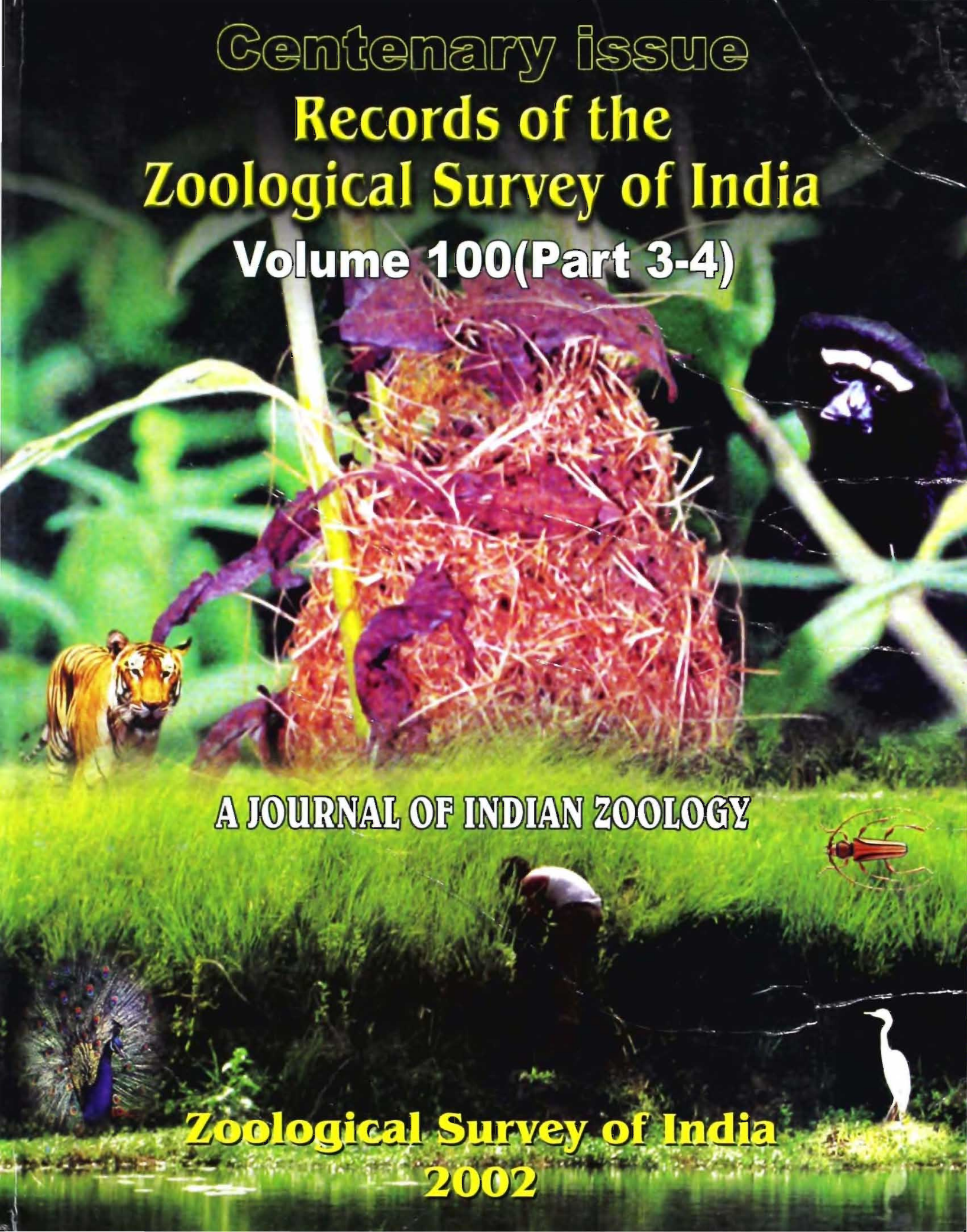


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DR. J. R. B. ALFRED
Director
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RECORDS OF THE ZOOLOGICAL SURVEY OF INDIA

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STUDIES ON THE PHYSICOCHEMICAL AND BIOLOGICAL PROPERTIES OF TWO MAN MADE LAKES OF CALCUTTA

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INTRODUCTION

Lakes, both natural as well as man made, constitute an important component of fresh water resources, because of their diverse uses. The aquatic environment of such lakes support a variety of flora and fauna which include the biotic community of phytoplankton, macrophytes, zooplankton, benthos, necton etc. Together with the prevailing physico-chemical condition of water and soil, these biotic communities form an interdependent and balanced ecological system. Generally, lakes situated in urban areas are mainly used for recreational purposes like swimming, bathing and other water sports. However, many a times, these water bodies are subjected to undesirable uses such as discharge of industrial and domestic effluents or excessive use by surrounding dense human population for a variety of purposes and thereby degrading the water quality considerably.

In Calcutta metropolitan, there are two medium sized man made lakes viz. Rabindra Sarovar and Subhas Sarovar. Subhas Sarovar, situated in north eastern part of city covers an area of 39.5 acre. Rabindra Sarovar situated in Southern part of city is larger than Subhas Sarovar and covers an area of nearly 72 acres. No organised fishing activity is being carried out in these lakes, except sport angling in Subhas Sarovar. Recently these two lakes have been included in National Lake conservation plan by Ministry of Environment and Forests and Rabindra Sarovar has been declared as National Lake.

Several earlier studies on the urban recreational ponds of the country (Michael, 1962, Sreenivasan, 1964, 1965, 1976; George, 1966; Ganapati and Sreenivasan, 1970; Jana, 1979; Zutsi and Vaas, 1982; Zafar, 1966 Kulshrestha, 1988,) also pointed out their altered ecological condition due to excessive undesirable uses. In spite of their importance in Calcutta Metropolitan, these lakes have yet not been properly investigated. Excepting few earlier studies of specific nature on primary productivity and zooplankton by Khan (1979, 1981, 1985) in Rabindra Sarovar practically no information is available on general limnological condition of these two lakes. Therefore, the present studies were undertaken for two consecutive annual cycles, 1996-97 and 1997-98. with a view point to work out the physico-chemical characteristics of water, phytoplankton, rate of primary production and diversity and abundance of zooplankton of the two lakes.

DESCRIPTION OF STUDY AREA

Rabindra Sarovar lake is almost elongated in shape and covers an area of nearly 72 acres. Its maximum length is around 1770 m and width at broadest point is approximately 206 m. The mean depth varied between 9 and 10 m at different sampling stations. The main source of water supply is surface run off during rainy season. There is practically no out let. The lake is characterized by dense macrophyte growth in its entire littoral zone.

Subhas Sarovar is comparatively smaller with an area of 39 acres. Its length from east to west is 533.3 m and width at broadest point, south to north, is about 366 m. The littoral zone is almost devoid of macrophyte during major part of years. This lake is also fed mainly by rain water.

MATERIALS AND METHOD

The studies were carried out between the period of February 1995 to January 1997. Sampling were done fortnightly at three different station of both lakes. Water samples were collected from 15-20 cm below the surface. Air and water temperature, pH and conductivity were recorded in the field by electronic meters. Dissolved oxygen was determined by modified Winkler's method. Titrametric method was used to measure the alkalinity of water. For other parameters, water samples collected in clean glass stopper bottles of 500ml capacity were carried to laboratory and analysed immediately. Chloride, phosphate, nitrate, nitrite and ammonium contents were analysed by Spectroquant SQ118 electronic spectrophotometer (EMerck, Germany). Phytoplankton primary production and respiration were determined by classical light and dark bottle technique (Gaarder and Gran 1927) following Vollenweider (1974). Qualitative and quantitative samples of zooplankton were collected from littoral zone with the help of a plankton net made of bolting nylon cloth (no 21). Qualitative sampling for taxonomic and relative abundance studies were done by sweeping the net several times in different directions. Samples were preserved in 4% formalin. Detail taxonomic identification was carried out following Edmondson (1959), Pennak (1978), Michael and Sharma (1987), Sehgal (1983), Battish (1984) and Sharma (1998).

For quantitative analysis of relative abundance and density, identification and enumeration were done simultaneously in a Sedgwick Rafter counter by taking 1 ml sub sample and then raised to total volume of water filtered. All data collected from there stations were pooled together so as to obtain single values for each sampling day. These were further pooled month-wise and season-wise. Seasons have been defined as premonsoon (Feb-May), monsoon (June-Sep) and post monsoon (Oct-Jan).

RESULTS

A. Physico-chemical factor :

Physicochemical characteristics of water of both Rabindra Sarovar and Subhas Sarovar fluctuated moderately during different seasons (Tables 1 and 2). In Rabindra Sarovar, water temperature

Table 1. Physico-chemical Analysis of water of Rabindra Sarovar in two Annual Cycle (1995–1996 and 1996–1997).

Physico-chemical factors	1st annual cycle (1995-1996)			2nd annual cycle (1995-1996)		
	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
Water temp (°C)	32.83	31.62	26.56	30.94	30.61	25.91
pH	8.86	8.64	7.98	8.74	8.64	8.18
Turbidity (NTU)	12.0	31.5	13.1	10.88	21.0	10.04
Conductivity (mmhos)/cm	657.33	613.59	487.08	719.92	655.42	405.35
Dissolved O ₂ (ppm)	4.7	4.14	5.63	4.34	5.44	6.53
Total Alkalinity (mg/l)	366.75	323.75	334.50	337.50	328.75	330.75
Chloride (mg/l)	61.00	67.34	54.63	66.75	60.38	33.65
Phosphate (mg/l)	0.43	0.20	0.10	0.43	0.39	0.10
Nitrate (mg/l)	1.00	0.73	0.39	0.73	0.46	0.15
Nitrite (mg/l)	0.08	0.16	0.23	0.11	0.14	0.19
Ammonium (mg/l)	0.18	0.17	0.09	0.16	0.12	0.10

varied between 25.9°C and 32.8°C, highest during premonsoon and lowest in postmonsoon. Conductivity varied from 487.08 to 657.33 mmhos/cm and 405.35 to 719.92 mmhos/cm during first and second annual cycle. Highest turbidity value was recorded in monsoon and the water remained comparatively clear during rest of the year. Dissolved oxygen content was always moderate during the study period. Its values were slightly higher in late postmonsoon of both years and remained more or less similar in premonsoon and monsoon. The pH fluctuated narrowly between different seasons from 7.98 to 8.86 and 8.18 to 8.74 in first and second annual cycle. The contribution of chloride, phosphate, nitrate, nitrite and ammonia were lowest during postmonsoon and highest in premonsoon excepting alkalinity value which was lowest during monsoon.

Table 2. Physico-chemical Analysis of water of Subhas Sarovar in two Annual Cycle (1995–1996 and 1996–1997).

Physico-chemical factors	1st annual cycle (1995-1996)			2nd annual cycle (1995-1996)		
	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
Water temp (°C)	33.13	32.46	25.46	32.26	31.95	26.17
pH	8.40	8.18	7.85	8.60	8.41	8.04
Turbidity (NTU)	12.0	31.5	13.1	10.88	21.0	10.04
Conductivity (mmhos)/cm	471.25	419.00	328.25	458.25	427.25	400.25
Dissolved O ₂ (ppm)	4.69	4.71	6.75	5.98	5.08	6.96
Total Alkalinity (mg/l)	246.58	186.08	192.08	229.6	212.93	231.58
Chloride (mg/l)	44.71	46.54	40.75	50.71	45.79	28.42
Phosphate (mg/l)	0.03	0.02	0.10	0.07	0.01	0.03
Nitrate (mg/l)	0.68	0.31	0.12	0.20	0.27	0.20
Nitrite (mg/l)	0.08	0.31	0.12	0.09	0.11	0.04
Ammonium (mg/l)	0.27	0.27	0.14	0.25	0.22	0.06

The physico-chemical characteristics of Subhas Sarovar was more or less similar to that of Rabindra Sarovar including the concentration of nutrients and seasonal variation pattern also followed closely to Rabindra Sarovar. However, noticeable variations were recorded in the values of alkalinity, chloride and conductivity which were somewhat lower than Rabindra Sarovar.

B. Primary productivity :

The Gross Primary Productivity in Rabindra Sarovar varied between 1443.75 and 3662.5 mgC/m³/day with an annual mean of 2397.42 mgC/m³/day, while Net primary productivity fluctuated widely and varied from 412.5 to 2237.5 mgC/m³/day.

Maximum net gross ratio was observed in monsoon (0.71) and minimum in post-monsoon (0.44). Percentage of respiration to GPP fluctuated between 28.87-56.1%

The Gross Primary Productivity values in Subhas Sarovar ranged between 2171.25–3512.00 mgC/m³/day (Table 3) with annual mean of 2397.42 mgC/m³/day. Values of net primary productivity ranged between 1375.00-2250.25 mgC/m³/day with a mean of 1683.54 mgC/m³/day. The range of fluctuation in community respiration value was between 718.62 and 1261.00 mgC/m³/day with annual mean of 986.95 mgC/m³/day.

Net gross ratio varied from 0.59–0.62. Respiration as a percent of gross production varied from 37.91-50.29%.

Table 3. Gross and Net Primary Productivity in Rabindra Sarovar and Subhas Sarovar (mgC/m³/day).

	Rabindra Sarovar				Subhas Sarovar			
	Pre- monsoon	Monsoon	Post- monsoon	Mean	Pre- monsoon	Monsoon	Post- monsoon	Mean
Gross Primary Productivity (mgC/m ³ /day)	3662.50	1443.75	2086.00	397.42	512.00	2171.25	2356.25	2679.83
Community Respiration (mgC/m ³ /day)	1425.0	412.50	1144.06	993.85	1261.00	718.62	981.25	986.95
Net primary Priduction (mgC/m ³ /day)	2237.00	1031.25	412.50	1226.83	2250.00	1425.63	1375.00	1683.54
Respiration as % of gross	38.30	28.87	56.10	41.09	41.00	50.29	37.91	430.06
Net gross ratio	0.62	0.71	0.44	0.59	0.59	0.62	0.62	0.61

C. Phytoplankton :

Phytoplankton flora were constituted mainly by diatoms (Bacillariophyceae), green algae (Chlorophyceae), blue green algae (Myxophyceae) and phytoflagellates (Euglenophyceae) in these two lakes. A total of 28 species of phytoplankton were recorded from these water bodies.

Rabindra Sarovar harboured 26 species which included 7 species of Chlorophyceae, 7 of Myxophyceae, 9 of Bacillariophyceae and 2 of Euglenophyceae (Table 4). Green algae were mainly comprised by *Closterium sp*, *Scenedesmus sp*, *Oedogonium sp*, *Spirulina sp*, *Cosmarium sp*, *Ankistrodesmus sp*, *Pediastrum sp* and *Spirogyra sp*. Blue green were chiefly represented of *Anabaena sp*, *Anacystis sp*, *Oscillatoria sp*, *Phormidium sp*, *Nostoc sp* and, *Cocconinies sp*. Dominant Diatom flora were comprised of *Denticula sp*, *Cyclotella sp*, *Nitzchia sp*, *Caloneis sp*, and *Navicula sp*.

In Subhas Sarovar too, the Bacillariophyceae was found to dominate both qualitatively and quantitatively and were represented by 8 species. Chlorophyceae were represented by 7 species, Myxophyceae by 5 species and Euglenophyceae by 2 species.

Table 4. Phytoplankton abundance in Rabindra Sarovar and Subhas Sarovar.

	Rabindra Sarovar	Subhas Sarovar
I Chlorophyceae		
1. <i>Closterium sp.</i>	•	•
2. <i>Scenedesmus sp.</i>	•	•
3. <i>Oedogonium sp.</i>	•	•
4. <i>Spirulina sp</i>	•	•
5. <i>Cosmarium sp.</i>	•	•
6. <i>Ankistrodesmus sp.</i>	•	•
7. <i>Pediastrum sp.</i>	•	•
8. <i>Spirogyra sp.</i>	•	•
II Myxophyceae		
9. <i>Anabaena sp.</i>	•	•
10. <i>Anacystis sp.</i>	•	
11. <i>Oscillatoria sp.</i>	•	•
12. <i>Phormidium sp.</i>	•	•
13. <i>Nostoc sp.</i>	•	•
14. <i>Lyngbya sp.</i>	•	•
15. <i>Cocconies sp.</i>	•	•

Table 4. *Contd.*

		Rabindra Sarovar	Subhas Sarovar
III Bacillariophyceae			
16.	<i>Navicula sp.</i>	•	•
17.	<i>Gramatophora sp.</i>	•	•
18.	<i>Achananthes sp</i>	•	•
19.	<i>Amphiphora sp.</i>	–	•
20.	<i>Brachysira sp.</i>	–	•
21.	<i>Caloneis sp.</i>	•	•
22.	<i>Denticula sp.</i>	•	•
23.	<i>Fragillaria sp</i>	•	•
24.	<i>Rhopalodia sp.</i>	•	–
25.	<i>Cyclotella sp.</i>	•	•
26.	<i>Nitzchia sp</i>	•	•
IV Euglenophyceae			
27.	<i>Volvox sp.</i>	•	•
28.	<i>Euglena sp.</i>	•	•

- indicates presence
- indicates absence

D. Zooplankton :

Rabindra Sarovar, which is characterised by dense macrophytic littoral vegetation, harbored a total of 45 species with 19 of Cladocera, 5 of Copepoda, 20 of Rotifera and 1 of Ostracoda (Table 5). Cladocerans were represented by 19 genera under 6 family. Highest number of species belonged to family Chydoridae (9 species) followed by Daphnidae (4 species), Sididae (3 species). Macrothricidae, Moinidae and Bosminidae were represented by one species each. Among the Copepoda both Calanoida and Cyclopoida were represented by two genera, each comprising of 5 species altogether. The Rotifer fauna of this lake were composed of 20 species. Alkaline and highly polymorphic cosmopolitan species dominated the faunal composition. Ostracodes were represented by single species, *Cypris subglobosa*.

