FUTURE STUDIES

As has already been mentioned that the beneficial arachnids are in great danger, this is the high time to formulate strategies for their conservation. The first and foremost task is to check destruction of habitat and use of poisonous chemicals. Later a system of regular monitoring of the management activities is to be ensured.

It may not be an under statement that only about one-tenth of the arachnid fauna has been documented in our country. There is an urgent need to take up extensive surveys and studies on taxonomy, ecology and bionomics of Indian arachnids. The young scholars and students are to be encouraged to

undertake studies on faunal taxonomy which is the basic tool for biodiversity conservation.

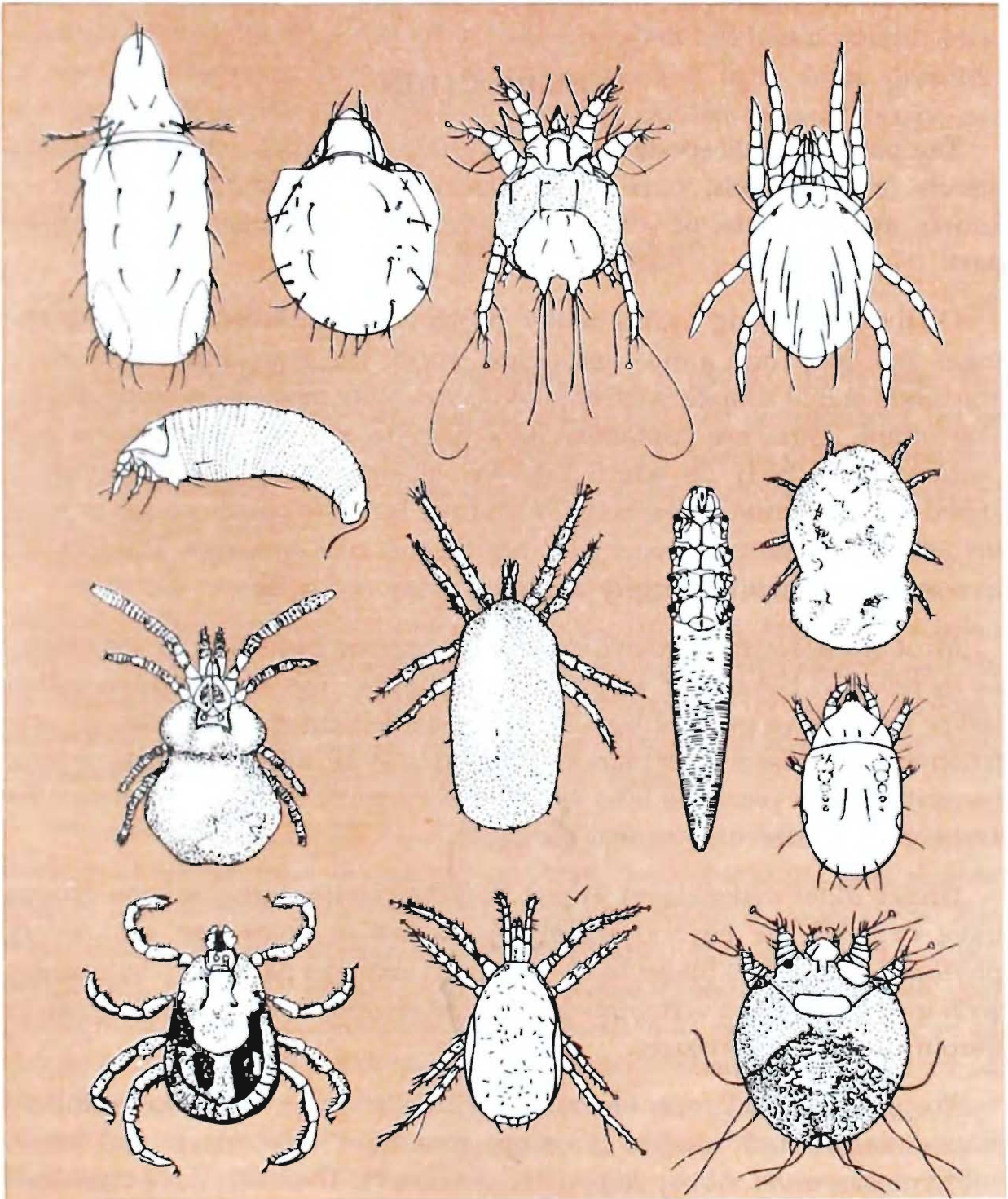
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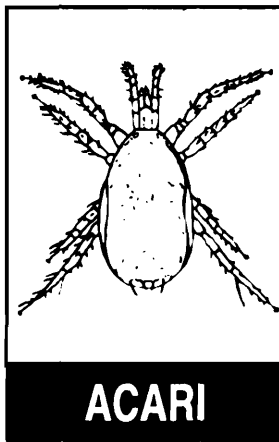
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Faunal Diversity in India : Acari

A. K. SANYAL

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The phylum Arthropoda includes a group of animals which, unlike the insects or myriapods, have neither antennae nor mandibles. These are known as chelicerata, of which the class Arachnida makes up the largest part.

Of the nine living orders under Arachnida, the Acari comprising the mites and ticks form a most important group. The acari differs from most arachnids in that somatic segmentation is generally inconspicuous or absent. The mouth parts are contained in a discrete anterior gnathosoma and portion of the body on which legs are inserted (the podosoma) broadly joined to the portion of the body behind the legs (the opisthosoma) to form the idiosoma. Idiosoma bears legs, genital and anal openings. The legs are five segmented with variously modified claws at the tip.

Most of the acarines are oviparous. The eggs are laid singly or sometimes as in ticks, in batches of several hundred eggs. The first stadium called larvae bears three pairs of legs. The later stadia named proto-, deuto- and tritonymphs possess four pairs of legs. Almost all mites complete several generations in a year. The ticks usually have a generation of several months and some may have an annual life cycle.

Unlike other assemblages in the class Arachnida, many acarine groups have evolved far beyond primitive predation. Some are exclusively phytophagous, while others have developed complex parasitic relationships with invertebrate and vertebrate animals. Many are also beneficial to man as decomposers and predators.

The mites and ticks may be found in virtually any environment including severe desert and tundra situation, mountain tops, deep soil layer, subterranean caves, hot springs and ocean floors. The mites have colonized almost every terrestrial, marine and fresh water habitat known to man. The high degree of habitat diversity illustrated by the mites and ticks is no more remarkable than is their range of form, size, structure and behaviour. The

size of mites vary from 1.5 to 16 mm and ticks from 1.7 to 12.7 mm. Engorged individuals of tick may attain 20-30 mm.

The fossil evidence of Arachnida in general or of the Acari in particular indicates that a major adaptive break through occurred in Acari during the late Mesozoic and early Cenozoic era. The acarine radiation may have been stimulated by an "evolutionary synergism" between radiating biota during the late Mesozoic period. During this time, tremendous development of angiosperm plants and a concomitant speciation "explosion" of the insects, a group with which the Acari have close ecological ties had occurred. Most of the acarologists believe that the Acari evolved from some primitive arachnid stock and branched into two separate entities as Acariformes and parasitiformes.

STATUS OF THE TAXON

Global and Indian Status

The existence of mite was referred to as early as 850 B.C. by Homer. The term 'Akari' or mite was originated in 1650. The first consolidated list of mite was given in the book 'Systema Naturae' by Linnaeus (1758). Later this group of arachnid was extensively studied by hundreds of workers throughout the world.

The earlier record of the study of mites in India was made as far back as 1868 when Peal discovered prostigmatid mites on tea in Assam and named it as red-spider. The Indian ticks were taken up for research as early as 1758 by Linnaeus. Later more than thousand of papers on taxonomy, ecology, bionomics, physiology, management and other aspects of acarina have been published by nearly hundred acarologists in India.

Though no attempt has been made by any one to estimate the total number of species from the world but it is presumed that the total acarine species known from the world is not less than 30,000 (Krantz, 1978). The total number of acarine species so far known from India is estimated as 2,186 distributed over 643 genera and 207 families (Table 1). Of these, the prostigmatid mites occupied the highest position in respect of number of species and genera. This is because this suborder contains species that are of significant economic importance. The other suborders in descending order of number of species are Mesostigmata, Cryptostigmata, Astigmata and Metastigmata (Table 1). Nearly 45% of the species so far known from India are described as new to science. Further it is noted that almost all the astigmatid species found in India are cosmopolitan in distribution.

Table – 1
Number of family, genus and species of Acari from India

Acarine Suborders	Family	Genus	Species
Prostigmata	60	261	1125
Astigmata	30	72	152
Mesostigmata	43	124	395
Cryptostigmata	72	174	407
Metastigmata	2	12	107
Total	207	643	2186

DISTRIBUTION

The distribution of acarine species in different States in India is shown in Table 2. It indicates that West Bengal alone represents 19.4% of Indian fauna and occupies highest position among the other States. The second highest number of species occurs in Karnataka. The other States in order of number of species are Tamil Nadu, Maharashtra, Kerala, Delhi, Uttar Pradesh, Tripura, Orissa, Punjab, Assam, Haryana, A & N Islands, Himachal Pradesh, Bihar, Manipur, J & K, Madhya Pradesh, Meghalaya, Andhra Pradesh, Sikkim, Rajasthan, Arunachal Pradesh, Nagaland, Pondichery, Goa, Daman and Diu and Mizoram.

The suborder-wise distribution of species shows that highest number of prostigmatid mites is known from Tamil Nadu followed by Maharashtra and Karnataka. Similarly, maximum numbers of mesostigmatid, astigmatid and cryptostigmatid mites and metastigmatids (ticks) are recorded from West Bengal and Karnataka, respectively. No mite species is so far known from Mizoram and only few ticks have been reported from the States. Several species of cryptostigmatid mites and a few species of metastigmata are known from Sikkim. No variation in present and past distribution of this taxon is observed. The pattern of distribution shown here does not reflect the actual picture as extensive and systematic surveys have not yet been done in many States of the country.

Table – 2

Distribution of acarine species in different states of India

States	Prostigmata	Astigmata	Meso-stigmata	Crypto-stigmata	Metastigmata
Andaman & Nicobar Islands	29	—	15	—	10
Andhra Pradesh	11	—	7	2	4
Arunachal Pradesh	—	—	4	—	12
Assam	20	2	26	11	10
Bihar	30	5	7	3	4
Delhi	100	5	17	—	6
Gujarat	8	—	10	—	2
Goa, Daman, Diu	3	—	—	—	3
Haryana	30	28	1	—	8
Himachal Pradesh	29	15	3	—	4
Jammu & Kashmir	41	—	1	6	1
Karnataka	135	29	40	—	36
Kerala	90	3	20	35	2
Madhya Pradesh	30	—	12	—	3
Maharashtra	138	15	28	4	5
Manipur	33	—	5	5	4
Meghalaya	11	—	25	—	5
Mizoram	—	—	—	—	4
Nagaland	2	—	—	5	4
Orissa	15	3	15	40	27
Pondichery	—	—	5	—	3
Punjab	65	7	22	—	2
Rajasthan	14	—	3	1	2
Sikkim	—	—	—	21	2
Tamil Nadu	140	20	50	4	4
Tripura	—	—	10	90	6
Uttar Pradesh	55	15	20	24	10
West Bengal	108	25	74	180	32

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

A wide range of biological diversity has been observed in this taxon. The class has been divided into five suborders, *viz.*, Prostigmata, Astigmata, Mesostigmata, Cryptostigmata and Metastigmata. The first four suborders include the mites and tick is the sole member of the last suborder. These suborders are further divided into several families, subfamilies, tribes, genera and species, the numbers of which are given in Table 1. The taxon may be divided into eight major groups (Plant associates, soil associates, invertebrate associates, vertebrate associates, storage associates, nest associates, dust associates and water associates) on the basis of habitat preference. Maximum number of genera and species are found to occur in association with plants. The acarines living in soil, occupied the second position in terms of number of species known from India. The total number of species known from vertebrate and water associated groups showed third and fourth position, respectively.

ENDEMICITY

As the acarine fauna of majority of the States of India still remain unexplored (except plant mites) and whatever distributional data available are insufficient, it is rather difficult to make any comment on the degree of endemism in this taxon. However, on the basis of data so far available, it may be noted that the Indian acarine fauna has a number of endemic genera and species. More than 45% of the total species known from India are considered to be endemic. The endemism is more pronounced in Prostigmata, in which the distribution of nearly 48% of the species known from India are restricted to this country only.

INTRODUCED SPECIES

Since the acarines are soil inhabiting animals and associated with agricultural crops, stored products and also parasitic to animals, the chances of their being transported/introduced from outside cannot be ruled out. The discontinuous or restricted distribution of many genera/species of mites or description/record of species based on solitary specimen raises doubts about their establishment in India. But there is no record of species introduced in India.

VALUE

The acarines have achieved tremendous value because of their manifold beneficial as well as harmful effect in agriculture, medical and veterinary sciences, public health and poultry. There are mites which are recognised as very serious pests of agricultural, horticultural and commercial crops. They suck the plant sap and also act as vectors of many plant viral diseases. All these effects reduce the yield as much as 50-80% resulting in economic loss to the extent of several crores of rupees in India. Mites of different families are known to infest stored grains and other stored products. They feed on the germ tissues and surrounding endosperm of the grains, causing serious losses every year. Most of the animals in nature are attracted by different species of mite. These mites either suck blood from the host body or feed on the tissue material, resulting in loss of health and ultimately death of the animal. These mites cause serious loss in poultry and apiculture. There are several mites which are a serious problem to man, for they cause harm to livestock and other domesticated animals. They cause severe mange in cattle, dog, cat, pig and horse. Various helminth diseases caused by anoplocephaline cestodes in cattle and domesticated animals are transmitted by different species of mites. These tiny creatures are also responsible for scabies, tumors, nodules, thickening of skin and other allergic dermatitis, loss of hair, anaemia, pneumonia, scrub typhus, respiratory allergies including bronchial asthma, rhinitis to man, etc.

However, not all mites are enemies of man as there are many who are friends too. Many species of mites are definitely known as efficient and useful predators of the plant feeding mites and can successfully suppress their population below economic injury level. Few species also act as predators of soil nematodes. Many of the predatory mites are used as biotic agents for control of housefly and other insect pests. The soil inhabiting mites have drawn special attention because many of these are related to the process of humification of organic matter resulting in increase of soil fertility. The decomposition process of forest litter and the resultant fertility is due mainly to this group of mites. Likewise, there are some water mites which are known to feed upon mosquito larvae and thus check their population.

The other member of the order acarina-the ticks live as ectoparasites of vertebrates and feed obligatorily on the blood of mammals, reptiles and birds. They surpass all other arthropods as transmitters in the number and variety of diseases of man and domestic animals. These acarines cause paralysis and anaemia and serve as reservoirs and vectors for many infective

viruses, rickettsias, bacteria, sporozoans and spirochaetes. Ticks are the main vectors of kysanur forest disease in man and monkeys in Karnataka State. Other arboviruses like Kaisodi, Ganjam and Bhanja are also present in ticks in India.

THREATS

Most of the acarine species are harmful to human beings, and there is no question of threat for those species. But the economically important species of mites are really in threat due to their habitat destruction. The land is being polluted by pollutants and gradually degraded due to massive felling of trees. As the degraded lands or wastelands contain no or very little moisture content, the mites inhabiting there are died. Further, excessive and indiscriminate use of chemical pesticides and fertilizers causes the loss of the predatory mites, which control the population of phytophagous mites in nature.

CONSERVATION STRATEGIES AND FUTURE STUDIES

As the population of mites of economic importance is considerably high, the loss of these tiny creatures has not yet attracted the attention of conservationists. But it is high time to formulate strategies for conservation of the taxon for the role they play in maintaining the ecological balance specially in soil ecosystem. So, the destruction of habitat of the beneficial acarines should be checked and the use of poisonous chemicals either in the form of pesticides or fertilizers and discharge of industrial effluents must be controlled.

The studies in the fields like taxonomy of soil mesostigmatid and astigmatid mites, bionomics and ecology of both the mites and ticks are urgently needed. These studies will certainly find out the ways for effective and useful conservation strategies needed for this taxon.

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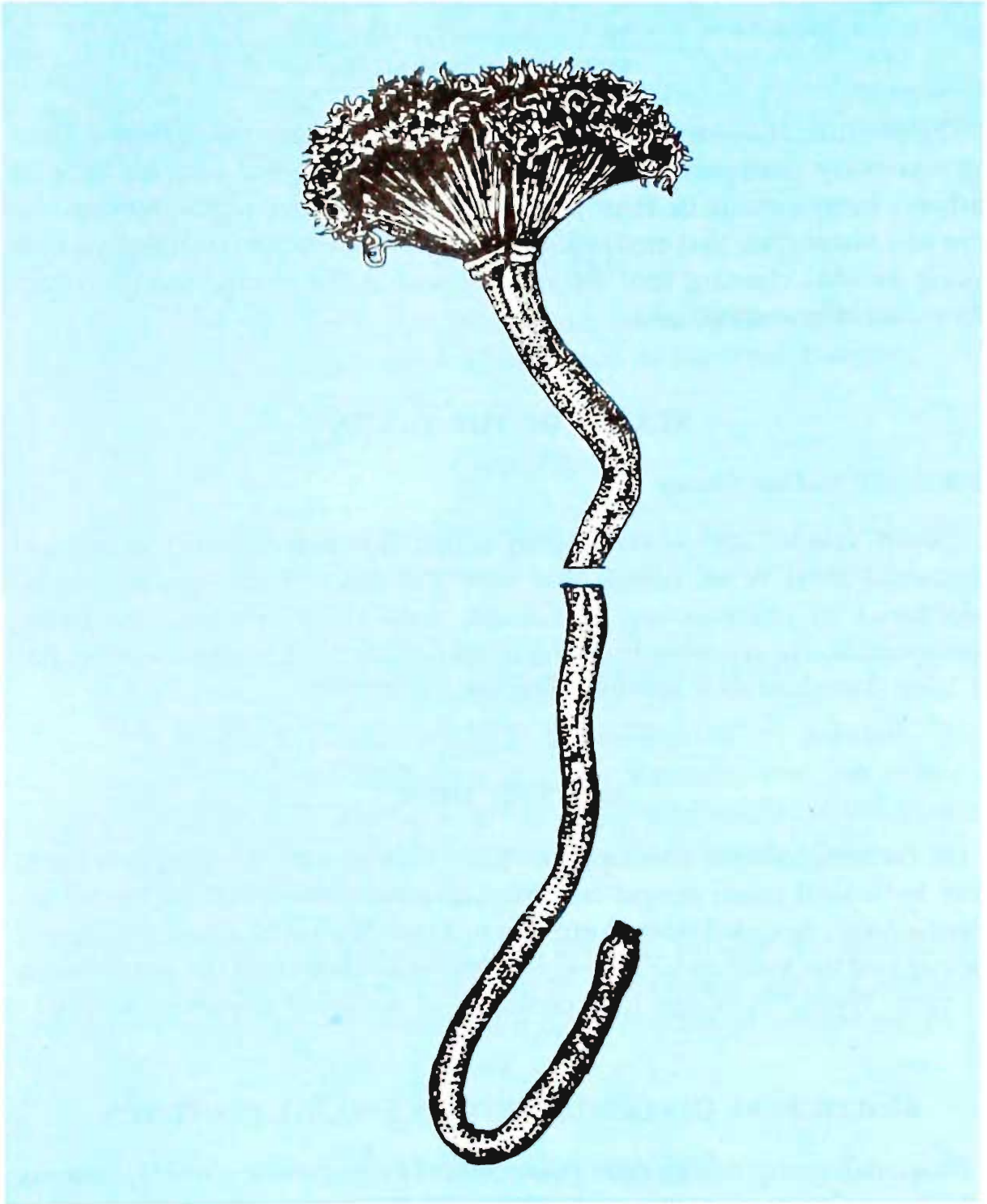
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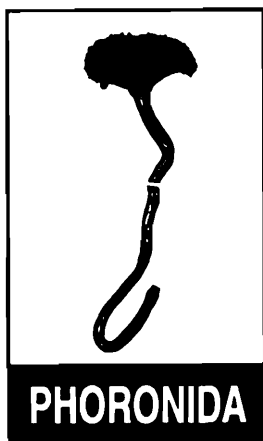
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Faunal Diversity in India : Phoronida

BADRI PRASAD HALDAR

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

The phylum Phoronida comprises slender worm-like, free-living solitary and sedentary creatures of various sizes housed in a self-secreted tube of leathery, membranous or limy texture, with a terminal lophophore in the form of a horse-shoe that embraces the mouth, with recurved digestive tract having an anal opening near the mouth, with a closed circulatory system and a pair of metanephridia.

STATUS OF THE TAXON

Global and Indian Status

Eleven species are so far known under this taxon found in several substantial areas of all oceans and seas and most of the species can be considered as cosmopolitan. Of them, only three species, one being cosmopolitan, are reported from the Indian coast. No phoronid species has yet been described as a keystone species.

DISTRIBUTION

Of the three species, cosmopolitan form *Phoronis australis* are reported to occur in Gujarat coast; second one, *Phoronis psammophila* (= *P. architecta*), an Atlantic form, reported from Porto Novo, Tamil Nadu coast and the Gulf of Mannar and the third one, *Phoronis bhadurii* described from the sandy beach of Digha, West Bengal and the species is not recorded elsewhere so far.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

As a small group this phylum possesses only two genera, namely, *Phoronis* and *Phoronopsis* and of them, former contains eight species. The genus *Phoronopsis* possesses the epidermal collar-fold below the lophophore, while the genus *Phoronis* has no such collar-fold.

Table – 1

Group	No. of species	
	World	India
Phylum Phoronida		
Genus <i>Phoronis</i>	8	3
Genus <i>Phoronopsis</i>	3	—
Total	11	3

Phoronis bhadurii lives singly in sandy bed and *P. psammophila* dwells singly in a separated tube while *P. australis* is a commensal form inhabiting inside the leathery tube of *Cerianthus* sp., a sea-anemone.

ENDEMICITY

Only one species *Phoronis bhadurii* is endemic to Indian coast and reported from sandy bed of Digha coast, West Bengal as mentioned earlier.

VALUE

This group is still regarded as of academic as well as scientific interest and used in the biological laboratories for scientific experiments.

THREATS AND CONSERVATION

The main threat to this taxon is the destruction of habitats. During educational field trips the college students regularly visit sea coasts and collect *Cerianthus* (Sea-anemone) in which the phoronid inhabits. Moreover, for collection of this sea-anemone they dig the substratum at random and thereby damage the habitat.

Very recently measures have been taken to prevent the destruction of habitat. Government has declared the area of Gulf of Mannar and Gulf of Kutch as Marine National Park and thereby removal of natural wealth from the aforesaid areas may be checked.

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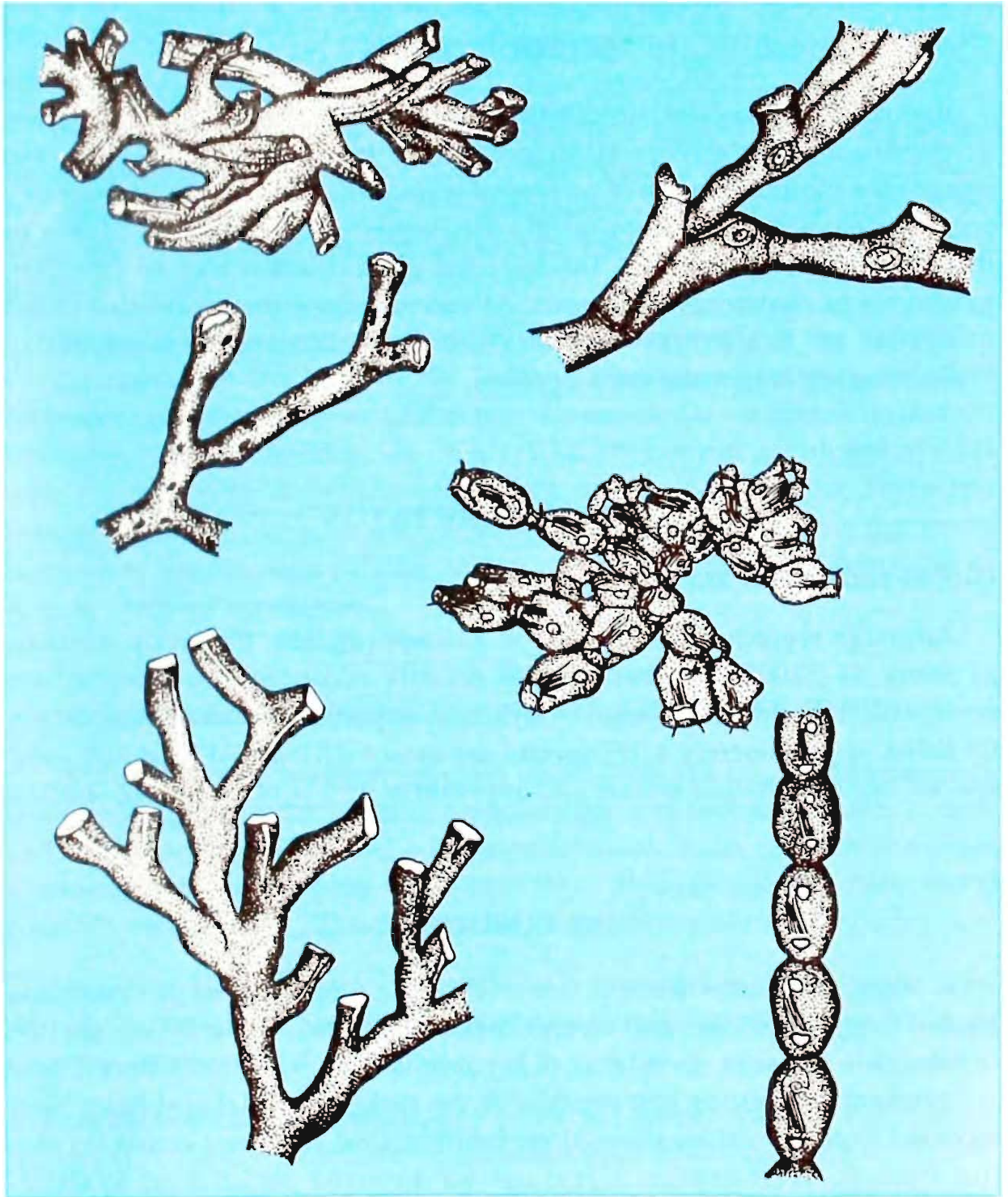
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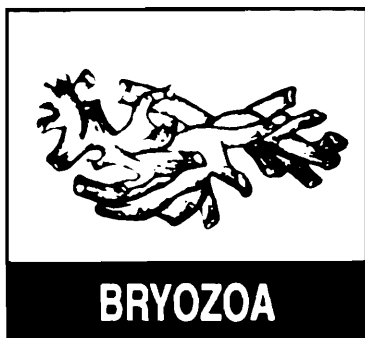
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Faunal Diversity in India : Bryozoa

K. SATYANARAYANA RAO

Wood Biodegradation Division (Marine) Institute of Wood Science & Technology (ICFRE), Bangalore - 560 003, India.





INTRODUCTION

Bryozoa are sessile, lophophorate, aquatic, colonial, coelomate invertebrates with a recurved digestive tract bringing the anus near, but outside the mouth. They have no special respiratory, circulatory or excretory organs. Colonies may comprise of a single feeding zooid or hundreds or thousands or even a million. The supporting exoskeleton may be cuticular, gelatinous or commonly calcareous. At various times, they were also called 'polyzoa' or 'Ectoprocta' in literature, but majority of present day bryozoologists accept the term Bryozoa.

STATUS OF THE TAXON

Global and Indian Status

Although regarded traditionally as a minor phylum, the group contains as many as 20,000 described species actually occupying an intermediate position in the hierarchy of animal phylum in respect of species representation. Of these, approximately 4,000 species are extant (living). At least 200 valid species occur in Indian waters i.e., approximately 5% of the living species.

DISTRIBUTION

In India, as in other parts of the world, only a few species of bryozoans inhabit fresh water lakes and rivers (Phylactolaemates), but most are marine or estuarine. Greatest abundance of bryozoa is in the shallow waters. These are common interesting components of the rocky intertidal and have been reported from several localities along both the East and West coasts, as also the Islands. Well explored regions for bryozoa include (i) Waltair-Visakhapatnam on the East Coast along the North Andhra coast, where over 100 species have been reported in recent works and (ii) the South-West Coast

from where about 130 speies were reported from samples mostly collected from the shelf zone (with dredges) as well as the intertidal. Bryozoa have also been reported from several estuarine localities (eg. Godavari estuary, Ashthamudi estuary) and as 'fouling species' in harbours wherever such studies were conducted. It is, however, to be noted that vast stretches of the long Indian coastline still remain unexplored and without doubt many species hitherto undetected, occur in these areas. Especially examination of shelf-sediments (from the littoral zone upto Continental Shelf) should be rewarding. Fresh water bryozoa (Phylactolaemata) have been well-worked out in Madhya Pradesh—Narmada river system and Rajasthan, from where about 35 species are recorded.

The present knowledge of the distributional aspects of bryozoa in the Indian Ocean region is meagre. This is not only due to inadequate surveys but also for frequently doubtful determinations of species, especially in the early works. However, in a general way, the following observations could be made.

Species known to occur exclusively or predominantly in the Indo-West Pacific constitute the bulk of the Indian collections. Examples include : *Steganoporella sulcata*, *Parasmittina tropica*, *Thalamoperella stapifera*, *Rhynchozoon globosum*, *Nolella papauensis*, etc. A good number of circumtropical species with a much wider distribution (eg. *Aetea anguina*, *Electra pilosa*, *Trypostega venusta*, *Cribrilaria innominata*, etc.) also are encountered, indicating that many bryozoans, despite their delicate constructions, are "obviously adaptable to a wide range of conditions"

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Modern bryozoa are now grouped under 3 classes i.e., Phylactolaemata (containing fresh water species); Stenolaemata and Gymnolaemata. A total of 126 families are recognised—100 from Gymnolaemata (15 from the order Ctenostomata and 85 from Cheilostomata) ; 21 from Stenolaemata and 5 from Phylactolaemata. These comprise of approximately 4,000 species.

The order Cheilostomata (of the class Gymnolaemata) is by far the most dominant group constituting 80% of the total species recorded in India, as in many other parts of the world.

It is known that transportation by ships etc., effect bryozoan distribution. Species like *Bugula stolonifera*, *Hippopodina feegenensis* occurring in fouling communities appear to be examples of introduced species. These are now well-established and play an important role in the fouling communities.

ENDEMICITY

Endemism is known to be rare in marine/brackish water bryozoa. Among the species reported 50-60 years earlier, only *Membranipora hugliensis* has not been located anywhere else and could probably be considered an endemic species. In the '60s and '70s, a number of new species have been described by recent investigators. These include : *Electra indica*, *Bicellariella cookae*, *Kinetoskias klugei*, *Bugula bengalensis*, *Vittaticella ganapatii*, *Alderina arabiensis*, *Lacrimula visakhensis*, *Hippoporina indica*, etc., among gymnolaemata (marine or brackish water realm) and *Swarupella andamanensis*, *Plumatella ganapati*, *Hyalinella diwaniensis* and *Varunella indorana* from among Phylactolaemata (freshwater bryozoa). These species have so far not been reported from outside Indian waters and can probably be regarded as endemic species.