The zooplankton species richness of Subhas Sarovar was comparatively higher than Rabindra Sarovar as fauna were represented by 48 species (Table 5). Cladoceran were comprised of 20 species belonging to 16 genera under 6 families. Families Daphnidae and Chydoridae (6 species each) were found to be more diverse than other families. The other families viz. Sididae represented by 4 species, Moinidae by 2 species and Macrothricidae and Bosminidae by one species, also

Table 5. Systematic account of zooplankton taxa in. Rabindra Sarovar and Subhas Sarovar.

Species	Rabindra Sarovar	Subhas Sarovar
Class : Rotifera		
Subclass : Eurotaria		
Order : Ploimida		
I. Family : Lecanidae		
1. <i>Lecane aculata</i> (Jakubski, 1912)	●	●
2. <i>Lecane</i> (Monostyla) <i>bullata</i> (Goss, 1851)	●	●
3. <i>Lecane</i> (<i>Lecane</i>) <i>curvicornis</i> (Murray 1913)	●	—
4. <i>Lecane</i> (<i>Lecane</i>) <i>leotina</i> (Turner, 1892)	●	—
5. <i>Lecane</i> (<i>Lecane</i>) <i>luna luna</i> (O. F. Muller, 1776)	●	●
6. <i>Lecane</i> (<i>Heninostyla</i>) <i>inopinata</i> (Harring and Myer, 1916)	—	●
7. <i>Lecane</i> (<i>Monostyla</i>) <i>hamata</i> (Stokes, 1896)	●	—
8. <i>Lecane</i> (<i>Monostyla</i>) <i>unguitata</i> (Fadeev, 1925)	—	●
II. Family : Brachionidae		
9. <i>Brachionus angularis</i> Goose, 1851	●	●
10. <i>B. calciflorus</i> Pallas, 1761	●	—
11. <i>B. caudatus</i> Barrois & Daday, 1894	●	●
12. <i>B. fulcatus</i> Zacharias, 1898	●	●
13. <i>B. forficula</i> Wierzeyski, 1891	—	●
14. <i>B. quadridentatus</i> Hermann, 1783	●	●
15. <i>B. patulus</i> (O. F. Multer, 1786)	●	●
16. <i>B. rubens</i> Ehrenberg, 1838	●	●
17. <i>Keretella tropica</i> (Apstein, 1907)	●	●
III. Family : Mytilinidae		
18. <i>Mytilina ventratis</i> (Ehrenberg, 1832)	●	●
IV. Family : Asplanchnidae		
19. <i>Asplanchna brightwelli</i> Gosse, 1850	●	●
20. <i>Trichocerca</i> (<i>Diurella</i>) <i>weberi</i> (Jennings, 1903)	—	●
V. Family : Testudinellidae		
21. <i>Testudinella patina</i> (Hermann, 1783)	●	●
VI. Family : Synchaetidae		
22. <i>Polyartha vulgaris</i>	●	●
VII. Family : Filinidae		
23. <i>Filinia opoliensis</i> Zacharias, 1898	—	●
24. <i>Filinia longesita</i> Ehrenberg, 1834	●	●
VIII. Family - Philodinidae		
25. <i>Rotatoria neptunia</i> Ehrenberg, 1832	●	●
Total Rotifera species	20	21

Table 5. Cont'd.

Species	Rabindra Sarovar	Subhas Sarovar
Class : Crustacea		
Subclass : Copepoda		
Order : Calanoida		
I. Family : Calanidae		
26. <i>Heliodiaptomus viduus</i>	●	●
27. <i>Heliodiaptomus contortus</i>	●	●
Order : Cyclopoida		
II. Family : Cyclopidae		
28. <i>Mesocyclops leuckarti</i> (Claus)	●	●
29. <i>Mesocyclops hyalinus</i> Rehberg)	●	●
30. <i>Microcyclops varicans</i> (Sars)	●	●
Total Copepoda species	5	5
Class : Crustacea		
Subclass : Branchipoda		
Order : Cladocera		
I. Family : Sididae		
31. <i>Sida crystallina</i> (O. F. Muller, 1776)	●	●
32. <i>Diaphanosoma sarsi</i> Richard, 1894	●	●
33. <i>Diaphanosoma excisum</i> Sars, 1885	●	●
34. <i>Pseudosida bidentata</i> Herrick, 1884	—	●
II. Family : Daphnidae		
35. <i>Ceriodaphnia cornuta</i> Sars, 1885	●	●
36. <i>Daphnia carinata</i> King, 1853	—	●
37. <i>Daphnia lumholtzi</i> Sars, 1885	—	●
38. <i>Scapholeberis kingi</i> Sars, 1903	●	●
39. <i>Simocephalus expinosus</i> (Koch, 1841)	●	●
40. <i>Simocephalus vetulus</i> (O. F. Muller, 1776)	●	●
III. Family : Moinidae		
41. <i>Monia micrura</i> Kurz, 1874	●	●
42. <i>Moinodaphnia macleayi</i> King, 1841	—	●
IV. Family : Bosminidae		
43. <i>Bosmina longirostris</i> (O. F. Muller, 1776)	●	●
44. <i>Macrothrix triserialis</i> (Brady, 1886)	●	●

Table 5. Cont'd.

Species	Rabindra Sarovar	Subhas Sarovar
Family : Chydoridae		
45. <i>Chydorus barroisi</i> Richard, 1894	●	●
46. <i>Chydorus sphaericus</i> (O. F. Muller, 1776)	●	●
47. <i>Dunhevedia crassa crassa</i> King, 1853	●	●
48. <i>Pleuroxus similis</i> Vavra, 1900	●	●
49. <i>Pseudochydorus globosus</i> (Baird, 1843)	●	–
Sub-Family : Aloninae		
50. <i>Alona davidi</i> Richard, 1895	●	●
51. <i>Alona pulchella</i> King, 1853	●	●
52. <i>Oxyurella singalensis</i> (Daddy, 1898)	●	–
53. <i>Acropus harpae</i> (Baird, 1834)	●	–
Total Cladocera species	19	21
Class : Crustacea		
Subclass : Ostracoda		
Family : Cyprinidae		
54. <i>Cypris subglobosa</i> Sowerby, 1840	●	●
Total Ostracoda species	1	1
Total Zooplankton species	45	48

● Indicates presence; – Indicates absence

contributed to the Cladoceran diversity. Like Rabindra Sarovar, Copepod fauna of this wetland was also comprised by three Cyclopoids viz, *Mesocyclops leuckarti*, *Mesocyclops hyalinus* and *Microcyclops varicans* and two Calanoides, *Heliodyptomus viduus* and *Heliodyptomus contortus*. Ostracoda was represented by only species *Cypris subglobosa*. Rotifera fauna of Subhas Sarovar were mainly comprised by 6 species of family Lecenidae, 8 species of Brachionidae, 2 of Trichoceridae and a single species of family Mytilinidae, Testudinellidae, Synchaetidae, Filinidae, and Philodinidae.

In Rabindra Sarovar, the zooplankton density varied between 668- 1134/l and 619–1144 units/l in first and second annual cycle with peak in post-monsoon (Fig. 1). Seasonal fluctuation pattern was almost similar in both lakes. In Subhas Sarovar, total density varied between 608-936 units/l and 673–1238 units/l in the two cycles respectively (Fig. 2).

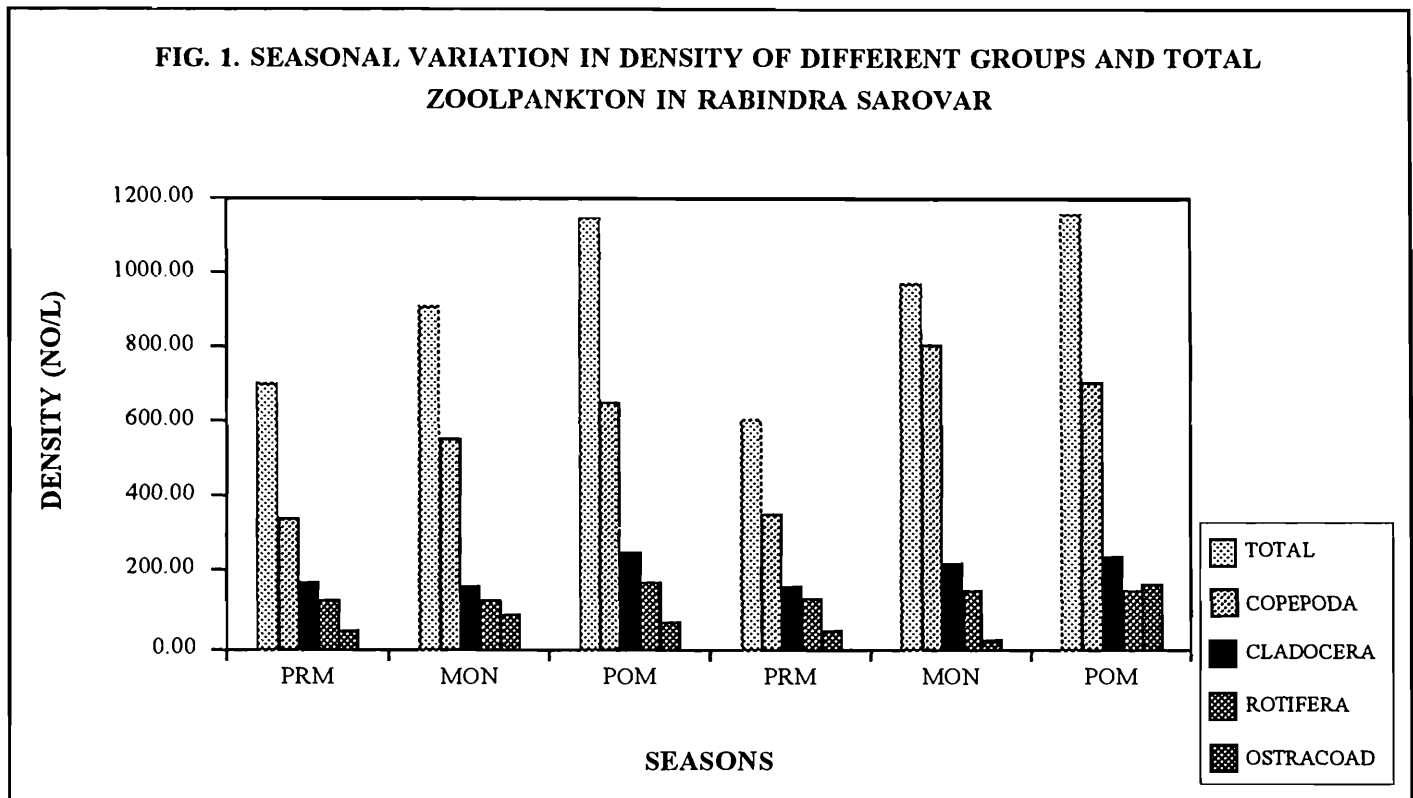


Fig. 1. Seasonal variation in density of different groups and total zooplankton in Rabindra Sarovar.

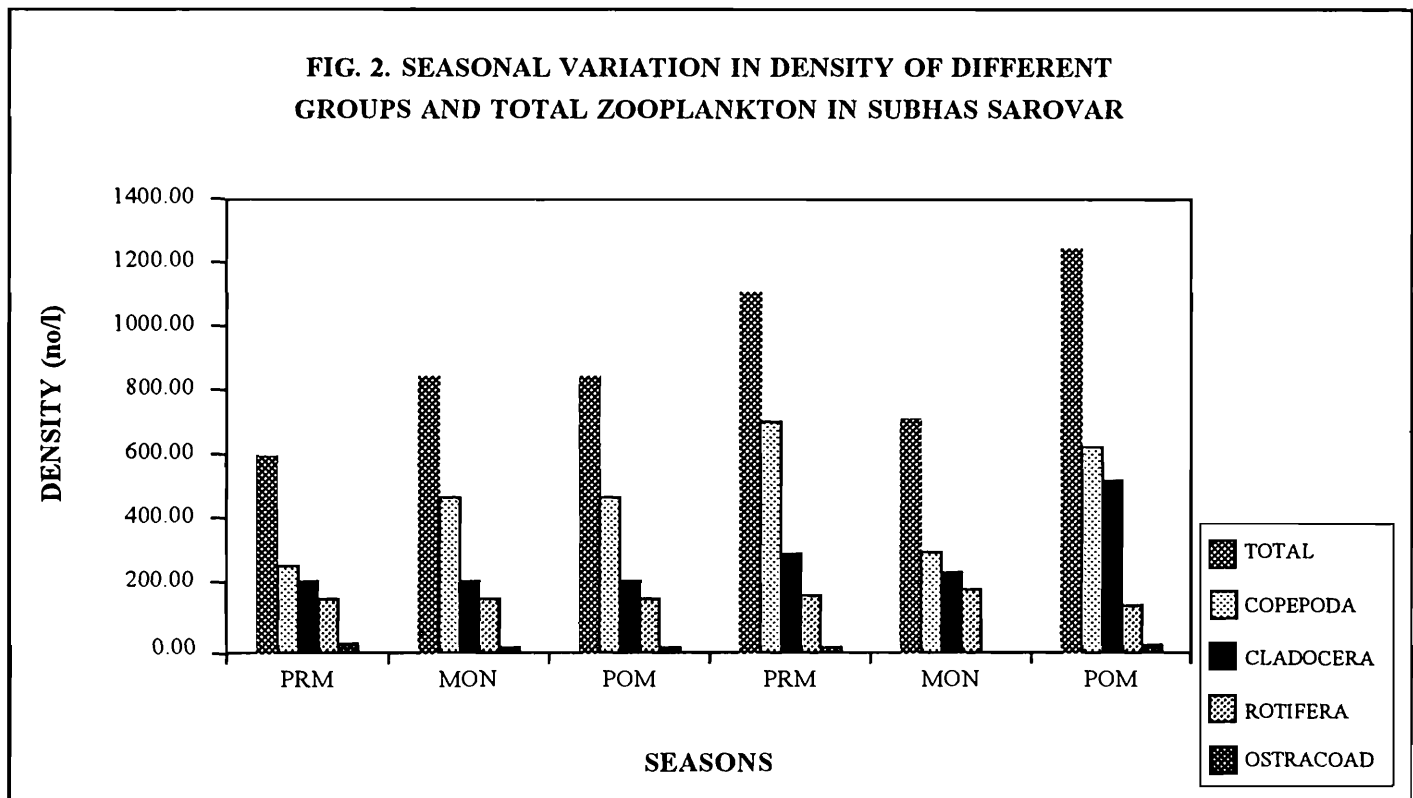


Fig. 2. Seasonal variation in density of different groups and total zooplankton in Subhas Sarovar.

The zooplankton community as a whole was dominated by Copepods (56.69% in Rabindra Sarovar and 53.17% in Subhas Sarovar) followed by Cladocera (22.11% in Rabindra Sarovar and 30.53% in Subhas Sarovar). Rotifers contributed only 14.26% in Rabindra Sarovar and 15.91% in Subhas Sarovar. Ostracodes constituted only a small proposition in Subhas Sarovar (0.86%) but their share in Rabindra Sarovar was comparatively higher (6.94%) (Figs. 3 and 4).

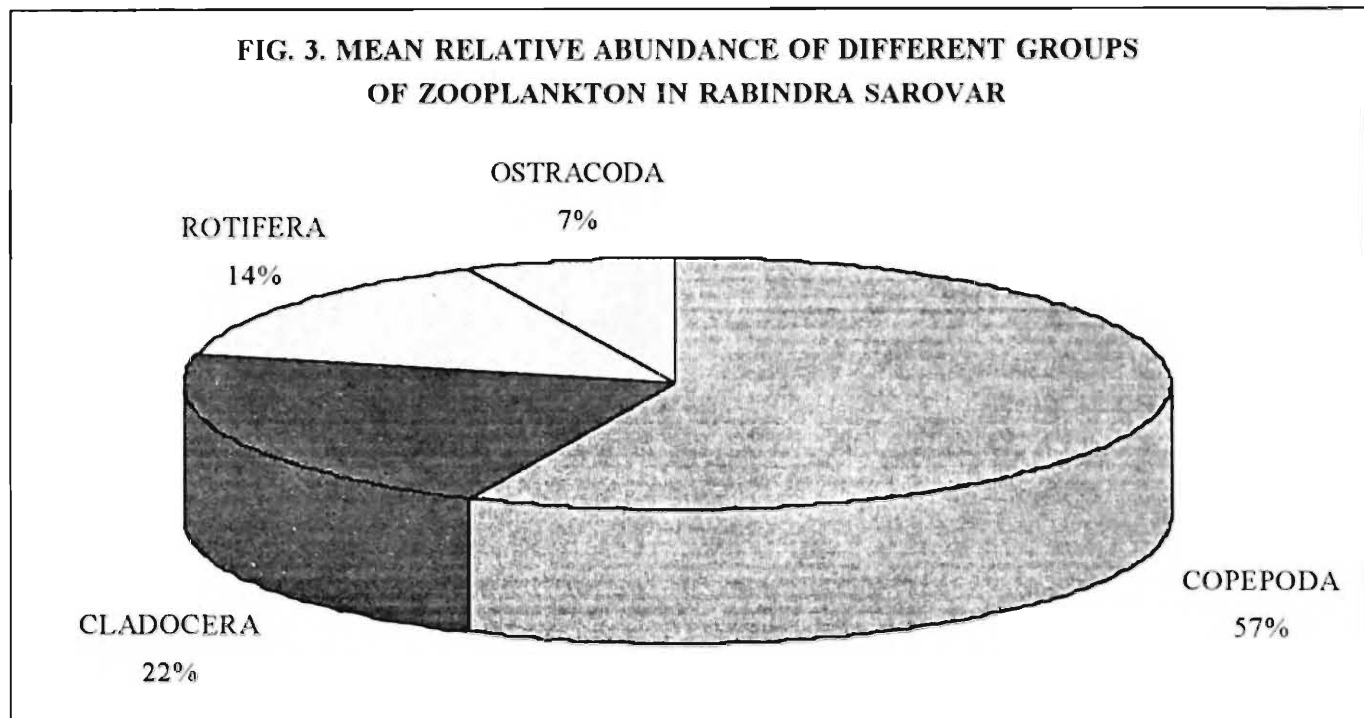


Fig. 3. Mean relative abundance of different groups of zooplankton in Rabindra Sarovar.

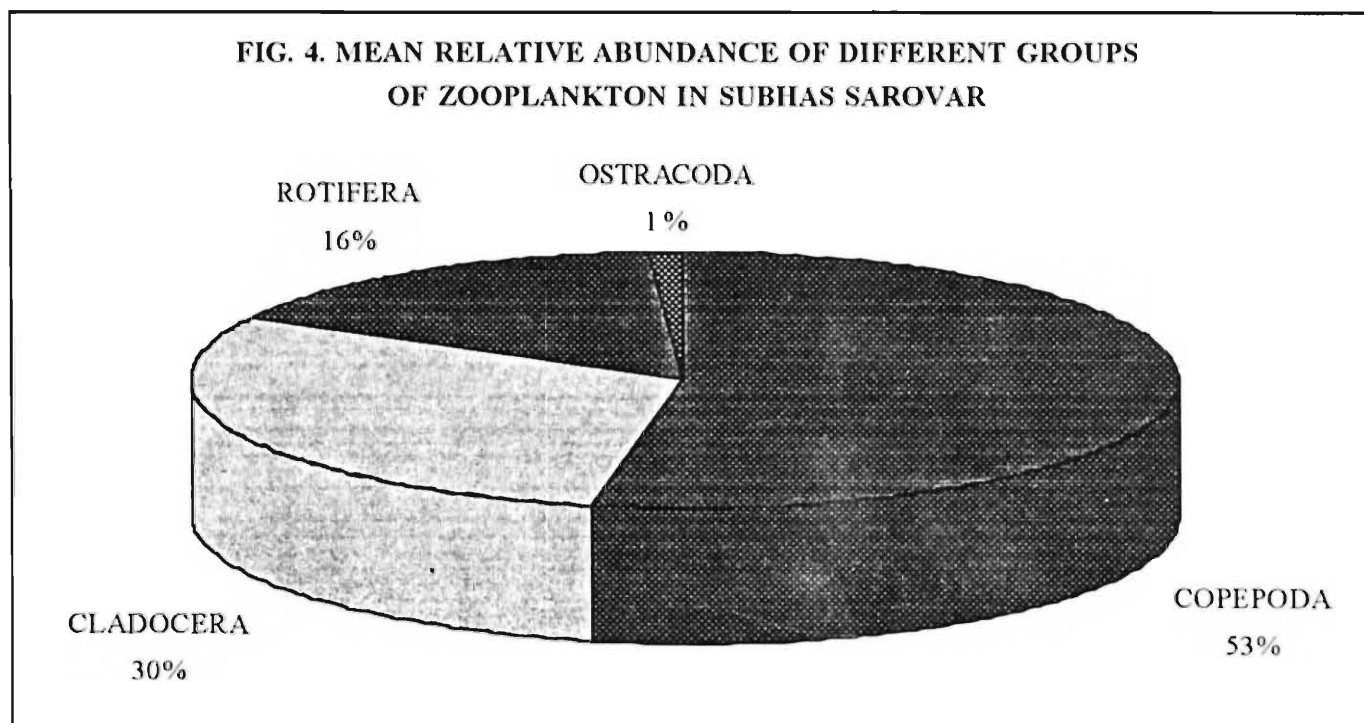


Fig. 4. Mean relative abundance of different groups of zooplankton in Subhas Sarovar.

DISCUSSION

The present investigations revealed that general physico-chemical nature of the water of both lakes was comparatively good and almost similar to other water bodies of this region (Michael 1966, Banerjee 1967, Khan 1979). The water temperature fluctuated narrowly, except during a brief period of late post-monsoon (Dec-Jan), which corresponds to a moderate winter season of the region and did not affect significantly the seasonal dynamics of zooplankton of two lakes. Unlike northern or high altitude region of the country (Sarwar and Wazir, 1991; Hazarika and Dutta, 1997), where temperature drops drastically during winter affecting considerably the dynamics of aquatic fauna, the impact of temperature drop on aquatic organisms in this region in general is not very significant. Similarly pH of both lakes also fluctuated narrowly. Banerjee (1967) too reported a narrow variation in pH of a number of ponds of Howrah and 24 Parganas which ranged between 7.2 and 8.2. However, Khan (1979) reported a slightly higher range of pH in Rabindra Sarovar. The dissolved oxygen content of both the lakes were moderate throughout the year and at no time it decreased substantially. The two lakes differed considerably in respect to their chloride, alkalinity and nutrient contents, which were always higher in Rabindra Sarovar than Subhas Sarovar. The higher nutrient content, specially phosphates, in Rabindra Sarovar was mainly due to increased human activities.

The higher rate of primary productivity in both lakes exhibited eutrophic nature of these water bodies. High primary productivity of Rabindra Sarovar was also observed by Khan (1979) who reported the annual means as 3733 mgc/m³/day of Gross Primary Productivity, 1558 mgc/m³/day of Community Respiration and 2175 mgc/m³/day of Net Primary Productivity. High primary productivity and consequent accumulation of biomass are probably due to improper utilization as no proper exploitation of fishery resources are being done in these wetlands.

The freshwater zooplankton fauna of the wetlands studied comprised of 3 major groups, viz. Rotifera, Cladocera : Crustacea and Copepoda : Crustacea. Besides these, another Crustacean group, Ostracoda was also represented constantly but by a single species. Altogether 54 species of zooplankton were recorded from these wetlands over the entire period of the study. This include 25 species of Rotifera, 23 of Cladocera, 5 of Copepoda and one of Ostracoda. Regarding the diversity of zooplankton fauna in tropical waters, there are divergent views. An earlier concept was that the diversity of zooplankton, particularly of Cladocera, is very much restricted in tropical water bodies. (Green 1976, 1990, Fernando and Kanduru 1984, Fernando et. al., 1987, Dussart *et al.* 1984, Kerfoot and Lynch, 1987. Ravera 1996). However, recently this view point has been questioned by Dumont (1994). He reported that, contrary to earlier concept, the diversity of zooplankton fauna in tropical water bodies is no way lesser than those reported from temperate water bodies. Considering the existence of 54 species in two wetlands, it can be very safely said

that the diversity of zooplankton of this region is considerably rich. This is also evident from some earlier works carried out on the zooplankton fauna of the region. Venkatraman and Das (1993) and Sharma (1998) recorded 148 species of Rotifera and 56 of Cladocera respectively from a few districts of West Bengal surrounding Calcutta. Khan and Sinha (1999) reported the existence of 90 species from few wetlands of Calcutta and surrounding districts situated in southern West Bengal. This rich zooplankton faunal diversity of the wetlands of the country has also been substantiated by several workers who have paid proper attention to taxonomic aspects (George 1966, Zutsi and Vaas 1982, Yousuf *et. al.* 1983). However, due to lack of proper taxonomic treatment, the number of zooplankton species reported from majority of wetlands of the country were extremely under represented (Sinha *et. al.* 1987; Ahmed and Singh, 1991; Singh and Pandey, 1991; Khatri, 1992; Sinha *et. al.* 1992; Baruah *et. al.* 1993; Bose and Gorai 1993, Pushpendra 1994, Kumar 1995). This is due to the fact that majority of studies dealt with general limnological condition and variation in total zooplankton density and identification of individual species was given only a passing reference. It is strongly viewed that when these waterbodies will be explored thoroughly for the zooplankton fauna and proper taxonomic studies are carried out, the diversity will increase several folds.

The dominance of 3 major groups of zooplankton in freshwater lentic ecosystem differed widely and like present study Copepods were found to dominate in many other lakes/ponds/reservoirs of the country (Chacko and Krishnamurthi 1954, Ganapati 1943, Das and Srivastava 1959, Khatri 1992, Baruah *et. al.* 1993, Dash *et al.* 1993). However, dominance of Cladocera (Kaul and Hando 1993) or Rotifera (George 1966, Joshi and Adoni 1993, Pandit 1993, Kumar 1995) in the freshwaters of the country has also been widely reported. In the light of markedly varying dominance, no generalisation seems possible, and it can be concluded that the dominance of any group solely depends upon local factors. Sehgal (1983) found the occurrence and abundance of Cyclopoid Copepods in turbid as well as in clear waters infested with aquatic plants. He also gave ranges of some physico-chemical parameters for abundance of Copepods (water temperature 25.7°C–31.5°C, pH-7.2–8.8, dissolved oxygen 6.6–7.8 ppm and total alkalinity 160–220 ppm). During present investigation, similar type of physico-chemical environment was found in these two wetlands.

On the basis of above observations it can be said that non exploitation of fishery resources from Rabindra Sarovar is chiefly responsible for increased organic decay, hence, increased nutrients load and high primary production resulting in high eutrophication. It is suggested that for the proper management and conservation of Rabindra Sarovar, a rational policy should be evolved and due emphasis should be given to commercial exploitation of the aquatic resources. Biomanipulation of the lake by introduction of suitable species of fish and other organisms are urgently needed, particularly for the control of macrophytes.

SUMMARY

Generally, lakes situated in urban areas are mainly used for recreational purposes like swimming, bathing and other water sports. However, many a times, these water bodies are subjected to undesirable uses such as discharge of industrial and domestic effluents or excessive use by surrounding dense human population for a variety of purposes and thereby degrading the water quality considerably. In Calcutta metropolitan area there are two such man made lakes, situated in the heart of the city, namely Rabindra Sarovar and Subhas Sarovar. Studies were undertaken for two consecutive annual cycles, 1996-97 and 1997-98. with a view point to work out the physico-chemical characteristics of water, phytoplankton, rate of primary production and diversity and abundance of zooplankton of the two lakes.

Physicochemical characteristics of water of both Rabindra Sarovar and Subhas Sarovar fluctuated moderately during different seasons. In Rabindra Sarovar, water temperature varied between 25.9°C and 32.8°C, highest during premonsoon and lowest in postmonsoon. Conductivity fluctuated between 405.35 to 719.92 mmhos/cm. Highest turbidity value was recorded in monsoon and the water remained comparatively clear during rest of the year. Dissolved oxygen content was always moderate during the study period. The pH fluctuated narrowly (7.98-8.86) between different seasons. The contribution of chloride, phosphate, nitrate, nitrite and ammonia were lowest during postmonsoon and highest in premonsoon excepting alkalinity value which was lowest during monsoon. The physico-chemical characteristics of Subhas Sarovar was more or less similar to that of Rabindra Sarovar excepting noticeable variations were in alkalinity, chloride and conductivity. The Gross and Net Primary Productivity values in Rabindra Sarovar varied between 1443.75 and 3662.5 mgC/m³/day and 412.5 to 2237.5 mgC/m³/day respectively. In Subhas Sarovar the values for gross and net productivity varied from 2171.25–3512.00 mgC/m³/day and from 1375.00–2250.25 mgC/m³/day. Maximum net : gross ratio was observed in monsoon and minimum in postmonsoon.

Rabindra Sarovar, which is characterised by dense macrophytic littoral vegetation, harbored a total of 45 species of zooplankton with 19 of Cladocera, 5 of Copepoda, 20 of Rotifera and 1 of Ostracoda (Table 5). Among Cladocera highest number of species belonged to family Chydoridae (9 species), followed by Daphnidae (4 species). Copepods were represented by 5 species, 2 of Calanoida and 3 of Cyclopoida. The Rotifer fauna of the lake were composed of 20 species. Alkaline and highly polymorphic cosmopolitan species dominated the faunal composition. Ostracods were represented by single species, *Cypris subglobosa*. The zooplankton, species richness of Subhas Sarovar was comparatively higher than Rabindra Sarovar from where 48 species were recorded. This was due to higher number of species of Cladocera (20) and Rotifera (22). The zooplankton density varied between 619–1144 units/l in Rabindra Sarovar and between 608–1238

units/l in Subhas Sarovar with peak in post-monsoon. Seasonal fluctuation pattern was almost similar in both lakes. The zooplankton community as a whole was numerically dominated by Copepods followed by Cladocera. Rotifers contributed only 14- 16% in both lakes.

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ECHINODERMATA ASSOCIATED WITH CORAL REEFS OF ANDAMAN AND NICOBAR ISLANDS

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INTRODUCTION

Coral reefs are an important ecosystem of the coastal environment. The reef ecosystem is highly productive and provides substratum, shelter, food *etc.* to a variety of biota. Consequently a number of faunal and floral elements are attracted towards the reef ecosystem and are closely associated with each other to form a community. Thus the reefs are also rich in biodiversity. Among the coral reef associates echinoderms are a conspicuous element on account of their size, abundance and effect on the reef ecosystem including the corals. In spite of their importance in the coral reef ecosystem and its conservation, very few studies were made on the echinoderm associates of the coral reefs. Though there were some studies elsewhere, the information on reef-associated echinoderms of Indian coast is meager and scattered (see Anon, 1995). Hence an attempt is made here to collate the scattered accounts and unpublished information available with Zoological Survey of India. Since the information is from several originals and quoted references and many are to be cited often, these are avoided in the text and a comprehensive bibliography is appended which served as source material and also provides additional references of details and further information.

ECHINODERMS OF CORAL REEFS

More than 200 species of echinoderms occur in the reef ecosystem of Andaman and Nicobar Islands. These belong to five extant classes with 30 to 60 species of each class. The ecology of many echinoderms with particular reference to coral reef habitats is not extensively studied. Most of the available information is from scattered literature and casual observations. Comprehensive studies of only a few reef-associated species elsewhere are available because of their economic importance or threat to coral reefs. Jones and Endean (1973, 1976) compiled the information available till then. The following account is based on the scattered literature, information available with Zoological Survey of India and author's observations. In the list of species, species reported in the literature or present in the National Zoological Collections whose current status is not known are also included with the same identity. Also species that are likely to have been collected or occurring in the coral reefs are included. The distribution of each species in different islands

is given from the published literature and the unpublished information available with Zoological Survey of India. Most of the earlier literature does not contain the exact locality details and some are observed only in the field but not collected. These are given as Andamans and Nicobars without localities. Other localities are classified into North, South and Middle Andamans, Ritchie's Archipelago and Nicobars. Some localities or islands are administratively under North Andamans but geographically fall under Middle Andamans. These are listed under Middle Andamans. The position of some islands is such that they are to be arbitrarily taken under North, Middle or South Andamans.

Class CRINOIDEA

The Crinoidea have arms in multiples of five at the base, which later branch though regularly, but resulting in odd number of arms. The arms are beset with side branches called pinnules, which help in swimming, feeding and reproduction. Of the two groups of Crinoidea, members of one group namely the stalked crinoids commonly known, as 'sea lilies' are inhabitants of soft substrata in the deep sea. They lead a sedentary life with the stalk attached to a hard object or buried in the substratum and do not occur in coral reefs. Members of the other group called 'feather stars' lead a free life in shallow waters mostly on hard substrata. They generally appear dark green or black though quite a few exhibit attractive red, white or yellow patterns on their pinnules. They are rarely of a single colour.