VALUE

Bryozoa are among the most commonly encountered components in the 'intertidal' essentially as 'cryptic fauna' and also on the phytal (colonising extensively certain algae species). In some localities, they form distinct 'bryozoan bands' which provide shelter for numerous organisms (eg. small crustaceans, polychaetes, young molluscs, tunicates, etc.). In their own right, they also support a number of epizooites and are especially favourable for settling of a number of planti-grade bivalves. Intensive studies on the ecology of bryozoans are necessary for a proper understanding of shore ecosystem, reef-biology and progression of biofouling communities.

Bryozoan 'reefs' are significant nourishing areas for commercial fish. Such reefs, although not located in India so far, are known to exist elsewhere.

The greatest importance of bryozoans in shallow waters, perhaps, concerns their role in marine biofouling, a problem of immense economic importance. World-wide annual costs due to just one aspect of fouling, i.e., ship fouling, are estimated to be over \$ 1,000 millions. Bryozoans are 'among the most abundant, diverse and consistently present group of marine fouling organisms' Over 130 species have so far been listed from representative areas and the list would be much more exhaustive if information from all other localities is available. In India, 30 species have so far been identified from fouling communities. Eventhough they are known to constitute at times nearly 100 percent of organisms on a given surface especially in the initial stages of community development , eg. *Electra bengalensis* at Vishakhapatnam harbour, their contribution to fouling biomass (weight) may not be necessarily high. However, they are known to be playing an important and subtle role

in the biofouling process. For instance, on hulls of ships made of copper or copper alloys, which are unfavourable to most other groups, encrusting species have been reported to provide a conducive surface for further settlements (examples of bryozoa settling on copper/copper alloy include *Watersipore arcuata*, *Mambranipora* sp., *Hippoporina americana*, *Hippopodina feegenensis*, etc.). Bryozoans especially ctenostomes (*Bowerbankia* sp., *Amathia*, *Zoobotryon*, etc.) are known to clog pipes, and conduits and entangle propeller blades. Thin encrusting species like *Electra tenella* also interfere with maricultural operations.

The soft bodied Ctenostomes may form trailing masses of upto 1 m in length or when mixed with branching Cheilostomes, form a thick felt work. These growths in turn provide shelter for numerous small crustaceans, polychaetes, young molluscs, tunicates and algae. At some harbours, however, dense bryozoan growths were reported to prevent settlement of other organisms. Heavy settlement of filamentous bryozoa may also prevent or reduce the attack of ship worms. Many species are quite sensitive to all the local environmental regimes and endemic to relatively small regions.

Because of their sessile mode of life, short larval period and generally stenohaline response to the environmental regime, they are considered excellent zoogeographical, ecological indicators among biofouling groups. The group has a great potential to be used as an important biological resource for environmental impact analysis.

Several bryozoan species occur as fossils and many geological formations are well-characterised by their bryozoa. However, the stratigraphic value of bryozoa, despite a voluminous literature, is often underestimated and their application to economic geology, particularly in petroleum research has perhaps not been fully exploited.

Recent investigations suggest that several bryozoan species produce substances with pronounced biological activity. Some of the chemicals have a great potential for application in medical and pharmacological fields. Thus, *Bugula neritina*, the most commonly encountered 'fouling species' in Indian harbours, contains a compound highly effective against leukemia cells at a low dosage level. *Flustra foliacea* is known to produce monotrepans having anti-insect, anti-septic and anti-bacterial properties. Hemolytic activity has been demonstrated in species like *Carbesea curva*. Both *Bugula stolonifera* and *B. neritina* showed an inhibitory effect on gram—positive microorganisms. *Zoobotryon verticillatum* is one of the few marine organisms that produces alkaloids.

It is however to be noted that investigations on the natural products from bryozoa are of a very recent origin and a great deal remains to be done in this highly promising field.

THREATS

Pollution (especially by oil pollutants), eutrophication, silting and sedimentation are the main threats to bryozoa. Indiscriminate over-turning of rocks and other hard substrata in the intertidal while picking up ornamental shells for Commercial purposes leading to exposure (to air) or even trampling by batches of students during study tours are quite harmful. Habitat protection is the most urgent need for protection of bryozoan fauna as in the case with many marine organisms. Sites with high diversity of bryozoan fauna (eg. palm beach and Shingle areas at Vishakhapatnam, where over 90 species have so far been identified in the intertidal area) have to be identified and area-specific measures to protect the habitat need be taken.

CONSERVATION AND FUTURE STUDIES

Inventorying bryozoan fauna is the first and most urgently needed step in providing proper scientific basis for implementation of any conservation measures for the groups. Except for a few localities, information even on occurrence, leave alone aspects such as functional roles, is not available. To establish patterns of variation among regions and to test hypotheses relating to constraints in diversity, it is also essential to monitor the changes in the groups occurrence and abundance. Inventorying and monitoring has to be carried out at both 'extensive' and 'intensive' sites which need to be designated for the purpose.

Our knowledge of bryozoa from the Indian region is far from satisfactory. Vast structures of the coastline remain yet to be explored and studies in respect of majority of the species have not progressed beyond taxonomy. Biology and ecology of several species still remain uninvestigated. Phylogenetic relationships of the classes, families and genera are not yet clear. These aspects need to be investigated in detail.

Habitats to be conserved : Littoral region, especially the rocky outcrops, shingles in the intertidal; Mangrove vegetation, Coral formations and firm (hard) substrata on the sea-bed.

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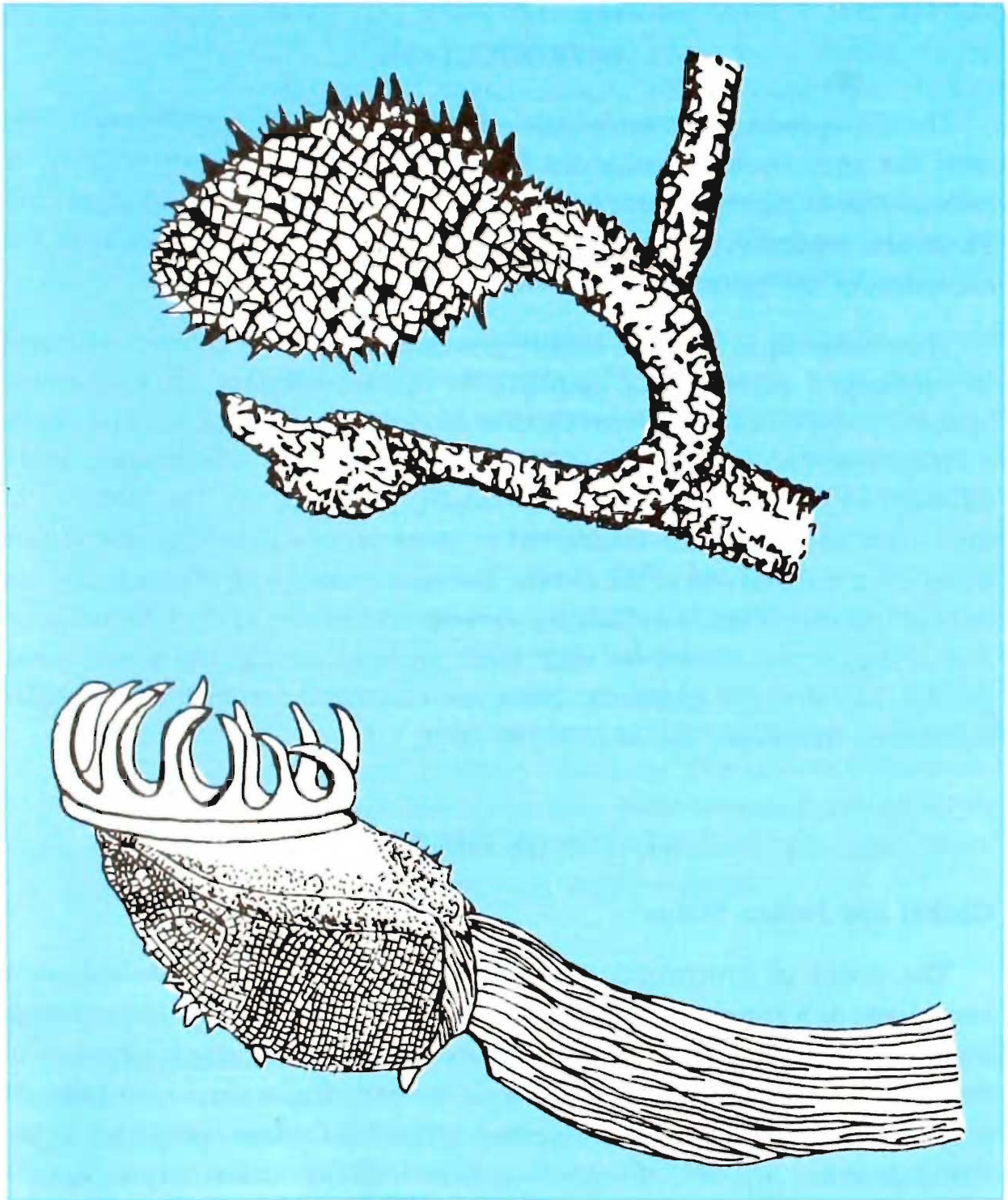
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Faunal Diversity in India : Entoprocta

K. S. RAO AND JAYASHREE THILAK

School of Studies in Zoology, Vikram University, Ujjain, M.P., India





INTRODUCTION

The Entoprocta are microscopic, stalked, sessile or epizoic organisms with the anus opening inside the tentacular circlet. These are solitary or colonial free living organisms, widely distributed, even though less abundant. These are predominantly marine having about 60 known species with the exception of the genus *Urnatella* which occurs in freshwaters.

They range upto 5 mm in length, growing singly or in colonies attached to submerged substrates or epiphytic or epizoic habitats. They resemble hydroid polyps, but differ from them in having ciliated tentacles. They have a circular tentacular crown area called calyx leading into a small body followed by the stalk having an attachment disc at the tip. The tentacles in the crown have the same length, but in some groups there are four longer tentacles at the oral end of the crown. The crown alongwith the tentacles can be bent inwards which is a characteristic response for any kind of disturbance. The tentacles are ciliated on their inner surface leading into a vestibular groove. Distally, the tentacular bases are connected by an intertentacular membrane that forms the edge of the calyx.

STATUS OF THE TAXON

Global and Indian Status

The status of Entoprocta in the world is yet to be established. It is considered as a group of highly specialised organisms with high phylogenetic significance amongst the pseudocoelomate bilateria. A regular exploration of this group in India will definitely result in exploring several new taxa. At present, the Indian Entoproct diversity is the least when compared to the world diversity. Reports of Entoprocta from India are also scanty except for the brackish and marine water species reported by Annandale (1908 and 1916) and Harmer (1915).

The freshwater Entoprocta are mainly represented by a single genus *Urnatella* described by Leidy (1884) in the Schuylkill River near Philadelphia, Pennsylvania, U.S.A. This species is widely spread over the Eastern part of North America like Ohio (Davenport 1883, Rogick 1936), Illinois (Kofoid 1898, Richardson 1928), Mississippi (Davenport 1893), Texas (Davenport 1904, Weise 1961), Kentucky (Williams 1930; Weise 1961), Michigan (Rogick and Vander Schalie 1950), Indiana (Rogick and Vander Schalie 1950), and Iowa (Weise 1961). In Europe, *Urnatella gracilis* was found in 1938 in the Mense River in Belgium (Damas 1939). It was later reported from Donao river in Rumania (Becescu 1954), Tissa river and Dannbe river in Hungary (Kolosvari and Abricossov 1960), Havel river near Berlin, Germany (Ludemann and Kayser 1961, Emschermann, 1955 a,b), Zambriborshch (1958) described this as *Urnatella dujestriensis*, from the materials collected from Dryester River in Ukraine, USSR. This species was recorded from Don and Dinepra rivers in USSR (Skiliarov 1969; Protasov 1980). This was recorded from Argentina (Bonetto and Cordiviola 1963) and Uruguay (Mane-Garzon 1964) in South America and Tanzania in Central Africa (Wiebach 1965).

Systematic descriptions of these organisms were made by Annandale (1908, 1910 and 1916), in which various Indian genera were described in detail. The Entoprocta from the marine and brackish water areas in the State of West Bengal were reported, along with details of their biology, systematics and variational range of the genera *Loxosomatoides*, *Loxosoma*, *Pedicellina* and *Barentsia*. The freshwater Entoproct genus *Urnatella* was recorded from India only in the year 1944 as a new species *U. indica* by Seshaiya (1944, 1947). A sustained culture of this species was maintained for several years in Portonovo laboratories by him. After this discovery, it has been recorded only twice so far which was confirmed in the recent review of this group by Rao (1991). The freshwater Entoproct resources need wide exploration to bring about the full potential of Indian Entoproct diversity. The authors believe that the freshwater Entoproct material reports from India are based only on accidental discovery and unless planned regional explorations are made, their full diversity potential in this country cannot be realised.

DISTRIBUTION

The genera *Loxosoma*, *Loxocalyx*, *Pedicellina* and *Barentsia* are cosmopolitan. These are common in U.S.A., along the European coasts, in Africa, Asia and Indo-Malay region. These are widely reported from the Atlantic coast of U.S.A., by Osburn (1910, 1944), Rogick (1948) reported the genera of *Barentsia* and *Pedicellina* from Californian coastal waters. These have been reported

from S. America by Marcus (1937, 1939), from the coastal belt of Brazil. Johnston and Angel, 1940 recorded Entoprocta from the Antarctic and Subantarctic, reporting excessive growths of *Barentsia*. Studies from the Siboga expeditions in the Indo-Malayan region reported dominant growth of *Loxocalyx*, *Loxosoma*, *Pedicellina*, and *Barentsia* (Harmar 1916). The distribution of the genus *Myosoma* seems to have been restricted to California.

Annandale (1910, 1922) reported several marine and brackish water Entoproct genera from the Indian subcontinent. These include *Loxosomatoides*, *Pedicellina*, *Barentsia*, *Bowerbankia* mainly from the east coast area of Port Canning, Calcutta. Annandale (1916) reported *Chitaspis athleticus* from the Gulf of Siam. *Arthropodaria kowalevskii* is endemic to Black sea and *A. benedeni* to the Belgium coast.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The diversity in Entoprocta is limited and restricted basically into the following 3 families, viz., Loxosomatidae, Pedicellinidae and Urnatellidae.

Family Loxosomatidae comprises of solitary forms with a stalk which is attached to a substratum with the help of an adhesive disc. These organisms are epilithic, epiphytic and epizooic. They essentially live attached to sponges, gorgonians, sipunculoids, ectoprocts, polychaetes, ascidians and other organisms. In this family, the two genera *Loxosoma* and *Loxocalyx* are quite common.

Family Pedicellinidae are colonial and grow extensively over the substrates by basal horizontal stolons from which new vertical stalks arise intermittently. The genera *Pedicellina*, *Myosoma*, *Chitaspis*, *Loxosomatoides*, *Pedicellinopsis*, *Barentsia*, *Gonypodaria*, *Arthropodaris* are commonly represented.

The Urnatellidae comprises of the single genus *Urnatella* which is mainly represented by three species. *Urnatella gracilis*, *Urnatella indica* and *U. dujenstriensis*. This family is represented in freshwaters.

ENDEMICITY

The freshwater Entoprocta represented by the genus *Urnatella* has been reported from U.S.A. and India. The species *U. indica* seems to be endemic to the subcontinent, even though it has been only recorded from Madras Presidency. The rare records of this species only from two localities so far, show its extreme specialisation, restricted survival and least diversification

suggesting it to be an endangered species in this country. It is recommended that detailed exploration of this species should be made, to assess its incidence in different states of India.

VALUE

The Entoproct taxa are represented both in saltwaters and freshwaters. These have been reported amongst the fouling organisms from underneath the ships and other marine substrates. These are filter feeders with a ciliary mechanism. The reasons for their conservation are ethical, scientific and ecological. They represent a specialised genetic pool which is of high scientific interest and calls for their immediate conservation since they are already endangered. The possibilities like extracting biotoxins of specialised type exist if this group is allowed to flourish. The economic reasons include their control as fouling organisms.

THREATS

The main threat to these taxa seems to be their rarity which might lead them to their subsequent disappearance and possible extinction. The rapidly deteriorating water quality of the marine and freshwater ecosystems compel us to anticipate their possible extinction. It is believed that they are in the process of being eliminated since no detailed reports occurred in the last 45 years from this subcontinent.

CONSERVATION AND FUTURE STUDIES

The Indian Entoprocta were a neglected group of Pseudocoelelemates which have interesting genetic composition. Prolonged lack of interest in the group of organisms, have lead to a chronic ignorance regarding their constitution, structural, biological and taxonomic aspects. Their detailed exploration is needed before the conservation programmes are planned and undertaken.

The recent realisation to conserve the genetic setup makes Entoprocta as one of the group of organisms which should be immediately subjected for inclusion in the conservation policies. They represent the end product of the prolonged evolutionary process which will be lost if not properly conserved.

For their future conservation following measures are suggested : (i) their detailed exploration to exactly derive their incidence; (ii) improving the

quality of the freshwaters to conserve the single freshwater Entoproct species *Urnatella indica* and (iii) to establish extensive cultures of *U. indica* in various freshwater biological laboratories in the country. Lastly it is suggested to study their preferences and other biological aspects and draw out their exact conservation strategies.

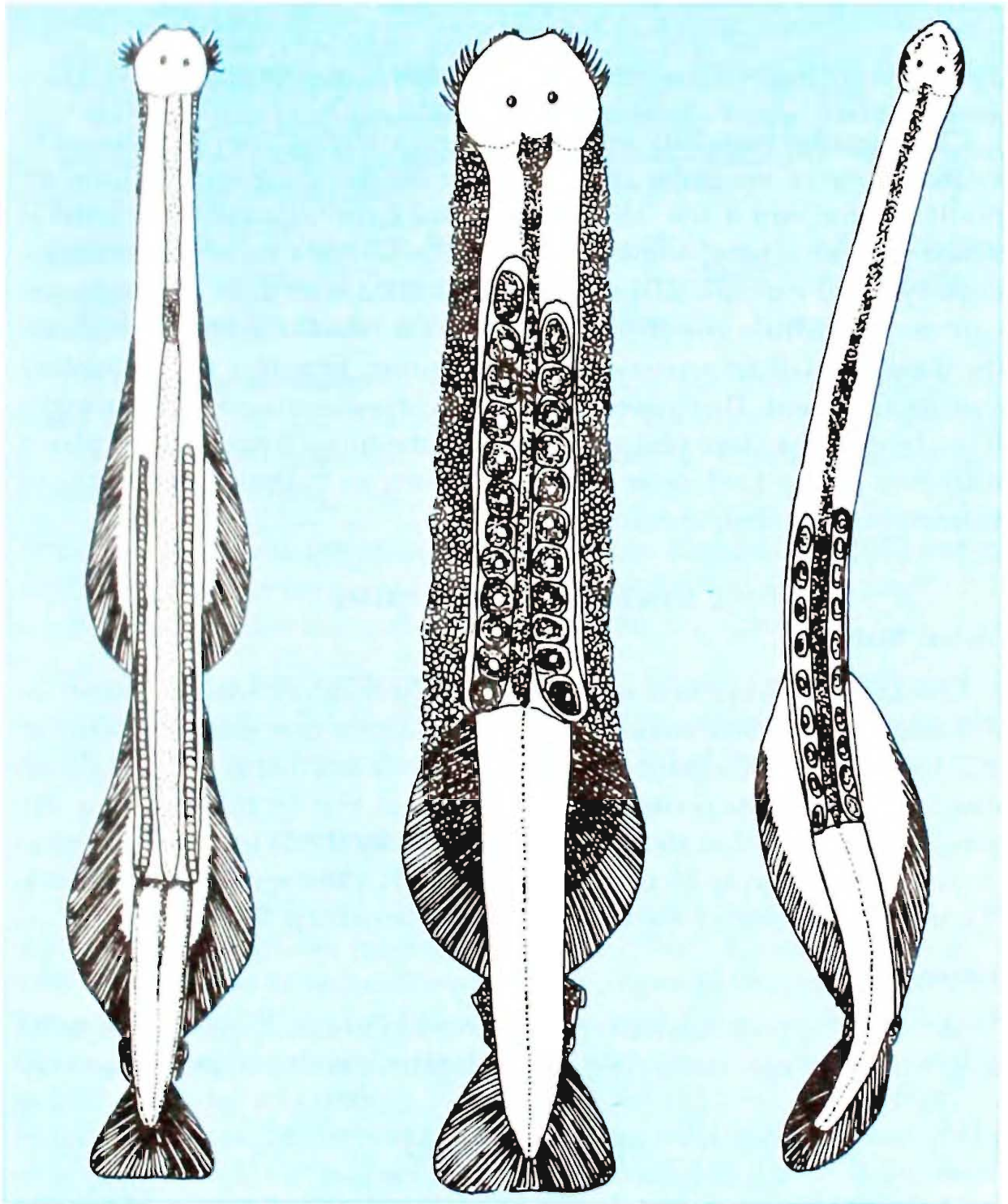
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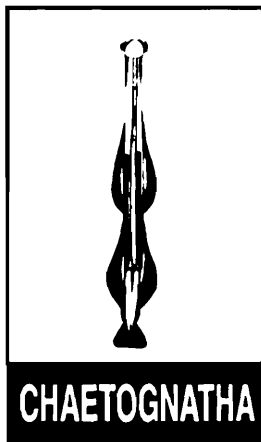
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Faunal Diversity in India : Chaetognatha

M. SRINIVASAN

Zoological Survey of India, Marine Biological Station, Chennai - 600 028





INTRODUCTION

Chaetognatha popularly known as “Arrow-worms” or “Glass-worms” constitute one of the major components of the marine plankton. They are mostly marine, but a few are estuarine. They are bilaterally symmetrical carnivores with a head, trunk and tail. The head has a set of lateral hooks, teeth, eyes and a mouth followed by a trunk filled with fluid. The trunk has a gut and the female gonad. The male gonad is situated in the tail segment. The trunk and tail are separated by a tail septum. Excretory and circulatory systems are absent. They have an elaborate nervous system with six ganglia in the head and a large ventral ganglion in the trunk. Chaetognaths play a main role in the food cycle and well known as indicator organisms of watermasses and their movements.

STATUS OF THE TAXON

Global Status

Chaetognaths were first reported as ‘Sea-worms’ by Martin Slabber in 1778 and the next information about these ‘worms’ was published only in 1827 by Quoy and Gaimard. Though there are a few papers on this group after 1827, a complete revision was done only in 1911 by Ritter-Zahony. He recognised 27 species in six genera. Later, Tokioka (1965) listed 58 species in 15 genera and recently Bleri (1991) reported 111 valid species in 23 genera. Out of these, 22 species are benthic and the remaining 89 are pelagic.

Indian Status

Out of 111 species reported from the World Oceans, 30 species are so far known from the epi-, meso-, and bathy-planktonic waters of the Indian seas.

DISTRIBUTION

Chaetognatha are seen at the surface, sub-surface and bottom of the sea. Based on the pattern of distribution they could be classified as cosmopolitan, Indo-pacific and endemic species.

Cosmopolitan species : Genus *Sagitta* : *S. bipunctata*, *S. decipiens*, *S. enflata*, *S. gazellae*, *S. hexaptera*, *S. lyra*, *S. macrocephala*, *S. maxima*, *S. minima*, *S. tasmanica*, *S. zetesios*; Genus *Eukrohnia* : *E. bathyantartica*, *E. fowleri*, *E. hamata*; Genus *Heterokrohnia* : *H. mirabilis*; Genus *Krohnitta* : *K. pacifica*, *K. subtilis*; Genus *Pterosagitta* : *P. draco*.

Indo-pacific species

Genus *Sagitta* : *S. bedoti*, *S. ferox*, *S. neglecta*, *S. oceania*, *S. pulchra*, *S. regularis*, *S. robusta*, *S. pacifica*.

According to the depth in the ocean in which the chaetognaths are found, they are known as epi-, meso, and bathy-planktonic forms. The following are the epi-planktonic species seen between the surface and 200 metres depth from the surface of the sea.

Genus *Sagitta* : *S. bedoti*, *S. bipunctata*, *S. bombayensis*, *S. enflata*, *S. ferox*, *S. hexaptera*, *S. minima*, *S. neglecta*, *S. oceania*, *S. pulchra*, *S. tropica*; Genus *Krohnitta* : *K. pacifica* and *K. subtilis*; Genus *Pterosagitta* : *P. draco*.

The following are the meso-planktonic chaetognaths from the Indian seas found between 200 and 1000 metres depth of the ocean : Genus *Sagitta* : *S. lyra*, *S. decipiens*, *S. gazellae*; Genus *Eukrohnia* : *E. fowleri*, *E. hamata* and *E. minuta*; Genus *Pterokrohnia* : *P. arabica*.

In the Indian seas the following three species found below 1000 metres depth of the ocean are considered as bathy-planktonic. Genus *Sagitta* : *S. macrocephala* and *S. maxima*; Genus *Heterokrohnia* : *H. mirabilis*.

The following two species of *Spadella*, viz., *S. angulata* and *S. cephaloptera* are seen attached to the sea weeds at the bottom of the sea in the coastal waters of the Indian seas and they are considered as benthic forms.

BIOLOGICAL DIVERSITY

This is a small phylum with limited number of species. In 1903, Doncaster reported only 11 species from the Indian ocean with 4 new species and in 1906, Fowler listed 16 of the 33 species known from the World Oceans. Then Ritter-Zahony (1911) reported the occurrence of 27 species from the Indian Ocean. The number of species known from the Indian seas has gone upto 58 in 1965 (Tokioaka) and recently Bieri (1991) listed 111 valid species from the World Oceans and he has stated that the number will increase because many new species remain to be discovered. So it is evident that even in this small phylum, due to biological variations for survival, the number of species has been gradually going up from the then known 33 species from the World

Oceans in 1906 (Fowler) to 111 in 1991 (Bieri). As stated by Bieri (1991) the number of valid species may ultimately reach more than 200.

As pointed out by Bieri (1991), the Chaetognatha now shows a much greater morphological diversity than previously recognized. Owre (1973) described a species of the genus *Bathyselos* with a dorsal nerve ganglion instead of the usual ventral nerve ganglion. Other interesting morphological diversities are the presence of tubules connecting the ovaries and testes in *Heterokrohnia* and *Archeterokrohnia* (Casanova, 1985), occurrence of three sets of teeth in *Eukrohnia sinica* (Zhang and Chen, 1983), strange seminal vesicles in *Pterokrohnia arabica* (Srinivasan, 1988) and differences in gut structure (Dallot, 1970).

Among the 12 genera reported in this account, the genus *Sagitta* is the most dominant than the remaining genera and 61 species are known under this genus. When Fowler (1906) reported 16 species from the Indian Ocean, 12 species are known under the genus *Sagitta*. In 1965 among the 48 species in five genera reported from the World Oceans (Alvarino), 39 species are listed in the genus *Sagitta*. From these statistics, it is evident that the number of species in the genus *Sagitta* has been steadily increasing due to biological diversity.

ENDEMICITY

The three species of the Phylum Chaetognatha, viz., *Sagitta bombayensis*, *Eukrohnia minuta* and *Pterokrohnia arabica* are endemic to the Indian ocean.

S. bombayensis was described from Bombay Harbour by Lele and Gae (1936) and later reported from Lawson's Bay, Waltair (Rao, 1958), from Bombay harbour (Silas and Srinivasan, 1968) and from Malayan waters (Pathansali, 1974). *E. minuta* was described from the meso-pelagic waters of the Southern Arabian sea by Silas and Srinivasan (1969) and later reported from the deeper waters of the Arabian sea by Srinivasan (1972) and Casanova and Ardrew (1989). *P. arabica* was described from 900 metres depth off the Northern Arabian sea by Srinivasan (1988).

VALUE

Chaetognaths play a key role in the food cycle of the marine ecosystem and are of great significance in transferring the energy from copepods to higher trophic levels. The biomass of chaetognaths has been estimated as 10-30% of that of copepods in the World Oceans (Reeve, 1966). Further they form the food of a wide variety of larger organisms (Bigelow, 1924; David, 1955).

Certain species of Chaetognaths are seen associated with particular type of watermass. This association is useful in identifying a particular type of watermass in a region where there are several water bodies, in which the salinity conditions are not well marked (Russel, 1930). In such cases only the planktonic organisms could provide information on the origin of such waters. Along the west coast of India, Srinivasan (1976, 1996) pointed out the possibility of utilising *Sagitta decipiens* as an indicator of upwelling. Alvarino (1964, 1967) along the coast of California and Segura *et al.* (1992) along the Costa Rica, have also reported that this species could be used as an indicator of upwelling. As this is an inhabitant of the waters of low temperature, low oxygen and high salinity, it could be made use to identify the movements of deep waters (Sund, 1961). The presence of *S. decipiens*, a meso-pelagic species in the epi-pelagic waters of California, Costa Rica and South west coast of India indicates the process of upwelling.

THREATS

Polluting the sea water due to oil spillage and dumping the wastage and draining the sewerage water into the sea will affect the hydrography, which ultimately affect the planktonic and other living organisms. These man-made changes will definitely affect the survival of the coastal neritic species than the offshore oceanic species. The reclamation of the backwaters for construction purposes will also affect these estuarine forms as the estuaries are good nursing grounds. Certain species of *Sagitta* (*S. bedoti*, *S. enflata* and *S. apulchra*) are found in the estuarine waters.

FUTURE STUDIES

Chaetognaths of the deeper waters of the seas around India are not well known. Further studies on the samples from the deeper waters may increase the number of species known from the Indian seas. Further, seas around the Andaman and Nicobar Islands and central and northern part of the Bay of Bengal are also have to be thoroughly explored as these areas are not studied well for the chaetognath fauna. So, insufficient sampling is mainly responsible for our ignorance about the unknown species of Chaetognatha from the Indian seas.

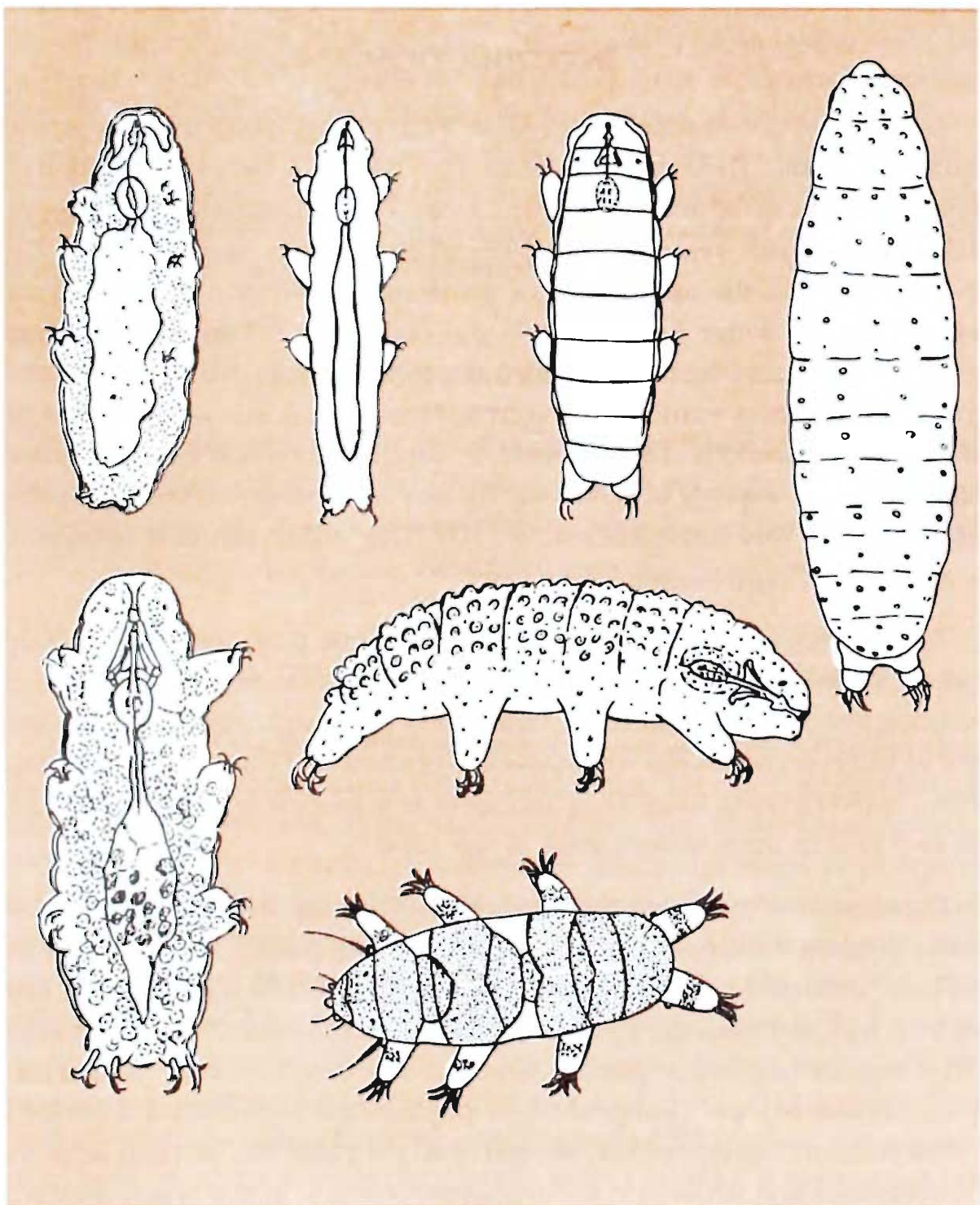
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Faunal Diversity In India : Tardigrada

K. VENKATARAMAN

Zoological Survey of India, Marine Biological Station, Chennai-600 028





INTRODUCTION

Tardigrades are commonly called as 'Water Bears' since they are strictly aquatic animals. They are minute in size (about 1 mm long) and have characteristic external and internal structures. The body is flattened or slightly arched and carries ventrally four pairs of stubby legs bearing claws. This gives the animal the appearance of a miniature bear and hence they are referred to as water bears. The body surface is covered with varied ornamented plates which sometimes bear spines or hairs. Many species have eyes. The mouth is terminal or ventroterminal. Sexes are separate and the females are oviparous. Development is direct, the cuticle being moulted. Tardigrades are capable of withstanding very adverse conditions by passing into a state of very low metabolic activity. This phenomenon is referred to as anabiosis (Cryptobiosis).

Tardigrades are not planktonic organisms, but they are collected from aquatic mosses and algae, rooted aquatic weeds, or mud and debris of puddles, ponds and lakes. Active tardigrades are found only in droplets and film of water on terrestrial wet masses, liverworts and certain angiosperms with a rosette growth form. They also occur as meiofauna in the sandy beaches up to 2 or 3 m from water's edge of sea coast.

There is some confusion about whether the tardigrades are to be placed in the phylum Arthropoda or Annelida. They are placed near mites in the phylum Arthropoda, especially because of their indistinct segmentation, four pairs of legs and piercing stylets. Some authors consider them crustaceans, and a further suggestion places them near the Onychophora. Ramazzotti (1962) considered the Tardigrada as a phylum and separated it from both Arthropoda and onychophora. Several workers place this phylum after the Chaetognatha and Bryozoa in the phylogenetic series. In this report they will be regarded as Phylum Tardigrada until more definite evidence is forthcoming.

STATUS OF THE TAXON

Global and Indian Status

Global Tardigrada species diversity is around 600. From United States alone 70 species have been reported and this number includes marine, moss and freshwater forms (Pennak, 1978). Europe has 40-50 species of freshwater tardigrades (Edmondson, 1959). These numbers do not represent anywhere near the actual number of existing species.

The third edition of "II Phylum Tardigrada", to be published, by Ramazzotti includes 514 species of tardigrades from the globe. From the monographs, it is found that only eight species are recorded from India including some of the stray records. So far 30+ species of tardigrades have been reported from India (Table – 1). However, it is likely that Indian species of Tardigrada will be at least 70 considering the wide range of aquatic habitats and the cooler temperatures in the hills.

DISTRIBUTION

Tardigrades are commoner at lower temperatures. Their favourite habitat is moss and they are also often found in the littoral region of lakes and among vegetation at the edge of ponds. Few marine species are also recorded in India. Majority of the species have been recorded from wet moss.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The structure of buccal apparatus, claws of the legs and armour sculpturing (trunk plates) are largely taken into consideration for the classification of tardigrades. There are three main orders, the Heterotardigrada, Mesotardigrada and Eutardigrada, based on the morphology of pharynx. The heterotardigrada is again divided into 2 suborders based on the structure of claws, the Arthrotardigrada and Echiniscoidea. The Arthrotardigrada has three families, the Halechiniscidae with nine genera (16 species), the Batillipedidae with 2 genera (12 species) and the Stygarctidae with 2 genera (2 species). The suborder Echiniscoidea has two families, the Oreellidae with three genera (5 species) and Echiniscidae with four genera (179 species). The other two orders have five families, with 13 genera (299 species). Among the eleven families of the phylum Tardigrada only 3 families 5 genera and 30 species are known from India (Table – 1). Research on Tardigrada has received very little attention in India and there is no single worker engaged in the

study of this group. This may be due to their microscopic size and the difficulty in separation from the habitat. However, many areas on the Indian continent still remain unexplored. At present, the taxonomy of this group is being studied in the Zoological Survey of India based on the stray collections made during the general faunistic surveys.

Table - 1
Number of family, genera, species of tardigrades recorded so far,
showing their habitat

Order	Number in World			Number in India			Habitat
	Family	Genera	Species	Family	Genera	Species	
Heterotardigrada	5	20	214	2	3	10+	Marine freshwater & High altitude mountains
Mesotardigrada	2	1	1Not	found in India			Hot spring Japan
Eutardigrada	4	12	299	1	2	20+	Freshwater & high altitude mountains
Total	11	33	514	3	5	30+	

VALUE

Tardigrades are capable of withstanding very adverse climatic conditions by passing into a state of Cryptobiosis or very low metabolic activity. The mechanism of this remarkable property is the gradual removal of surrounding moisture, which reduces the size and configuration of the water bear to a protective state called the tun. In this state they are able to withstand extremes in temperature, radiation, oxygen and water concentrations. Tardigrades, thus provide a unique experimental living system for use in the study of basic biological phenomena including the role of water in the maintenance of macromolecular and membrane structure, the characteristics of life itself and the events which result in sensescence (IUCN, 1984).

THREATS, CONSERVATION AND FUTURE STUDIES

Tardigrades occur in high altitude mountains, freshwater, brackishwater habitats and intertidal zone of coast line area. At present most of the areas of wetlands, coast line and high altitude mountains are under threat due to over exploitation and pollution and hence these little known forms may become extinct before their discovery. Due to agricultural activities, urbanisation, industrial development programmes and over exploitation of natural resources, most of natural habitats are altered and will become a death trap for the fauna depending on them. For example, a study in the U.S.A. and Hungary showed that the use of DDT, and other herbicides and pesticides was found to greatly reduce both the density and diversity of tardigrades. However, another study has shown tardigrades to be fairly resistant to insecticides. Substrate structure disturbance can also reduce tardigrade population and the disruption of soil structure by cultivation has a detrimental effect on tardigrade abundance.

The lack of detailed ecological and environmental studies allow only speculation in this area. Increased studies of the density and development of comparative faunal lists to monitor population changes are vital. Greater care must be directed to the supporting substrates as there are delicate microhabitats which have a direct role on tardigrades as well as on many other microorganisms. Thus, it is apparent that conservation of natural habitats will conserve the fauna depending on them.

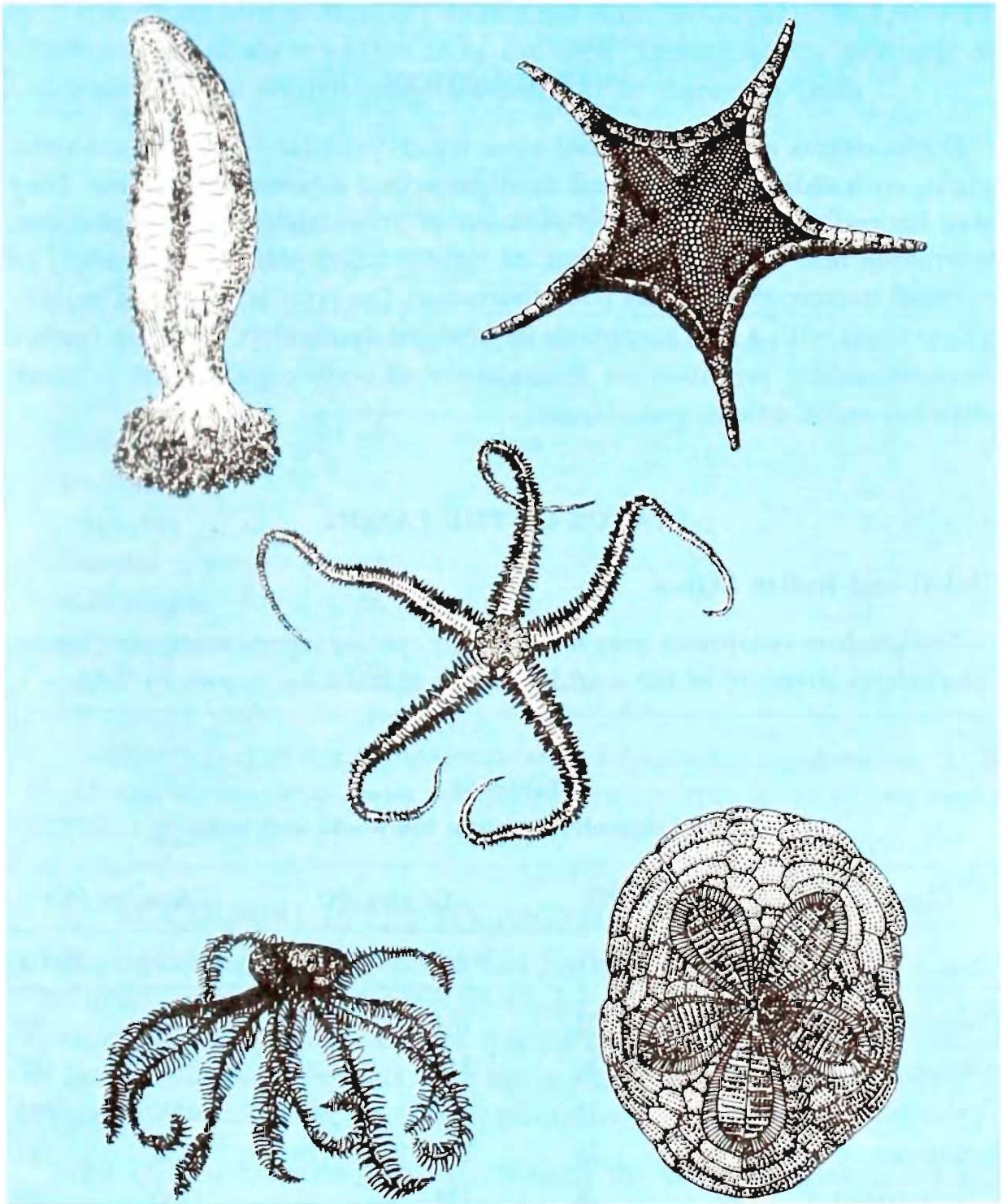
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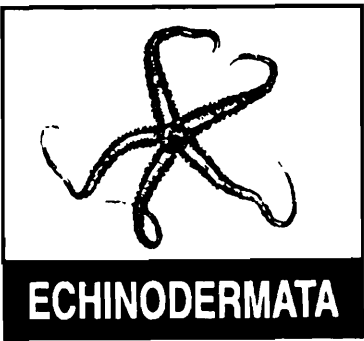
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Faunal Diversity in India : Echinodermata

D. R. K. SASTRY

Zoological Survey of India, Port Blair-744 101





INTRODUCTION

Echinoderms are characterised by a water vascular system of coelomic origin, with radiating canals and their projecting tubefeet or papillae. They have an endodermal calcareous skeleton of articulating plates (Crinoidea, Asteroidea and Ophiuroidea), box of rigidly fused plates (Echinoidea) or scattered microscopic spicules (Holothuroidea). The body is in general radially symmetrical with a few exceptions of bilateral symmetry. They are further characterised by pentamerous arrangement of body organs such as arms, tentacles, radial canals, gonads, etc.

STATUS OF THE TAXON

Global and Indian Status

The phylum comprises over 6,000 extant species representing six classes. Echinoderm diversity of the world and that of India are shown in Table – 1.

Table – 1
Number of Echinoderm taxa in the world and India

Class	Families (N)		Genera (N)		Species (N)	
	World	India	World	India	World	India
Crinoidea	24	13	164	43	623	95
Asteroidea	35	20	318	81	1500	180
Ophiuroidea	17	15	275	67	2000	150
Echinoidea	47	28	230	79	950	150
Holothuroidea	25	14	154	62	1150	160
Total	148	90	1141	332	6223	765

DISTRIBUTION

The ehinoderms occur from the intertidal region to great depths of all the world oceans. Their habitats include a variety of rocky, sandy, muddy and coral environments. Only the class Concentricycloidea comprising two nominal species under a single genus and a single family is not so far discovered from Indian waters.

The enchinoderm diversity is not the same throughout Indian waters. Although some areas are yet to be explored thoroughly, the available data indicates certain regions with rich diversity as shown in Table 2.

Table – 2
Regions in India with rich echinoderm diversity

Class	Species (N)				
	Andaman & Nicobar Is.	Gulf of Mannar	Lakshadweep	West Bengal	Gujarat
Crinoidea	28	9	1	—	4
Asteroidea	79	26	19	6	8
Ophiuroidea	87	19	22	7	12
Echinoidea	77	19	23	5	4
Holothuroidea	88	39	32	5	5
Total	359	112	97	23	33

A greater part of the echinoderm fauna inhabits the shelf area up to 200 m. However, the deep water component varies from 37 to 47 per cent in different groups.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Biological diversity of echinoderms has been shown in Tables – 1 and 2. The adults of almost all the species are freeliving, while the males of some ophiuroids are epizoic on females. Some crinoids and ophiuroids are known to be epizoic on gorgonids and some are endozoic. A few species are frequently encountered among phytal fauna.

The stalked crinoids (sea-lilies) inhabit the deeper waters and lead a sedentary life with their stalk fixed to the substratum. The unstalked crinoids (feather stars) are capable of free swimming, though most forms such as *Tropiometra carinata* and *Lamprometra palmata* can be found attached to the

undersurface of rocks and corals or crawling on the bottom of shallow pools during ebb tide period. They mostly feed on the floating organisms caught in the mucous secretions of their pinnules.

Asteroides are inhabitants of both hard and soft substrata. Species of *Astropecten* inhabit soft substrata and often burrow onto the subsurface leaving a characteristic mark on the surface. *Culcita*, *Linckia*, *Asteropsis*, *Asterina*, etc., inhabit rocky and coral environs. They are predominantly carnivorous, feeding on a variety of animals such as crabs, molluscs, coral polyps, etc.

Ophiuroids are inhabitants of rocky, coral, sandy and algal habitats. Quite a few species of euryalids are epizoic on gorgonids. The tropicopolitan species, *Ophiactis savignyi* inhabits crevices in rocks, sponges and algae. The amphiuroid *Amphiura tenuis* lives deeply buried in the muddy habitats of the Sunderbans in West Bengal. Ophiuroids are carnivores and detritus feeders. They also feed on floating organisms and organic matter caught in the mucous secretions of the arms.

Most regular echinoids (*Toxopneustes*, *Colobocentrotus*) occur in rocky and coral habitats while the sand dollars (*Clypeaster*) and heart-urchins (*Lovenia*) are inhabitants of soft substrata. The regular echinoids are herbivores, resorting to occasional omnivorous habit. Other echinoids are substrate feeders.

Though holothurians are common in the coral and rocky habitats, their preferred habitat is soft substratum at least for feeding visits. They pass large quantities of the sediment through their digestive system and subsist on its organic content.

From the view point of science, echinoderms are a puzzling group with regard to their origin, diversity and evolution, as can be seen from the frequent changes in the views regarding these aspects right from the times of their discovery up to the present time.

ENDEMICITY

The Indian echinoderms are constituents of Indo-West Pacific fauna with a wide zoogeographical range from East coast of Africa to Hawaii and Australia. Very few species have a limited distribution along the Indian and neighbouring coasts. There are several genera of Indian fauna such as *Metrodora*, *Acanthaster*, *Ophiocomella*, *Stomopneustes*, etc., which are monotypic but not endemic to India. Several species are still known only by their original discovery from deep waters. However, some were later found to be occurring in other oceans also. As such, no endemicity can be attributed to Indian echinoderms.

VALUE

Economically only Holothuroidea are exploited on a commercial scale for export. More than 12 species of Holothurians belonging to the genera *Actinopyga*, *Bohadschia*, *Holothuria*, *Stichopus* and *Thelenota* are known to be of commercial importance. However, only three species, *Bohadschia marmorata*, *Holothuria scabra* and *H. spinifera* are being exploited to a limited extent in the Gulf of Mannar. The potentiality of developing the industry at Lakshadweep and Andaman and Nicobar Islands and exploitation of sea-urchins, such as, *Stomopneustes* and *Tripneustes* for the purpose are to be explored. Sea-urchin exploitation is limited and localised. Their cleaned tests with symmetrical ornamentation of ambulacral and interambulacral areas serve as decorative pieces.

Research on the extracts of echinoderms for bio-active compounds has started only recently and there are already indications of their importance as potential sources of toxins and hormones. The holothurian extracts have been found to be useful in controlling the menace of starfishes in shellfish cultures.

Echinoderms are very sensitive to deteriorating environment. As such they are good indicators of healthy habitats. Their developmental stages, particularly of echinoids, can be successfully used in environmental monitoring studies.

Echinoderms interact with the biotic and abiotic environment in a significant way. They extract calcium from the sea-water for building their skeleton which contributes to the bottom sediments of the ocean. The holothurians with their burrowing and feeding activity are good substrate reworkers and can be compared to earthworms of the terrestrial habitat. Many sea-urchins such as *Stomopneustes*, *Diadema*, *Echinometra* and *Echinostrephus* live in bores in the rocks, often made by themselves or widening the existing depressions through abrasive action. Thus they contribute to the biodeterioration of the environment as well. Many echinoderms are involved in biological associations with a variety of faunal groups such as crustaceans, fish, polychaetes, etc. providing them food, shelter and substratum.

Asteroids are mostly carnivorous, though other types of feeding are known. They are a menace in oyster and other shellfish cultures. The crown-of-thorns starfish, *Acanthaster planci* is a voracious carnivore preferring live coral polyps. When occurring in large numbers, they can destroy vast areas of coral habitat beyond recovery until a few decades to come.

Several regular echinoids are herbivores. When migrating in large aggregations, they can denude vast areas of algal forests on the sea bottom

or denude large rocky habitats of their algal cover. On Indian coast, the feeding rate of *Stomopneustes variolaris* during the pre-spawning period has been found to be more than the growth rate of the algae on which they feed. This however seems to be compensated by a very low feeding rate during the spawning and immediate post-spawning periods.

THREATS

Most echinoderms inhabit only healthy habitats. Their absence indicates fouling of the environment because of organic enrichment with consequent depletion of oxygen. While the activity at even large fishing villages along the open coast has been found to be no nuisance to the environment, berthing facilities for a moderate number of mechanised fishing boats at harbours and narrow mouths of gulfs have been found to be a threat to the healthy habitats in the surroundings.

Because of limited flushing and organic enrichment through accumulation of fish wastes, the habitat becomes uninhabitable for echinoderms. In some places, echinoderm species which were once abundant are found to be absent subsequent to provision of such facilities.

They are also vulnerable to habitat destruction at shingle beds and coral environments. Indiscriminate collection and wanton disturbance by unguided enthusiastic amateurs cause considerable damage to the echinoderm populations, particularly of ecologically and economically important species.

In addition, exploitation of corals and shells for domestic and industrial purposes or curio trade, not only deteriorate the environment, but also disturbs the natural balance of the community resulting in population explosion of unwanted or harmful species. This causes further damage to the community as well as the environment.

CONSERVATION STRATEGIES AND FUTURE STUDIES

Local authorities and institutions should generate awareness in the public, regarding the importance of the faunal wealth and natural habitats, check indiscriminate exploitation of fauna and damage to the habitats. Developmental projects also are to be so planned as to cause the least disturbance to the fragile habitats like gulfs, coral reefs and shingle beds.

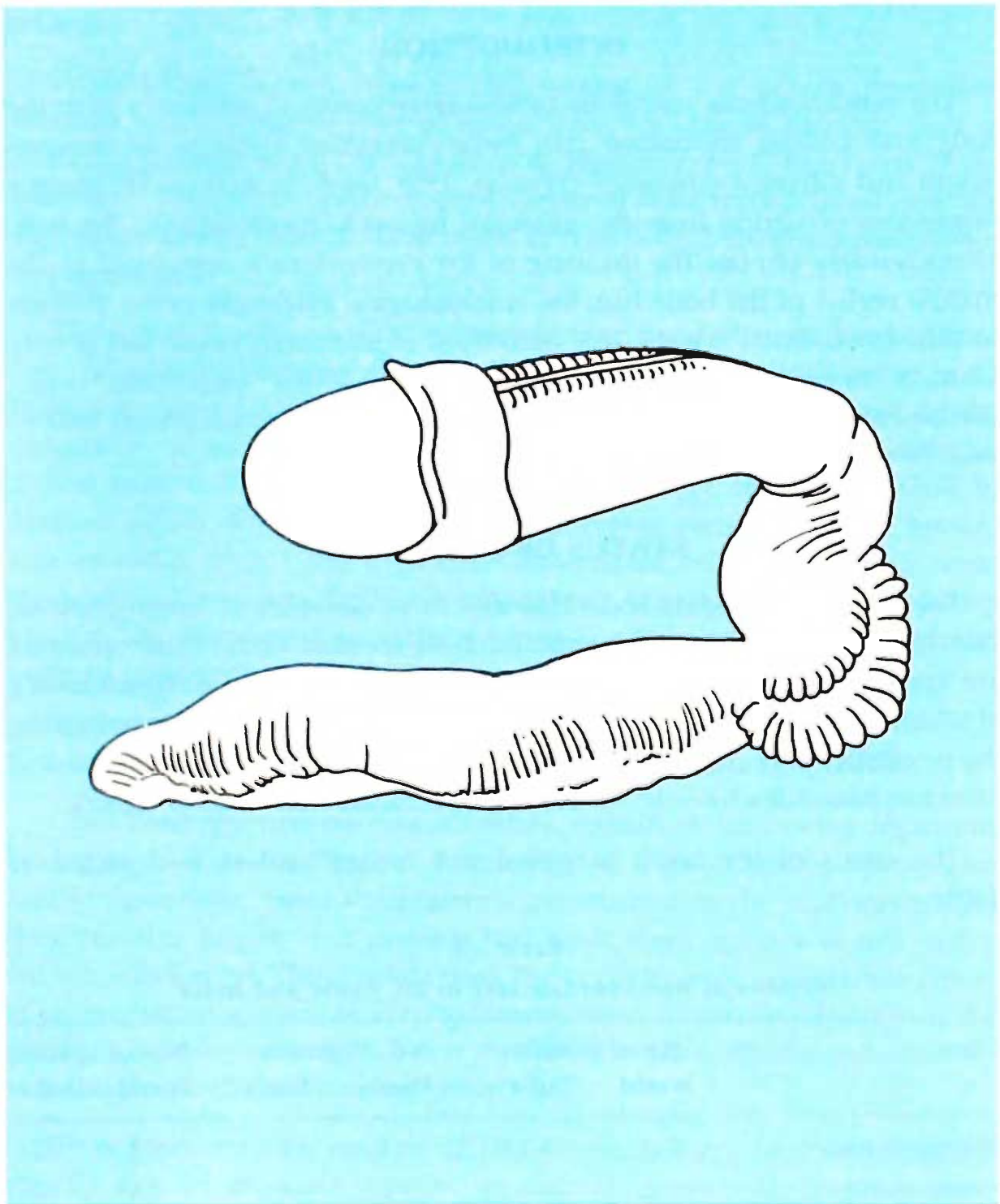
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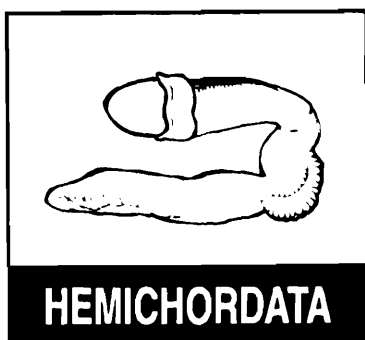
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Faunal Diversity in India : Hemichordata

P. DHANDAPANI

Zoological Survey of India, Marine Biological Station, Chennai – 600 028





INTRODUCTION

The hemichordates are “more or less enterocoelous coelomates with the body and coelom regionated into three successive divisions of unequal length and different structure” (Hyman, 1959), and are exclusively marine organisms occurring from the intertidal region to great depths. The term Hemichordata implies the meaning of the presence of a notochord in the middle region of the body but, the embryological evidences prove that the so called notochord is not a true notochord of middorsal origin but is only a buccal diverticulum (Hyman, 1959) developed into a “rachis like” organ presumably to support the function of the proboscis in enteropneust worms than of any use in the other groups of hemichordates:

STATUS OF THE TAXON

Phylum Hemichordata is divided into three classes, *i. e.*, Enteropneusta, Pterobranchia and Planctosphaeroidea. Four families under Enteropneusta are known (Ptychoderidae, Harrimanidae, Spengilidae and Saxipenniidae), of which all but Saxipenniidae have been recorded from India, thus indicating the possibility of finding more taxa in Indian waters. Both Pterobranchia and Planctosphaeroidea have so far not been recorded from Indian waters.

The status of the taxon in global and Indian context is depicted in Table – 1.

Table – 1
Number of hemicherdate taxa in the world and India

Class	No of Families		No. of genera		No. of species	
	World	India	World	India	World	India
Enteropneusta	4	3	12	4	102	12
Pterobranchia	2	—	2	—	16	—
Planctospheroidea	1	1	1	—	2	—

DISTRIBUTION

The species of the Enteropneusta occur both in tropical and temperate waters. Genera *Ptychodera*, *Balanoglossus*, *Glossobalanus*, *Glandiceps*, *Saccoglossus* and *Harrimania* are popularly known by their occurrence in all the oceans of the world. Pterobranchs are usually colonial forms but live in individual tubes. These are well studied from temperate waters but rarely from tropical belt, the reason could be due to improper coverage of this belt for study. The planktonic Planctosphaeroidea are oceanic in distribution and are rarely collected.

From Indian waters enteropneust worms of the genera *Ptychodera*, *Glossobalanus*, *Glandiceps* were collected from the Gulf of Mannar, Gulf of Kutch, Andaman Seas, Lakshadweep & Maladive Seas, the Tamil Nadu coast upto Cape Comerin (Zoological Survey of India records), and from the high saline marshy areas of Sunderbans, in West Bengal, the genus *Saccoglossus* were recorded.

The reported occurrence of *Saccoglossus* from Sunderbans is a new record and indicates that intense search is likely to lead to the discovery of more species in other parts of Indian coastal region. No authentic report on the occurrence of either Pterobranchia or Planctosphaeroidea is available for Indian waters. *Ptychodera flava* appears to be more endemic to Gulf of Mannar region, although one specimen of colour variety (blackish brown) was recorded from Cape Comerin, *Glossobalanus minutus* seems to occur more along the coasts of oceanic islands, i.e., Andaman and Lakshadweep groups. The *Saccoglossus* sp. collected from Sunderbans is a new record and perhaps endemic.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Class Enteropneusta consists of solitary, vermiform burrowing organisms belonging to four families, i.e., Harrimanidae, Ptychoderidae, Spengilidae and Saxipennidae. Since these worms live burried in the seafloor, and as they are also fragile, it is possible that great many species of this group remain uncollected. This evident from the occurrence of tornaria, the larvae of enteropneust worms, of varying descriptions, occurring regularly in the plankton samples collected all over the world which indirectly indicates the rich taxonomic diversity of the group.

Class Pterobranchia consists of tentaculate, solitary or colonial forms, usually tiny or even microscopic in size. The class includes only three genera, i.e., *Cephalodiscus*, *Atubaria* and *Rahabdopleura*. While genus

Cephalodiscus is a well studied group, the genera *Atubaria* and *Rhabdopleura* need extensive survey and intensive study.

Class Planctosphaeroidea is known by a single species *Planctosphaera pelagica*. The description reviewed by Hyman (1959) indicates that this group may perhaps be a neotonic from of a Tornaria larva and adopted to planktonic life.

ENDEMIC AND THREATENED SPECIES

But for *Planctosphaera* spp., all other species are benthic in habitat. By studying the habit of *Ptychodera flauva*, it may even be assumed that some species may be occurring as "locally distributed communities" The only commonly available enteropneust worm in India is *Ptychodera flauva* which is extensively used for studies hence faces threat of over exploitation.

VALUE

Although no economic value can be attributed, there are reports of *Ptychodera flauva* being used as fish line baits.

THREATS

Ptychodera flauva is the only species that is within the easy reach of collection at one point of intertidal region in Krusadai Island of the Gulf of Mannar area and is likely to be over collected for research if proper measures are not taken to prevent it. Rarity and endemism of certain species along the intertidal region of island ecosystems emphasises the need to preserve this taxon.