Order COMMATULIDA

Family COMASTERIDAE

1. *Capillaster mariaae* (A. H. Clark) : Andamans – 0 to 108 m.
2. *C. multiradiatus* (Linnaeus) : Andamans – 110 m; North Andamans-eight miles west of Interview Island, 82 m; Oliver Island; South Andamans – Pongibalu; Rutland Island, 64 m; West of South Andaman Island, 11° 49' 30" N, 92° 55' 00" E, 100 m; Nicobars.
3. *Comanthus nobilis* (P.H. Carpenter) : South Andamans – Pongibalu; Invisible Bank; littoral to 77 m.
4. *C. parvicirrus* (Mueller) : North Andamans – Table Island; South Andamans – Port Blair; Ritchie's Archipelago – Havelock Island; Nicobars-Kamorta Island; Nancowry Island; littoral to 77 m.
5. *C. samoanus* A. H. Clark/*C. wahlbergi* (Mueller) : North Andamans – Orchid Island; Interview Island; Egg Island; Swamp and Dotrel Islands; Curlew (BP) Island; South Andamans – Off Port Blair; Invisible Bank; Ritchie's Archipelago-Havelock Island; Sir William Peel Island; Nicobars – Kamorta Island; Trinket Island.
6. *Comaster gracilis* (Hartlaub) : South Andamans – Port Blair; littoral to 55 m.
7. *C. multibrachiatus* (P. H. Carpenter) : Andamans – 31 to 55 m.

8. *C. multifidus* (J. Mueller) : North Andamans-Curlew (BP) Island; Ritchie's Archipelago-Sir William Peel Island.
9. *Comatella maculata* (P. H. Carpenter) : North Andamans – Swamp and Dotrel Islands; South Andamans – Pongibalu; Nicobars – Trinket Island.
10. *C. nigra* (P. H. Carpenter) : North Andamans – Oyster-1 Island; South Andamans – Alexandra Island; Pongibalu; Ritchie's Archipelago – Havelock Island.
11. *C. stelligera* (P. H. Carpenter) : North Andamans – Interview Island; Ritchie's Archipelago – Havelock Island; Sir William Peel Island.
12. *Comatula brevicirra* (Bell) : Nicobars – Kamorta Island; Nancowry Island.
13. *C. pectinata* (Linnaeus) : Nicobars – Nancowry Island.
14. *Oxycomanthus bennetti* (Mueller) : North Andamans – Table Island; 27 to 64 m; Ritchie's Archipelago-Sir William Peel Island.

Family HIMEROMETRIDAE

15. *Amphimetra mollerii* A. H. Clark : Andamans.
16. *A. mortenseni* Clark : Andamans.
17. *A. philiberti* (Mueller) : South Andamans – Port Blair.
18. *Craspedometra acuticirra* (P. H. Carpenter) : Andamans.
19. *C. anceps* (P. H. Carpenter) : Andamans, 18–80 m.
20. *Heterometra bengalensis* (Hartlaub) : Andamans, 0–44 m.
21. *Himerometra magnipinna* (A. H. Clark) : South Andamans – Pongibalu.
22. *H. robustipinna* (P. H. Carpenter) : South Andamans – Pongibalu; Boat Island; Little Andaman Island.

Family MARIAMETRIDAE

23. *Dichrometra protectus* (P. H. Carpenter) : South Andamans – Port Blair; Cinque Island.
24. *Lamprometra palmata* (J. Mueller) : North Andamans – Oliver Island; Egg Island Ritchie's Archipelago – Havelock Island.
25. *Stephanometra indica* (Smith) : Ritchie's Archipelago – Havelock Island.
26. *S. monacantha* (Hartlaub) : South Andamans – Port Blair; Nicobars. 0–38 m.

Family COLOBOMETRIDAE

27. *Colobometra discolor* (A. H. Clark) : North Andamans – Table Island; South Andamans Port Blair, 27–64 m.

28. *Cotylometra gracilicirra* (A. H. Clark) : Andamans.
29. *Oligometra serripinna* (P. H. Carpenter) : Andamans.
30. *Iconometra intermedia* (A. H. Clark) : Andamans.
31. *Pontiometra andersoni* (P. H. Carpenter) : Andamans, 0–44.

Family ANTEDONIDAE

32. *Dorometra nana* (Hartlaub) : Andamans; Nicobars; 0–75 m.

Class ASTEROIDEA

Members of Asteroidea commonly known as 'sea stars' have a central disc gradually drawn into five arms along the five radii represented by the five ambulacra. A few however have more than five arms regularly or as an exception. Most species are of uniform dull colours while a few exhibit variegations or bright colours. They live hidden under hard substrata or burrow into the soft substratum.

Order PAXILLOSIDA

Family LUIDIIDAE

1. *Luidia maculata* Mueller and Troschel : South Andamans–Cinque Island, 20–46 m.
2. *L. savignyi* (Audouin) : Andamans.
3. *L. hardwicki* (Gray) : Andamans.

Family ASTROPECTINIDAE

4. *Astropecten monacanthus* Sladen : North Andamans – Centre of West Coral Bank, 27 m; South Andamans – Off Port Monatt, 37 m; Little Andaman Island.
5. *A. polyacanthus* Mueller and Troschel : North Andamans – Table Island, 27 to 55 m; Middle Andamans – Mayabunder; South Andamans – Port Blair.
6. *Astropecten zebra* Sladen : South Andamans – Cinque Island, 20 m.

Order VALVATIDA

Family ARCHASTERIDAE

7. *Archaster typicus* Mueller and Troschel : North Andamans – Ross Island; Diglipur; Aerial Bay; Middle Andamans – Mayabunder; South Andamans – Ross Island; Port Blair; Chidyatapu; Little Andaman Island; Ritchie's Archipelago – Havelock Island; Nicobars – Car Nicobar Island; Kamorta Island; Nancowry Harbour.

Family GONIASTERIDAE

8. *Anthenea pentagonula* (Lamarck) : South Andamans – Port Blair; Middle Andamans – Long Island.
9. *Anthenea* sp. : Andamans.

Family OREASTERIDAE

10. *Choriaster granulatus* Luetken : North Andaman – Sound Island.
11. *Culcita novaeguineae* Mueller and Troschel[#] : North Andamans – Brown Point, Ray Hill; Ritchie's Archipelago-Havelock Island; South Andamans – Port Blair; Ross Island; Chidyatapu; Nicobars – Kamorta Island; Katchal Island.
12. *C. schmideliana* (Retzius) : North Andamans – East Island; South Andamans – Port Blair; Chester Island; Ritchie's Archipelago – Inglis Island; Nicobars – Katchal Island.
13. *Poraster superbis* (Möbius) : South Andamans – Port Blair.
14. *Protoreaster lincki* (de Blainville) : Middle Andamans – Rangat; Nicobars – Kamorta Island; Great Nicobar Island.
15. *P. nodosus* (Linnaeus) : Nicobars – Great Nicobar Island.

Family OPHIDIASTERIDAE

16. *Dactylosaster cylindricus* (Lamarck) : North Andamans – Channel Island; Ritchie's Archipelago – Outram Island; Nicobars – Great Nicobar Island.
17. *Fromia armata* Koehler : South Andamans – Port Blair; Chidyatapu; Nicobars – Trinket Island.
18. *F. indica* (Perrier) : South Andamans – Port Blair; Pongibalu; Macpherson Strait, north side of eastern end near Chidyatapu; Ritchie's Archipelago – Henry Lawrence Island.
19. *F. milleporella* (Lamarck) : Andamans.
20. *F. monilis* Perrier : North Andamans – Curlew (BP) Island; South Andamans – Pongibalu.
21. *Gomophia egyptiaca* Gray : South Andamans – Off Port Monatt, 37 m.
22. *Heteronardoa carinata* (Koehler) : Andamans.
23. *Leiaster glaber* Peters : Andamans.
24. *Linckia guildingi* Gray : North Andamans – Table (Excelsior) Island; West Island; South Andamans – Port Blair; Pongibalu; Rutland Island; Nicobars.

[#] Though some specimens can be identified with *C. novaeguineae* or with *C. schmideliana*, it is not always possible particularly in the case of young specimens. According to some the former might be a junior synonym of the latter.

25. *L. laevigata* (Linnaeus) : North Andamans – Table (Delgarno) Island; Table (Excelsior) Island; Trilby Island; Tree Island; Landfall Island; Point Island; East Island; West Island; Orchid Island; Oliver Island; Oyster-1 Island; Brown Point, Ray Hill; Curlew (BP) Island; Middle Andamans – Mayabunder; South Andamans – Port Blair; Pongibalu; Malay Island; Twin Islands; Ritchie's Archipelago – Outram Island; Havelock Island; Nicobars – Kamorta Island; Nancowry Island; Katchal Island.
26. *L. multifora* (Lamarck) : South Andamans – Port Blair; Chidyatapu; Pongibalu; Nicobars-Car Nicobar Island; Kamorta Island.
27. *Nardoa frianti* (Koehler) : Andamans.
28. *Nardoa galathea* (Luetken) : South Andamans – Little Andaman Island.
29. *Neoferdina offreti* (Koehler) : South Andamans – Little Andaman Island, 18 m.
30. *Ophidiaster armatus* Koehler : North Andamans – Off Passage Island, 31 m.
31. *O. hemprichi* Mueller and Troschel : Nicobars – Car Nicobar Island.
32. *Paraferdina sohariae* Marsh and Price : Andamans.
33. *Tamaria dubiosa* (Koehler) : Andamans.
34. *T. megaloplax* (Bell) : Andamans; Nicobars – Trinket Island.
35. *Chaetaster vestitus* Koehler : Andamans.

Family ASTEROPSEIDAE

36. *Asteropsis carinifera* (Lamarck) : North Andamans – Channel Island.

Family ASTERINIDAE

37. *Asterina burtoni* Gray : North Andamans – Tree Island; Channel Island; South Andamans – Port Blair; Rutland Island; Little Andaman Island; Ritchie's Archipelago – Inglis Island; Nicobars – Nicobars.
38. *A. sarasini* (de Loriol) : Middle Andamans – Mayabunder; South Andamans – Port Blair; Pongibalu; Rutland Island; Ritchie's Archipelago – Outram Island; Inglis Island; Neil Island; Nicobars – Car Nicobar Island.
39. *Disasterina spinosa* Koehler : South Andamans – Port Blair.
40. *D. spinulifera* H.L. Clark : South Andamans – Northern side of eastern end of Macpherson Strait near Chidyatapu.
41. *Patiriella pseudoexigua* Dartnall : North Andamans-Smith Island; Middle Andamans–Mayabunder; Strait Island; Rangat; South Andamans – Port Blair; Ross Island; Rangachang; Chidyatapu; Rutland Island; Little Andaman Island; Nicobars.
42. *Tegulaster emburyi* Livingstone : Nicobars – Katchal Island.

Family ACANTHASTERIDAE

43. *Acanthaster planci* (Linnaeus) : Middle Andamans – Mayabunder. South Andamans – Pongibalu; Alexandra Island; Chester Island; Grub Island; Redskin Island; Twin Islands; Ritchie's Archipelago – Inglis Island; Neil Island; Nicobars – Nancowry Island; Katchal Island.

Family VALVASTERIDAE

44. *Valvaster striatus* (Lamarck) : North Andamans-Brown Point, Ray Hill.

Order VELATIDA

Family PTERASTERIDAE

45. *Euretaster cribrosus* (von Martens) : Nicobars – Kamorta Island.

Order SPINULOSIDA

Family ECHINASTERIDAE

46. *Echinaster callosus* Marenzeller : South Andamans – Rutland Island.
47. *E. luzonicus* (Gray) : Andaman Sea; Nicobars – Kamorta Island.

Family METRODIRIDAE

48. *Metrodira subulata* Gray : Andamans; Nicobars – Kamorta Island.

Class OPHIUROIDEA

The ophiuroids, commonly known as 'brittle stars' have a central disc and distinct arms. The arm segments are box-like and articulate like vertebrae. In most species belonging to suborder Euryalina the arms are branched. All others have only five arms excepting the fissiparous ones, which possess more than five arms.

Order PHRYNOPHIURIDA

Family GORGONOCEPHALIDAE

1. *Astrocladus exiguus* (Lamarck) : Andamans.

Family EURYALIDAE

2. *Trichaster acanthifer* Doederlein : Andamans Sea – Stn 554. 12° 47' 30'' N 98° 15' 30'' E, 44 m.
3. *Asteromorpha flosculus* (Alcock) : Andamans.

Family ASTEROSCHEMATIDAE

4. *Asteroschema fastosum* Doederlein : Nicobars.
5. *Asteroschema subfastosum* Doederlein : Nicobars.
6. *Ophiocreas sibogae* (Doederlein) : Nicobars.
7. *Ophiocreas* sp. : Andamans.

Family OPHIOMYXIDAE

8. *Ophiomyxa australis* Luetken : Andamans, 24 – 62 m; Andaman Sea, 316 m.

Order OPHIURIDA

Family AMPHIURIDAE

9. *Amphioplus (Amphioplus) personatus* (Koehler) : Andamans; Nicobars – Nancowry Harbour.
10. *A. (Lymanella) depressus* (Ljungman) : Andamans – Andamans, 13 – 18 m; West coast of Andamans, 27 m; South Andamans – Off Little Andaman Island, 13 – 18 m.
11. *A. (L.) hastatus* (Ljungman) : Andamans.
12. *A. (L.) laevis* (Lyman) : Andamans.
13. *Amphipholis misera* (Koehler) : Andamans.
14. *A. squamata* (Delle Chiaje) : North Andamans – Port Cornwallis; Nicobars – Car Nicobar Island.
15. *Amphiura septemspinosa* H. L. Clark Andamans.
16. *Ophiocentrus dilatatus* (Koehler) : Andamans.

Family OPHIACTIDAE

17. *Ophiactis modesta* Brock : Andamans – Andamans; South Andamans-Port Blair; Ritchie's Archipelago – Sir William Peel Island.
18. *O. picteti* (de Loriol) : Andamans, 13 – 18 m.
19. *O. savignyi* (Mueller and Troschel) : Andamans, 0 – 66 m; South Andamans – Port Blair; Pongibalu; Alexandra Island; Little Andaman Island; Ritchie's Archipelago – Havelock Island; Neil Island; Nicobars – Kamorta Island; Nancowry Harbour; Nancowry Island; Great Nicobar Island.

Family OPHIOTHRICIDAE

20. *Macrophiothrix aspidota* (Mueller and Troschel) : North Andamans – Ray Hill; South Andamans – Port Blair.
21. *M. demessa* (Lyman) : Ritchie's Archipelago-Neil Island.
22. *M. galatea* (Koehler) : South Andamans – Port Blair.
23. *M. koehleri* A. M. Clark : North Andamans – Tentul Tikri; Aerial Bay; Middle Andamans –Mayabunder; Long Island; South Andamans – Port Blair; Nicobars – Car Nicobar Island.
24. *M. longipeda* (Lamarck) : North Andamans – Interview Island; South Andamans – Port Blair, Rangachang; Pongibalu; Rutland Island; Alexandra Island; Jolly Buoy Island; Malay Island; Ritchie's Archipelago – Havelock Island; Nicholson Island; Nicobars.
25. *M. propinqua* (Lyman) : Andamans – Port Monatt; North Andamans – Diglipur; South Andamans – Chidyatapu; Pongibalu; Ritchie's Archipelago – Havelock Island; Sir William Peel Island; Neil Island; Nicobars – Nancowry Island; Kamorta Island.
26. *M. speciosa* (Koehler) : South Andamans – Port Blair.
27. *Ophiocnemis marmorata* (Lamarck) : Andamans.
28. *Ophiolophus novarae* Marktanner-Turneretscher : Nicobars.
29. *Ophiomaza cacaotica* Lyman : Andamans and Nicobars (on various crinoid hosts).
30. *Ophiopterion elegans* Ludwig : South Andamans-South Sentinel Island.
31. *Ophiothela danae* Verrill : South Andamans – Jolly Buoy Island; Ritchie's Archipelago– Havelock Island.
32. *Ophiothrix (Acanthophiothrix) proteus* Koehler : Nicobars – Nancowry Harbour.
33. *O. (A.) purpurea* von Martens : Andamans, 62 – 75 m; South Andamans – Pongibalu.
34. *O. (A.) vigelandi* A. M. Clark : South Andamans –North of Rutland Island.
35. *O. (Keystonea) nereidina* (Lamarck) : Andamans, 0 – 37 m; North Andamans – Curlew (BP) Island; South Andamans – Pongibalu; South Sentinel Island; Nicobars – Nancowry Harbour; Nancowry Island; Kamorta Island.
36. *O. (Ophiothrix) ciliaris* (Lamarck) : Andamans, 64 m; North Andamans – Aerial Bay; South Andamans-South Sentinel Island.
37. *O. (O.) exigua* Lyman : North Andamans – Aerial Bay; Port Cornwallis; Diglipur; Ritchie's Archipelago – Havelock Island; Nicobars – Kamorta Island; Nancowry Island.
38. *O. (O.) foveolata* Marktanner – Turneretscher : Andamans, 37 m; South Andamans – Chidyatapu.
39. *O. (O.) trilineata* Luetken : Andamans, 0 – 24 m; North Andamans – Aerial Bay; South Andamans – Port Blair; Chidyatapu; Ritchie's Archipelago – Havelock Island; Sir William Peel Island; Neil Island; Nicobars – Kamorta Island.

Family OPHIOCOMIDAE

40. *Ophiarthrum elegans* Peters : Andamans, 27 – 64 m; North Andamans – Interview Island; Brown Point, Ray Hill; Middle Andamans – Mayabunder; South Andamans – Port Blair; Alexandra Island; Jolly Buoy Island; Nicobars – Kamorta Island; Trinket Island.
41. *O. pictum* Mueller and Troschel : South Andamans – Port Blair; New Wandoor; Pongibalu; Ritchie's Archipelago – Havelock Island; Inglis Island; Nicobars – Kamorta Island; Nancowry Island.
42. *Ophiocoma brevipes* Peters : North Andamans – Brown Point, Ray Hill; Middle Andamans – Rangat; South Andamans – Port Blair; Rutland Island; Off South Sentinel Island, 24 m; Little Andaman Island; Ritchie's Archipelago – Inglis Island.
43. *O. dentata* Mueller and Troschel : Middle Andamans – Mayabunder; South Andamans – Port Blair; Kaudiaghat; Jolly Buoy Island; Little Andaman Island; Ritchie's Archipelago – Inglis Island; Nicobars – Nicobars; Car Nicobar Island; Kamorta Island; Nancowry Harbour; Katchal Island; Trinket Island; Great Nicobar Island.
44. *O. doderleini* Loriol : South Andamans – Port Blair
45. *O. erinaceus* Mueller and Troschel : North Andamans – Table Island; Aerial Bay, Port Cornwallis; Diglipur; Avis Island; Interview Island; Ray Hill; Egg Island; Swamp and Dotrel Islands; Curlew (BP) Island; Middle Andamans – Mayabunder; Rangat Bay; South Andamans – Port Blair; Pongibalu; South Sentinel Island; Ritchie's Archipelago – Havelock Island; Inglis Island; Neil Island; Nicobars – Car Nicobar Island; Kamorta Island; Nancowry Island; Trinket Island; Great Nicobar Island.
46. *O. pica* Mueller and Troschel : Nicobars – Nancowry Island; Trinket Island.
47. *O. pusilla* (Brock) : North Andamans – Tentul Tikri, near Aerial Bay; Ritchie's Archipelago – Havelock Island; Inglis Island; Neil Island; Nicobars – Kamorta Island; Nancowry Island.
48. *O. scolopendrina* (Lamarck) : North Andamans – Sound Island; Ross Island; Middle Andamans – Mayabunder; Bakri Tikri; Long Island; Rangat; South Andamans – Port Blair; Ross Island; Rangachang; Wandoor; New Wandoor; Pongibalu; Chidyatapu; Macpherson Strait; Rutland Island; Alexandra Island; Jolly Buoy Island; Ritchie's Archipelago – Nicholson Island; Havelock Island; Inglis Island; Neil Island; Nicobars – Car Nicobar Island; Kamorta Island; Nancowry Island; Trinket Island; Katchal Island; Great Nicobar Island.
49. *Ophiocomella sexradia* (Duncan) : South Andamans – Port Blair.
50. *Ophiomastix annulosa* (Lamarck) : North Andamans-Ray Hill; South Reef Island; Middle Andamans – Mayabunder; Long Island; South Andamans – Port Blair; Chidyatapu;

Pongibalu; Rutland Island; Jolly Buoy Island; Ritchie's Archipelago – Inglis Island; Neil Island; Nicobars – Car Nicobar Island; Kamorta Island; Nancowry Island; Trinket Island; Katchal Island; Great Nicobar Island.

51. *Ophiopsila pantherina* Koehler : North Andamans – Table Island, 27 – 64 m.

Family OPHIONEREIDAE

52. *Ophionereis andamanensis* James : South Andamans – Port Blair.
 53. *O. dubia* (Mueller and Troschel) : South Andamans – North of Rutland Island.
 54. *O. porrecta* Lyman : North Andamans – Off Passage Island, 31 m; South Andamans – South Sentinel Island.

Family OPHIODERMATIDAE

55. *Gymnopelta indica* (Koehler) : Andamans.
 56. *Ophiarachna incrassata* (Lamarck) : South Andamans – Port Blair.
 57. *Ophiarachnella gorgonia* (Mueller and Troschel) : South Andamans – Port Blair; Cinque Island, 20 m; Nicobars – Kamorta Island.
 58. *O. infernalis* (Mueller and Troschel) : North Andamans – Interview Island; Egg Island; Nicobars – Kamorta Island.
 59. *O. sphenesci* (Bell) : Andamans.
 60. *Ophiopeza custos* Koehler : Andamans.
 61. *Ophiopsammus yoldii* (Luetken) : Andamans.

Family OPHIURIDAE

62. *Ophioelegans cincta* (Mueller and Troschel) : North Andamans – Port Cornwallis; Ross Island; Egg Island; Middle Andamans – Mayabunder; Strait Island; Long Island; Bakri Tikri; South Andamans – Port Blair; Rangachang; Kaudiaghat; Pongibalu; Alexandra Island; Ritchie's Archipelago – Neil Island; Nicobars – Car Nicobar Island.
 63. *Ophiolepis superba* H.L. Clark : Middle Andamans – Mayabunder; South Andamans – Port Blair; Ritchie's Archipelago – Henry Lawrence Island.
 64. *Ophioplocus imbricatus* (Mueller and Troschel) : Middle Andamans-Rangat; South Andamans – Little Andaman Island; Nicobars – Kamorta Island; Nancowry Island; Trinket Island.

Class ECHINOIDEA

These are variously known as sea urchins, sand dollars, cake urchins and heart urchins depending on the shape. The endoskeleton of the echinoids usually called as test, is a rigid box of calcareous plates arranged in ambulacral and interambulacral series. The regular echinoids, which have the anus opening in the apical system, are hemispherical in shape with a flat oral side and arched aboral side. In irregular echinoids, which have the anus opening outside the apical system, generally on the oral side, the test is flat or heart shaped. The spines on the test are well developed among which are different types of special structures called pedicellariae. The tube feet in regular echinoids are arranged in vertical series while they form petals in irregular echinoids. The roe of some echinoids is highly valuable though this resource is not exploited at present from India.

Order CIDAROIDA

Family CIDARIIDAE

1. *Eucidaris metularia* (Lamarck) : Middle Andamans – Long Island; South Andamans – Port Blair; Rutland Island; Off Port Monatt, 37 m; South Sentinel Island; Invisible bank.
2. *Phyllacanthus imperialis* (Lamarck) : Ritchie's Archipelago-Henry Lawrence Island.
3. *Prionocidaris verticillata* (Lamarck) Andamans – Andamans; Middle Andamans – Long Island; South Andamans – Pongibalu; Ritchie's Archipelago-Henry Lawrence Island.

Order DIADEMATOIDA

Family DIADEMATIDAE

4. *Astropyga radiata* (Leske) : North Andamans – Table Island.
5. *Diadema savignyi* Michelin : Distribution is given under the next species, *D. setosum* since the specimens might belong to either of the two species.
6. *D. setosum* (Leske) : North Andamans – Aerial Bay; Diglipur; Middle Andamans – Mayabunder; South Andamans – Ross Island; Port Blair; Chidyatapu; Pongibalu; Alexandra Island; Redskin Island; Malay Island; Jolly Buoy Island; Ritchie's Archipelago-Outram Island; Havelock Island; Neil Island; Nicobars – Car Nicobar Island; Kamorta Island; Nancowry Island; Katchal Island; Great Nicobar Island.
7. *Echinothrix calamaris* (Pallas) : North Andamans – Table Island; Aerial Bay; Diglipur; Ross Island; Middle Andamans – Rangat; South Andamans – Port Blair; Ross Island; Chidyatapu; Pongibalu; Alexandra Island; Grub Island; Little Andaman Island; Ritchie's Archipelago – Havelock Island; Henry Lawrence Island; Inglis Island.
8. *E. diadema* (Linnaeus) : North Andamans – Table Island; Nicobars – Car Nicobar Island.

Order PHYMOSOMATOIDA

Family STOMECHINIDAE

9. *Stomopneustes variolaris* (Lamarck) : South Andamans – Port Blair; Little Andaman Island; Ritchie's Archipelago – Havelock Island; Nicobars – Nancowry Island; Kamorta Island.

Order TEMNOPLEUROIDA

Family TEMNOPLEURIDAE

10. *Mespilia globulus* (Linnaeus) : South Andamans – Port Blair; Pongibalu; Ritchie's Archipelago – Henry Lawrence Island; Nicobars – Kamorta Island.
11. *Microcyphus ceylanicus* Mortensen : Andamans.
12. *Paratrema doederleini* (Mortensen) : Andamans.
13. *Salmaciella dussmieri* (L. Agassiz) : South Andamans – Cinque Island, 20 m.
14. *Salmacis bicolor* L. Agassiz : Nicobars-Nancowry Island.
15. *Temnopleurus toreumaticus* (Leske) : South Andamans-Port Blair.
16. *Temnotrema scillae* (Mazetti) : South Andamans – Port Blair.

Family TOXOPNEUSTIDAE

17. *Gymnechinus robillardi* (de Loriol) : Andamans.
18. *Toxopneustes pilelous* (Lamarck) : South Andamans – Chidyatapu; Ritchie's Archipelago – Neil Island; Nicobars – Car Nicobar Island; Kamorta Island; Great Nicobar Island.
19. *Tripneustes gratilla* (Linnaeus) : North Andamans – Table Island; South Andamans – Port Blair; Ross Island; Chidyatapu; Ritchie's Archipelago – Sir William Peel Island; Nicobars – Car Nicobar Island; Kamorta Island; Nancowry Island; Katchal Island.

Order ECHINOIDA

Family ECHINOMETRIDAE

20. *Colobocentrotus atratus* (Linnaeus) : South Andamans – Port Blair; Nicobars – Katchal Island; Great Nicobar Island.
21. *Echinometra mathaei* (de Blainville) : North Andamans – South Reef Island; Ray Hill; Curlew (BP) Island; Middle Andamans – Between Avis Island and Mayabunder; Long Island; South Andamans – Port Blair; Ross Island; Chidyatapu; Pongibalu; Jolly Buoy Island; Alexandra Island; East entrance to Macpherson Strait; North of Rutland Island;

Little Andaman Island; Ritchie's Archipelago – Outram Island; Havelock Island; Henry Lawrence Island; Inglis Island; Neil Island; Nicobars – Car Nicobar Island; Kamorta Island; Nancowry Island; Katchal Island; Great Nicobar Island.

22. *Echinostrephus molaris* (de Blainville) : Middle Andamans – Rangat; South Andamans – Port Blair; Ross Island; Kaudiaghat; Pongibalu; Chidyatapu; Macpherson Strait; Nicobars – Kamorta Island; Nancowry Island; Trinket Island.
23. *Heterocentrotus trigonarius* (Lamarck) : Nicobars – Nancowry Island.

Order HOLECTYPOIDA

Family ECHINONEIDAE

24. *Echinoneus cyclostomus* Leske : South Andamans – Wandoor; Ritchie's Archipelago-Havelock Island; Nicobars – Car Nicobar Island; Kamorta Island; Great Nicobar Island.

Order CLYPEASTEROIDA

Family ARACHNOIDIDAE

25. *Arachnoides placenta* (Linnaeus) : North Andamans – North Andaman Island; Off Smith Island; Middle Andamans – Rangat; South Andamans – Port Blair; Chidyatapu; Ritchie's Archipelago – Havelock Island.

Family LAGANIDAE

26. *Laganum depressum* Lesson : North Andamans – Smith Island; Stewart Island; Middle Andamans – Rangat; South Andamans – Port Blair; Wandoor; Pongibalu; Chidyatapu; Ritchie's Archipelago – Havelock Island.
27. *L. laganum* Klein : Andamans – Andaman Sea; South Andamans – Port Blair; Wandoor; New Wandoor; Alexandra Island; Ritchie's Archipelago – Havelock Island; Nicobars – Katchal Island.
28. *Peronella lessueuri* (Valenciennes) Nicobars – Katchal Island.
29. *P. macroproctes* Koehler : Andamans.
30. *P. rubra* Doederlein : South Andamans – Port Blair.

Family ASTRICLYPEIDAE

31. *Echinodiscus auritus* Leske : South Andamans – Off Port Monatt 37 m.
32. *E. bisperforatus* Leske : South Andamans – Port Blair; Little Andaman Island.

Order SPATANGOIDA

Family SCHIZASTERIDAE

33. *Moira stygia* Luetken : South Andamans – Port Blair.

Family BRISSIDAE

34. *Metalia spatagus* (Linnaeus) : Andamans – Andamans; North Andamans – West Coral Bank, 27 m; South Andamans – Port Blair.
35. *M. sternalis* (Lamarck) : Andamans – Andamans; South Andamans – Port Blair.

Family SPATANGIDAE

36. *Maretia planulata* Gray : Andamans.

Family LOVENIIDAE

37. *Breynia vredenburgi* Anderson : South Andamans – Port Blair.
38. *Lovenia elongata* (Gray) : Andamans-Andamans; South Andamans – Port Blair; Ritchie's Archipelago – Havelock Island.
39. *Lovenia subcarinata* (Gray) : Andamans.

Class HOLOTHUROIDEA

Members of Holothuroidea commonly known as 'sea cucumbers' have the body elongated along the oro-anal axis with a thick leathery body wall. The tube feet are well developed particularly on the ventral side, reduced into pedicels or altogether absent in some. The tube feet around the mouth are modified into tentacles performing specialised functions such as burrowing and feeding. The endoskeleton consists of microscopic spicules of various shapes that help in taxonomic identification. Some of the species are of commercial value and find export market.

Order ASPIDOCHIROTIDA

Family HOLOTHURIIDAE

1. *Actinopyga echinites* (Jaeger) : South Andamans – Port Blair; Wandoor.
2. *A. lacanora* (Jaeger) : Andamans and Nicobars.
3. *A. mauritiana* (Quoy and Gaimard) : Middle Andamans – Rangat; South Andamans – Port Blair; Ross Island; Kaudiaghat; Chidyatapu; Jolly Buoy Island; Tarmugli Island; Little Andaman Island; Ritchie's Archipelago – Havelock Island; Neil Island; Nicobars – Car Nicobar Island; Nancowry Island; Trinket Island; Great Nicobar Island.

4. *A. miliaris* (Quoy and Gaimard) : South Andamans – Jolly Buoy Island; Malay Island; Ritchie's Archipelago – Neil Island.
5. *Bohadschia argus* Jaeger : South Andamans – Redskin Island; Twin Islands.
6. *B. marmorata* Jaeger : South Andamans – Port Blair; Little Andaman Island; Nicobars – Trinket Island.
7. *B. vitiensis* (Semper) : South Andamans – Chester Island; Malay Island.
8. *Holothuria (Acanthotrabeza) pyxis* Selenka : Andamans – Port Monatt, Surf line; South Andamans – Wandoor; Jolly Buoy Island; Rutland Island; Ritchie's Archipelago – Havelock Island; Nicobars – Kamorta Island.
9. *H. (Cystipus) rigida* (Selenka) : North Andamans – Sound Island; Middle Andamans – Mayabunder; Long Island; South Andamans – Port Blair; Rutland Island; Little Andaman Island; Ritchie's Archipelago – Neil Island; Nicobars – Nancowry Island.
10. *H. (Halodeima) atra* Jaeger : North Andamans – Interview Island; Middle Andamans – Mayabunder; Bakri Tikri; Long Island; South Andamans – Port Blair; Ross Island; Rangachang; Chester Island; Malay Island; Jolly Buoy Island; Little Andaman Island; Ritchie's Archipelago – Havelock Island; Inglis Island; Neil Island; Nicobars – Car Nicobar Island; Kamorta Island; Nancowry Island; Trinket Island; Great Nicobar Island.
11. *H. (H.) edulis* Lesson : South Andamans – Port Blair; Jolly Buoy Island; Rutland Island.
12. *H. (Lessonothuria) pardalis* Selenka : North Andamans – Sound Island; Middle Andamans – Mayabunder; Long Island; Rangat; South Andamans – Port Blair; Chidyatapu; Wandoor; Little Andaman Island; Ritchie's Archipelago – Inglis Island; Havelock; Nicobars – Car Nicobar Island; Nancowry Harbour; Katchal Island; Great Nicobar Island.
13. *H. (Mertensiothuria) fuscocinerea* Jaeger : South Andamans – Port Blair.
14. *H. (M.) leucospilota* Brandt : North Andamans – Sound Island; South Island; Middle Andamans – Rangat; Bakri Tikri; South Andamans – Port Blair; Macpherson Strait; Jolly Buoy Island; Little Andaman Island; Ritchie's Archipelago – Havelock Island; Neil Island; Nicobars – Nancowry Island; Trinket Island.
15. *H. (M.) pervicax* Selenka : South Andamans – Port Blair.
16. *H. (Metriatyla) scabra* Jaeger : North Andamans – Diglipur; Middle Andamans – Rangat; South Andamans – Port Blair; North Bay; Chidyatapu; Tarmugli Island; Ritchie's Archipelago – Inglis Island.
17. *H. (Microthele) nobilis* (Selenka) : South Andamans – Port Blair.
18. *H. (Platyperona) difficilis* Semper : Nicobars – Kamorta Island.
19. *H. (Selenkothuria) erinaceus* Semper : North Andamans – Interview Island; Middle Andamans – Mayabunder; South Andamans – Port Blair; Nicobars – Nancowry Island.