CONSERVATION STRATEGIES AND FUTURE STUDIES

Presently no action is taken to conserve this group in particular except that intense care is taken to avoid over collection of *Ptychodera flauva* from the Gulf of Mannar Biosphere Reserve which incidently is also a Marine National Park. Complete ban or moratorium for three years on collection of this species either for research or as demonstration species in educational institutions from the Gulf of Mannar Biosphere Reserve should be imposed in order to establish an appreciable density of population which is expected to encourage settlement of this species in new areas. Intense survey of ocean

floors with the use of suitable gears is needed to unravel the mystery of hemichordate diversity not only in the areas around India but also in other parts of the globe.

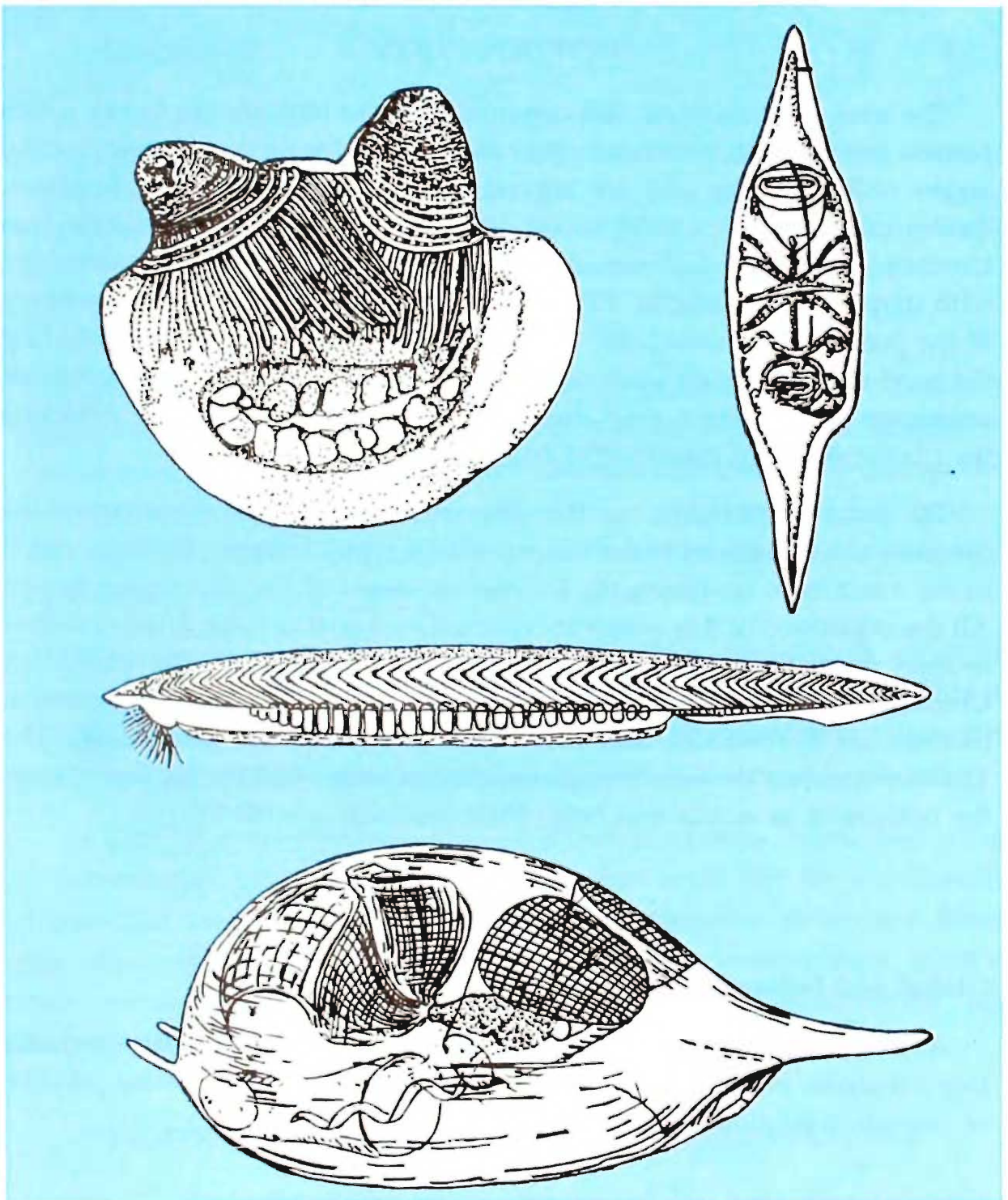
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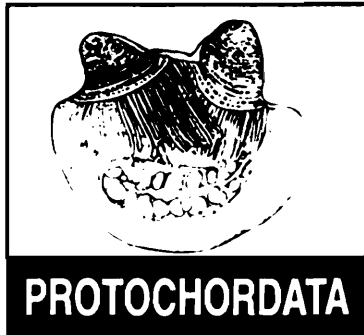
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Faunal Diversity in India : Protochordata

P. DANDAPANI

Zoological Survey of India, Marine Biological Station, Chennai –600 028





INTRODUCTION

The term Protochordata is a common name to indicate the fauna which possess cartilaginous notochord either as adults or during their developmental stages of life history and are regarded as forerunners of the chordates. Taxonomically, this includes subphylum Cephalochordata and subphylum Urochordata (=Tunicata), both of which come under phylum Chordata along with subphylum Vertebrata. This term Cephalochordata implies the meaning of the presence of a notochord throughout the length of the body including the head region. Known otherwise as lancelets, these are exclusively marine organisms resembling a primitive fish, the present day example depicting the phenomenon of evolution of true chordates.

The term Urochordata on the other hand implies the meaning of the presence of a notochord in the tail region of a group of Protochordates either in the adult form or during the life history stages of the developing larvae. All the organisms of this group are covered by a coat or tunic which is either leathery or gelatinous, and opaque, translucent or transparent. The subphylum Urochordata (=Tunicata) is divided into class Ascidiacea which are sessile or benthic, class Thaliacea and class Larvacea which are planktonic. The Thaliacea possess the notochord in their larval stages and the Larvacea retain the notochord as adults that helps their locomotion with the tail.

STATUS OF THE TAXON

Global and Indian Status

As mentioned earlier "Protochordata" is a common name that includes two subphyla, *viz.*, Cephalochordata and Urochordata. The Indian position of these taxa in global context is depicted in Table – 1.

Table – 1
Showing number of families, genera and species of Protochordata reported from India and world.

Group	Number of					
	Families		Genera		Species	
	World	India	World	India	World	India
Subphylum						
Cephalochordata	2	2	2	2	24	6
Subphylum						
Urochordata						
Class Ascidiacea	15	9	23	21	2000+	47
Class Thaliacea	4	4	19	19	57	48
Class Larvacea	2	2	15	14	25	18

DISTRIBUTION

Cephalochordates have been collected from Chennai city coast, Tuticorin coast and in the atolls of Lakshadweep Islands. While three species of *Brachistoma* have been recorded from Chennai city coast, only one species *B. belcheri* is known from Tuticorin. *Epigonycths cyngulense* and *E. lucayanum* were recorded from Tuticorin and Lakshadweep Islands respectively. *Amphioxides* occurs commonly in oceanic plankton.

Although, a major work was done from the Tamil Nadu coast, ascidians occur all over the coast of India. They are one of the major components of fouling organism found on the bottom surface of ships and boats, pillars and warfs and the outflow openings of any pipeline submerged in the sea.

As planktons the Thaliacea are distributed in all seas. When they occur in swarms they are abundant in the near shore areas and are occasionally driven into the coastal water bodies that are connected to the sea. Being planktonic, the Larvacea are distributed all over the world oceans. Most of them are stenohaline. A few euryhaline species like *Oikopleura dioca* has been recorded from the Chilka Lagoon, Orissa recently.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The Cephalochordates are represented by two families, viz., Branchiostomidae and Epigonyethidae. The former is represented by the

single genus *Branchiostoma* and the latter by genus *Epigonycthis*. The so called genus *Amphioxides* is presently recognised as a prolonged larval phase of species of the genus *Epigonycthis*. Three species of *Branchiostoma* and 2 species of *Epigonycthis* occur in Indian seas. Occasionally *Amphioxus* is recorded amongst oceanic plankton.

Urochordates are represented by 3 classes, viz., Ascidiacea, Thaliacea and Larvacea. The class Ascidiacea consists of 2 orders-Enterogona and Pleurogona while class Thaliacea is represented by 3 orders, viz., Salpida, Doliolida and Pyrosomida. The class Larvacea, however, comprises of 2 families-Oikopleuridae and Fritillariidae.

The cephalochordates always occur half buried in coarse sandy floors. They are very quick in their movements and occur in dredged collections that contain coarse sand. Occasional plankton samples which contain large number of post larval cephalochordates indicate mass breeding phenomena in the population.

The ascidians have the adaptability to settle on any substratum in the marine environment as biofoules. They sometimes look like mats or spongy algae and occur in the form of encrusted layers.

The Thaliaceans are pelagic tunicates leading a holoplanktonic life. They are covered by a transparent tunic and exhibit an alternation of generation of sexual and asexual reproduction.

The larvacea evolved as neotenic forms of ascidian tadpole larvae. Their body is enclosed in a chamber which acts more as a feeding chamber. The tail is used for locomotion and to create feeding current.

ENDEMICITY

It is very difficult to assign marine organisms, more particularly the marine planktonic organisms as endemic to any particular area.

VALUE

The developmental stages of cephalochordate eggs are used in academic circles to teach basic chordate embryology. *Branchiostoma belcheri* is of fishery value off the south China sea.

Thaliacea and Larvacea are indicators of water masses and thereby help in predicting a particular fishery belonging to a particular water mass. Thaliacea are decimators of phytoplankton bloom and maintain a balance between zooplankton and phytoplankton proportion in the sea.

THREATS, CONSERVATION STRATEGIES AND FUTURE STUDIES

Presently no species of Cephalochordates and Urochordates is under threat. However, constant discharge of effluents from various industries tend to pollute the intertidal and shelf areas affecting the benthos and their habitats. One among such areas are the sandy substratum which could allow these effluents to percolate, changing the seafloor into unsuitable substratum for cephalochordates.

Methodical survey of benthos and seasonal analysis of plankton for cephalochordate and urochordate adults and larvae respectively would reveal the presence of both new taxa and new distributional areas. Enormous scope is also available in the field of taxonomy, biology and biomedical studies of ascidians.

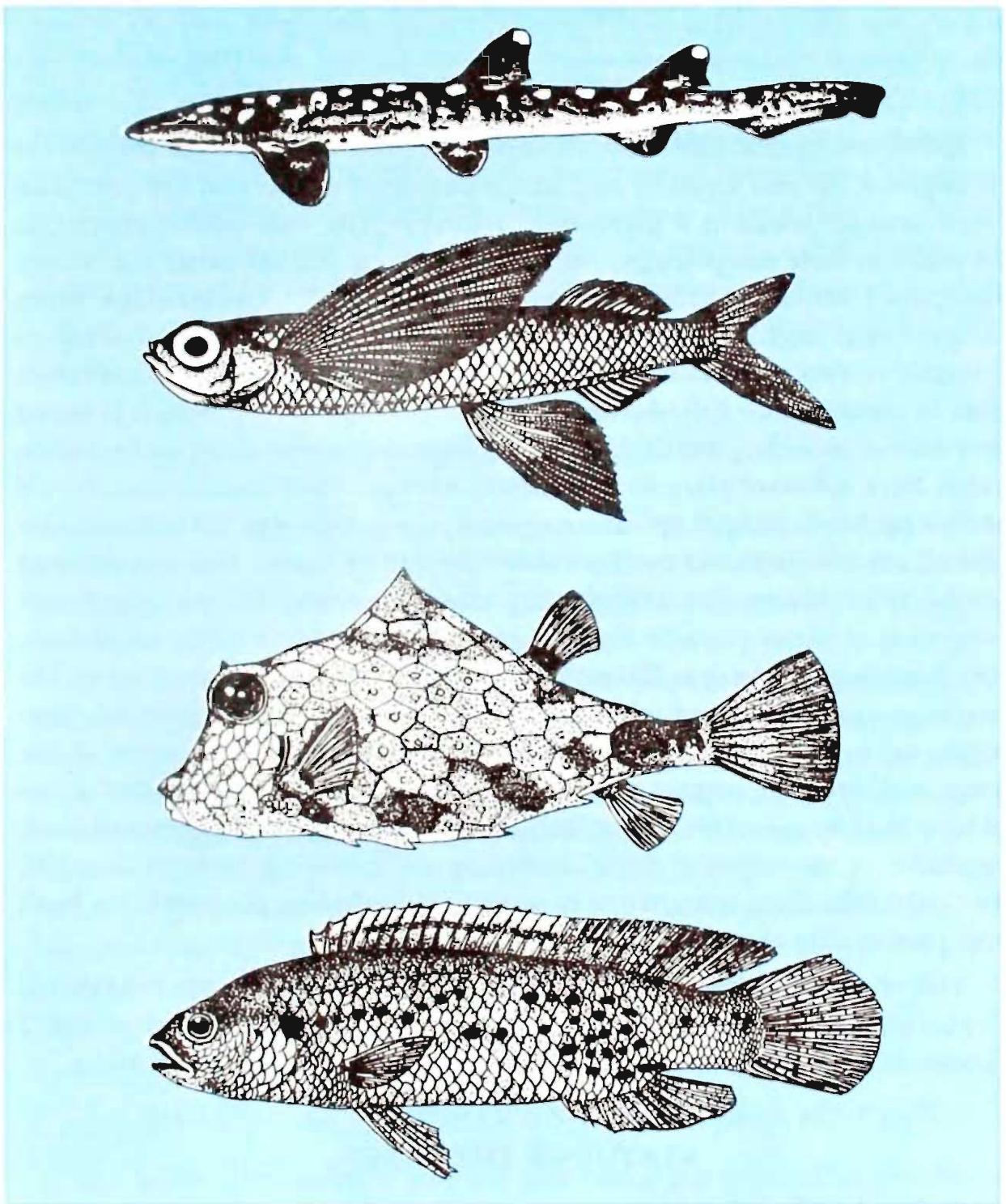
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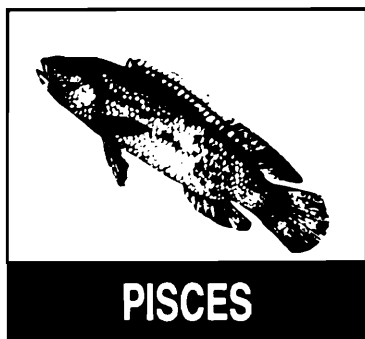
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Faunal Diversity in India : Pisces

R. P. BARMAN

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Fishes are aquatic cold-blooded vertebrates that have gills for respiration throughout life and limbs, if any, are in the shape of fins and are primarily dependent on water as a medium in which to live. Fish exhibit enormous diversity in their morphology, habitat and biology. Unlike other commonly recognized vertebrate groups, fishes are a heterogeneous assemblage. From lamprey and hagfish to lungfish and flatfish, they include a vast array of distantly related vertebrates. Many are even more closely related to mammals than to certain other fish. According to evolutionary theory, which is based on evidence including fossils, comparative anatomy, embryology and genetics, fishes have a distant place in the ancestry of man. Their ancient ancestry on earth's surface antedates ape-like ancestors of man by some 500 million years and all other vertebrates by more than 100 million years. This has allowed a vast span of time for evolutionary divergence and for the origin and extinction of major phyletic lines. Even the modern bony fishes or teleosts, had their origin as long as 200 million years, in the Triassic period, when the major groups (classes and subclasses) of fishes were firmly established. Man might never have evolved without piscine ancestry. Many features of life ways and structure of man were originated or were already present aeons of time in fishy ancestors. These features include the ground plans and basic functions of the organ systems, including such striking features as sight, internal fertilization, intrauterine nourishment (including placenta), live birth and presumably learning and memory.

The living fishes are divided into 4 classes, *viz.*, Myxini, Cephalaspidomorphi, Chondrichthyes and Osteichthyes, out of which 2 classes, *viz.*, Chondrichthyes and Osteichthyes are represented in India.

STATUS OF THE TAXON

Global and Indian Status

Fishes comprise about half the total number of vertebrates. Nelson (1984) estimated 21,723 extent species of fish under 4,044 genera, 445 families and

50 orders in the world, compared with 21,450 extant tetrapods (a total of almost 43,173 recognized vertebrate species have been described). Other workers, for various reasons, have arrived at different estimates, most of which range between 17,000 and 30,000 for the numbers of currently recognised fish species. Some groups are expanding with newly described species, whereas others are decreasing, for species are being synonymised faster than the new ones are described. However, a net increase is shown every year and the number of new species of fishes described annually exceeds that of the new tetrapods. The eventual number of living fish species may be close to 28,000 in the world. Day (1889) described 1418 species of fish under 342 genera from the British India. Subsequently almost 275 species were added, which were dredged by the R.I.M.S. Investigator from the deep waters. Jayaram (1981) listed 742 freshwater species of fishes under 233 genera, 64 families and 16 orders from the Indian region. Talwar (1991) estimated 2546 species of fish belonging to 969 genera, 254 families and 40 orders. The Indian fish species population represent 11.72 per cent of species, 23.96 per cent of genera, 57 per cent of families and 80 per cent of orders of the global fishes.

DISTRIBUTION

The distribution of marine fishes is rather wide, and some genera are common to the Indo-Pacific and the Atlantic regions. 57 per cent of the Indian marine fish genera are common to the Indian seas and to the Atlantic and Mediterranean.

Fishes have adapted themselves to diverse habitats along the coasts of the Indian subcontinent, whether rocky, sandy or muddy and amongst coral reefs, in deep sluggish rivers or in fast torrential streams, in lakes, ponds and wells, in estuaries, coastal lagoons and backwaters or total darkness in caves to higher elevations in the Himalayan mountains. The most diversity and abundance is found in the intertidal zone along the coast and in the coral reef ecosystems of the Gulf of Kutch, the Gulf of Cambay, the Gulf of Mannar, Lakshadweep, Andaman and Nicobar Islands, the Malabar coast, of the Indian Peninsula and the North-East India particularly along the bases of the Himalayas.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

The Indian fish fauna is divided into two classes, viz., Chondrichthyes and Osteichthyes. The Chondrichthyes (those with cartilaginous skeleton) are represented by 131 species under 67 genera, 28 families and 10 orders in

the Indian region. The cartilaginous fishes constitute a relatively small part of the global fish fauna. These fishes (sharks, skates and rays) form one of the important commercial fisheries in India. The annual average landings of the Indian chondrichthyes is 33,442 tonnes, of which 15,537 tonnes come from the east coast and 17,605 tonnes come from the west coast and the rest come from the Andaman and Nicobar, and Lakshadweep Islands.

The Indian Osteichthyes (those with bony skeleton) are represented by 2415 species belonging to 902 genera, 226 families and 30 orders.

If the North-Eastern states are extensively surveyed for the freshwater fishes and our seas are properly explored particularly the deep sea fishes, many more fishes (15%) will be added to the already existing fishes.

ENDEMIC SPECIES

The Fish fauna of India contains 2 endemic families, viz., Parapsilorhynchidae and Horaichthyidae. The fishes of the family Parapsilorhynchidae are small hill stream fishes comprising of a single genus, *Parapsilorhynchus* with 3 species, viz., *P. discophorus* Hora, *P. prateri* Hora and Misra and *P. tentaculatus* (Annandale) found in the Western Ghats, Satpura Mountains and the Bailadila range in Madhya Pradesh only. The family Horaichthyidae includes a monotypic genus, *Horaichthys* containing a single species, *H. setnai* Kulkarni occurring along the West coast of India from the Gulf of Kutch of Gujarat to Trivandrum of Kerala. Among the Indian families of fishes, the family Cyprinidae, the largest and the most dominating freshwater fishes of immense economic value in India; contain maximum number of endemic species (97 species), followed by the family Balitoridae (46 species) and the family Sisoridae (21 species) in India. The family Balitoridae (formerly Homalopteridae) consists of 2 subfamilies, viz., (i) Balitorinae (comprising of *Balitora*, *Bhavana*, *Homaloptera* and *Travancoria*) and (ii) Noemacheilinae (comprising of *Aborichthys*, *Triplophysa* and *Noemacheilus*). The fishes of the subfamily Balitorinae occur in the hills of Meghalaya and along the eastern Himalayas up to the Tista and Kosi drainage on one side and the Western Ghats of the peninsular India on the other side. The fishes of the subfamily Noemacheilinae (loaches) inhabit in the mountain and submountainous region of India. The fishes of the family Sisoridae (sucker catfishes) show the greatest diversity in India.

The fishes of India contain 223 endemic species, representing 8.75 per cent of the fish species known to India (Table – 1) and 127 monotypic genera representing 13.10 per cent of the Indian genera of fishes (Table – 2).

Table – 1
Number of species of fishes endemic to India

Order	Family	Genera (N)	Species (N)
Anguilliformes	Ophichthidae	1	1
Clupeiformes	Clupeidae	2	2
Cypriniformes	Cyprinidae	22	97
	Parapsilorhynchidae	1	3
	Balioridae	6	46
	Cobitidae	4	8
Siluriformes	Bagridae	5	10
	Siluridae	3	3
	Schibeidae	6	6
	Sisoridae	7	21
	Clariidae	2	3
	Olyridae	1	1
Cyprinodontiformes	Hemiramphidae	2	2
	Horaichthyidae	1	1
	Synbranchidae	1	2
	Chandidae	1	1
	Nandidae	1	1
	Cichlidae	1	1
	Gobiidae	7	9
	Eleotrididae	1	1
	Mastacembelidae	1	1
	Chaudhuriidae	1	2
Tetraodontiformes	Tetraodontidae	1	1
Total	6	23	78
			223

Table – 2
Monotypic genera of fishes found in india

Order	Genera
Orectolobiformes :	<i>Rhiniodon, Stegostoma, Nebrius</i>
Hexanchiformes :	<i>Heptranchias</i>
Carcharhiniformes :	<i>Chaenogaleus, Hemigaleus, Hemipristis, Galeocerdo, Lamiopsis, Loxodon, Prionace, Scoliodon, Triaenodon, Eusphyra</i>

Table – 2 —contd.

Order	Genera
Pristiformes :	<i>Anoxypristis</i>
Rajiformes :	<i>Rhina</i>
Myliobatiformes :	<i>Hypolophus</i>
Anguilliformes :	<i>Thyrsoidea, Gavialiceps</i>
Clueiformes :	<i>Dayella, Elirava, Hilsa, Raconda</i>
Gonorhynchiformes :	<i>Chanos</i>
Cypriniformes :	<i>Lepidopygopsis, Diptychus, Ptychobarbus, Oreichthys, Rohitee, Securicula, Bengala, Catla, Bhavania, Travancoria, Enobarbichthys, Neoeucirrhichthys, Somileptes</i>
Siluriformes :	<i>Horabagrus, Rama, Wallago, Pinniwallago, Neotropius, Proeutropiichthys, Amblyceps, Conta, Coraglanis, Erethistoides, Pseudecheneis, Sisor, Horaglanis, Ketengus, Batrachocephalus, Osteogeneiosus</i>
Stomiiformes :	<i>Triplophos</i>
Aulopiformes :	<i>Trachinocephalus</i>
Ophidiiformes :	<i>Tauredophidium, Spottobrutula</i>
Lophiiformes :	<i>Lophiomus</i>
Cyprinodontiformes :	<i>Euleptorhamphus, Xenentodon, Horaichthys</i>
Zeiformes :	<i>Cyttopsis</i>
Perciformes :	<i>Psammoperca, Cromileptes, Sillaginopsis, Lactarius, Rachycentron, Atropus, Elagatis, Gnathanodon, Megalaspis, Naucrates, Selaroides, Seriolina, Ulna, Apolectus, Mene, Aprion, Lipocheilus, Dipterygonotus, Gymnocaesio, Lobotes, Datnioides, Pentaprion, Diagramma, Crenidens, Gnathodentex, Monotaxis, Wattsia, Macrospinosa, Chrysochir, Daysciaena, Dendrophysa, Kathala, Otolithoides, Paranibea, Protonibea, Ephippus, Tripterodon, Badis, Rhinomugil, Pleuroscopus, Chiramenu, Apocryptes, Oxuderces, Incara, Ophieleotris, Ophiocara, Odontamblyopus, Paracanthurus, Acanthocybium, Gymnosarda, Katsuwonus, Xiphias, Ctenops, Eleutherochir</i>
Tetraodontiformes :	<i>Takifugu, Amblyrhynchotes, Tydemania, Mephisto, Pseudotriacanthus, Trixiphichthys, Abalistes, Chilomycterus, Lophodiodon, Ranzania, Mola</i>

INTRODUCED (EXOTIC) SPECIES

The history of introduced (exotic) fishes in the Indian water is more than a century old. The first such introduction can be said to be that of the English trout, *Salmo trutta fario* Linnaeus which Day in 1863 and 1867 attempted to introduce in the Nilgiri waters. However, it was Wilson in 1906 who succeeded with the rainbow trout. Different species of the genera, viz., *Salmo*, *Salvelinus* and *Onchorhynchus* of the family Salmonidae have been introduced at different times in the Indian waters. The members of this family are primarily denizens of the Arctic and northern seas. These fishes have been mainly introduced for game purposes and even now to a large extent they are fished for similar reasons. The gold fish, *Carassius auratus* Linnaeus and *Carassius carassius* Linnaeus, which occur in nature all over China, Korea, Japan, Taiwan, Europe, Siberia, East Asia, South to North Vietnam; have been introduced all over India as aquarium pet. The tench or shoemaker, *Tinca tinca* (Linnaeus) which naturally occurs in the freshwater of Europe and Western Siberia and part of Aral seas basin has been introduced into India. Both these gold fish and the tench or shoemaker were introduced in the Ooty Lake in 1874 by MacIvor as sport and ornamental fishes. These are now well established in the Nilgiri waters. Some other fishes have been introduced for commercial purposes. The silver carp, *Hypophthalmichthys molitrix* (Valenciennes), a native of South and Central Chinese rivers (River West and Yangtze) has been introduced in India and many other countries. This species was brought to India from Japan in 1959 and introduced in the ponds of CIFRI's fish culture division at Cuttack. The Bighead carp, *Hypophthalmichthys nobilis* (Richardson) naturally found in China has been introduced in the Indian waters for cultural purposes. The grass carp (also called white Amur), *Ctenopharyngodon idella* (Valenciennes), a riverine freshwater of Amur region (Siberia and Manchuria), North and South China, U.S.S.R., lower reaches of river Amur, has been introduced in India from Hong Kong in 1959. The consignment of grass carp was brought to Calcutta in 1959. The tilapia, *Oreochromis mossambica* (Peters), a riverine fish was introduced from its original home of East coast of Africa. It was brought from Bangkok and introduced in India in 1952. The gourami, *Osphronemus gorami* (Lacepede) was introduced from its natural habitats of Indonesia, Thailand, Malaya and Vietnam. It was first introduced in Calcutta during the first half of the last century from Java. A second lot was brought to Tamil Nadu from Mauritius in 1865. The common carp, *Cyprinus carpio carpio* Linnaeus with 3 of its varieties naturally found in China, Korea, Japan, Taiwan and Europe have been introduced in India at different times for cultural purposes. Two top minnows, *Gambusia affinis patruelis* (Baird and Girard)

and *Poecilia reticulatus* (Peters) naturally found in America have been introduced in India.

VALUE

Fishes, like many other forms of life, are of immense value to mankind. They are sources of protein, vitamins, minerals and a number of by-products such as liver oil, body oil, fish meal, fish flour, fish glue, isinglass, fish skin, fish protein, etc. The different species of marine and freshwater fishes can be used for a variety of purposes like food, sport, ornament and biological control. They have been a staple item in the diet of many people. Today they form an important element in the economy of many countries. Adverse effects (e.g., from the poisonous and man-eating species) are of immense concern in some areas. They are used as general indicators of pollution, partly to the direct benefit of mankind and partly to protect what people consider a valuable and necessary part of their heritage and life. Shark liver oil is considered to be a good source of vitamins and as such it has considerable medicinal value. This is why humanity should be concerned about preserving specifically the diversity of the fishes.

THREATS

There has been a considerable decline in the freshwater fishes of India in general and food and game fishes in particular. This decline is mainly due to indiscriminate fishing/exploitation and habitat alteration like dynamiting of rivers, construction of dams across rivers, over utilization of water, cutting down of forests, mismanaged farm lands and erosion, pollution by factory chemicals, competition from the introduced species, etc. Dams and weirs at higher reaches of tributaries of the major rivers of India have affected the world famous game fishes, the Mahaseers of India. The spawning runs of Mahaseers (species of *Tor*) and *Neolissocheilus hexagonolepis* have been affected. Mahaseers which used to grow to a size of 150 cm and a weight of 25 to 30 kg in the earlier days, have depleted and now catches of more than 5 kg size are rare. Dams and increased large-scale extraction of gravel stones (spawning niche of Mahaseers), silting of lakes and reservoirs are causes or threats for the decline. The shrinkage of wetland ecosystems is another threat to the production and growth of the freshwater fishes in particular.

Marine fishes are, however, not as much in danger as their counterpart in the freshwater ecosystems. But it should be kept in mind that the seas are not the place for the ultimate drainage of all kinds of waste products, as the seas harbour/shelter innumerable aquatic creatures which are providing the

mankind with different kinds of daily necessities. The pollutions of the seas or oceans will definitely affect the life of the terrestrial fauna.

CONSERVATION AND FUTURE COURSE OF ACTION

Fish and fisheries play a key role in bridging the yawning gap between the supply and demand in animal protein, in providing employment opportunities, international trade and in furthering the international co-operation among the developed and developing countries. In fact, it is the backbone of the economy to many island states. Keeping it in mind that the fishes are sources of protein, vitamins, minerals and a number of by-products necessary for the mankind, we should be very careful on the indiscriminate exploitation and habitat alteration of the fishing ground for protecting and preserving the diversity of fishes. Where dams and weirs are necessary to construct, the probability of the effect on the fish fauna should be carefully considered. Chemical wastes from the factories should not be allowed to drain their products in the water bodies. The shrinkage of the wetland ecosystems should be halted and undersized fish specimens should not be allowed/permitted to collect.

The world over, there is a greater concern today about conservation and management of the fish and fisheries resources and protection of environment than ever before. We must remember that the resources we exploit from the sea are bestowed to us by nature, to be preserved and handed over to next generations. We have no right to cause irreversible damage to the resource base, i.e., the fish fauna. It is, therefore, very essential that we give a high priority for the proper management and conservation of the marine fishery resources and especially the coastal fishery resources which is in occupation to the coastal people of India from the time immemorial, forming an integral part of the country's maritime heritage. Under the existing open access condition, fishermen are involved in a race to ensure their fair share of available fish stock and as long as this system continues, one can not expect responsible fishing. Fishermen should be told that they are only the custodians of the fishery resources and it is their responsibility to maintain their sustainability.

The care of the fishes, proper stocking of water body, observance of the legal size limits and permitted fishing methods and establishing of closed and open seasons are necessary for the protection and conservation of fish species. The most important consideration is the maintenance of stable ground water level for the protection and preservation of the fish fauna. All landscape alternations must be avoided and the use of herbicides and insecticides must be prohibited in the surrounds of the fishing ground. Even if the former

native fish species are missing from the chosen localities, artificial repopulation with indigenous species from other localities may be employed. A new integrated effort is now required for the protection and conservation of the fish fauna of India permanently, regardless of whether the species are small or large, palatable or unpalatable, provide good entertainment to the anglers and economically important or unimportant. Living indigenous fish fauna must be considered in the same way as any other cultural assets. If this is not given proper attention, it may well be that valuable genetic material will disappear forever.

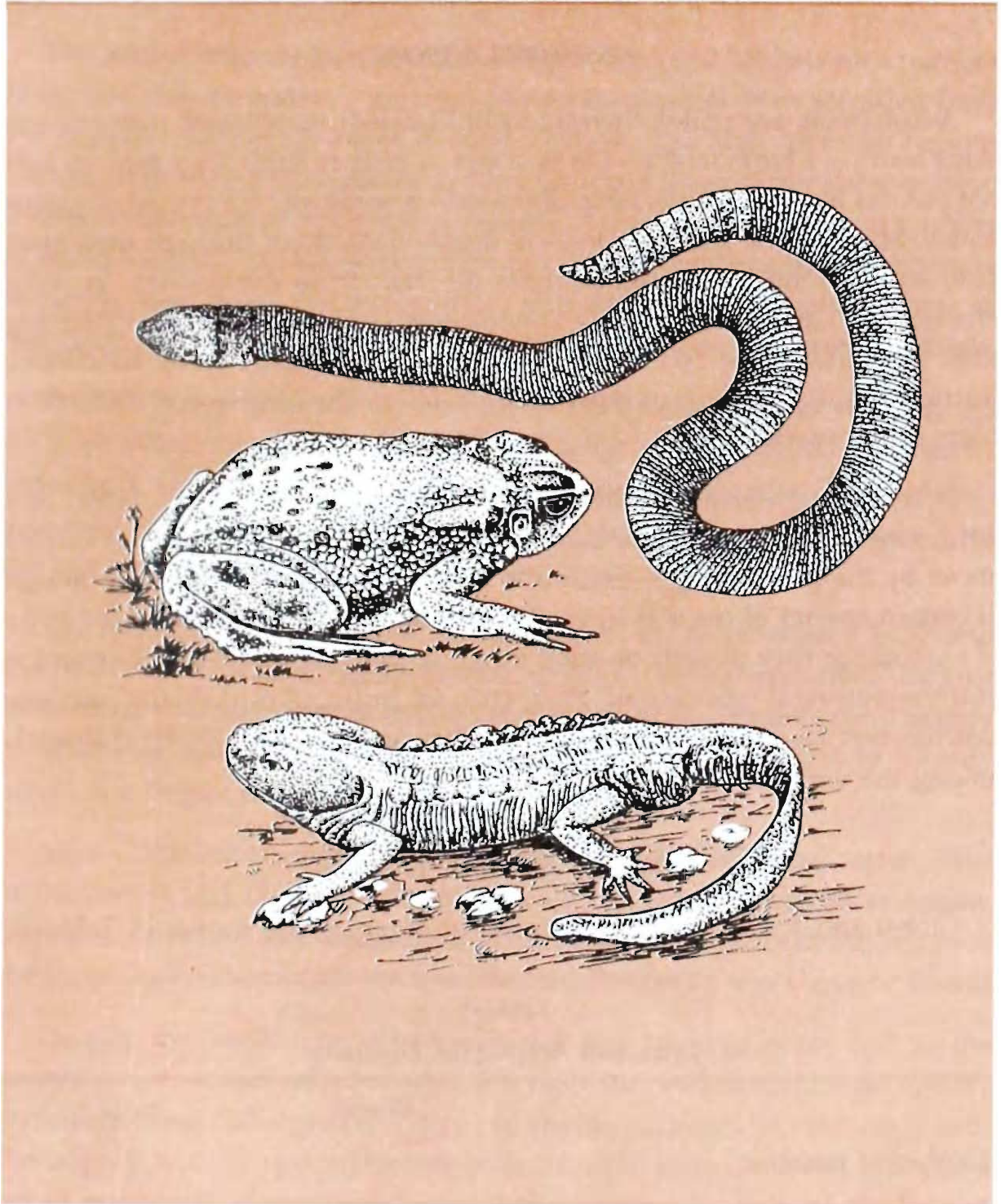
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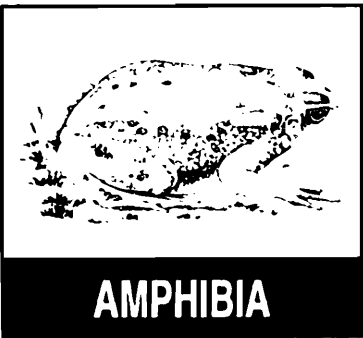
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Faunal Diversity in India : Amphibia

S. K. CHANDA

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Amphibians are poikilothermic (cold blooded) vertebrates with smooth skins leading a bimodal life - life in water as well as land. They may or may not possess limbs and tails. Amphibian skin is sensitive and devoid of visible scales. Much of the gas exchanges in amphibians occur through their skin. The skin secretion generally protects the skin from dessication. In some Neotropical amphibians (Family-*Dendrobatidae*), this secretion has extremely toxic properties. The fact that the skin has to be moist to be functional, restricts the distribution of most amphibians to the largely wet and warm parts of the world.

In most amphibians the life history is organized into eggs, larval and adult stages. The eggs may be freely deposited inside or near water or carried about by the parents. Eggs hatch into free-living larvae or tadpole, though in certain species of tropical frogs, the eggs hatch and grow within the body of a parent or they directly develop into tiny froglets. Direct development is known amongst species of *Philantus* in India. Amphibians include salamanders, caecilians, toads and frogs. They are the lowest group of animals among the vertebrates.

STATUS OF THE TAXON

Global and Indian Status of amphibian diversity are shown in Table 1.

Table-1
Estimated Amphibian Diversity

	World	India
Number of families	31	9
Number of genera	330	38
Number of species	5150	209

DISTRIBUTION

The abundance of amphibian species is very much uneven in India. The highest concentration of genera and species are in the Northeast region and Western Ghats (Table-2). The magnitude of the disparity between the two areas of highest diversity and the others shown in the table is partly a reflection of very unequal collecting intensity. This effect seems especially apparent in the case of Eastern Ghats (Table-2).

The semi-deciduous forests of that area provide good habitats for a number of species. Yet, no endemic arboreal anuran species has been recorded from the Eastern Ghats of Orissa or Andhra Pradesh. The high diversity regions are also those that until relatively recently had large areas of tropical evergreen forests, structurally complex environments, providing the maximum number of micro habitats. The interaction between forest environments and diversity is clearly seen when the proportions of bush and tree dwelling frogs of Northeast India and Western Ghats are compared to those in the other regions.

A small group of anuran species which are overlapping between regions are *Bufo melanostictus*, *Microhyla oranta*, *Euphlyctis cyanophlyctis*, *Limnonectes limnocharis*, *Hoplobatrachus tigerina* and *Polypedates leucomystax*. These species generally live in close association with man wherever they occur and all but the last have their ranges far beyond the borders of India.

The most distinctive regional fauna are from the Northeastern India and the Western Ghats. Chanda (1986), (1989), (1990), recorded largest concentration of 56 species from Northeast India, whose ranges extend mainly to Southeast Asia or China through Burma. In Western Ghats as already noted, the largest number of endemic forms occur.

Most of the Indian caecilians are confined to West Peninsular region. Two of the genera and 13 out of 16 species being restricted to Peninsular region. Intensive collection and observation in the near future will certainly increase the number of endemics known from the East Peninsular and Gangetic Plains.

Despite the present gaps in the faunal lists of large areas and in the known ranges of individual species, it is clear that Indian amphibian species constitute three distributional types : (i) species confined to Western Ghats, the largest unit; (ii) species known in India, only from northeast and (iii) a set of essentially ubiquitous species that comprise the bulk of the known fauna between the Western Ghats and Northeast.

Table - 2
Diversity in different geographical regions of India

Region	States included	Order	Genera	Species
Northwest	Jammu & Kashmir, Himachal Pradesh, Punjab, U. P. (Part)	Anura	9	21
West	Gujarat, Rajasthan	Anura	5	9
Deccan	Madhya Pradesh, Andhra Pradesh (Part), Bihar (Part), Maharashtra (Part), Tamil Nadu (Part)	Anura	7	19
Ganges-Brah- maputra Valley	U. P. (Part), Assam (Part), West Bengal (Part)	Anura	9	18
East Penin- sular	Orissa, Andhra Pradesh (Part), Tamil Nadu (Part)	Anura	8	21
Northeast	Arunachal Pradesh, Assam,	Anura	16	56
	Meghalaya, Manipur, Nagaland, Mizoram, Tripura	Caudata	1	1
West Penin- sular	Kerala, Maharastra,	Anura	17	101
	Karnataka, Tamil Nadu	Gymnophiona	4	13

ENDEMICITY

The Indian amphibian fauna has a number of endemic genera and species. In Western Ghats, a total of 92 species are found to be endemic and 35 species are endemic to Northeast India. One species, namely the Himalayan Newt, *Pleurodeles verrucosus* is at present included in Schedule II of the Indian Wildlife (Protection) Act, 1972 as amended from time to time. This species is known only from Darjeeling, Sikkim and Manipur. This is the only species of Salamander known from India and the population being in pockets is considered endangered. However, the exact population status of this species is not known. The Malabar tree toad, *Pedostibe tuberculosus* from Malabar (Kerala) and the Garo hills tree toad *Pedostibes kempi* from Tura, Garo hills, (Meghalaya) have also become extremely rare.

VALUE

Amphibians are of great scientific as well as economic importance. Amphibians are least harmful in nature and never devour or destroy agricultural crops, fruits, vegetation, etc. On the contrary, their food mainly consists of small insects and their larvae, snails, etc., which are pests of cultivated crops and vectors of diseases. Therefore a decline in amphibian population can have an adverse effect on the ecosystem as a whole. Moreover, a number of species are being used for biological laboratories as well as in educational institutions.

THREATS

Due to the modern agricultural technology, the ecosystem of our country has been adversely affected. The indiscriminate use of pesticides and artificial fertilisers has caused significant changes in the quality of water in which the amphibians spend the sensitive part of their life. On the other hand, the natural habitats of the amphibians, *viz.*, wetlands, have been drastically reduced due to urbanisation and industrial development. The extensive deforestation in our country has also damaged the natural habitats of the amphibians. Thus, the habitat destruction, over exploitation, indiscriminate capture of frogs and pollution have not only reduced the amphibian population of our country but also disturbed the ecological balance resulting in the multiplication of such insect vectors as mosquitoes which constitute major food item.

CONSERVATION

It is unfortunate that still not much attention has been paid to the conservation of amphibians. If the present rate of exploitation and habitat destruction continues the frog population would dwindle, a trend already discernible since 1980. Thus, it is high time for taking steps to conserve the amphibian resources of India for which following measures are suggested :

(i) A number of frog breeding centres should be established for artificial breeding of frogs and other commercially important amphibian species ; (ii) as the mortality rate of the tadpoles are very high, steps should be taken to collect and rear them in artificial ponds to increase the population of the adults; (iii) rigid restriction regarding the period of collection and size of the frogs must be observed so as to provide them a chance for breeding and (iv) the life cycles of the vulnerable forms should be studied in the laboratory.

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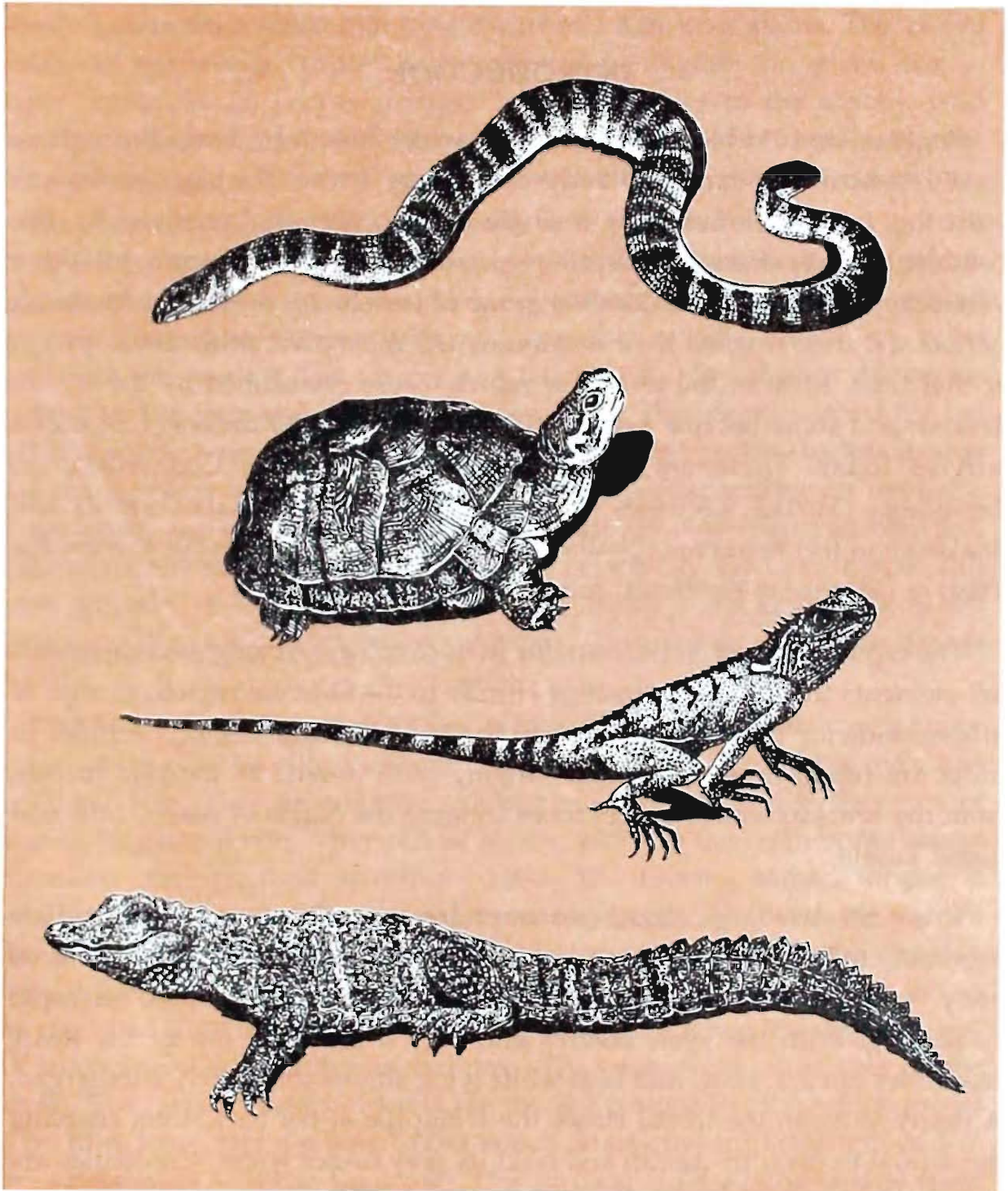
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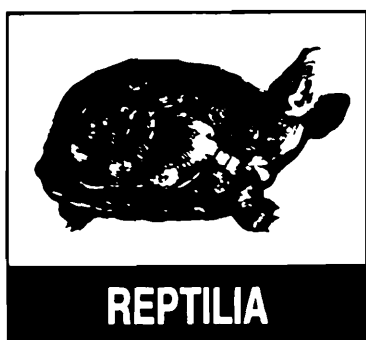
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Faunal Diversity in India : Reptilia

T. S. N. MURTHY AND M. S. RAVICHANDRAN

Zoological Survey of India, Southern Regional Station, Chennai – 600 028





INTRODUCTION

Reptiles are cold-blooded vertebrates which breathe by lungs throughout their existence and have the body covered by scales; the skull articulates with the vertebral column by a single median occipital condyle. By this combination of characters reptiles can be distinguished from all other vertebrates. They were the dominant group of vertebrates during the Mesozoic period and they reached their maximum and most diversified development at that time. Most of the orders of reptiles were established by the end of Triassic and some became extinct at that time. Of the 19 orders of reptiles 4 survive today. These are (i) Crocodylia (Gharials and Crocodiles); (ii) Testudines (Turtles, Tortoises and Terrapins); (iii) Squamata (Lizards and Snakes) and (iv) Rhynchocephalia which includes a single living species, the Tuatara (*Sphenodon punctatus*) found only in New Zealand.

The reptile fauna of India is unique in its diversity. Among its components are elements that have the greatest affinity to the Oriental region, as well as others, showing close relationship to the Indo-Malayan region. Reptiles in India are found in environments ranging from deserts to the rain forests, from the brackishwaters and beaches fringing the coasts of plains, hills and dense jungles.

Crocodiles are large, lizard-like amphibious reptiles found in immediate proximity to large lakes, swamps, marshes and rivers. The heavily armoured body, with its long and strong muscular tail, is well adapted to rapid swimming. With the eyes, nostrils and ears situated on top of the head, crocodiles can see, smell and hear while lying almost completely submerged. A fleshy valve in the throat closes the windpipe at the back, thus enabling the reptile to open its mouth and hold its prey under water. Crocodiles are carnivorous animals and relish meat or flesh. They are oviparous, laying several dozens of hard-shelled eggs in shallow excavations near the water edge.

Turtles are the only reptiles which have a shell. The characteristic dome-like shell, which serves as a protective armour of the turtle, is composed of two parts : an arched upper part called carapace, and the flat lower part, plastron, joined on either side by a bony bridge. Turtles are toothless but they have a beak with horny sheaths. They chew their food only to reduce it for swallowing. They are omnivorous, and like other reptiles, can survive without food for months. Although they are proverbially slow in movement, the turtles are powerful swimmers. All turtles nest on land. They vary greatly in size from a 300 mm long dwarf to 1.8 m long giants. The varied usage of the words "turtle" and "tortoise" in English has given rise to much confusion. In proper usage, "tortoise" refers to the strictly land dwelling species with elephant-like stubby feet and "turtles" are the aquatic forms inhabiting the sea, rivers and ponds with either flippers or webbed toes.

Lizards, characterised by a short body with four well-developed limbs, a short, flat tongue and an external ear-opening. Some limbless lizards which have elongated bodies are snake-like in appearance but they can be identified by their distinctive ear openings and movable eyelids which are quite foreign to the snakes. The tongue of a lizard is employed as a device for lapping up the prey and also as a sensory organ. The ability to shed the tail and regenerate a new one in its place is possessed by geckos, legless lizards and skinks. Most of the lizards can change colour, depending on the light, temperature, and the mood of the animal. Males are larger, quarrelsome and brilliantly coloured than females. Lizards principally feed on insects and small animals. In size, Indian lizards range from a 5 cm long skink to the 2.5 m long Water Monitor (*Varanus salvator*). There are no venomous lizards in India.

Snakes possess elongated bodies which are covered with overlapping scales which may be either smooth or keeled. They lack movable eyes and functional legs. They do not have external ear-openings and so they cannot hear in the normal way. They can, of course, pick up the earth-borne sound vibrations through their sensitive bodies. The flicking forked tongue is harmless and it is mainly employed as sensory organ. The teeth are needle-like and pointed backward, which enable the snake to grab the slippery prey. Poisonous snakes have hypodermic needle-like fangs which are in fact the modified front teeth used for injecting the venom when the snake strikes. All snakes hunt and eat live animal prey. The youngs are miniatures of the adults. The largest snakes of India are the Reticulated Python which grows to be 10 m long and the king Cobra which attains the record length of 5 m for a poisonous snake in the world. The smallest are the blind snakes some of which are less than 30 cm in length. Of about 240 species of snakes of India, some 52 species are venomous in nature.

STATUS OF THE TAXON

Global and Indian status

A comparison of the global and Indian reptilian diversity as per available information is shown in Table – 1.

Table – 1

Class	Families (N)		Species (N)		%
	World	India	World	India	
Crocodylia	3	2	22	3	
Testudines	13	5	242	31	
Squamata					
Lacertilia	20	8	2808	178	
Serpentes	13	10	2744	244	
Rynchocephalia	1	–	1	–	
Total	50	25	5817	456	7.84

According to a recent estimate the countries leading in possessing a rich and diverse reptilian fauna are Mexico, Australia, Indonesia, Brazil, Colombia, India, Ecaudor, Peru, Malaysia and Thailand in that order. A brief synopsis of the composition of the reptilian fauna of India is given in Table – 2.

Table – 2

Order	Family	No. of species
Crocodylia (Crocodiles)	Crocodylidae	2
	Gavialidae	1
Testudines (Turtles & Tortoises)	Dermochelyidae	1
	Cheloniidae	4
	Bataguridae	16
	Testudinidae	4
	Trionychidae	6
Lacertilia (Lizards)	Gekkonidae	61
	Agamidae	45

Order	Family	No. of species
Serpentes (Snakes)	Chamaelonidae	1
	Dibamidae	1
	Scincidae	55
	Lacertidae	10
	Anguidae	1
	Varanidae	4
	Typhlopidae	16
	Xenopeltidae	1
	Uropeltidae	33
	Boidae	4
	Acrochoridae	1
	Colubridae	132
	Dasypeltidae	1
	Elapidae	17
	Hydrphiidae	20
	Viperidae	19
Total		456

DISTRIBUTION

Among the components of Indian reptilian fauna are representatives that have the greatest affinity to the Oriental Region, as well as others influenced by the Indo-Chinese and Indo-Malayan areas. The climate, varying vegetation and the soil of India offer a great range of biotopes for the highly diverse fauna of the reptiles in India. It is not surprising then that the pockets recording a heavy rainfall with a canopy of thick rain forests such as the Western Ghats, northeastern India and the Andaman and Nicobar Islands hold between them the lion’s share of India’s lizards and snakes. Almost the entire snake family, Uropeltidae (33 species) comprising the primitive burrowing snakes is restricted to the Western Ghats. Some 67 genera and nearly 56 genera of Indian reptiles are found in the Western Ghats and rainforests of northeastern India.

The Marsh or Freshwater Crocodile (*Crocodylus palustris*) is the most widely distributed of all the Indian crocodiles as it is a highly adpatable

species being found in stagnant waters, jheels, reservoirs, tanks and rivers with placid current, throughout India. Though it is called "Marsh crocodile" it is reported from the Himalayan foothills as well as the arid tracts of Rajasthan. Its present breeding populations are found in Airan Lake, Gir Sanctuary (Gujarat) and Amaravathi Reservoir (Tamil Nadu). The Indopacific Crocodile (*Crocodylus porosus*) is restricted to parts of the east coast of the States of Orissa and West Bengal (Sunderbans) and to some pockets of the Andaman and Nicobar group of Islands. The Gharial (*Gavialis gangeticus*) is mainly an inhabitant of the fast-flowing rivers of northern India. It presently is found in the Indus, Ganges, Brahmaputra and Mahanadi and extends its range outside India to Nepal, Bangladesh, Burma and Pakistan.

Barring five species of marine turtles which nest on our coasts, of the remaining 25 species, a majority of the emydid and softshelled turtles inhabit mainly the rivers of northern India. The land dwelling tortoises are confined to the hills of eastern India and Western Ghats. The Gahirmatha beach of Orissa is reckoned as the world's largest rookery for the Olive ridley (*Lepidochelys olivacea*). The Cochin (Kavalai) forest cane turtle (*Geoemyda silvatica*), which was supposed to have become extinct as it was not collected since its discovery in 1911, has been collected in 1982 again. The critically endangered river turtle (*Batagur baska*) is found in the estuaries around the Sunderbans of West Bengal.

Available information on distribution of lizards shows that the Eastern Himalayas and the forests of the Western Ghats closely followed by the Western Himalayas are homes to more than two-thirds of the lizard fauna of India.

Snakes, as a major group of reptiles, are widely distributed all over India from the higher elevations of the Himalayas to the land's tip in Kanyakumari. They live on and below the ground, in trees and in fresh as well as salt water.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

Of the three species of Indian crocodiles, the mugger (*Crocodylus palustris*) and the Saltwater crocodile (*Crocodylus porosus*) look very much alike and are distinguishable only on the basis of proportions of the snout after they are fully grown. However, the gharial (*Gavialis gangeticus*) can be rather easily recognised by its unique extremely long and slender snout. The turtles of India exhibit remarkable capabilities of modification to suit their existence in different niches such as the sea, rivers, plains and forests. Apart from the

characteristic bony shell, marine turtles have paddle-like limbs. The freshwater turtles or terrapins have hard shells and partially webbed feet whereas the soft shells have a disc-like shell covered with soft skin, tubular nostrils and fully webbed toes. The land tortoises have high-domed carapaces and blunt elephant-like webless feet in keeping with their terrestrial habits. As for the lizards and snakes which are widely diversified. The shape of the body gives the clue to the habits of the species. While a majority of the lizards are characterised by well-developed limbs, a few which lack them can be differentiated from snakes by the presence of eyelids. Snakes have elongate bodies and lack limbs, eyelids and an external ear-opening all of which are characteristic features of a typical lizard. The adaptive radiation is best shown by the huge assemblage of snakes of the major family Colubridae. As might be expected of such widely distributed snakes the Colubrids are found in a wide range of habitats, some are terrestrial, some fossorial, some aquatic, and some estuarine. The snakes of the families Elapidae, Hydrophiidae and Viperidae are highly venomous. The fangs of the cobra and its allies, such as, the krait, the coral snake and the sea snake are short, grooved and immovably fixed to the front of the upper jaw while the fangs of a viper are long foldable and can be erected at the time of striking.

The lizard fauna of India is moderate in terms of diversity on a world wide basis. There are no venomous lizards in India. That the reptilian fauna of India is mainly dominated by Indo-Chinese element is a well known fact. As regards the lizard fauna, it can be found that the eastern Himalayas and all the northeastern States of India are profoundly influenced by the Indo-Chinese connection. A most significant peculiarity is the discontinuous distribution exhibited by the genus *Draco* ('flying' lizards) whose present day representatives are found in eastern India and again in the Western Ghats with a wide intervening gap. Likewise, the skinks of the genera *Dasia*, *Lygosoma*, and *Scincella* have the same or allied species occurring in the eastern India and Western Ghats. The richest concentration of lizard fauna is in two regions of India namely the Eastern Himalayas and Western Ghats. The lizard fauna of the Nicobar Islands exhibits its Malayan affinity in the presence of a sole representative each of the genera *Ptychozoon* ('Flying' Geckos) and *Dibamus* (Worm Lizard).

The geckos (Family Gekkonidae) are hardy reptiles which can survive long periods without food and are often transported in the cargo of ships. The presence of some geckos such as *Cnemaspis kandiana*, *Gehyra mutilata* and *Lophopholis scabriceps* in India is probably due to their introduction through human agency.

The snake fauna of India comprises elements from three zoogeographical regions namely the Oriental, Indo-Chinese and Indo-Malayan with some

entrants from outside these regions. The majority of the primitive burrowing snakes with modified tails of the Family Uropeltidae are to be found only in the various hill ranges of Western Ghats with only 11 out of 44 species known, being found in Sri Lanka and nowhere else in the rest of the globe. Likewise, the five species of the Oriental Worm Snakes included in the Genus *Trachischium* found in the Eastern and Western Himalayas are a unique addition to the snake fauna of India. The rare Egg-eating snake *Elachistodon westernmanni*, the second species of the Family Dasypeltidae, is another peculiar and interesting addition. It is reported from a few pockets in the districts of Purnea (Bihar) and Jalpaiguri (West Bengal). The genus of hill species, *Xylophis*, confined to the Western Ghats of India and found nowhere else in the world is yet another interesting addition to the snake fauna of India.

ENDEMIC AND ENDANGERED SPECIES

All the three species of Indian crocodiles are now listed as endangered. Among the turtles, the edible species are severely threatened while the land tortoises have become scarce. The River terrapin seems to be critically endangered. The four monitor lizards of India are declared endangered. However, the status of several species of Indian lizards, such as, the spinytails and sand-living skinks are also causing concern. According to a recent study by Murthy and Sanyal (1993 : 'Rare Snakes of India' The Snake 25) some seventy species of Indian snakes are either extremely uncommon or rare and the distribution and status of nearly 17% of the known snake fauna is rather uncertain and is in doubt.

The Golden Gecko (*Calodactylodes aureus*) found in the Eastern Ghats is a unique species endemic to India. The four endemic species of the Cat Skinks of the genus *Ristella* restricted in their distribution to the Western Ghats are unique addition to the family Scincidae. Likewise, among the agamid lizards (Fam. Agamidae), mention should be made of the Fan-throated Lizard (*Sitana ponticeriana*) and the Rock Lizards of the genus *Psammodromus* which are unique to India. The Barkudi burrowing skink (*Barkudia insularis*), which can be reckoned as the world's most endangered skink, is a significant and interesting addition to the lizard fauna despite the fact that it has become scarce, even in the type-locality.

Some threatened species of reptiles in India is listed in Table – 3.

Table – 3

Some threatened Reptiles in India

Group	Family	Species
Crocodiles	Gavialidae	<i>Gavialis gangeticus</i>
	Crocodylidae	<i>Crocodylus porosus</i> , <i>Crocodylus palustris</i>
	Dermochelyidae	<i>Dermochelys coriacea</i>
	Cheloniidae	<i>Caretta caretta</i> , <i>Chelonia mydas</i> , <i>Eretmochelys imbricata</i> , <i>Lepidochelys olivacea</i>
Hardshelled turtles	Bataguridae	<i>Batagur baska</i> , <i>Kachuga tecta</i>
Softshelled turtles	Trionychidae	<i>Lissemys punctata</i> , <i>Aspideretes hurum</i> , <i>Aspideretes gangeticus</i>
Lizards	Varanidae	<i>Varanus salvator salvator</i> , <i>Varanus bengalensis</i> , <i>Varanus flavescens</i> , <i>Varanus griseus koniczmyi</i>
Snakes	Boidae	<i>Python molurus molurus</i> , <i>Python reticulata</i>
	Colubridae	<i>Elachistodon westernmanni</i>

VALUE

Reptiles are a most important group of predators, the interaction of which maintains the natural balance in the forests and deserts, rivers and lakes and the plains and hills of India. Crocodiles are master predators and play a key role in recycling of nutrients. The role played by the crocodiles in keeping down the populations of predatory fishes in our lakes, estuaries and river systems can not be overemphasised as studies of some crocodiles, such as, the gharial proves. The Indian gharial is found to prey on ‘Goonch’, the greatest destroyer of eggs and young of the commercially important fishes of the Gangetic system. When crocodiles are absent predatory fishes multiply and consume all the smaller fishes of commercial value and adversely affect the fishery interests. Turtles are not mere animals for

worship but they play a vital role in keeping a check on the growth of water weeds as otherwise the unchecked weed growth can be disastrous to the aquatic life. Some species found in the major rivers of India used to feed upon the half-burnt human corpses which helped in the recycling of nutrients and keeping the river system clean. Lizards and snakes mostly feed on different kinds of insects including the pest species. The monitor lizards are efficient destroyers of the coconut pests like crabs, beetles and snails. By eating insects, rat and mice, many of which may carry disease and damage crops, snakes perform a major ecological role. There is no vegetarian snake in nature and hence the feeding habits of snakes are of more than passing interest to us. Because of their mode of life and feeding habits snakes are perfectly suited to follow the rat down to its hole and finish off both the young and adult alike. The venomous snakes are kept in captivity for the production of antivenin and other medical purposes.