20. *H. (Semperothuria) cinerescens* (Brandt) : Middle Andamans – Rangat; South Andamans – Port Blair; Rutland Island; Ritchie's Archipelago – Neil Island; Nicobars – Car Nicobar Island; Kamorta Island.
21. *H. (Thymiosycia) arenicola* Semper : North Andamans; South Andamans – Port Blair; Ritchie's Archipelago – Neil Island; Nicobars – Car Nicobar Island; Kamorta Island.
22. *H. (T.) gracilis* Semper : Andamans – Andamans; South Andamans-Port Blair.
23. *H. (T.) hilla* Lesson : Middle Andamans – Rangat; South Andamans – Port Blair; Chidyatapu; Jolly Buoy Island; Little Andaman Island; Nicobars – Trinket Island.
24. *H. (T.) impatiens* Forskal : North Andamans – Curlew Island; Sound Island; Middle Andamans – Long Island; South Andamans – Port Blair; Malay Island; Ritchie's Archipelago – Inglis Island; Havelock Island; Henry Lawrence Island; Neil Island; Nicobars – Kamorta Island; Trinket Island; Katchal Island.

Family LABIDODEMATIDAE

25. *Labidodemas rugosum* (Ludwig) : South Andamans – Port Blair; North Andamans – South Reef Island, Surf line; Nicobars – Great Nicobar Island.

Family STICHOPODIDAE

26. *Stichopus chloronotus* Brandt : North Andamans – Sound Island; South Andamans – Port Blair; Ross Island; Wandoor; Alexandra Island; Redskin Island; Jolly Buoy Island; Port Monatt, surf line; Rutland Island; Ritchie's Archipelago – Havelock Island; Neil Island; Nicobars – Car Nicobar Island; Nancowry Island; Great Nicobar Island.
27. *S. horrens* Selenka : South Andamans – Ross Island; Nicobars – Nancowry Harbour.
28. *S. variegatus* Semper : South Andamans – Port Blair; Ritchie's Archipelago – Inglis Island; Nicobars – Trinket Island.
29. *S. vastus* Sluiter : South Andamans – Wandoor; Nicobars.

Order DENDROCHIROTIDA

Family CUCUMARIIDAE

30. *Aslia forbesi* (Bell) : Ritchie's Archipelago – Havelock Island.

Family PHYLLOPHORIDAE

31. *Afrocucumis africana* (Semper) : Andamans – Andamans; North Andamans – Sound Island; South Andamans – Port Blair; Rangachang; Little Andaman Island; Ritchie's Archipelago – Havelock Island; Neil Island; Nicobars – Trinket Island.

32. *Phyllophorus celer* Nicobars – Katchal Island.
 33. *Phyrella fragilis* (Ohshima) : South Andamans – Port Blair

Order APODIDA

Family SYNAPTIDAE

34. *Opheodesoma grisea* (Semper) : Middle Andamans – Rangat; South Andamans – Port Blair; Nicobars – Car Nicobar Island; Nancowry Island.
 35. *Patinapta ooplax* (von Marenzeller) : Andamans.
 36. *Synapta maculata* (Chamisso and Esenhardt) : North Andamans – Sound Island; South Andamans – Port Blair; Chidyatapu; Jolly Buoy Island; Alexandra Island; Ritchie's Archipelago – Inglis Island; Nicobars – Car Nicobar Island; Kamorta Island.
 37. *Synaptula recta* (Semper) : South Andamans – Port Blair; Nicobars – Kamorta Island.
 38. *S. striata* Sluiter : Nicobars – Kamorta Island.

Family CHIRIDOTIDAE

39. *Polycheira rufescens* (Brandt) : North Andamans – Sound Island; Port Cornwallis; Middle Andamans – Rangat; Long Island; South Andamans – Port Blair; Ross Island; Wandoor; Chidyatapu; Macpherson Strait; Nicobars – Kamorta Island; Nancowry Island; Trinket Island; Great Nicobar Island.
 40. *Trochodota havelockensis* Rao : Ritchie's Archipelago – Havelock Island.

Family MOLAPADIIDAE

41. *Acaudina molpadioides* (Semper) : Andamans.

DISCUSSION

Coral reefs are a highly productive and stable ecosystem providing a variety of habitats to different groups of animals with varied modes of life and catering to their needs. Hence several groups of animals with diverse habits of life make the coral reef their habitat. Of the several groups of biota inhabiting the reef ecosystem, echinoderms are important because of their size, numbers, living habits and effect on coral cover. Echinoderms inhabit both hard and soft substrata and a variety of suitable habitats are provided by the coral reef ecosystem. They interact through dwelling, feeding and reproductive activities, both with corals and other denizens of the ecosystem. In the process the corals experience both advantages and disadvantages. The association of echinoderms with corals is mostly facultative, the echinoderm taking advantage of the facilities available in the reef habitats.

Among the crinoids, species such as *Capillaster multiradiatus*, *Comanthina nobilis*, *Comaster gracilis*, *Comatella maculata* and *Himerometra magnipinna* are common even in knee-deep water. They are most common among the dead branches and bases of corals. They firmly hold the substratum with the help of the cirri. A few species with small and nonfunctional cirri or lacking cirri inhabit hollows in the massive colonies or the intricate branches of acroporans. During daytime they are cryptic. At night they lay perched on vertical surfaces to feed on the floating microorganisms filtered by pinnules of the spread out arms. Thus they compete with corals and other animals with a similar mode of feeding. Along with the microorganisms they also trap the suspended particles in their mucus and reduce silt settlement on the corals. The feeding on microorganisms does not affect the corals in view of their abundance but it helps corals by trapping the silt in mucus secreted for feeding.

A few asteroids such as *Luidia*, *Astropecten* and *Archaster* inhabit patches of soft substratum among the coral colonies or in their neighborhood. During low-tide periods they lie buried. The inhabitants of hard substratum take shelter under dead coral bases and massive corals or in the crevices of conglomerates. Forms of small to moderate size such as *Fromia*, *Linckia multifora*, *Dactylosaster*, and *Asteropsis* hide in crevices or under massive corals. Even the large sized *Acanthaster planci*, the crown-of-thorns sea star (CoT) lies hidden under boulders and massive colonies in the vicinity of live corals. However the large sized *Linckia guildingi*, *L. laevigata*, *Culcita*, *Pentaceraster*, and *Protoreaster* lie exposed in open places mostly on hard substrata. Though no specific preference can be attributed, *Dactylosaster* was reported from *Favites*, *Tamaria* from *Synarea* and *Asterina* from several species of *Acropora*, *Pocillopora damicornis* and equally from *Millepora*.

The feeding habits of asteroids are varied. Forms such as *Pentaceraster regulus*, *Dactylosaster cylindricus*, *Linckia guildingi*, *L. multifora*, and *Echinaster purpureus* feed on surface film. Some exhibit a combination of different feeding habits. Some oreasterids such as *Protoreaster lincki* feed on oysters while other ophiasterids and asterinids feed on sponges, ascidians, small crustaceans, molluscs, algae and encrusting organisms. *Protoreaster nodosus* is known to feed on algae, meiobenthos as well as substrate film. *Linckia laevigata*, feeds on coralline algae, detritus and microscopic organisms. Goniasterids are omnivorous feeding on encrusting organisms, detritus, decaying organisms *etc.* The surface film feeders and epifaunal carnivores prevent destructive organisms settling on dead bases and their environs. Among the carnivores, astropectinids feed on infaunal elements such as crabs, bivalves and gastropods. Only a few sea stars are known to feed on coral polyps. Notables among these are *Culcita* and CoT. The former is known to feed on a variety of coral species belonging to *Acropora*, *Galaxea*, *Porites*, *Goniopora* *etc.* It also feeds on substrate film, sponges, and algae and sometimes on soft corals. The juveniles and young specimens up to 8mm diameter of CoT inhabit and feed exclusively on coralline algae. Only larger specimens exclusively feed on live polyps of a variety of hermatypic corals particularly branching species. They also feed on *Millepora*, *Tubipora*, sea anemones and soft corals.

The greatest destruction to corals is from CoT. Generally the population density of the sea star is low and their feeding activity restricted to nights. In addition, part of the colony is spared before moving to another. The herbivores such as *Trochus*, *Turbo*, sea urchins *etc.* feeding on algae particularly coralline algae, control the CoT populations at normal densities by destroying the larvae and juveniles taking shelter in them. Coral polyps also engulf the larvae in the plankton though not selectively. Several organisms taking shelter among the live corals such as crabs and shrimps nibble the tube feet of the sea star restricting their feeding intensity. The deadly predator of *Acanthaster* is the giant triton, *Charonia tritonis* that engulfs whole young specimens. However the adults are partly eaten and the sea star also escapes by severing the attacked arm. At high densities called infestation resulting from population explosion or mass scale invasion the sea star feeds continuously even during daytime leaving no part of the colony untouched. However the windward reef slopes with currents and wave action are spared.

Of the ophiuroids, forms with branched arms filter the floating microorganisms in the network of branched arms. Some amphiuroids, particularly *Amphipholis squamata* and the ophiactids *Ophiactis* species are associated with algae and sponges of coral reefs and also take shelter in narrow crevices. Among the Ophiothricidae several species of *Ophiothrix* and *Macrophiothrix* are common in reef habitats taking shelter in the crevices of dead bases. Some are associated with alcyonarians of the reef. Species with very long arms like *Macrophiothrix longipeda* bury the disk and one or two arms under the rubble or anchor in deep crevices, projecting the remaining arms out into the waters for feeding. The other common species belong to Ophiocomidae. *Ophiomastix annulosa* is common on undersurfaces and in crevices during low tide periods. The spines are long and the arms have characteristic coloration. Among the species of *Ophiocoma*, species such as *O. erinaceus* and *O. brevipes* extend up to about 40 m depth on reef slope while *O. pica*, *O. pusilla*, *O. scolopendrina*, *etc.* occur in shallow waters. *O. brevipes* is most common on *Acropora digitifera* and exceptionally found also on *Pocillopora*. Others are found on a number of species of *Acropora*, *Pocillopora*, *Stylophora*, *Pavona*, *Porites*, *Favia*, *Galaxea*, *etc.* *O. erinaceus* is very commonly associated with *Millepora* also. The fissiparous ophiocomid *Ophiocomella sexradia* also occurs on a number of corals. The ophiurids *Ophioplocus imbricatus* and *Ophioelegans cincta* occur on dead coral base and on *Pocillopora*. *Ophiolepis superba* with an attractive brilliant star shaped dark marking on disc is common on branching corals. Of the ophiodermatids, *Ophiarachnella gorgonia* and *Ophiarachna incrassata* are common among reef habitats. Most ophiuroids are substrate or filter feeders. Species with branching arms filter the microorganisms of the water currents. Others trap microorganisms and organic detritus in mucous secretions. The food trapped also includes the silt that would otherwise settle on corals and mucus as well as microorganisms released by the polyps. Only a few ophiuroids with branching arms along with feather stars are competitors of corals for food consisting of floating microorganisms. Considering the richness of microorganisms in the waters, they do not pose any threat to corals. On the other hand, the mucus and microorganisms from corals and silt in the waters are trapped by many ophiuroids, thus cleaning the waters and reducing silt load on corals.

Most regular echinoids are inhabitants of hard substrata and are common in the reef environments. The common cidariid on most reefs is *Prionocidaris verticillata*. It generally hides under rocks. The diadematids, *Diadema setosum* and *D. savignyi* hide under coral bases or in hollows of massive corals extending out their long needle like spines. The ambulacral primary spines of *Echinohrix calamaris* and *E. diadema* are fine needles with backwardly pointed barbs near the tip. The temnopleurids *Salmacis bicolor* and *Temnopleurus toreumaticus* are not so common in Andaman and Nicobar reefs and the later prefers sandy sea grass beds. The small sized *Mespilia globulus* has bare areas carpeted with pedicellariae and alternating with regions of short spines. The family Toxopneustidae is represented by two common species. *Toxopneustes pileolus* has short white spines and a thick forest of large globiferous pedicellariae with gaping jaws. The jaws are provided with large poisonous sacs. The other species, *Tripneustes gratilla* inhabits shallow lagoons with algae and sea grass beds. The spines are white and short while the black bare areas of test have a mat of minute globiferous pedicellariae.

Stomopneustes variolaris, the sole extant representative of the family Stomechinidae, inhabits undersurfaces frequently boring into rocks, shale and dead coral bases for protection from wave action. The other boring species are members of the family Echinometridae namely *Echinometra mathaei*, *Echinostrephus molaris* and *Colobocentrotus atratus*. Of these *E. molaris* makes vertical cylindrical burrows in calcareous rocks and sometimes in hard shale and stays at the opening of the burrow. At the slightest disturbance the animal quickly drops to the bottom of the burrow. *C. atratus* inhabits shallow depressions on rocks exposed to battering waves. As an adaptation to heavy wave action, the short and flat aboral spines form a mosaic to dissipate the wave energy and the marginal spines are broad like chisel to apply firmly on to the rock. The oral surface bears crowded tube feet for a firm grip of the substratum. The animal virtually looks like a limpet. The boring activity of sea urchins in the dead coral bases severs the attachment of the live portions to be detached and ultimately lost. *Heterocentrotus trigonarius* has long spines, which are triangular in cross section with flattened tip. The irregular echinoids are inhabitants of soft substrata and thus are not common in the reef proper. The frequently encountered members are the holectypoid *Echinoneus cyclostomus*, the sand dollars *Laganum depressum* and *L. laganum* and the heart urchin *Lovenia elongata*.

The regular sea urchins are mainly herbivores feeding on a variety of algae and occasionally omnivores feeding on encrusting organisms along with their vegetative diet. The excessive algal growth covers live corals depriving them of the light necessary for photosynthesis by zooxanthellae associated with them. The algae are also competitors of zooxanthellae for nutrients. Occasionally live basal portions are buried in the sediments trapped by the algae. The coralline algae are the habitat for settlement and growth of juveniles of CoT that may later pose a threat to coral polyps. The herbivorous regular echinoids control the excessive growth of algae and destroy the larvae and juveniles of CoT taking shelter in them. Species such as *Toxopneustes pileolus* and

Tripneustes gratilla with poisonous globiferous pedicellariae and species of *Diadema* and *Echinothrix* with long and brittle spines drive away many potential predators. Very few irregular echinoids occur in reef habitats and are not common. They burrow into the soft substratum and subsist on the organic content of the sediment. Their fecal pellets bring the nutrients to the surface.

Though most sea urchins take shelter under the stones and in depressions already available, these may be widened to suitable size through abrasion. Some actually bore into the dead bases and conglomerates. Notables among them are *Stomopneustes*, *Echinometra* and *Echinostrephus*. Thus they destroy the substratum for settlement. However this helps in the formation of beach sand and soft substratum for other benthic organisms as well as in early dissolution of calcium required by the corals.

Holothurians inhabit the protected places of hard substrata provided by the coral reefs and the soft substrata among them and adjoining vicinities. They take shelter under the coral bases and conglomerates as well as burrow into the soft substrata. However quite a few lie open on the soft bottom. Some species are abundant in the algae and sea grass beds. The most common are species of *Actinopyga*, *Bohadschia*, *Holothuria*, *Stichopus*, *Synapta*, *Polycheira*, etc. Of these *Actinopyga mauritiana*, *Bohadschia marmorata*, *Holothuria* species, *Stichopus chloronotus*, *Synapta maculata*, and *Polycheira rufescens* are common with a wide distribution in Andaman and Nicobar Islands. Many species lie openly on soft substrata with sea grasses or hide under rocks. Smaller specimens can also be found in the algae. Most holothurians are substrate feeders ingesting sediments rich in organic matter either from surface or by burrowing. Some however filter microorganisms from the water with a network of highly branched tentacles. They do not feed on live corals or degrade the dead pieces entering the gut. Through burrowing and feeding on the substratum they disturb the natural stratification of the sediment and thus act as substrata re-workers. In the marine environment holothurians are the counterparts of earthworms of terrestrial ecosystems. By ingesting organic matter of the substrate and trapping the suspended particles they help in reducing organic load of the environment and silt settlement on the polyps.

The echinoderms not only take advantage of the habitat but also contribute to the community. All the echinoderms produce millions of eggs and larvae, which are a source of food for many organisms of plankton, nekton as well as benthos. Many arrow worms, fishes, benthic invertebrates including the coral polyps feed on floating eggs and larvae of echinoderms. Echinoderms are habitat for several symbionts that usually take shelter and share the food of the host or feed on the food associated with the host. The symbionts mostly exhibit concealing coloration and are hard to notice. Crinoids are hosts for a number of symbionts belonging to several varied groups of animals. The alpheid and pontoninid shrimps, galatheid crabs, copepods, polychaetes, young ones of several molluscs and the ophiuroid *Ophiomaza cacaotica* are some important associates of crinoids. All these exhibit cryptic coloration of the host crinoid and mostly share its food. Some asteroids such as *Culcita* and *Acanthaster* are known to shelter alpheid and pontoninid shrimps.