In his quest for food man has not spared the reptiles. Since time immemorial turtles, of all the reptiles, gained culinary importance and provided staple diet to man. The Green sea turtle is a rich source of protein. Freshwater tortoises of the genera, such as, *Hardella* and *Kachuga* and river turtles of the genus *Aspiderates* found in the Ganges and Brahmaputra river systems are captured in large numbers for food. The eggs of monitor lizards are a great delicacy and the animals themselves provide a wholesome meal. The spiny-tailed lizard, *Uromastix hardwickii* is considered good for eating and specially the curious tail of the lizard is most favoured. The demand for the reptilian-derived skin, in particular the crocodiles, monitor lizards and the rat snake is so well known that it needs no mention here. The monitor lizards and some curious-looking forms have become "medicinal" species because of the purported value of their fat as medicine for curing human disorders. Thus, the preparations made from the visceral fat of the monitors, spinytails and some desert-dwelling skinks are said to be effective as aphrodisiacs.

THREATS

A great number of living reptiles of India, are slowly disappearing mainly due to the increasing human interference. Not only are reptiles deprived of their habitats but their direct persecution and slaughter are intensified by the rapid growth of industrialization and land exploitation.

With the growing demand for their skin, ruthless killing of the harmless as well as the venomous kinds of snakes continue unabated. So much so, in some parts of the country the entire populations of some of the formerly abundant species, such as, the Rat Snake are wiped out. In India yet another

natural hazard is the devastating forest fire. Snakes seem to make little attempt to escape when a forest fire is about to engulf them. In the circumstances we do not know how many species of snakes disappear from the scene if the whole of the biotope is destroyed.

Crocodiles are primarily threatened by the gradual destruction of their habitat and hunting for their skin. A lesser but a cause for concern is the egg collection for food and occasional killing of crocodiles indulged by some tribals notably in the Andaman and Nicobar group of Islands. The destruction of mangroves for converting them into rice fields has severely limited the survival chances of the vanishing Indopacific crocodile. The depletion in the populations of the gharial is the direct consequence of huge dams and barrages constructed over the reptile's abode-the River Ganges and its tributaries. The fishermen have also turned adversaries of crocodiles because they complain the depletion in their catches is due to the presence of crocodiles in the traditional fishing grounds.

Turtles of all kinds are on the decline now because of their direct persecution in their habitat by man. The meat and eggs of all species are edible and their skin is valuable. The other factors that endanger the turtles are the effects of deforestation, pollution and destruction of habitat. The environmental pollution, has had unforeseen effects on the water systems, particularly such as the River Ganga. The accumulation of the stinking human corpses/half burnt bodies in the absence of natural scavengers in water like the turtles, is causing a serious hazard not only to the aquatic life but also to the inhabitants on the banks of the river.

The clearance of their original habitats, the destruction of virgin forests and their indiscriminate killing/capture are the chief factors responsible for the decline in the lizard fauna of India. The famous herpetologist, Malcolm Smith, has as early as 1935, warned of the severe consequences that might eventually lead to the disappearance of the giant lizards such as monitors if the trade in the lizard's skin continues unabated. True to his words the skin trade has today drastically reduced the abundant populations of all the Indian monitor lizards. The unabated exploitation of the monitors and the spinytailed lizards for their edible meat and medicinal fat is another grave threat facing these reptiles.

The IUCN's list of threatened animals (1988) includes the Indian Python (*Python molurus*) as 'Vulnerable' and the Acellate Cobra (*Naja oxiana*) as 'Endangered'. The Indian Wildlife (Protection) Act, 1972 accords protection to the Pythons and the Indian Egg-eating snake (*Elachiston westermanni*). But the populations of the once abundant Rat snake (*Ptyas mucocous*) and the

common cobra (*Naja naja*) have been greatly reduced because of the demand for their skin in international market. The populations of several rare hill species of snakes are depleted with the gradual loss in the forest cover for them. To illustrate an example the author in a study of over two decades could collect only 21 species of the unique burrowing snakes of the family Uropeltidae (Shieldtails), confined to the Western Ghats. However, the literature records that the Western Ghats are home to as many as 33 species of these snakes. Like the Uropeltids, the status of several species is in doubt and we do not know how many of them have become extinct.

CONSERVATION STRATEGIES AND FUTURE STUDIES

Since the survival of reptiles, which are closely associated with our religion, art and culture is of paramount importance we have to initiate additional conservative measures over and above the steps taken by the Government in affording protection to several reptiles under the Indian Wildlife (Protection) Act 1972 and by clamping a total ban on the capture killing of some rare species. While it can now be safely assumed that the crocodiles are given a fresh lease of life thanks largely to the conservation measures initiated by the Government and the captive breeding programme undertaken by the Madras Crocodile Bank, it should be realised that the wild habitats of these reptiles should continue to be protected. It is also suggested that suitable areas for the purpose of breeding and restocking of the crocodiles should be identified. As for the conservation of sea turtles, any activity that hampers the breeding cycle of the species visiting our coasts should be avoided. Also, the sea turtle nests should be protected from both the man and the beast. It is also essential to involve local people and seek their cooperation in protecting the turtle habitats. A significant strategy aimed at conserving the unique lizards and snakes is the creation of nature reserves for them in remote regions inaccessible to man. In areas of this kind, it is still possible to preserve whole ecosystems in which all reptiles have their appropriate niches. Most important is public education to make the people aware the value of reptiles and their relevance to mankind. Despite the legal protection afforded to the reptiles and the increasing awareness among the educated public about the beneficial role played by the reptiles in nature the real problem is that we have yet to make the layperson realise that the reptiles are an integral part of the environment and that they too are part of the biological resources that can be renewed.

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Faunal Diversity in India : Aves

S. S. SAHA

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

Class Aves of the phylum Chordata includes the fascinating warm blooded vertebrate creatures which are known as Birds. They are characterized by the presence of feathers which serve many purposes like insulating the body and contributing to the flying apparatus of wing and tail.

STATUS OF THE TAXON

Global and Indian Status

Birds evolved about 150 million years ago, their diversification of forms were noticeable sometime during 60 million years ago. Since then speciation process continued rapidly and majority of the families and many genera living today have already appeared some 11 million years ago. By virtue of their flying ability, birds have great mobility and dispersed over every corner of the planet. Birds have colonized in the arctic tundra, in the hottest deserts, in the dense forests, all over the continents including the remotest oceanic islands, and even explored the vastness of the oceans and the houses of the human dwelling. Many species are gregarious, teaming in flocks of thousands while others are solitary or move in pairs and in small parties of 5-20. World List of living birds computes about 9026 species (Morony, Beck and Farrand, 1975) under 1800 + genera, 182 families and 30 orders. About 437 species and subspecies have been designated threatened for their survival (Red Data Book. Vol. 2, 2nd Ed.), but many more are likely to be covered under this category and some are at the brink of extinction unless concerted measures are taken in time for habitat preservation as well as species conservation.

The Indian subcontinent has 1232 species, 2123 species and subspecies under 78 families and 20 orders. And India can boast of having 1166 species, 1964 species and subspecies under the 405 genera and same number of families and orders as above. About 47 species have been designated as threatened, of them 3 are suspected to be extinct, namely, the Mountain Quail, Pink

Headed Duck and Forest Owlet. Yet another, Jerdon's Courser which was also bracketed with them has recently been redicovered.

The avifauna abridges Palearctic, Oriental, Ethiopian and Australasian zoogeographic regional elements, in addition to its 176 endemic forms. About 350 migrating species and subspecies winter in Indian territory while some migrate to neighbouring regions from India. Geographical diversity in India, its topographical features, climate, vegetation, etc., which is often referred to representing almost every feature of the planet, offer excellent habitats of diverse nature to suit almost all branches of adaptive radiation in birds, and each habitat has been suitably colonized by one form or the other separately or collectively.

DISTRIBUTION

India has several zoogeographical regions; of them the Himalayas, Gengetic plains, Western Desert and Arid-Zone, North-eastern Hill states, Andaman & Nicobar, and Lakshwadweep & Minicoy Islands are important. These biotic regions cover altitudinal range from the sea level to the World's highest point, vegetational diversity from sandy deserts to snow clad moution peaks through scrub jungle, shrubs to pristine high forests of Alpine, Temperate, Subtropical and Tropical Forests of various forms including the Tropical Rain Forests, and from continental landmass to isolated islands amidst vast oceans and seas.

Although through the ages, change in ecology accentuated by the change in land use pattern, much of the pristine bird habitats have been subjected to mutilation or extermination. Yet residual habitats today are still somewhat comfortable and can sustain viable population unless further deterioration occurs. Distribution of every species and/or its associating fellow birds and other biotic elements is largely dependant on the access to the place, availability of food, nesting ground and shelter toogether with other ecological factors. Since there has been change in various degrees in gross ecology and over all pattern of geographical features coupled with human activities, there has been a change in distribution pattern of many species of birds. In the process, there have neen noticeable shrinkage in range, in population, so much so that some species have bocome rarer or have been exterminated altogether from many places of their previous abundance.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

As stated earlier, India contains 1166 species, 1964 species and subspecies in 405 genera, 78 families and 20 orders (Table 1).

Table – 1
Species diversity

Order	Family	Number of	
		World species	Indian species
Gaviformes	Gaviidae	4	2
Podicipediformes	Podicipedidae	20	3
Procellariiformes	Procellariidae	80	7
	Hydrobatidae	22	3
Pelecaniformes	Phaethontidae	4	3
	Pelecanidae	8	2
	Sulidae	9	3
	Phalacrocoracidae	41	5
	(family Anhingidae included)		
Ciconiiformes	Fregatidae	5	3
	Ardeidae	70	20
	Ciconiidae	17	8
	Threskiornithidae	31	4
	Phoenicopteridae	6	2
Anseriformes	Anatidae	158	43
Falconiformes	Accipitridae	223	54
	(Family Pandionidae included)		
Galliformes	Falconidae	61	12
	Megapodidae	121	1
	Phasiandae	185	43
Gruiformes	Turnicidae	15	3
	Gruidae	14	6
	Rallidae	162	17
	Heliornithidae	3	1
	Otididae	25	5
Charadriiformes	Jacanidae	8	2
	Haematopodidae	9	1

Order	Family	Number of	
		World species	Indian species
	Charadriidae	152	56
	Rostratulidae	2	1
	Recurvirostridae	8	3
	Dromadidae	1	1
	Burhinidae	9	2
	Glareolidae	16	5
	Stercorariidae	7	3
	Laridae	90	28
Columbiformes	Pteroclididae	16	6
	Columbidae	306	27
Psittaciformes	Psittacidae	360	12
Cusculiformes	Cuculidae	130	21
Strigiformes	Strigidae	158	29
	Podargidae	26	2
Caprimulgiformes	Caprimulgidae	80	7
Apodiformes	Apodidae	87	15
Trogoniformes	Trogonidae	38	3
Coraciiformes	Alcedinidae	90	12
	Meropidae	26	6
	Coraciidae	17	3
	Upupidae	11	1
	Bucerotidae	49	9
Piciformes	Capitonidae	85	9
	Inindicatoridae	13	1
	Picidae	216	32
Passeriformes	Eurylaimidae	14	2
	Pittidae	25	5
	Alaudidae	77	19
	Hirundinidae	80	13
	Laniidae	78	8
	Oriolidae	28	4
	Dicruridae	20	9
	Artamidae	10	2

Order	Family	Number of	
		World species	Indian species
	Sturnidae	19	17
	Corvidae	111	21
	Bombycillidae	8	2
	Campephagidae	72	14
	Irenidae	14	6
	Pycnonotidae	126	18
	Muscicapidae	933	324
	Troglodytidae	65	1
	Cinclidae	5	2
	Prunellidae	12	7
	Paridae	45	17
	Sittidae	22	8
	Certhiidae	6	4
	Motacillidae	54	19
	Dicaeidae	58	9
	Nectarinidae	116	14
	Zosteropidae	86	1
	Ploceidae	270	25
	Fringillidae	123	42
	Emberizidae	283	16

About 350 species and subspecies are migratory and the rest are resident.

MONOTYPIC GENERA

There are 25 monotypic genera known, they are : *Anastomus*, *Aix*, *Rhodonnessa*, *Netta*, *Cairina*, *Butastur*, *Torgos*, *Lerwa*, *Tetraophasis*, *Ophrysia*, *Catreus*, *Sypheotides*, *Hydrophasianus*, *Metopidius*, *Limnodromus*, *Eurynorhynchus*, *Philomachus*, *Recurvirostra*, *Ibidorhyncha*, *Dromas*, *Phoenicomaias*, *Aceros*, *Propyrrhula*, *Haematospiza* and *Pyrrhoplectes*.

ENDEMIC SPECIES

About 176 species, contained in 106 genera, 39 families and 11 orders are endemic to Indian subcontinent. Many of them are spill over to Pakistan, Nepal, Bhutan, Bangladesh, Myanmar and Sri Lanka. Many species are relictual. And 50 species, 11 genera are endemic to India exclusively. Besides, 106 endemic species of the subcontinent also occur in India.

INTRODUCED SPECIES

There are stray accidental introduction of exotic species in India, chiefly concerned with the escaped imported pet birds like Javan Sparrow, but, such species seem to be gradually exterminated by now. Until recently, before the trade restriction, there has been a considerable import of exotic species of family Psittacidae and Phasianidae mainly from southeast Asian countries, Australia, South American countries and Africa, by authorised menageries and also by private collectors. Macacow, Cockatoo, Lory, Pheasants, Coccyzidae, etc. are well represented exotic species in captivity.

RARE AND ENDANGERED BIRDS

There are various degrees of threats and birds are categorized accordingly as Endangered, Threatened, Vulnerable, Rare and Extinct. Pinkheaded Duck, Mountain Quail and Forest Owlet are suspected to be extinct. Jerdon's Courser was also thought to be extinct but rediscovered recently. In addition to these, there are Rare and Vanishing species. There are 24 species exceedingly rare 31 species critically endangered. Besides, local population of many birds, specially in the areas of drastic change of land use pattern through industrial set up, mining, river valley projects, deforestation of various purpose and other human activities, have been subjected to the adverse impact of them and resulted in dwindling or withering away.

Due to hunting, trapping and trade, taxa belonging to 'Game birds' and 'Ornamental birds' belonging to family Ciconiidae, Threskiornithidae, Phoenicopteridae, Anatidae, Phasianidae, Megapodidae, Gruidae, Otidae, Columbidae and Bucerotidae are suspected to be under threat. Predaceous species belonging to family Falconidae and Strigidae have been suffering from the impact of chemical pollution and trapping. Pesticides have also played havoc to many species of insectivorous and some graminivorous birds of the order Passeriformes. More importantly, habitat destruction has created detrimental effect specially to forest dwelling species of various orders and also the piscivorous species, when Water pollution played its

role. Schedules I of the Indian Wildlife (Protection) Act, include the threatened species of birds.

VALUE

There are ethical, social and economic relation between man and the birds besides other relation. Economic relation is many fold. Birds are friends as well as foes to mankind. Some are beneficial being agent for pollination, germination and dispersal of seeds of plants, for controlling pests like insects, rodents, etc., scavenging the carcasses and offering flesh and eggs for the table. On the other hand, destroying crop in field as well as in ponds by devouring seeds and fishes likewise, and helping in spreading diseases, birds also become our enemy. Besides, birds offer themselves as prey species and many others depend directly on bird life. The Ecological balance in nature is also shared by the avian members' participation; hence their absence will disturb the balance of nature.

THREATS

As mentioned earlier, hunting, trapping and trade in birds as well as their habitat destruction are the major threats. All these were prevailing in the past. At present, hunting, trapping and trade have been controlled but habitat destruction persists. In future, it is largely habitat destruction and illegal trade which may cause severe damage. Shrinking of forest, mutilation of waste land and wetland may indicate the extent of damage, because these are directly linked. Maximum destruction has been done in the forest zone, wetland and waste land by curbing habitats for total bird life; hunting and trapping for trade of the so-called game birds and birds with ornamental features, have destroyed many.

CONSERVATION

In 1956 with the formation of wildlife Board of India, its bird wing under the stewardship of Salim Ali formulated the game laws for protection and preservation. Declaration of Sanctuaries and National Park helped to protect habitat as well as the denizens even before independence. The trend has been followed up till date. Indian Wild Life (Protection) Act, 1972, which has been ammended from time to time, has been proclaimed for meaningful protection and preservation. Signing the CITES treaty check on international trade has been extended. The creation of the Department of Environment & Forests has extended the scientific approach to conservation. And, above all,

creating awareness among masses has created a conducive atmosphere, helping protection, preservation and conservation. Captive breeding programme for Whitewinged Woodduck became successful. This has been extended to Cheer Pheasant and Blacknecked Crane. More and more endangered species should be brought under the umbrella of captive breeding programme to increase their survival value.

FUTURE DIRECTION

Although the knowledge on the Biodiversity of the avian members are nearing saturation, knowledge regarding the state of range, movement and biology of majority of birds is lacking. Many species are only known from the museum specimens.

Field studies are essential to obtain full knowledge, specially on the threatened species. Faunistic account should be monitored from time to time to understand the dynamic phase of the biodiversity through faunistic explorations.

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Faunal Diversity in India : Mammalia

V. C. AGRAWAL

Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700053





INTRODUCTION

One of the most fascinating features of the Indian biodiversity is its mammalian fauna, which encompasses species as large as whales, elephants, rhinoceroses and tigers, and as small as shrews, mice and bats. They are found in all types of habitats of the country, both terrestrial and aquatic. They may be volant, arboreal, ground dwelling, fossorial or aquatic in habits. Each species has its own unique set of characteristics enabling it to survive in its particular environment.

The term 'mammals' refers to animals possessing mammary or milk producing glands for nourishing their young ones. Another important feature of the group is the possessing of hairs on the body at least during some period of their life cycle.

STATUS OF THE TAXON

Global and Indian Status

The mammalian fauna of the world is represented by 4629 species belonging to 1135 genera, 136 families and 26 orders (Wilson and Reeder, 1993). Of these, 390 species belonging to 180 genera, 42 families and 13 orders are found in the Indian Union. Another 13 orders do not occur in our country. The egg-laying mammals belonging to the order Monotremata are found only in Australia, Tasmania and new Guinea; 7 orders of Marsupials in Australia, Indonesia and South America, orders Hyracoidea. Tubilidentata and Macroelidea in Africa; order Xenarthra in South America; and order Dermoptera in Java, Sumatra and the Philippines.

DISTRIBUTION

Mammals are found in all types of habitats, from snowy heights of the Himalayas to the plains, from thick rain forests to the arid region, and from

terrestrial to aquatic realm. The Indian aquatic mammals mainly belong to orders Cetacea and Sirenia. All the cetaceans found in India except the Gangetic Dolphin, *Platanista gangetica*, which is a freshwater form, are marine. The chiropterans (bats) are fliers. Of all the ecosystems in India, the mammalian fauna is richest in the northeastern India, followed by Western Ghats, Eastern Ghats, and the Desert. The Indian fauna is heavily influenced by the Indo-Chinese, Malayan, Ethiopian and Palaearctic elements.

The past distribution of mammals, in India, is not strikingly different from the present one, except that a few species like the Hunting Leopard (*Acinonyx jubatus veneticus*) and the lesser one-horned Rhinoceros (*Rhinoceros sondaicus*) have become extinct, and about 50% of the species have shrunk in their distributional range due mainly to destruction of habitat, and their exploitation for various purposes.

BIOLOGICAL DIVERSITY AND ITS SPECIAL FEATURES

An order-wise break up of families, genera and species found in India (*vide* Wilson and Reeder 1993) as against the total number found throughout the world is given below. However, the orders not represented in India but found elsewhere have not been mentioned here.

Table – 1

Orders	Families		Genera		Species	
	India	World	India	World	India	World
Insectivora	3	7	11	66	28	428
Scandentia	1	1	2	5	3	19
Chiroptera	6	17	36	177	110	925
Primates	3	13	6	60	15	233
Pholidota	1	1	1	1	2	7
Carnivora	7	11	33	129	55	271
Proboscidea	1	1	1	2	1	2
Sirenia	1	2	1	3	1	5
Perissodactyla	2	3	2	6	3	18
Artiodactyla	5	10	20	81	32	220
Lagomorpha	2	2	3	13	10	80
Rodentia	4	29	43	443	101	2021
Cetacea	6	10	21	41	29	78
Total	42	107	180	1027	390	4307

Introduced species

The House mouse (*Mus musculus*) and the Norway rat (*Rattus norvegicus*) have reached India through human agencies and established here. In addition, the Andaman and Nicobar Islands are the only areas where some species of mammals are said to have been introduced in the past from the mainland by human beings (Tikader & Das 1985). These species are the Crab-eating Macaque (*Macaca fascicularis*), Pig-tailed Macaque (*Macaca nemestrina leonina*), Jungle Cat (*Felis chaus*), Chital (*Axis axis*), Barking Deer (*Muntiacus muntjak*), Sambar (*Cervus unicolor*) Palm Civet (*Paguma larvata*), Wild pig (*Sus scrofa*), Elephant (*Elephas maximus*), Northern Palm Squirrel (*Funambulus pennanti*), rats and mice. Of these, the Crab-eating Macaque, Chital, Palm Civet and Wild Boar and various species of rats have established themselves well, so much so that, of late, chital became a pest of crops. However, rest of the species, could not adequately adapt themselves, and hence, in the course of time either disappeared or are present in negligible number. Some of the captive elephants escaped into the jungle and formed small herds of their own and started roaming in the wild.

Domestic species

The pariah dog (*Canis familiaris*), domestic cat (*Felis catus*), ass (*Equus asinus* and *E. caballus*), pig (*Sus domesticus*), camel (*Camelus dromedarius*), cow (*Bos frontalis*), buffalo (*Bubalus bubalis*), sheep (*Ovis aries*), goat (*Capra hircus*), yak (*Bos grunniens*) and mithun are domesticated species which occur in India.

Human-Mammal Relationship

The knowledge about the Indian mammals is very old. Descriptions of some mammals are available in the Vedas and even in the prevedic edicts. There are ethical, social, mythological and economic relationship between man and wild mammals. Authorities of Ayurvedic and Unnani medicines were aware of medicinal values of some products obtained from certain species of mammals. Some species of monkeys like the Rhesus macaques and the Norway rats are used in experiments of biomedical research. A number of species of rodents are reservoirs of many of the dreadful diseases of man and livestock.

Some species of mammals such as rats, hanuman langur, gaur (bull), elephant, tiger, lion, etc., have special mythological significance amongst Hindus. This is due to their being associated with different gods and goddesses in the Hindu mythology, and, hence, are worshipped.

Table – 2
Monotypic genera and their species found in India

Order	Species
Insectivora	<i>Anourosorex sqamipes</i> , <i>Nectogale elegans</i> , <i>Parascaptor leucura</i> and <i>Feroculus feroculus</i>
Scandentia	<i>Anathana ellioti</i>
Chiroptera	<i>Otonycteris hemprichi</i> , <i>Sphaerias blanfordi</i> , <i>Latidens salimalii</i> and <i>Scotozous dormeri</i>
Primates	<i>Loris tardigradus</i>
Carnivora	<i>Helarctos malayanus</i> , <i>Cuon alpinus</i> , <i>Melursus ursinus</i> , <i>Aliurus fulgens</i> , <i>Arctonyx collaris</i> , <i>Mellivora capensis</i> , <i>Arctogalidea trivirgata</i> , <i>Paguma larvata</i> , <i>Arctictis binturong</i> , <i>Neofelis nebulosa</i> , <i>Acinonyx jubatus</i> , <i>Lutrogale perspicillata</i> , <i>Hyaena hyaena</i> , <i>Pardofelis marmorata</i> , <i>Viverricula indica</i> , <i>Caracal caracal</i> , <i>Otocolobus manul</i> and <i>Lynx lynx</i> .
Proboscidea	<i>Elephas maximus</i>
Sirenia	<i>Dugong dugon</i>
Artiodactyla	<i>Boselaphus tragocamelus</i> , <i>Tetracerus quadricornis</i> , <i>Antilope cervicapra</i> , <i>Budorcas taxicolor</i> and <i>Pantholops hodgsonii</i>
Rodentia	<i>Biswamoyopterus biswasi</i> , <i>Eupetaurus cinereus</i> , <i>Platacanthomys lasiurus</i> , <i>Cannomys badius</i> , <i>Hadromys humei</i> , <i>Golunda ellioti</i> , <i>Dacnomys millardi</i> , <i>Diomys crumpi</i> , <i>Nesokia indica</i> and <i>Micromys minutus</i>
Lagomorpha	<i>Caprolagus hispidus</i>
Cetacea	<i>Tursiops truncatus</i> , <i>Steno bredanensis</i> , <i>Peponocephala electra</i> , <i>Delphinus delphis</i> , <i>Grampus griseus</i> , <i>Lagenodelphis hosei</i> , <i>Orcinus orca</i> , <i>Globicephala macrorhynchus</i> , <i>Ziphius cavirostris</i> , <i>Orcaella brevirostris</i> , <i>Psudorca crassidens</i> , <i>Feresa attenuata</i> , <i>Neophocaena phocaenoides</i> , <i>Physeter macrocephalus</i> and <i>Megaptera novaeangliae</i>

ENDEMICITY

Out of 180 genera of Indian mammals, 61 genera are monotypic (Table 2) and 105 are represented in India by a single species. Of these, 10 genera namely, *Scotozous* (Chiroptera), *Loris* (Primates), *Melursus* (Carnivora), *Antilope*,

Boselaphus, *Tetracerus* and *Pantholops* (Artiodactyla), *Eupetaurus* and *Golunda* (Rodentia) and *Caprolagus* (Lagomorpha) are endemic to Indian subregion, and another 4 genera, namely, *Anathana* (Scandentia), *Latidens* (Chiroptera) and *Biswamoyopterus*, and *Platacanthomys* (Rodentia) are endemic to the Indian Union. At specific level, 36 species (Insectivora—4, Scandentia—2, Chiroptera—9, Primates—3, Carnivora—4, Artiodactyla—1, Rodentia—13) are endemic, of which 9 species are localised to Andaman and Nicobar groups of islands, 14 species to Western Ghats, 7 species to peninsular India, 4 species to northeastern India and the rest two to Western Himalaya (Table – 3).

Table – 3

List of mammalian species endemic to the Indian Union

Order	Species
Andaman & Nicobar Islands	
Insectivora :	<i>Crocidura jenkinsi</i> , <i>Crocidura andamanensis</i> , <i>Crocidura hispida</i> and <i>Crocidura nicobarica</i>
Chiroptera :	<i>Pteropus faunulus</i> and <i>Rhinolophus cognatus</i>
Rodentia :	<i>Rattus stoicus</i> and <i>Rattus palmarum</i>
Scandentia :	<i>Tupaia nicobarica</i>
Western Ghats	
Chiroptera :	<i>Latidens salimalii</i> , <i>Otomops wroughtoni</i> and <i>Hipposideros hypophyllus</i>
Primates :	<i>Macaca silenus</i> and <i>Trachypithecus johnii</i>
Carnivora :	<i>Paradoxurus jerdoni</i> and <i>Viverra civettina</i>
Artiodactyla :	<i>Hemitragus hylocrius</i>
Rodentia :	<i>Funambulus tristriatus</i> , <i>Platacanthomys lasiurus</i> , <i>Millardia kondana</i> , <i>Rattus ranjiniae</i> , <i>Mus famulus</i> and <i>Cremnomys elvira</i>

Peninsular India

Scandentia :	<i>Anathana ellioti</i>
Primates :	<i>Macaca radiata</i>
Chiroptera	<i>Hipposideros schistaceus</i>
Carnivora	<i>Martes gwatkinsii</i>
Rodentia	<i>Ratufa indica, Cremnomys cutchicus and Mus phillipsi</i>

Western Himalaya

Chiroptera :	<i>Murina grisea</i>
Rodentia	<i>Alticola montosa</i>

Northeastern India

Chiroptera :	<i>Eptesicus tatei and Rhinolophus mitratus</i>
Carnivora :	<i>Herpestes palustris</i>
Rodentia :	<i>Biswamoyopterus biswasi</i>

THREATENED SPECIES

Of a total of 390 species of mammals reported from India, 175 species are threatened with extinction, But the degree of threat varies, and on that basis 75 species have been listed in Schedule I, 73 in Schedule II, 8 in Schedule III and 19 in Schedule IV of the Wild Life (Protection) Act (Appendix III). Of the 75 species in Schedule I, two species namely, the Hunting Leopard and the Lesser One-horned Rhinoceros are supposed to be extinct from India, and 32 species are highly endangered. These species are Lion-tailed Macaque, Phayre's Leaf Monkey, Hoolock Gibbon, Chinese Pangolin, Malayan Sun Bear, Red Panda, Ratel, Malabar Civet, Desert Cat, Marbled Cat, Pallas Cat, Golden Cat, Rusty-spotted Cat, Caracal, Indian Lion, Snow Leopard, Great one-horned Rhinoceros, Indian Wild Ass, Kiang, Pigmy Hog, Musk Deer, Thamin, Hangul, Swamp deer, Four-horned Antelope, Yak, Indian Buffalo, Himalayan Tahr, Markhor, Nilgiri Tahr, Hispid Hare, and Small Travanvore Flying Squirrel (Agrawal *et al.* 1991). From Table 4, it is clear that practically all the species of mammals except insectivores, tree-shrews, bats and murid rodents are threatened, of course to a varying degree.

Table – 4

Number of endangered species of mammals (order-wise) in India

Orders	Total No. of known Species from India	No. of endangered species			
		I	II	III	IV
Insectivora	28	—	—	—	1
Scandentia	3	—	—	—	—
Chiroptera	110	—	—	—	—
Primates	15	9	6	—	—
Carnivora	55	28+(1)	21+(4)	—	6+(1)
Artiodactyla	32	24	—	8	—
Perissodactyla	3	3	—	—	—
Cetacea	29	3	26	—	—
Sirenia	1	1	—	—	—
Proboscidea	1	1	—	—	—
Lagomorpha	10	1	—	—	9
Rodentia	101	2	16	—	2
Pholidota	2	2	—	—	—
Total	390	75	73	8	19

Figures within brackets denote subspecies.

VALUE

Mammals are friends as well as foes to mankind. Large scale destruction of crops is caused by rodents, monkeys, langurs, deer, antelopes, wild boars, hares, elephants, etc. Fruit-bats and squirrels cause damage to orchards. On the other hand, many of the mammalian species are exploited by human beings for their skin, fur and wool (deer, antelopes, large and small cats, sheep), horns and antlers (rhinoceros, cervids and bovids), tusks (elephants), musk (musk deer) liver and gall bladder (bears), bezoar, meat and oil (whales), etc. Above all many of the species are killed for their meat value. The bones of tigers are used in the preparation of medicine and soup in China. Whales and dolphins are captured for their oil, fins are used for soup, skin for making leather and the flesh as fish meal and manure. Tamed elephants are used for dragging logs, carrying people in difficult terrains and form part of the royal processions. The domesticated species are used as pets, beasts of burden etc., and are a good source of wool, meat and milk.

THREATS

The human population of India which is about 17% of the total humanity of the world is highly disproportionate keeping in view the land area of the country which is hardly 2% of the world's total land mass (Jairajpuri 1991). Still it is increasing with a galloping rate. This has necessitated developments in various spheres like the urbanisation, construction of dams and hydro-electric projects, encroachment of land for agriculture, industry, mining operation, etc., which have brought severe imbalances in several ecosystems particularly the forests and wetlands of the country. The result is that the forest resources of the country have declined to about 22% of the total geographical area. This, in turn, has severely effected the wildlife. Further, the undue exploitation of several species of wild animals and their parts for trade, medicinal purposes and flesh have threatened many of them to a point of no return. Competition for food and transmission of diseases by domestic livestock are other threats to herbivores, particularly to cervids and bovids.

The threats to dolphins in Indian waters are due to the prevalence of gill-net fishery along the Sri Lankan coast and their vulnerability to fishing gears, and reckless killing along the southeast coast of India. Further, fast deterioration of ecology due to anthropomorphic activities is aiding in the disappearance of whales and dolphins from the Indian coasts.

CONSERVATION

The primary concern of conservation is to maintain a balanced ecosystem. If the latter is preserved, animal species contained in these ecosystems will have greater chances of survival. To achieve this goal, a network of scientifically managed wildlife protected areas in representative biogeographical regions have been established in India where the forestry operations and other usages such as grazing by domestic livestock are completely banned. About 151,342 sq. km. or 4.6% of the total land area of the country is proposed to be gradually brought under this network, from an area of 109,652 sq. km. or 3.3% during 1987 (Jairajpuri, 1991).

In order to conserve whatever remains of our wildlife, the Government of India has taken various steps aimed at prohibiting killing, trapping or collecting by any other means of such species of animals which are endangered or rare, and at regulating exploitation of those species which, though apparently in abundance at present, may become rare if utilised excessively (Agrawal 1989).

A general legislation was enforced in 1972 under the name of Wild Life (Protection) Act, 1972, for providing legal protection to wildlife, particularly to endangered species of mammals, birds and reptiles. Subsequently, endangered and scientifically valuable species of insects were included in the list. The Act contains a set of rules governing the protection of wild animals, and schedules I to V, naming the species of animals governed by the said Act. As mentioned earlier, depending upon the degree of threat, four levels of protection (Schedules I to IV) have been accorded to species. The Schedule V includes vermins. The preservation of wild animals and forests have been included in the concurrent list as per 42nd amendment of the Indian constitution.

To control trade in endangered species of animals in the international market, a convention has been ratified by nearly all the important countries of the world which is known as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1973). India became a party to it in 1976. This convention has framed rules and regulations to control the world-wide trade in endangered species of wild animals and their products. It consists of 25 articles. Three levels of protection (Appendix I to III) have been accorded to species, depending upon the degree of threat.

The programme of translocation of the endangered species of mammals like the Greater one-horned Rhinoceros (*Rhinoceros unicornis*) from Kaziranga to Dudwa National Park in Uttar Pradesh, and the captive breeding programme as of the Manipur Brow-antlered Deer (*Cervus eldi eldi*) in some of the Indian zoos have already been taken up. Further, a comprehensive programme to breed some of the endangered species of mammals in Indian zoos has recently been finalised by the Central Zoo Authority of India.

For the conservation of endangered species of mammals, species-oriented programmes are being taken up in India by the Central and State Governments independently as well as manned and funded by WWF—I, FAO, UNDP, IUCN, etc. The foremost being the project Hangul (1970), Gir Lion Sanctuary project (1968-72), project Tiger (1973), Manipur Brow-antlered Deer project (1977), Himalayan Musk Deer project (1979), and the Lesser Cats Project (1981). Recent addition to this list is the 'Elephant Project' initiated in 1992 by the Ministry of Environment and Forests, Government of India. The main thrust of these projects was on the conservation of habitats in which these animals live in, restoration of their quality, and to eliminate all forms of exploitation (both of habitats and animals) by human-beings. The results are encouraging. These measures not only helped to improve the degraded habitats but also there is an increase in the population of both the

prey and predator-species. The main constraint of these projects is to shift the local residents from the core areas and their socio-economic upliftment.

FUTURE DIRECTION

Habitat restoration, proper management and strict implementation of the Wildlife Act, along with socio-economic development of the local community are desirable to restore wildlife, in future. Public understanding and support are crucial for conservation. Long term studies are required to determine the habitat requirements, population dynamics of animals, etc. A centre for the conservation of India's National heritage in animals may be established in the country. This could specialise in developing a DNA-library of genetic material of species under threat of extinction (Swaminathan, 1990).

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PROTOZOA

- Das, A. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Freeliving Protozoa : Sarcodina and Ciliophora; Symbiotic Protozoa : Zoomastigophorea and Ciliophora].
- Halder, D. P., Department of Zoology, University of Kalyani-741 235, Nadia, West Bengal. [Parasitic Protozoa : Gregarina and Myxozoa].
- Kalavati, C., Department of Zoology, Andhra University, Vishakhapatnam-530 003, Andhra Pradesh. [Parasitic Protozoa : Microspora and Myxozoa].
- Krishnamurthy, R., Department of Zoology, Marathawada University, Aurangabad-431 004, Maharashtra. [Parasitic Protozoa : Coccidia and Zoomastigophorea].
- Mandal, A. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Parasitic Protozoa : Coccidia and Kinetoplastida].
- Mishra, K. K., Rishi Bankim College, Naihati, North 24-Parganas, West Bengal. [Parasitic Protozoa : Kinetoplastida].
- Nandi, N. C., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Parasitic Protozoa : Haemosporida and Myxozoa].
- Ray, R., Department of Zoology, Presidency College, Calcutta, West Bengal. [Parasitic Protozoa : Blood parasites of amphibia].
- Sarkar, N., Rishi Bankim College, Naihati, North 24-Parganas, West Bengal. [Parasitic Protozoa : Myxozoa].
- Tiwari, D. N., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Symbiotic Protozoa : Zoomastigophorea].

MESOZOA

- Kalavati, C., Department of Zoology, Andhra University, Visakhapatnam-530 003, Andhra Pradesh.

PORIFERA

- Khan, M. A., Department of Zoology, N. B. Science College, Hyderabad-500 002, Andhra Pradesh.
- Pattanayak, J. G., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Rao, Seshagiri, Department of Zoology, N. B. Science College, Hyderabad-500 002, Andhra Pradesh.

Soota, T. D., Retired Scientist, Zoological Survey of India, 24/4, Lake Terrace (3rd Floor), Calcutta-700 020.

Thomas, P. A., Central Marine Fisheries Research Institute Research Centre, Vizhinjam-695 521, Kerala.

CNIDARIA

Daniel, R., Marine Biological Station, Zoological Survey of India, 100, Santhome High Road, Chennai-600 028, Tamil Nadu.

Jasmine, S., Central Marine Fisheries Research Institute Research Centre, Vizhinjam-695 521, Kerala. [Taxonomy of corals].

Patel, M. I., Gujarat State Fisheries Aquatic Science Station, Sikka, Gujarat. [Taxonomy and ecology of corals of Gulf of Kutch].

Pillai, C. S. G., Retired Scientist, Central Marine Fisheries Research Institute, Cochin-31. [Taxonomy of corals, Anthropogenic and natural impact on reefs and reef resources, Conservation of ecosystem].

Rangarajan, K., Central Marine Fisheries Research Institute, Ernakulam, Kerala.

CTENOPHORA

Pillai, Krishnan, N., Retired Professor, Department of Zoology, University of Kerala, Trivandrum, Kerala.

Ramakrishna, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

PLATYHELMINTHES

Agarwal, N., Department of Zoology, University of Lucknow, Lucknow-226 007, Uttar Pradesh. [Monogenea].

Chauhan, B. S., Retired Scientist, Zoological Survey of India, 220, Civil Lines, Narsinghpur, Madhya Pradesh. [Monogenea, Digenea].

Ghosh, R. K., Retired Scientist, Zoological Survey of India, B-11/13 E. C. T. P. Phase-IV, Kosba, Gold Park, Calcutta-700 078. [Digenea, Cestoda].

Hafezzullah, M., Retired Scientist, Zoological Survey of India, 9/1, Ekbalpore Lane, Flat-01, Kidderpur, Calcutta-700 023. [Digenea].

Madhabi, M., Department of Zoology, Andhra University, Vishakhapatnam-530 003, Andhra Pradesh. [Digenea].

Mukherjee, R. P., Retired Scientist, Zoological Survey of India, CD, 292 Salt Lake, Calcutta-700 064. [Digenea, Cestoda].

- Pandey, K. C., Department of Zoology, Lucknow University, Lucknow-226 007, Uttar Pradesh. [Digenea].
- Raina, M. K., Kashmir University, Srinagar, Jammu and Kashmir. [Cestoda].
- Ramalingam, K., Annamalai University, Annamalai Nagar-608 002, Tamilnadu. [Monogenea].
- Rao, Hanumantha, Department of Zoology, Andhra University, Vishakhapatnam-530 003, Andhra Pradesh. [Digenea].
- Rao, V. Ramakrishna, Regional Centre, Ministry of Environment and Forests, Bhubaneswar, Orissa. [Turbellaria].
- Srivastava, C. B., Retired Scientist, Zoological Survey of India, 631/P-308/1A opposite D, 1290, Old Picnic spot Road, Indiranagar, Lucknow-226 016, Uttar Pradesh. [Digenea, Cestoda].
- Tandon, V., NEERU, Shillong, Meghalaya. [Digenea].
- Vijayalakshmi, C., Department of Zoology, Andhra University, Vishakhapatnam-530 003, Andhra Pradesh.

ROTIFERA

- Battish, S. K., Department of Zoology, Punjab Agricultural University, Ludhiana, Punjab. [Taxonomy and ecology].
- Chandra Mohan, P., Department of Zoology, Andhra University, Vishakhapatnam-530 003, Andhra Pradesh. [Taxonomy and ecology].
- Dhanapathi, M. V. S. S., Department of Zoology, DNR College, Bhimavaram, Andhra Pradesh. [Taxonomy, distribution].
- Gouder, B. Y. M., Department of Zoology, Karnataka University, Dharwar, Karnataka. [Taxonomy and ecology].
- Michael, R. G., Dep. C/o, School of Life Sciences, Madurai Kamraj University, Madurai, Tamil Nadu.
- Nayar, C. K. G., Department of Zoology, Christ College, Irinjalakuda, Kerala. [Taxonomy and ecology of planktonic rotifers].
- Pant, M. C., Department of Zoology, Kumaun University, Nainital, Uttar Pradesh. [Composition and ecology].
- Patil, S. G., Western Regional Station, Zoological Survey of India, Vidya Nagar, Sector 29, P. B. No. 3053, Rawot Road, Pune-411 044, Maharashtra. [Taxonomy].
- Rao, T. Ramakrishna, Department of Zoology, University of Delhi, Delhi-110007. [Autecology, population dynamics, production].
- Saksena, D. N., School of Studies in Zoology, Jiwaji University, Gwalior, Madhya Pradesh. [Taxonomy, ecology, polymorphism].
- Sehgal, H. S., Department of Zoology, Punjab Agricultural University, Ludhiana, Punjab. [Taxonomy and ecology].

Sharma, B. K., Department of Zoology, North-Eastern Hill University, Shillong-793 014, Meghalaya. [Taxonomy, biogeography, ecology].

Sharma, P. C., Department of Zoology, Kumaun University, Nainital, Uttar Pradesh. [Composition and ecology].

Sharma, Sumita, Eastern Regional Station, Zoological Survey of India, Fruit Gardens, Risa Colony, Shillong-793 003, Meghalaya.

GASTROTRICHA

Rao, G. C., Retired Scientist, Freshwater Biological Station, Zoological Survey of India, Hyderabad-500 020, Andhra Pradesh.

KINORHYNCHA

Rao, G. C., Retired Scientist, Freshwater Biological Station, Zoological Survey of India, Hyderabad-500 020, Andhra Pradesh.

NEMATODA

Ahmad, Wasim, Department of Zoology, Aligarh Muslim University, Aligarh - 202 002, Uttar Pradesh.

Bajaj, Harish Kant, Department of Nematology, Haryana Agricultural University, Hissar, Haryana.

Baqri, Q. H., Desert Regional Station, Zoological Survey of India, 107, Kamla Nehru Nagar, Chopsani Road, Jodhpur-342 008, Rajasthan.

Das, S. N., Department of Nematology, Orissa University of Agriculture & Technology, Bhubaneswar, Orissa.

Deshmukh, P. G., Department of Zoology, Marathwada University, Aurangabad-431 004. Maharashtra.

Dey Sarkar, S. R., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Dhanachand, Ch., Department of Zoology, Manipur University, Imphal, Manipur.

Gupta, S. P., Department of Zoology, Lucknow University, Lucknow-226 007, Uttar Pradesh.

Gupta, V., Department of Zoology, Lucknow University, Lucknow-226 007, Uttar Pradesh.

Jairajpuri, Durdana S., Department of Zoology, Aligarh Muslim University, Aligarh-202 002, Uttar Pradesh.

Jairajpuri, M. S., Maulana Azad National Urdu University, Hyderabad-500 008, Andhra Pradesh.

Kalyankar, S. D., Department of Zoology, Marathwada University, Aurangabad-431 004, Maharashtra.

- Khan, E., Division of Nematology, Indian Agricultural Research Institute, Pusa, New Delhi-110 012.
- Khan, Shahid Hasan, Department of Zoology, Aligarh Muslim University, Aligarh - 202 002, Uttar Pradesh.
- Luqman, M., Department of Nematology, Himachal Agricultural University, Solan, Himachal Pradesh.
- Majumdar, G., Department of Zoology, Burdwan University, Golapbag, Burdwan, West Bengal.
- Phukan, P. N., Department of Nematology, Assam Agricultural University, Jorhat, Assam.
- Rahman, M. F., Department of Nematology, Assam Agricultural University, Jorhat, Assam.
- Sahay, U., Department of Zoology, Ranchi University, Ranchi, Bihar.
- Sood, M. L., Department of Zoology, Punjab Agricultural University, Ludhiana, Punjab.
- Soota, T. D., Retired Scientist, Zoological Survey of India, 24/4, Lake Terrace (3rd Floor), Calcutta-700 029.
- Sultan, Sarwat, Department of Nematology, Punjab Agricultural University, Ludhiana, Punjab.
- Swarup, Gopal, Division of Nematology, Indian Agricultural Research Institute, Pusa, New Delhi-110 012.

ACANTHOCEPHALA

- Bhattacharya, S. B., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
- Fatma, S., Department of Zoology, University of Lucknow, Lucknow-226 007, Uttar Pradesh.
- George, P. V., Department of Zoology, Mar Ivanis College, Trivandrum-695 015, Kerala.
- Gupta, V., Department of Zoology, University of Lucknow, Lucknow-226 007, Uttar Pradesh.
- Jain, Mridula, Department of Zoology, Punjab University, Chandigarh-160 014, Punjab.
- Nadakal, A. M., Department of Zoology, Mar Ivanis College, Trivandrum-695 015, Kerala.
- Soota, T. D., Retired Scientist, Zoological Survey of India, 24/4 Lake Terrace (3rd Floor), Calcutta-700 029.

SIPUNCULA

- Haldar, B. P., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta- 700 016.

MOLLUSCA

- Agarwal, H. P., Retired Scientist, Central Regional Station, Zoological Survey of India, 424, New Adarsha Colony, Kamala Nehru Nagar, Jabalpur-482 002, Madhya Pradesh.
- Appukuttan, K., Central Marine Fisheries Research Institute, Cochin-31, Kerala. [Shell fisheries and marine molluscs].
- Barua, S., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Mangrove molluscs].
- Das, A. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Wood borers].
- Dey, A., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Mangrove molluscs].
- Jothinayagam, J. T., Southern Regional Station, Zoological Survey of India, 100, Santhome High Road, Chennai-600 028, Tamil Nadu. [Cephalopods].
- Kashinathan, R., Centre for Advanced Studies in Marine Biology, Porto Novo, Tamil Nadu. [Mangrove and Marine molluscs].
- Madhyastha, N. A., Poornaprajna College, Udipi-576 101, Karnataka.
- Maitra, Sipra, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Mangrove molluscs].
- Mane, U. H., Department of Zoology, Marathwada University, Aurangabad-431 004, Maharashtra. [Physiology, neurosecretion, marine molluscs, borers and foulers].
- Manna, R. N., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Mangrove molluscs].
- Mitra, S. C., Zoological Survey of India 'M' Block, New Alipore, Calcutta-700 053. [Land and Freshwater molluscs].
- Mukherjee, H. P., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Marine molluscs].
- Nagabhushanam, R., Department of Zoology, Marathwada University, Aurangabad-431 004, Maharashtra. [Physiology, neurosecretion, marine molluscs, borers and foulers].
- Rambabu, M., Department of Zoology, Nagarjuna University, Nagarjuna Nagar, Guntur, Andhra Pradesh.
- Rao, Balaparameswara, Department of Zoology, Nagarjuna University, Nagarjuna Nagar, Guntur, Andhra Pradesh.
- Rao, K. V. Surya, Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Marine molluscs].

Rao, N. V. Subba, Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Marine molluscs].

Santhakumaran, L. N., Wood-Preservation Centre (Marine) C/C, National Institute of Oceanography, Dona Paula, Panaji, Goa-403 004. [Wood borers].

ECHIURA

Halдар, B. P., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.

Singhal, R. N., Department of Zoology, Kurukshetra University, Kurukshetra, Haryana.

ANNELIDA

Bano, Kubra, University of Agricultural Sciences, G. K. V. K., Bangalore-560 065, Karnataka.

Bhaduria, Tuneera Kumar, G. B. Pant Institute of Ecology & Environment, Kosi, Almora, Uttar Pradesh.

Chakraborty, R. K., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.

Chandra, Mahesh, Retired Scientist, Zoological Survey of India, High Altitude Field Station, Solan, Himachal Pradesh.

Dash, M. C., School of Life Sciences, Sambalpur University, Jyoti Vihar, Burla, Orissa.

Gaikwad, U. D., Department of Fish Hydrography, College of Fisheries, Ratnagiri-415 612, Maharashtra.

Ghosh, G. C., Retired Scientist, Zoological Survey of India, 27, J. L. Nehru. Road, Calcutta-700 016.

Halдар, K. R., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.

Handa, S. M., Punjab University, Chandigarh-160 014, Punjab.

Ismail, S. A., National College, Chennai, Tamil Nadu.

Julka, J. M., Retired Scientist, High Altitude Zoology Field Station, Zoological Survey of India, Solan, Himachal Pradesh.

Kale, R. D., University of Agricultural Sciences, G. K. V. K., Bangalore-560 065, Karnataka.

Krishnamoorthy, R. V., University of Agricultural Sciences, G. K. V. K., Bangalore-560 065, Karnataka.

Mishra, P. C., School of Life Sciences, Sambalpur University, Jyoti Vihar, Burla, Orissa.

Misra, A., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.

Raj, P. J. Sanjeeva, Department of Zoology, Madras Christian College, Tambaram, Chennai-600 059, Tamil Nadu.

Ramakrishnan, P. S., Department of Environment Biology, Jawaharlal Nehru University, New Delhi-110 067.

- Rao, C. A. N., Zoological Survey of India, Easturine Biological Station, Hill Patna, Berhampore-750 005, Orissa.
- Rao, D. Srinivasa, Noble college, Machilipatnam-521 001, Andhra Pradesh.
- Rao, R. V. S. S. R. Subba, Department of Zoology, Andhra University, Vishakhapatnam-530 003, Andhra Pradesh.
- Reddy, M. V., School of Environmental Studies, Kakatiya University, Warangal, Andhra Pradesh.
- Senapati, B. K., School of Life Sciences, Sambalpur University, Jyoti Vihar, Burla, Orissa.
- Singh, Janardan, Department of Entomology, College of Agriculture, Benaras Hindu University, Varanasi, Uttar Pradesh.
- Soota, T. D., Retired Scientist, Zoological Survey of India, 24/4, Lake Terrace (3rd Floor), Calcutta-700 029.
- Sreen, M. L., Punjab University, Chandigarh-160 014, Punjab.

CRUSTACEA

- Ajmalkhan, K., Centre for advanced Studies in Marine Biology, Annamalai University, Parangi pettai-608 502, Tamil Nadu.
- Chandran, Jaya, Department of Aquatic Biology Fisheries, Kerala Agricultural University, Cochin, Kerala.
- C. V. Kurian, Department of Marine Sciences, University of Cochin, Cochin-682 016, Kerala.
- Dev Roy, M. K., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.
- Jalihal, Marine Biological Research Station, Ratnagiri, Maharashtra.
- Krishna Murthy, Marine Biological Station, Zoological Survey of India, 100, Santhome High Road, Chennai 600 028, Tamil Nadu.
- Reddy, K. N., Zoological Survey of India, Sundarban Field Research Station, Canning, South 24 - Parganas, West Bengal.
- Roy, T., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.
- Sankolli, J., Marine Biological Research Station, Ratnagiri, Maharashtra.
- Venkataraman, K., Marine Biological Station, Zoological Survey of India, 100, Santhome High Road, Chennai- 600 028, Tamil Nadu.

APTERYGOTA

- Choudhuri, D. K., Department of Zoology, Burdwan University, Golapbag, Burdwan, West Bengal. [Collembola].

Hazra, A. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
[Thysanura, Collembola].

Mitra, S. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
[Thysanura, Diplura, Collembola].

ODONATA

Arun, Kumar, Northern Regional Station, Zoological Survey of India, 218 , Kaulagarh Road, Dehra Dun-248 195, Uttar Pradesh.

Lahiri, A. R., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Madhavan, S., School of Biological Sciences, Kamraj University, Palaklai Nagar, Madurai-625 021, Tamil Nadu.

Mitra, T. R., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Prasad, M., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Raja Ram, Zoological Survey of India, Nizam Place Complex, 2nd M. S. Building, 14 Floor, 234/4, A. J. C. Bose Road, Calcutta-700 020.

Srivastava, B. K., Department of Zoology, University of Sagar, Sagar-470 003, Madhya Pradesh.

Tyagi, V. K., Road No. 7, Milkman Colony, Jodhpur-432 003, Rajasthan.

PLECOPTERA

Das, B. C., Zoological Survey of India, 'M' Block, New Alipore, Calcutta – 700 053.

Singh, R. K., Central Regional Station, Zoological Survey of India, 424, New Adarsha Colony, Kamala Nehru Nagar, Jabalpur-482 002, Madhya Pradesh.

ORTHOPTERA

Bhowmik. H. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Dey, Anita, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Halder, P., Department of Zoology, Visva-Bharati University, Shantiniketan-731 235, West Bengal.

Hazra, A. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Mondal, S. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Shishodia, M. S., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Singh, Asket, Retired Scientist, Zoological Survey of India, 176, Adarsh Nagar, Jalandhar City-144 008, Punjab.

Tandon, S. K., Retired Scientist, Zoological Survey of India, Bidhan Abasan, FB Block, Salt Lake, Calcutta-700 091.

PHASMIDA

None.

DERMAPTERA

Kapoor, V. C., Punjab Agricultural University, Ludhiana, Kapurthala-144 601, Punjab.
Srivastava, G. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

EMBIOPTERA

Ananthakrishnan, T. N., Entomology Research Institute, Loyola College, Chennai-600 034, Tamil Nadu.
Ananthasubramanian, K. S., Loyola College, Chennai-600 034, Tamil Nadu.
Bradoo, B. L., Department of Zoology, D. A. V. College, Abohar, Punjab.
Joseph, K. J., Department of Zoology, University Centre, Calicut, Kerala.

MANTODEA

Hazra, A. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
Mukherjee, T. K., West Bengal Education Service, 65 A/6, Swinho Lane, Calcutta-700 042.

BLATTARIAE

Mandal, S. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

ISOPTERA

Bose, Gita, Retired scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
Maiti, P. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
Rathore, N. S., Desert Regional Station, Zoological Survey of India, 107, Kamla Nehru Nagar, Chopsani Road, Jodhpur-342 006, Rajasthan.

- Roy, P. H., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
- Saha, Nivedita, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
- Sen Sarma, P. K., Retired Scientist, Forest Research Institute, Dehra Dun-248 006, Uttar Pradesh.
- Thakur, M. L., Retired Scientist, Forest Research Institute, Dehra Dun-248 006, Uttar Pradesh.

PSOCOPTERA

None.

HEMIPTERA

- Agarwala, B. K., Department of Life Science, Tripura University, Agartala, Tripura. [Aphididae].
- Ambrose, P. Dutson, Entomology Research Unit, Department of Zoology, St. Xaviers College, Palayamkottai-627002. [Reduviidae].
- Ananthasubramanian, K. S., Loyola College, Chennai-600 034, Tamil Nadu. [Membracidae].
- Bal, A., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Aquatic Bugs].
- Basu, R. C., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Aphididae, Coreidae].
- Bhat, H. R., National Institute of Virology, 20A, Ambedkar Road, Pune, Maharashtra. 411 001, [Cimicidae].
- Biswas, B., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Cercopidae, Membracidae, Reduviidae].
- Chakraborty, S. P., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Pentatomidae].
- Chakrabarti, S., Department of Zoology, University of Kalyani, Kalyani-741 235, Nadia, West Bengal. [Aphididae].
- Chopra, N. P., Department of Entomology, Haryana Agricultural University, Hissar-125 004, Haryana. [Coreidae, Lygaeidae, Pentatomidae, Tingidae].
- Datta, B., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Cicadellidae].
- David, B. V., Department of Entomology, Fedrick Institute of Plant Protection and Toxicology, Padappi-601 301, Tamil Nadu. [Aleyrodidae].
- Ghosh, A. K., Retired Scientist, Zoological Survey of India, 329, Jodhpur Park, Calcutta-700 068. [Aphididae].
- Ghosh, L. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore,

- Calcutta-700 053. [Aphididae, Cercopidae, Cicadellidae, Cicadidae, Membracidae, Pentatomidae, Psyllidae].
- Ghosh, Maya, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Cicadellidae].
- Kandasamy, C., Montari Industries Ltd., 78 Nehru Place, New Delhi-110 019. [Psyllidae].
- Livingstone, David., Department of Entomology, Fedric Institute of Plant Protection and Toxicology, Padappi-601 301, Tamil Nadu. [Reduviidae].
- Mitra, S. C., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Coreidae].
- Mukhopadhyay, A., Department of Zoology, North Bengal University, Siliguri, Darjeeling, West Bengal. [Lygaeidae].
- Muraleedharan, N., UPASI Tea Estate, Coimbatore-642 106, Tamil Nadu. [Anthocoridae].
- Ravichandran, G., Department of Entomology, Bharathiar University, Coimbatore-641 046. Tamil Nadu. [Reduviidae].
- Raychaudhuri, D., Department, Zoology, University of Calcutta, 35, Ballygunge Circular Road, Calcutta-700 019. [Aphididae].
- Sen, G. C., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Cicadidae].
- Singh, Rajendra, Department of Zoology, Gorakhpur University, Gorakhpur-237 009, Uttar Pradesh. [Aphididae].
- Thirumalai, G., Southern Regional Station, Zoological Survey of India, 100, Santhome High Road, Chennai-600 028, Tamil Nadu. [Aquatic Bugs].
- Varshney, R. K., Retired Scientist, Zoological Survey of India, Raj Bhawan, Manik Chowk, Aligarh-202 001, Uttar Pradesh. [Coccoidea].
- Viraktamath, C. A., Department of Entomology, University of Agricultural Science, Hebbal, Bangalore-560 024, Karnataka. [Cicadellidae].

THYSANOPTERA

- Ananthakrishnan, T. N., Entomology Research Institute, Loyola College, Chennai-600 034, Tamil Nadu.
- Bhatti, J. S., Hans Raj College, New Delhi - 110 007.
- Kamble, R. H., Western Regional Station, Zoological Survey of India, Vidya Nagar, Sector-29, P. B. No. 3053, Rawot Road, Pune-411 044, Maharashtra.
- Pramanik, N. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
- Sen, S., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Sengupta, C. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

NEUROPTERA

Ghosh, S. K., Retried Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

COLEOPTERA

Basu, C. R., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Chrysomelidae].

Bhateja, B. R., S. G. N. Khalsa College, Sri Ganganagar-335 001, Rajasthan. [Curculionidae].

Biswas, D. N., Zoological Survey of India, 'M' Block, New Alipore, Calcutta- 700 053. [Staphylinidae].

Biswas, S., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta- 700 053. [Dytiscidae, Gyrinidae, Hydrophilidae, Scarabaeidae].

Chakraborty, S. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Coccinellidae, Histeridae].

Chandra, K., Central Regional Station, Zoological Survey of India, 424, New Adarsha Colony, Kamala Nehru Nagar, Jabalpur-482 002. [Scarabaeidae].

Chatterjee, S. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Scarabaeidae].

Chauhan, R. L., Department of Zoology, Kurukshetra University, Kurukshetra-132 119, Haryana. [Elateridae].

Ghosh, S. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta- 700 053. [Dytiscidae, Hydrophilidae].

Maiti, P. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta- 700 053. [Scolytidae].

Mann, J. S., Rice Research Station, Punjab Agricultural University, Kapurthala 144 601. [Chrysomelidae].

Mittal, I. C., Department of Zoology, Kurukshetra University, Kurukshetra - 132 119, Haryana. [Scarabaeidae].

Mukhopadhyay, P., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Dytiscidae, Cerambycidae, Curculionidae, Gyrinidae, Hydrophilidae, Cucujoidea].

Nandy, B. N., Zoological Survey of India, Nizam Place Complex, 2nd M. S. Building, 14 Floor, 234/4, A. J. C. Bose Road, Calcutta-- 700 020. [Platypodidae].