Polychaetes are known to take shelter on the arms of ophiuroids such as *Ophiocoma scolopendrina* and *Macrophiothrix longipeda*. Species belonging to echinoid genera such as *Diadema*, *Echinothrix*, *Stomopneustes* and *Echinometra* are associated with several symbionts such as shrimps, crabs, copepods and fish. The polychaete *Polydora antennata* was reported to bore into the test and form internal galls in *Stomopneustes variolaris*. A good number of parasitic gastropods of the families Stiliferidae and Pyramidellidae are known from echinoids and holothurians. Several species of polychaetes, crabs and fish are also known associated with many holothurians. These generally crawl on the surface or take shelter in the oral region or cloaca of the host. Thus the echinoderms provide shelter and food to many species and thus enrich the biodiversity of the reef ecosystem.

Among the different relationships between corals and echinoderm inhabitants presented above, most are neutral in the sense they do not directly or adversely affect the corals. The advantages to corals in general are few but are of significant nature. The mucus feeding crinoids, ophiuroids and holothurians clean the water free of silt, which may otherwise settle on coral polyps. The surface film feeders clean the surface free of harmful organisms settling in the environment. The feeding habit of holothurians prevents reducing effect of organic load in the sediments and brings up the nutrients and minerals locked up in the subsurface sediment, for use by the zooxanthellae of the corals.

Among the echinoderms that are beneficial to corals, the sea urchins deserve a special mention. Algae are threats to coral reefs in so much as they compete with the zooxanthellae of the reef-building corals for light and nutrients. In addition they promote accumulation of sand that may bury live coral bases. The coralline red algae are also the habitat and food for the settling larvae and juveniles of CoT, the adults of which are voracious feeders on live coral polyps. Most of the regular sea urchins are herbivores feeding on a variety of algae. The larger species of *Diadema*, *Echinothrix*, *Stomopneustes* and *Tripneustes* feed extensively on algae controlling the algae as well as the larvae and juveniles of the menacing crown-of-thorns sea star. In fully mature and spawning individuals of *Stomopneustes variolaris* the gut contents constituted 1.5 to 2.3% of the total weight while in spent and maturing stages they showed a maximum of 8.5% of total weight. These coincided respectively with the maximum and minimum standing crops of algae in the habitat. This inverse relationship between the algae and sea urchin populations is evident at places like Wandoor, Pongibalu, Ritchie's Archipelago, Kamorta *etc.* Similarly, other species were also reported to have been responsible for the status of algae at various other places in the world. Samarao *et al.* (1974) found that elimination of *Diadema antillarum* resulted in a great increase in macro-algal biomass shifts in dominance *etc.* Habitats occupied by *Paracentrotus lividus* in densities of five to 12 urchins per square meter were devoid of algae and an area cleared of the sea urchin developed algal covering to the extent of 50% in about two months (Kitching and Ebling, 1961). Similarly, a population of 2-15 adults of *Lytechinus variegatus* per square meter

was estimated to consume the annual production of *Thalassia* in a square meter. It was estimated that a population of *Lytechinus* in a square meter consumes about 45 kg of algae per year and that of *Stomopneustes variolaris* consumes about 43.6 kg per year. Similar effects were noticed in the case of other species of sea urchins also. This is a clear indication of the role of sea urchins in controlling algae and their harmful denizens helping the corals. The long and fragile spines of *Diadema* and *Echinothrix* projecting out from the hollows in conglomerates and dead coral bases and the large globiferous pedicellariae with poisonous sacs of *Toxopneustes* and millions of small globiferous pedicellariae of *Mespilia*, *Tripneustes* etc. drive away several predatory and destructive organisms and protect the corals. Even the fragmentation of dead coral through abrasion and boring contributes beach sand and helps in early recycling of calcium and formation of fine substratum for other organisms of the reef. Threats to corals arising from the association with echinoderms appear to be mainly competition for food, destruction of substratum and predation on live polyps.

Crinoids, ophiuroids and to some extent holothurians feed on the floating microorganisms which are also a source of food for the corals. But this competition does not seem to be detrimental in view of the abundance of the planktonic organisms in the ambient waters and supplementary nature of the resource since the corals depend also on the photosynthetic activity of their zooxanthellae. However this feeding habit of echinoderms is advantageous to the corals since the suspended silt as well as mucus and microorganisms released by the corals are also trapped thus helping in cleaning the waters.

A few species of echinoids destroy the dead coral rocks through abrasion to make, widen or deepen the depressions. However this helps in the formation of beach sand protecting the shoreline and providing substratum for organisms increasing the biodiversity and biomass of the community. It also helps in easy dissolution of calcium in water facilitating sufficient supply for building coral skeleton.

The only echinoderms, which feed on coral polyps, are a few carnivorous asteroids such as *Culcita*, *Dactylosaster*, *Linckia*, *CoT* etc. All the species excepting the *CoT*, feed on polyps only occasionally and not exclusively or voraciously. *CoT* is widely distributed in the coral reef environments of tropical Indo – West Pacific region from Red Sea and East Coast of Africa to Hawaiian Islands. It was Bell (1887) who first reported *Acanthaster planci* from Andamans. Subsequently it was recorded from several localities of Andaman and Nicobar Islands. It is an important inhabitant of any coral reef ecosystem. The juveniles are herbivores. The adults feed mainly on the hermatypic corals. It was noted that *Acropora* and *Pocillopora* of most exposed areas and *Goniastrea*, and *Goniopora* of less exposed areas are heavily predated. In the protected areas, *Porites* was attacked in greater proportion. The alcyonaceans, *Millepora* and *Heliopora* are rarely attacked. At low population densities, they feed only at night and only a portion of the colony is attacked either because of its habit or because of the menace from crustaceans and

mollusks inhabiting the colony. Then they move to another colony at some distance away. However at high densities, they feed continuously even during daytime and the whole colony is devoured leaving no live portion before moving to the next colony. Even then some portions of the windward slopes are spared for recovery.

Acanthaster planci occurs in many reefs of Andaman and Nicobar Islands but usually noticed in sparse numbers because of cryptic nature. High densities of the sea star were noticed once in 1989 at some islands. Some of these might be breeding aggregations. However, subsequent studies immediately afterwards did not reveal high densities at any locality. Even during the recent surveys at the selected reefs of North Reef Island, Ritchie's Archipelago, Cinque Island, Little Andaman and Great Nicobar, only a few feeding scars due to *Acanthaster* were noticed but not the sea star in large numbers.

Under natural conditions, many inhabitants of the reef ecosystem and pelagic elements control CoT and protect the coral reef. In the coral reef ecosystem the fish *Abudeduf* feeds on the eggs released by the sea star. Many benthic and pelagic organisms feed on planktonic larvae. The surface film feeders feed on the settling larvae. The herbivores such as gastropods and sea urchins feeding on algae destroy the settling larvae and juveniles taking shelter in the algae and feeding on them. Even coral polyps trap the eggs and larval stages floating in the waters and engulf whole juveniles when they try to feed on the polyps. Carnivorous mollusks such as giant tritons and probably also helmet shells and fishes such as wrasses attack adult sea stars and devour whole juvenile and smaller specimens. Many of the coral reef crustaceans such as xanthid crabs and members of several families of shrimps are a menace to the sea star since they nibble the tube feet and dislodge the climbing acanthasters. However, when these controlling organisms or their habitats are destroyed, there will be greater success in recruitment of juveniles and colonization of adults leading to high densities. High densities are also attained through mass invasion of large adults from reefs destroyed in the neighborhoods. The reasons for both are lack of controlling elements and prevalence of favorable conditions. These may be natural or anthropogenic.

Selective exploitation of predatory species reduces pressure on the *Acanthaster* resulting in population explosions. Wanton destruction of live corals, excessive silt and fresh water drainage through bad land usage are some of the causes for dead reefs. Deprived of food, the acanthasters of dead reefs are forced to invade healthy reefs where they culminate in infestations and further devastate live coral habitats. Effective land management practices, sustainable exploitation, and conservation of reef inhabitants protect the corals in a healthy condition. Exploitation of herbivorous organisms such as *Trochus*, *Turbo*, sea urchins *etc.* results in abundant algal habitats promoting settlement of larvae and growth of juveniles of *Acanthaster*.

Potential causes in the Andaman and Nicobar Islands for the destruction of reefs and reef inhabitants and increase in the *Acanthaster* populations to infestation densities are :

- Terrestrial run off
- Pollution from domestic, industrial and agricultural wastes
- Over fishing of reef fishes and
- Selective exploitation of predatory and herbivorous organisms for trade

Of these the first two destroy the corals forcing CoT to invade the healthy reefs. The other two factors help successful recruitment and colonization at high rates increasing the density of resident populations to infestation levels. Hence it is pertinent to keep the possible effects and their magnitude in mind before undertaking any activity that directly or indirectly affects the corals and their inhabitants. Effective land management practices preserve a healthy environment for the corals. Awareness programmes and alternate livelihood for the locals help in preventing wanton destruction of habitats and avoiding selective and overexploitation of reef resources which affect the natural balance in the reef community. Towards providing alternative livelihood and protection of corals in the islands there are prospects in the culture of some echinoderms. In addition to being a food resource for several pelagic and benthic inhabitants of the sea, the echinoderms are a rich source of food for human beings also. Two groups of echinoderms namely sea urchins and sea cucumbers serve as food for man.

The fleshy gonads of sea urchins in their mature stages are edible and considered a delicacy in several parts of America, Europe and Southeast Asia. The mature gonads of sea urchins comprise more than 20% of the wet weight. There is no local market for these, but the coral reef environments of Andaman and Nicobar Islands support populations of sea urchins of commercial value. These are *Stomopneustes variolaris*, *Tripneustes gratilla* and to some extent *Colobocentrotus atratus* and *Heterocentrotus trigonarius*. The sea urchins are occasionally collected and eaten by the Nicobarese. Other local communities also should be encouraged to adopt sea urchin food and provide facilities for their culture.

The processed body wall of sea cucumbers is commercially known as *Beche-de-Mer*. It is considered a great delicacy in several parts of the world particularly Southeast Asia. Among the holothurians that inhabit the reef areas of Andaman and Nicobar Islands, 12 to 15 species are useful for *beche-de-mer* and half a dozen species are abundant with fishery potential. These are species of *Holothuria*, *Actinopyga*, *Bohadschia* and *Stichopus*. It was reported that Diglipur and Mayabunder were rich in *Holothuria scabra* and *Bohadschia vitiensis*, Middle Andamans in *Actinopyga* spp. and *H. scabra*, South Andamans in *Holothuria* spp. , *Actinopyga* spp. and *B. vitiensis*, and Little Andaman in *H. leucospilota*. In the Nicobar group, though some species are common, their populations are not abundant since the local Nicobarese occasionally eat them. At Car Nicobar the Nicobarese collect indiscriminately all the intertidal organisms including the stray sea cucumbers, bivalves and even sipunculans for food. Hence they are not easily available. At other islands, the Nicobarese collect the sea cucumbers to supplement their main food consisting

of fish and pig or for a change. Hence *Stichopus* spp. at Nancowry and *Actinopyga* spp. at Great Nicobar occur in good numbers. *Holothuria atra* occurs abundantly in many reefs but it is of relatively less commercial value compared to other species available and not a preferred diet of Nicobarese.

In spite of the ban to collect sea cucumbers for commercial purposes, there is clandestine fishing and processing by poachers in uninhabited and inaccessible remote islands. This is leading to depletion of natural population, the cause for low densities of many common species at several localities. Hence there are prospects only for farming sea cucumbers for processing but not for exploitation of natural populations. James (1983,1993) gave details of sea cucumber breeding and farming for commercial exploitation and mentioned successful attempt to farm *H. scabra* at Aberdeen Bay. Similar farming of juveniles in enclosed pens at sheltered mangroves and creeks can be undertaken. These can be leased out to unemployed poor for farming sea cucumbers. However harvesting should be properly monitored to avoid collection of adults from natural populations to increase the income. Otherwise, the natural population cannot withstand the pressure of greedy exploitation.

Recent studies showed that several echinoderms produce bioactive compounds chiefly of saponin type. They are mainly toxic and hemolytic in nature. The extracts also showed anti-fungal and anti-bacterial effects. The toxic nature of the echinoderms, particularly of holothurians is supposed to be a chemical defense mechanism of organisms that are otherwise easily susceptible to predation. Holothurian extracts were also successfully used to eradicate unwanted organisms from fish farms. Some holothurians showed Central Nervous System stimulants and substances of diuretic and anti-viral properties.

SUMMARY

Among the various inhabitants of the coral reef ecosystem of Andaman and Nicobar Islands, echinoderms are conspicuous by their size, abundance and role in the ecosystem. Altogether 224 species of echinoderms belonging to Crinoidea (32 spp.), Asteroidea (48 spp.), Ophiuroidea (64 spp.), Echinoidea (39 spp.) and Holothuroidea (41 spp.) have been found to be occurring in the coral reefs of Andaman and Nicobar Islands. Their detailed distribution in the different islands is given. The general life styles and relationships with corals and other denizens of the coral reef ecosystem have been discussed. The effects of echinoderms are presented in neutral, beneficial and negative categories. The effect of the Crown-of-Thorns sea star, *Acanthaster planci* is discussed in detail with reasons for plague densities and measures to be taken for their control. The prospects for culture of sea urchins and holothurians for the benefit of the communities and reef health are presented. A note on the bioactive compounds of echinoderms is also added.

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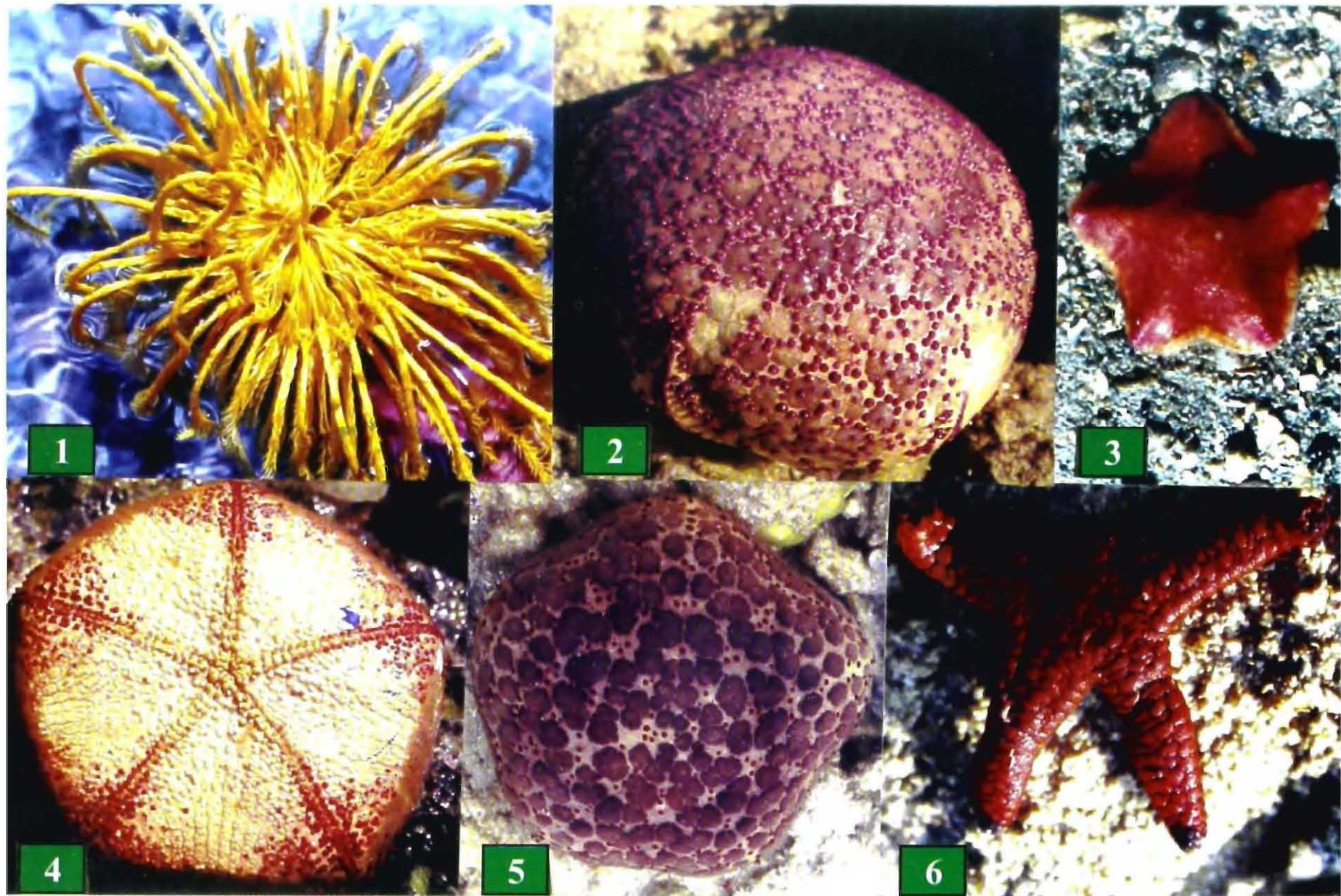


PLATE I.

1. *Himerometra magnipinna*; 2. *Culcita novaeguineae* (abactinal view); 3. *Asterina lorioli* (abactinal view); 4. *Culcita schmideliana* (actinal view); 5. *Culcita schmideliana* (abactinal view); 6. *Fromia indica* (abactinal view).