- Pajni, H. R., Department of Zoology, Punjab University, Chandigarh - 160 014, Punjab. [Bruchidae, Curculionidae].
- Pal, T. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta- 700 053. [Cucujoidea].
- Ramamurthy, V. V., Entomology Division, Indian Agricultural Research Institute, Pusa, New Delhi - 110 012. [Curculionidae].
- Saha, G. N., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta- 700 053. [Meloidae, Tenebrionidae].
- Saha, Nivedita, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Scolytidae].
- Saha, S. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta- 700 053. [Carabidae, Cicindelidae].
- Sengupta, T., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta- 700 053. [Clavicornia].
- Singh, J. P., Department of Zoology, Punjab University, Patiala - 147 002-Punjab. [Chrysomelidae].
- Singhal, S. K., Entomology Department, Haryana Agricultural University, Hissar - 125 004, Haryana. [Curculionidae].
- Vats, L. K., Department of Zoology, Kurukshetra University, Kurukshetra - 132 119, Haryana. [Elateridae].
- Verma, K. K., Government Girls' College, Durg - 491 001, Madhy Pradesh. [Chrysomelidae].
- Yadav, C. P. S., Agricultural Research Station, I. C. A. R., Jaipur - 302 018. [Scarabaeidae].
- Yadav, J. S., Department of Zoology, Kurukshetra University, Kurukshetra-132 119, Haryana. [Chrysomelidae].

STREPSIPTERA

- Chaudhury, P. K., Department of Zoology, University of Burdwan, Golapbag, Burdwan, West Bengal.
- Dasgupta, S. K., Department of Zoology, Presidency College, Calcutta, West Bengal.

MECOPTERA

None.

DIPTERA

- Alfred, J. R. B., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Chironomidae].
- Choudhuri, P. K., Department of Zoology, University of Burdwan, Golapbag, Burdwan, West Bengal. [Ceratopogonidae, Chironomidae, Sciaridae].
- Cherian, P. T., Southern Regional Station, Zoological Survey of India, 100, Santhome High Road, Chennai-600 028, Tamil Nadu. [Chloropidae].
- Datta, M., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Simuliidae, Tabanidae, Syrphidae, Celyphidae, Diopsidae].
- Garg, P. K., School of Entomology, St. John's College, Agra, Uttar Pradesh. [Agromyzidae].
- Ghorpade, K. D., P. O. Box 2564, 123, Brigade Road, Bangalore, Karnataka. [Synrphidae].
- Gupta, J. P., Department of Zoology, Benaras Hindu University, Varanasi, Uttar Pradesh. [Drosophilidae].
- Ipe, M., School of Entomology, St. John's College, Agra, Uttar Pradesh. [Phlebotomidae, Agromyzidae].
- Joseph, A. N. T., Retired Scientist, Southern Regional Station, Zoological Survey of India, 100, Santhome Road, Cheennai-600 028, Tamil Nadu. [Asilidae, Tipulidae].
- Kapoor, V. C., Department of Zoology, Punjab Agricultural University, Kapurthala-144 601, Punjab.
- Kaul, B. K., Department of Zoology, H. P. Krishi Visva Vidyalaya, Palampur-176 062, Himachal Pradesh. [Blephariceridae].
- Kulshrestha, A. K., Department of Zoology, Garhwal University, Garhwal, Srinagar-246 174, Uttar Pradesh. [Chironomidae].
- Nandi, B. C., Department of Zoology, Krishnanagar Government College, Krishnanagar, Nadia, West Bengal. [Sarcophagidae].
- Parui, P., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Asilidae, Tipulidae].
- Radhakrishnan, C., Western Ghats Field Research Station, Zoological Survey of India, 13/787-A, Annie Hall Road, Calicut-673 002, Kerala. [Tephritidae].
- Sehgal, V. K., Department of Entomology, G. B. Pant University of Agriculture and Technology, Pant Nagar, Nainital, Uttar Pradesh. [Agromyzidae].
- Sharma, R. M., Western Regional Station, Zoological Survey of India, Vidya Nagar, Sector 29, P.B. No. 3053, Rawot Road, Pune-411 044, Maharashtra. [Cecidomyiidae].

Singh, A., Department of Zoology, Punjab University, Chandigarh-160 014, Punjab. [Tephritidae].

Singh, B. K., Department of Zoology, Kumaun University, Nainital, Uttar Pradesh. [Drosophilidae].

LEPIDOPTERA

Arora, G. S., Retired Scientist, Zoological Survey of India, G-175, Preet Vihar, Vikas Marg, New Delhi-110 092.

Bhattacharya, D. P., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Chander, A., Forest Research Institute, Dehra Dun-248 006, Uttar Pradesh. [Geometridae, Pyralidae].

Ghosh, S. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Ghosh, Sanjit K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Gupta, I. J., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Gupta, S. L., Division of Entomology, Indian Agricultural Research Institute, Pusa, New Delhi-110 012. [Lymantriidae and allied moths].

Haribal, M., Bombay Natural History Society, Hornbill House, Shahid Bhagat Singh Road, Mumbai-400 023. [Rhopalocera].

Majumdar, M., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Maulik, D. R., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Mondal, D. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Nandi, B., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Pajni, H. R., Department of Zoology, Punjab University, Chandigarh. [Pyralidae].

Radhakrishnan, C., Western Ghats Field Research Station, Zoological Survey of India, 13/787-A, Annie Hall Road, Calicut-673 002, Kerala.

Rose, H. S., Department of Zoology, Punjab University, Chandigarh-160 014, Punjab. [Pyralidae].

Singh, P., Forest Research Institute, Dehra Dun, Uttar Pradesh. [Geometridae, Pyralidae].

Varshney, R. K., Retired Scientist, Zoological Survey of India, Raj Bhawan, Manik Chowk, Aligarh-202 001, Uttar Pradesh.

TRICHOPTERA

Ghosh, S. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Majumdar, M., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

HYMENOPTERA

Chandra, Girish, Department of Zoology, K. M. College, University of Delhi, Delhi.
Farooqui, S. I., Division of Entomology, Indian Agricultural Research Institute, Pusa, New Delhi-100 012.

Gupta, R. K., Department of Zoology, Rajrishi College, Alwar-301 001, Rajasthan.

Gupta, S. K., Northern Regional Station, Zoological Survey of India, 218, Kaulagarh Road, Dehra Dun-248 195, Uttar Pradesh.

Hayat, M., Department of Zoology, Aligarh Muslim University, Aligarh-202 002, Uttar Pradesh.

Jonathan, J. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

Joseph, K. J., Agricultural University, Vellanikkare, Trichur-680 654, Kerala

Mani, M. S., Department of Zoology, Presidency College, Chennai, Tamil Nadu.

Narendran, T. C., University of Calicut, Calicut-673 635, Kerala.

Nikam, P. K., Department of Zoology, Marathawada University, Aurangabad-431 004, Maharashtra.

Sharma, S. K., St. John's College, Agra-282 002, Uttar Pradesh.

Sharma, V., Department of Zoology, Jodhpur University, Jodhpur, Rajasthan.

Singh, D., Department of Zoology, Punjabi University, Patiala-147 002, Punjab.

Singh, Sudhir, Forest Protection Division, Institute of Rain and Moist deciduous Forests Research, Na-ali, Jorhat-785-001, Assam.

Sujauddin, Department of Zoology, Aligarh Muslim University, Aligarh-202 002, Uttar Pradesh.

Sureshan, P. M., Western Ghats Field Station, Zoological Survey of India, 13/787-A, Annie Hall Road, Calicut-673 002, Kerala.

Tiwari, R. N., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

MYRIAPODA

Achar, K. Prabhakar, Bhuvendra Nature Club-India, Sri Bhuvendra College, Karkala-574 104, Karnataka.

Jangi, B. S., 'Arvind', B 1/348, Janakpuri, New Delhi-110 058.

Khanna, Vinod, Northern Regional Station, Zoological Survey of India, 218, Kaulagarh Road, Dehra Dun-248 195, Uttar Pradesh.

Mary Bai., Southern Regional Station, Zoological Survey of India, 100, Santhome High Road, Chennai-600 028, Tamil Nadu.

Yadav, B. E., Western Regional Station, Zoological Survey of India, Vidya Nagar, Sector 29, P. B. No. 3053, Rawot Road, Pune-411 044, Maharashtra.

ARACHNIDA

Bastawade, B. B., Western Regional Station, Zoological Survey of India, Vidya Nagar, Sector 29, P. B. No. 3053, Rawot Road, Pune-411 044, Maharashtra. [Scorpionida].

Bhaduri, A. K., Department of Zoology, Vidyasagar College, 39, Sankar Ghosh Lane, Calcutta-700 006. [Soil cryptostigmata].

Bhat, H., National Institute of Virology, Pune-411 001, Maharashtra. [Trombiculids, Ticks].

Bhattacharyya, S. K., Retired Scientist, Zoological Survey of India, Sitala Nibas, Basu Para, Sonarpur-743 369, West Bengal. [Soil mesostigmata].

Bhattacharya, T., Department of Zoology, Vidyasagar University, Midnapore-721 102, West Bengal. [Soil cryptostigmata].

Biswas, B. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Araneae].

Biswas, K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Aranene].

Chakraborty, D. K., Department of Zoology, Presidency College, Calcutta, West Bengal. [Soil cryptostigmata].

Chakrabarti, S., Department of Zoology, University of Kalyani, Kalyani-741 235, Nadia, West Bengal. [Eriophyoids].

Channa Basavanna, G. P., Retired Professor, University of Agricultural Sciences, Hebbal, Bangalore, Karnataka; 603, II Block, Rajajinagar, Bangalore-560 010, Karnataka. [Plant mites].

De, S. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Ticks].

Dutta, Ashit Kumar, Revti House, Santipara, Dibrugarh-786 001, Assam. [Soil mesostigmata].

Gajbe, U. A., Zoological Survey of India, Nizam Palace Complex, 2nd M. S. Building, 14 Floor, 234/4, A. J. C. Bose Road, Calcutta-700 020. [Araneae].

Gupta, S. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Plant, Soil, Parasitic mites].

Gupta, Y. N., Central Regional Station, Zoological Survey of India, 424, New Adarsha Colony, Kamala Nehru Nagar, Jabalpur-482 002, Madhya Pradesh. [Plant mites].

Haq, M. A., Acarology Division, Department of Zoology, University of Calicut, Calicut-673 635, Kerala. [Soil cryptostigmata].

- Hiregaudar, L. S., University of Agricultural Sciences, Dharwad, Karnataka. [Parasitic mites].
- Kaul, H. N., National Institute of Virology, Pune-411 001, Maharashtra. [Trombiculids, Ticks].
- Kulkarni, S. M., National Institute of Virology, Pune-411 001, Maharashtra. [Trombiculids, Ticks].
- Kundu, B. G., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Soil cryptostigmata].
- Majumdar, S., Zoological Survey of India, Sundarban Field Research Station, Canning-743 329, West Bengal. [Araneae].
- Mallik, B., University of Agricultural Sciences, Hebbal, Bangalore-560 024, Karnataka. [Plant mites].
- Mathur, R. B., Haryana Agricultural University, Hisar-125 004, Haryana. [Parasitic and bee mites].
- Mathur, S., Haryana Agricultural University, Hisar-125 004, Haryana. [Parasitic and bee mites].
- Misra, A. C., National Institute of Virology, Pune-411 001, Maharashtra. [Trombiculids, Ticks].
- Mittal, O. P., Department of Zoology, Punjab Agricultural University, Chandigarh-160 014, Punjab. [Araneae].
- Mohansundaram, M., Tamil Nadu Agricultural University, Coimbatore.-641 003, Tamil Nadu.[Eriophyoids, Tetranychoids, insect mites].
- Mondal, B. K., Department of Zoology, Ananda Chandra College, Jalpaiguri-735 101, West Bengal. [Soil cryptostigmata].
- Patel, B. H., Department of Zoology, P. P. Institute of Science, Bhavnagar, Gujarat. [Araneae].
- Putatunda, B. N., Haryana Agricultural University, Hisar-125 004, Haryana. [Parasitic and bee mites].
- Ramani, N., Acarology Division, Department of Zoology, University of Calicut, Calicut-673 635, Kerala. [Soil cryptostigmata].
- Rather, A. Q., Sher-e-Kashmir University, Srinagar, Jammu and Kashmir. [Plant mites].
- Sadana, G. L., Punjab Agricultural University, Chandigarh-160 014, Punjab. [Tetranychoids, Araneae].
- Saha, Gautam, Department of Zoology, Durgapur Government College, Durgapur, West Bengal. [Dust mites].
- Sanyal, A. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Soil mites, Ticks].
- Sarkar, P. K., Bidhanchandra Krishi Viswa Vidyalaya, Kalyani-741 235, Nadia, West Bengal. [Plant mites].

Sarkar, Sadhana, Department of Zoology, M. B. B. College, Agartala, Tripura. [Soil cryptostigmata].

Singh, J., Benaras Hindu University, Varanasi, Uttar Pradesh. [Plant mites].

Som Choudhuri, A. K., Bidhanchandra Krishi Viswa Vidyalaya, Kalyani-741 235, Nadia, West Bengal. [Plant mites].

PHORONIDA

Haldar, B. P., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.

BRYOZOA

Diwan, A. P. Government Science College, University of Indore, Mhow, Madhya Pradesh.

Karande, A. A., Naval Chemical and Metallurgical Laboratory, Mumbai. [Fouling species].

Menon, N. R., Biology Department, Cochin University, Cochin. Kerala. [Taxonomy, Ecology].

Nair, K. V. K., Water and Stream Chemistry Laboratory, Indira Gandhi Centre for Atomic Research, Kalpakkam. [Fouling species].

Nair, N. B., Kerala University, Trivandrum. [Taxonomy, Ecology].

Nair, P. S. R., Centre for Advanced Studies in Marine Biology, Porto Novo, Tamil Nadu. [Estuarine Bryozoa].

Rao, K. Satyanarayana, Wood Biodegradation Division-Marine, Institute of Wood Science & Technology, C/o Department of Zoology, Andhra University, Vishakhapatnam-530 003, Andhra Pradesh. [Taxonomy, Fouling biology, Ecology].

Rao, K. S., School of Studies in Zoology, Vikram University, Ujjain, Madhya Pradesh.

Shrivastava, P., Bhopal University, Bhopal, Madhya Pradesh.

Swamy, B., Naval Chemical and Metallurgical Laboratory, Mumbai. [Fouling species].

Viswanadham, B., Department of Zoology, Andhra University, Vishakhapatnam-530 003, Andhra Pradesh.. [Taxonomy, Biology].

Wagh, A. B., National Institute of Oceanography, Dona Paula, Panaji, Goa-403 004. [Fouling species].

ENTOPROCTA

Haldar, B. P., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.

Rao, K. S., School of Studies in Zoology, Vikram University, Ujjain, Madhya Pradesh.

CHAETOGNATHA

Nair, Vijayalakshmi R., National Institute of Oceanography, Dona Paula, Panaji, Goa-403 004.

Srinivasan, M., Southern Regional Station, Zoological Survey of India, 100, Santhome High Road, Chennai-600 028, Tamil Nadu.

TARDIGRADA

Rao, G. C., Retired Scientist, Zoological Survey of India, Freshwater Biological Station, Hyderabad-500 020, Andhra Pradesh.

Venkataraman, K., Marine Biological Station, Zoological Survey of India, 100, Santhome High Road, Chennai- 600 028, Tamil Nadu.

ECHINODERMATA

James, D. B., Tuticorin Research Centre, Central Marine Fisheries Research Institute., Tuticorin-628 001, Tamil Nadu.

Jayasree, V., National Institute of Oceanography, Dona Paula, Panaji, Goa-403 004.

Krishnan, S. Department of Zoology, Bangalore University, Bangalore-560 056, Karnataka.

Mary Bai., Southern Regional Station, Zoological Survey of India, 100 Santhome High Road, Chennai-600 028, Tamil Nadu.

Mukhopadhyay, S. K., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.

Rajan, P. T., Zoological Survey of India, Andaman and Nicobar Regional Station, Middle Point, Port Blair-744 101, Andaman and Nicobar Islands.

Reuben, S. Waltair Research Centre, Central Marine Fishers Research Institute, Visakhapatnam-530 003, Andhra Pradesh.

Sastry, D. R. K., Andaman and Nicobar Regional Station, Zoological Survey of India, Middle Point, Port Blair-744 101, Andaman and Nicobar Islands.

HEMICHORDATA

Azaria, Jayapaul, Department of Zoology, University of Madras, Chennai-600 020, Tamil Nadu. [Enteropneusta].

Balasubramaniam, M., Centre for Advanced Studies in Marine Biology, Porto Novo, Tamil Nadu. [Enteropneusta].

Dandapani P., Retired Scientist, Marine Biological Station, Zoological Survey of India, 100, Santhome High Road, Chennai-600 028, Tamil Nadu. [Enteropneusta].

PROTOCHORDATA

- Azaria, Jayapaul, Department of Zoology, University of Madras, Chennai-600 020, Tamil Nadu. [Cephalochordata].
- Bhavanarayana, P. V., Department of Zoology, Andhra University, Visakhapatnam-530 003, Andhra Pradesh. [Salpida].
- Dandapani, P., Retired Scientist, Zoological Survey of India, Marine Biological Station, 100, Santhome High Road, Chennai-600 028, Tamil Nadu. [Protochordata except ascidians].
- Ranganathan, T., Department of Zoology, Hindu College, Tuticorin, Tamil Nadu. [Ascidacea].

PISCES

- Barman, R. P., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.
- Chatterjee, T. K., Marine Aquarium and Research Centre, Zoological Survey of India, Digha-721 428, Midnapore, West Bengal.
- Datta, A. K., Retired Scientist, Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.
- Datta, N. C., Department of Zoology, University of Calcutta, 35, Ballygange Circular Road, Calcutta-700 019.
- Dey, S. C., Department of Zoology, Guwahati University, Guwahati, Assam.
- Husain, A., Zoological Survey of India, 1-1-300/B, Ashok Nagar, Hyderabad-500 020, Andhra Pradesh
- James, P. S. B. R., Central Marine Fisheries Research Institute, P.B. No. 1912, Cochin-682 018, Kerala:
- Jayaram, K. C., Zoological Survey of India, 100, Santhome High Road, Chennai-600 028, Tamil Nadu.
- Johal, M. S., Department of Zoology, Punjab University, Chandigarh-160 014, Punjab.
- Karmakar, A. K., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.
- Krishnan, S., Southern Regional Station, Zoological Survey of India, 100, Santhome High Road, Chennai-600 028, Tamil Nadu.
- Kumaran, M., Central Marine Fisheries Research Institute, Calicut, Kerala.
- Luther, G., Central Marine Fisheries Research Institute, Waltair, Andhra Pradesh.
- Mehta, H. S., High Altitude Zoology Field Station, Zoological Survey of India, Jandev Nivas, Hospital Road, Solan-173 212, Himachal Pradesh.
- Menon, A. G. K., Retired Scientist, Marine Biological Station, Zoological Survey of India, Chennai-600 028, Tamil Nadu.

- Mohan, R. S. Lal, Central Marine Fisheries Research Institute, Calicut, Kerala.
- Ramaiyan, V., Centre for Advanced Studies in Marine Biology, Porto Novo, Tamil Nadu.
- Rao, K. Srinivasa, Department of Zoology, Andhra University, Vishakhapatnam-530 003, Andhra Pradesh.
- Rao, K. V. Rama, Retired Scientist, Freshwater Biological Station, Zoological Survey of India, 1-1-300/B, Ashok Nagar, Hyderabad 500 020.
- Sen, N., Eastern Regional Station, Zoological Survey of India, Fruit gardens, Risa Colony, Shillong-793 003, Meghalaya.
- Sen, T. K., Retired Scientist, Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.
- Sudarsan, D., Fishery Survey of India, Verosa, Bombay.
- Talwar, P. K., Retired Scientist, Flat No. 963, Sector-A, Pockets Vasant Kemj, New Delhi-110 070.
- Tandon, K. K., Department of Zoology, Punjab University, Chandigarh-160 014, Punjab.
- Yazdani, G. M., Retired Scientist, Western Regional Station, Zoological Survey of India, Vidya Nagar, Secor 29, P. B. No. 3053, Rawot Road, Pune-411044, Maharashtra.

AMPHIBIA

- Chanda, S. K., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016.
- Daniel, J. C., Bombay Natural History Society, Hornbill House, Shahid Bhagat Singh Road, Mumbai- 400 023, Maharashtra.
- Das, Indraneil, IUCN, Amphibia/Reptilia of Indian Sub-continent, Centre for Herpetology, Madras Crocodile Bank Trust, Chennai, Tamil Nadu.
- Dutta, S. K., Utkal University, Vani-Vihar, Bhubaneswar-751 004, Orissa.
- Pillai, R. S., Retired Scientist, Southern Regional Station, Zoological Survey of India, 100, Santhome High Road, Chennai - 600 028, Tamil Nadu.

REPTILIA

- Acharjyo, L N., Nandankanan Biological Park, Barang-754 005, Cuttack, Orissa.
- Bhaskar, Satish, Chennai Crocodile Bank, Perur, Chingleput-603 104, Tamil Nadu.
- Biswas, S., Retired Scientist, Zoological Survey of India, 84, Baburanipara Road, Bhatpara, North 24-parganas-743 123, West Bengal.
- Choudhury, B. C., Wildlife Institute of India, F. R. I. Campus, New Forest, Dehra Dun-248 006, Uttar Pradesh.

- Daniel, J. C., Bombay Natural History Society, Hornbill House, Shahid Bhagat Singh Road, Mumbai-400 023, Maharashtra.
- Dattatre, Shekar, Plot 40, 3rd East Street, Tiruvanmiyur, Chennai-600 041, Tamil Nadu
- Deoras, P. J., Hoffkins Institute, Parel, Mumbai, Maharashtra.
- Duda, P. L., Department of Bio-Sciences, University of Jammu, Canal Road, Jammu-180 001, Jammu and Kashmir.
- Dutta, Sushil K., Department of Zoology, Utkal University, Vani-Vihar, Bhuvaneshwar-751 004, Orissa.
- Kar, C. S., Forest Department, Government of Orissa, Bhuvaneshwar, Orissa.
- Kar, Sudhakar, Crocodile Project, Office of the Chief Wildlife Warden, 315, Kharbel Nagar, Bhuvaneshwar-751 001, Orissa.
- Khairae, Anil, Indian Herpetological Society, "Ushant", Pune-Satara Road, Pune-411 009, Maharashtra.
- Mahendra, B. C., The Academy of Zoology, Khandari Road, Agra-2, Uttar Pradesh.
- Mathew, R., Eastern Regional Station, Zoological Survey of India, Fruit Garden, Risa Colony, Shillong-793 003, Meghalaya.
- Mohanty-Hejmadi, Priyamvada, Department of Zoology, Utkal University, Vani Vihar, Bhuvaneshwar-751 004, Orissa.
- Murthy, T. S. N., Retired Scientist, Southern Regional Station, Zoological Survey of India, 100, Santhome High Road, Chennai – 600 028, Tamil Nadu.
- Rajagopalan, M., Central Marine Fisheries Research Institute, Madras Research Centre, 141, Marahsll Road, Egmore-600 008, Tamil Nadu.
- Rajendran, M. V., 31, Devaloga Street, Palayamkottai, Tirunelveli-627 002, Tamil Nadu.
- Rao, M. V. Subba, Department of Environmental Sciences, Andhra University, Vishakhapatnam-530 003, Andhra Pradesh.
- Rao, R. J., Jiwaji University, School of Zoology, Gwalior 474 011, Madhya Pradesh.
- Sanyal, D. P., Retired Scientist Zoological Survey of India, 27, J. L. Nehru Road, Calcutta - 700 016
- Sharma, B. D., Mountain Eco-Conservation and Wildlife Society of India, P. O. Box 18, Jammu- 180 001, Jammu and Kashmir.
- Sharma, R. C., Retired Scientist, Desert Regional Station, Zoological Survey of India, Pataudi House, Paota Lines, Jodhpur – 342 006, Rajasthan.
- Singh, A. K., Similipal Tiger Reserve, Khairi-Jashipur, Orissa-757 091.
- S. K. Talukdar, Zoological Survey of India, 27, J. L. Nehru Road, Calcutta- 700 016.
- Vyas, Raju, Sayaji Baug Zoo, Baroda-390 018, Gujarat.
- Vyas, Tej Prakash, Environmental Conservation Society, L-176, Housing Board Colony, Dhar-454 001, Madhya Pradesh.

Whitaker, Romulus, Chennai Crocodile Bank, Perur, Chingleput-603 104, Tamil Nadu.
M. R. Yadav, Turtle Research and Conservation Centre, 3/16, Murai Tola,
Faizabad- 224 123, Uttar Pradesh.

AVES

- Abdulali, Humayun, 75, Abdul Rehman Street, Bombay-400 003, Maharashtra.
Basu Roy, S., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
Bhatnagar, R. K., Indian Agricultural Research Institute, Pusa, New Delhi-110 012.
Chattopadhyay, S., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
Dasgupta, J. M., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
Dutta, B. B., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
Dutta, B. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
Ghosal, D. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
Ghosh, S., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
Gole, Prakash, 1B, Abhimanshree Society, Pashan Road, Pune-411 008, Maharashtra.
Grubh, Robert B., Bombay Natural History Society, Hornbill House, Shaheed Bhagat Singh Road, Bombay-400 023, Maharashtra.
Lamba, B. S. Retired Scientist, Zoological Survey of India, 2/11, Old Survey Road, Dehra Dun-248 001, Uttar Pradesh.
Mahabal, A. S., Western Regional Station, Zoological Survey of India, Vidya Nagar, Sector 29, P. B. No. 3053, Rawot Road, Pune-411 044, Maharashtra.
Majumdar, N. , Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
Mathew, D. N., University of Calicut, Calicut-673 635, Kerala.
Mukherjee, A. K., Retired Scientist, Zoological Survey of India, 28/15 New Ballygung Road, Calcutta-700 039.
Naik, R. M., Saurashtra University, Rajkot, Gujarat.
Neelakantan, K. K., 26/1643, Unni's Lane, Trivandrum, Kerala.
Pittie, Aasheesh, 14-7-370 Begum Bazar, Hyderabad-500 012, Andhra Pradesh.
R. Rahmani, Asad, Bombay Natural History Society, Hornbill House, Shaheed Bhagat Singh Road, Bombay-400 023, Maharashtra.
Roy, C. S., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.

- Saha, S. S., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053.
- Tak, P. C., Northern Regional Station, Zoological Survey of India, 218, Kaulagarh Road, Dehra Dun-248 125, Uttar Pradesh.

MAMMALS

- Agrawal, V. C., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Rodentia, Primates, Scandentia-taxonomy, Zoogeography, ecology].
- Alfred, J. R. B., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Primates-ecology, behaviour zoogeography].
- Bhattacharyya, T. P., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Systematics, distribution].
- Chakraborty, R., Zoological Survey of India, 27, J. L. Nehru Road, Calcutta-700 016. [Rodentia-ecology, behaviour, taxonomy].
- Chakraborty, Sujit, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Rodentia, Perissodactyla, Insectivora-taxonomy, zoogeography, ecology].
- Chakraborty, T. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Systematics].
- Chandrashekar, M. K., Department of Animal behaviour and Biological Sciences, Madurai Kamraj University, Madurai, Tamil Nadu. [Chiroptera-chronobiology].
- Das, P. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Chiroptera-taxonomy, zoogeography biology].
- De, J. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Ultra-structure of mammalian hair].
- Ghosh, M. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Systematics, distribution].
- Ghosh, P. K., Central Arid Zone Research Institute, Jodhpur-342 003, Rajasthan. [Rodentia-physiology, control of arid zone species].
- Ghose, R. K., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Lagomorpha, Carnivora, Insectivora, Rodentia-taxonomy, zoogeography, ecology].
- Gopalakrishna, A., Institute of Science, Nagpur University, Nagpur, Maharashtra. [Chiroptera -embryology, breeding biology].
- Ishwar, Prakash, Central Arid Zone Research Institute, Jodhpur-342 003, Rajasthan. [Rodentia, Insectivora, Chiroptera-taxonomy, ecology, biology of arid zone species].

- Jain, A. P., Central Arid Zone Research Institute, Jodhpur-342 003, Rajasthan. [Rodentia-behaviour, breeding, control of arid zone species].
- Khajuria, H., Retired Scientist, High Altitude Zoology Field Station, Zoological Survey of India, Jandev Niwas, Hospital Road, Solan-173 212, Himachal Pradesh. [Chiroptera, Primates-taxonomy, zoogeography, ecology].
- Kurup G. U., Retired Scientist, Western Ghats Field Research Station, Zoological Survey of India, 13/787-A, Annie Hall Road, Calicut-673 002, Kerala. [Primates-systematics, zoogeography, ecology].
- Lal, J. P., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Chiroptera-taxonomy].
- Mandal, A. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Rodentia-taxonomy, ecology].
- Mukherjee, R. P., Retired Scientist, Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053 [Primates-ecology, behaviour].
- Podder, A. K., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Systematics].
- Pradhan, M. S., Zoological Survey of India, Western Regional Station, Vidya Nagar, Sector 29, P. B. No. 3053, Rawot Road, Pune-411 044, Maharashtra. [Rodentia-chemotaxonomy, ecology, behaviour].
- Saha, S. S., Zoological Survey of India, 'M' Block, New Alipore, Calcutta-700 053. [Systematics, ecology, behaviour].
- Sati, J. P., Northern Regional Station, Zoological Survey of India, 218 Kaulagarh Road, Dehra Dun-248 195, Uttar Pradesh. [Primates-ecology, behaviour].
- Sinha, N. K., Northern Regional Station, Zoological Survey of India, 218, Kaulagarh Road, Dehra Dun-248 195, Uttar Pradesh. [Ecology].
- Sinha, Y. P., Gangetic Plains Regional Station, Zoological Survey of India, Handloom Bhawan, Rajendra Nagar, Patna-800 016, Bihar. [Chiroptera-taxonomy, distribution].
- Srihari, K., Department of Vertebrate Zoology, Agricultural University, Bangalore, Karnataka. [Rodentia-ecology, control].
- Tak, P. C., Zoological Survey of India, Northern Regional Station, 218, Kaulagarh Road, Dehra Dun-248 195, Uttar Pradesh. [Systematics, ecology].

Dr. J. R. B. Alfred, M. Sc., Ph. D. is the Director, Zoological Survey of India. His major scientific contributions have been in the field of Chironomid (Diptera:Insecta) Taxonomy, Fresh-water Biology, Soil Biology and now in Animal Ecology and Behaviour with particular reference of non-human primates. He has visited a number of hydrobiological laboratories in the continent like Italy, Switzerland and Germany to name a few. He is writing the Fauna of India Volume on Chironomidae in collaboration with Burdwan University, West Bengal, and is bringing out the detailed study on Hoolock Gibbon.

Dr. A. K. Das, M. Sc., Ph. D. is a Senior Scientist in the Zoological Survey of India. He has been engaged in researches in the field of taxonomy and ecology of Freelifving and Symbiotic Protozoa for more than three decades. His research interests also cover Marine Borers, more particularly molluscan and crustacean borers, Mangrove Biology and Island Biogeography.

Dr. A. K. Sanyal, M. Sc., Ph. D. is a Senior Scientist in the Zoological Survey of India. He is engaged in researches on Soil Microarthropods specially on taxonomy and ecology of acari and ticks. He is also working on different aspects of biodiversity in India and Environmental Impact Assessment.