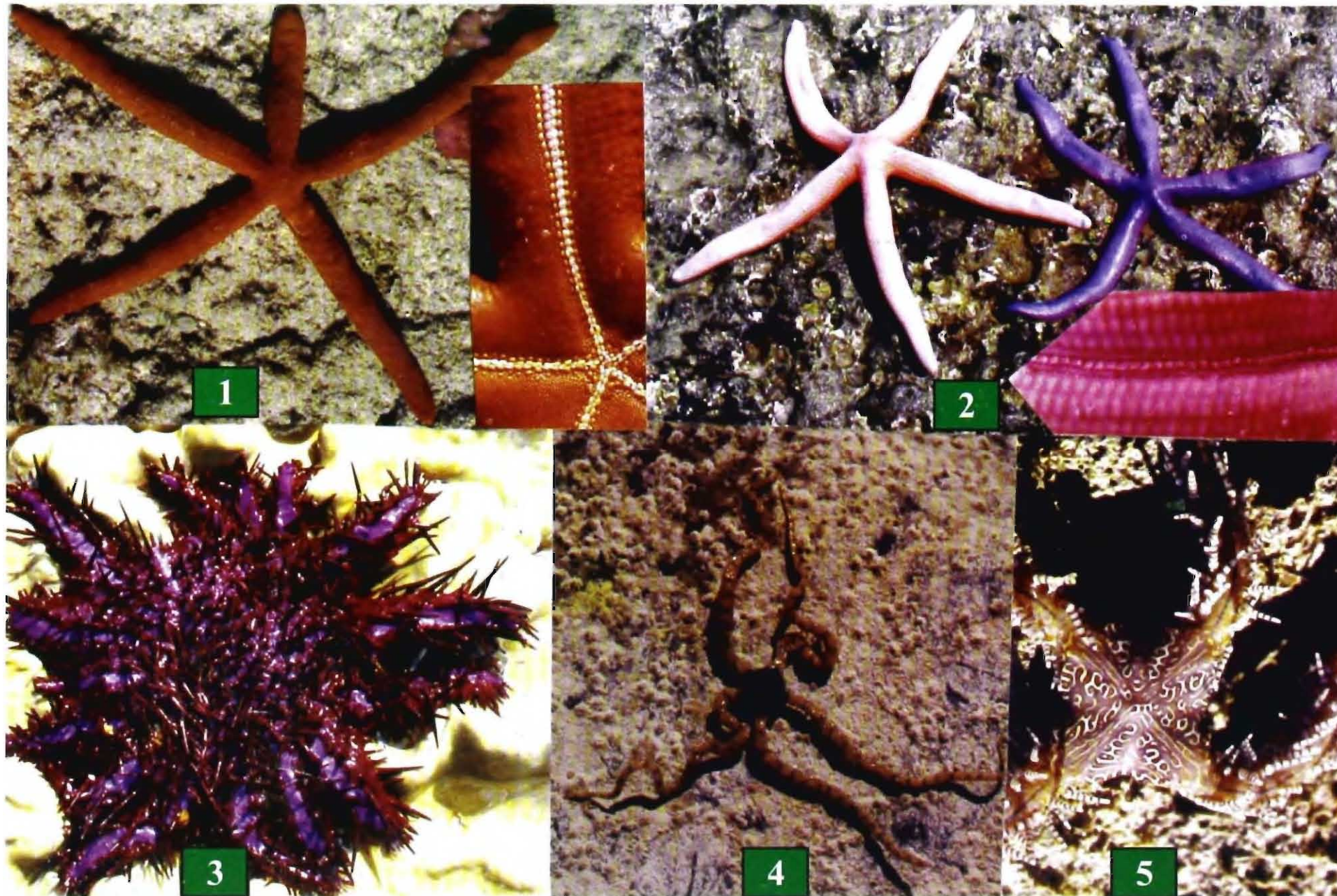


PLATE II.

1. *Linckia guildingi* (abactinal view; inset—enlarged actinal view of part of an arm); 2. *Linckia laevigata* (abactinal view of two colour forms; inset—enlarged actinal view of part of an arm); 3. *Acanthaster planci* (abactinal view); 4. *Ophiarthrum elegans* (dorsal view); 5. *Ophiarthrum pictum* (dorsal view).

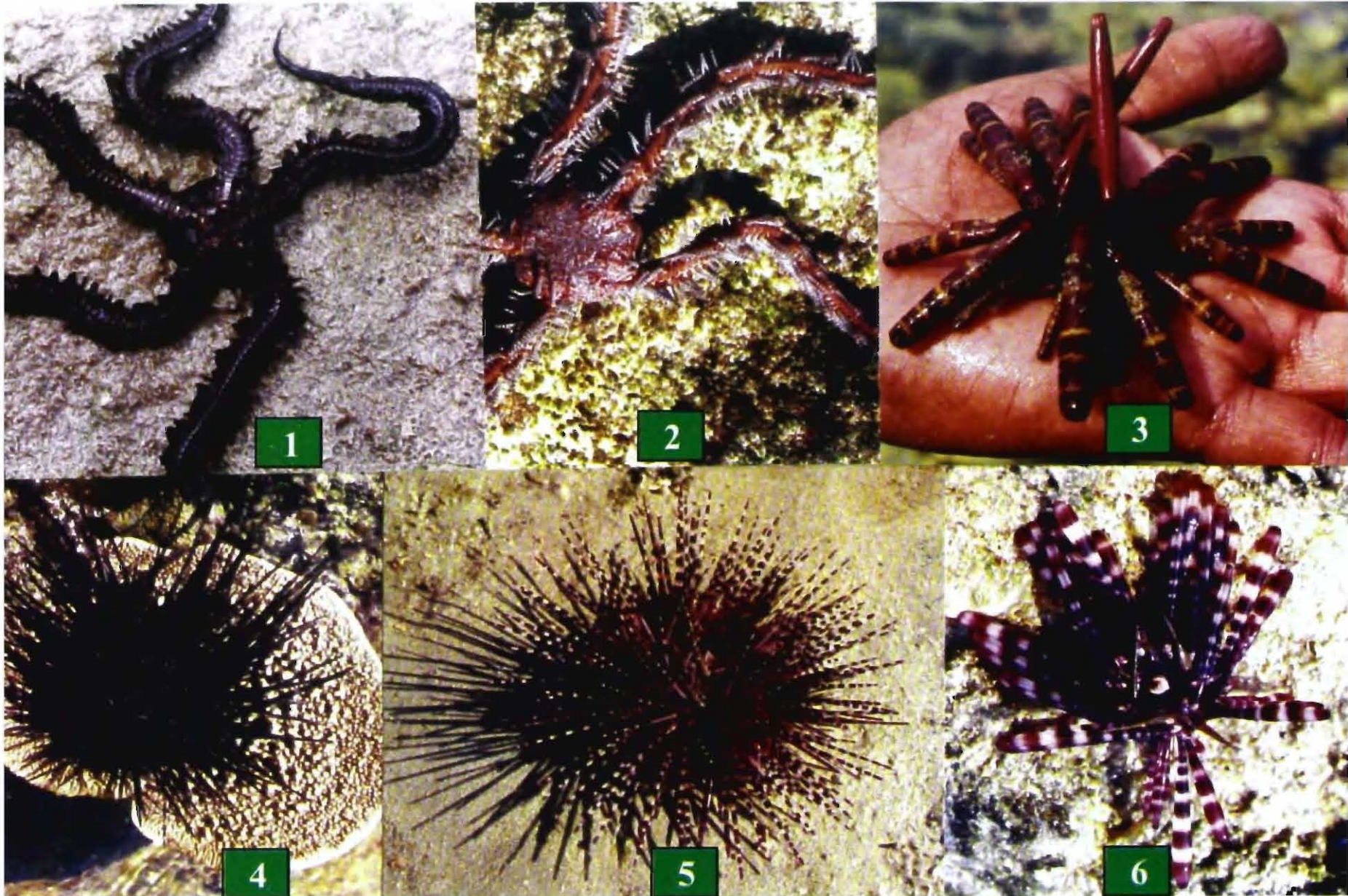


PLATE III.

1. *Ophiocoma erinaceus* (ventral view); 2. *Ophiomastix annulosa* (dorsal view); 3. *Phyllacanthus imperialis* (aboral view, partly ambital);
4. *Diadema* sp. (aboral view, partly ambital); 5. *Echinothrix calamaris* (aboral view); 6. *Echinothrix calamaris* (aboral view of a juvenile).

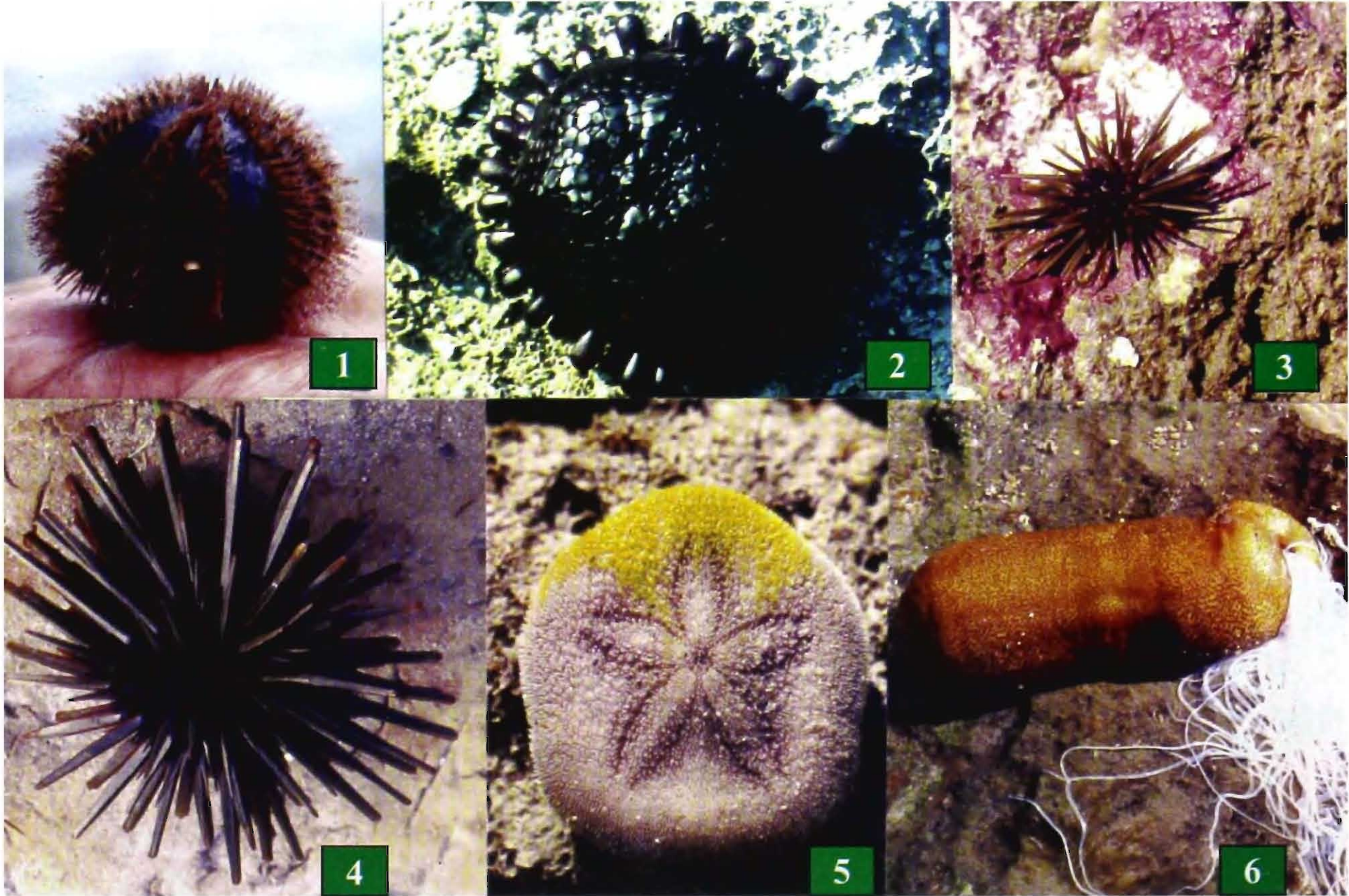


PLATE IV.

1. *Mespilia globulus* (ambital view); 2. *Colobocentrotus atratus* (aboral view); 3. *Echinometra mathaei* (aboral view);
 4. *Heterocentrotus trigonarius* (aboral view, partly ambital); 5. *Laganum laganum* (aboral view); 6. *Bohadschia marmorata*.

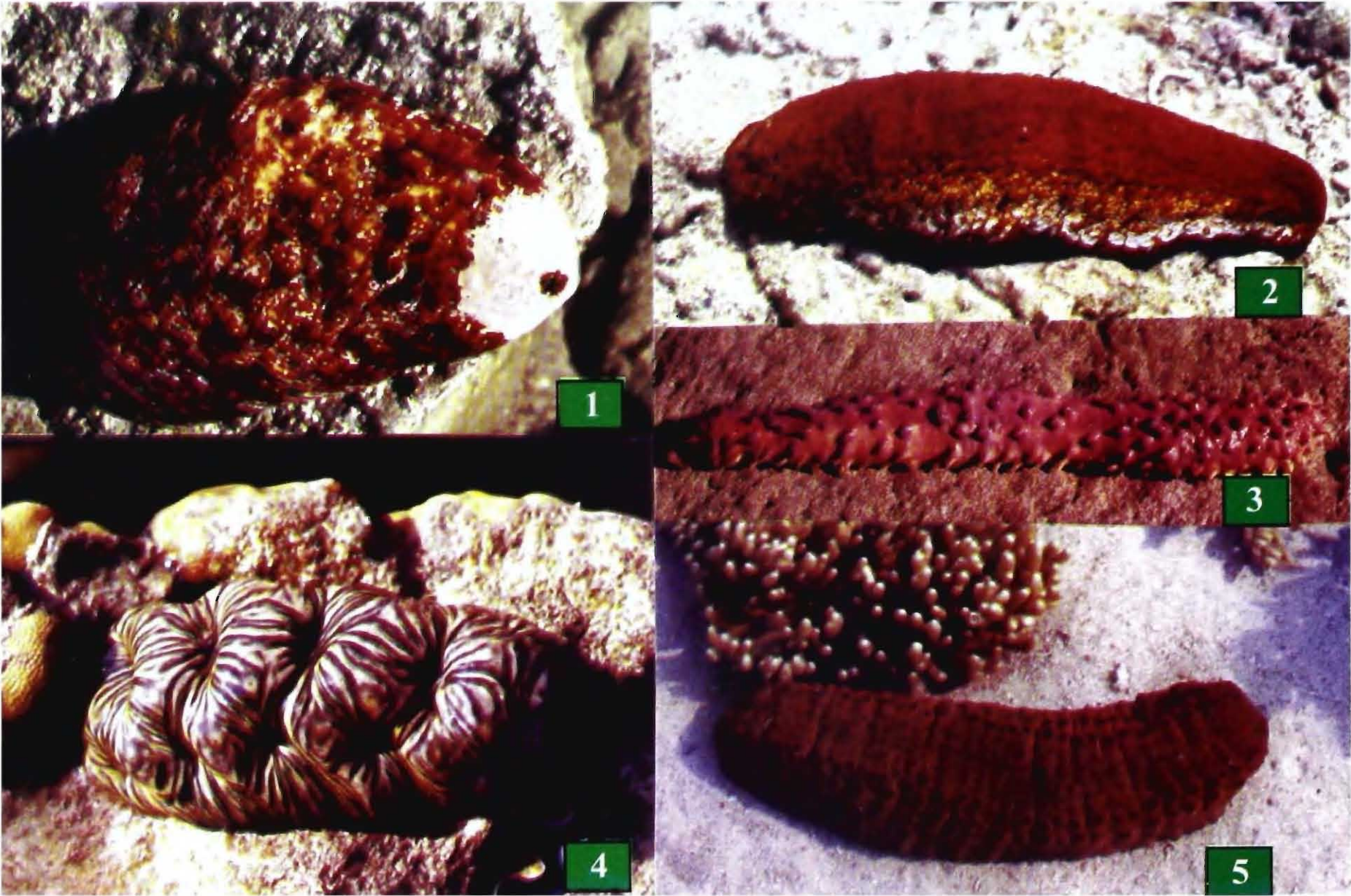


PLATE V.

1. *Actinopyga lacanora*; 2. *Actinopyga mauritiana*; 3. *Holothuria pyxis*; 4. *Stichopus vastus*; 5. *Stichopus variegatus*.

RECORDS OF SOME COLLEMBOLA FROM AGRICULTURAL FIELDS OF NORTH 24-PARGANAS, WEST BENGAL

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INTRODUCTION

Collembolans are the commonest soil insects. Being extremely soft bodied and sensitive to various measures adopted in agroecosystem, their population and diversities are depleted. Particularly mechanical abrasive action involved in ploughing, application of chemical fertilizers, pesticides, herbicidal chemicals, etc. impair their growth and development. The species of Collembola, particularly the hyperedaphic and hemiedaphic ones, that occur in agroecosystem from Barrackpore, North 24-Parganas, West Bengal, indicate their tolerance to such rigors of cultivation. In the present investigation, eleven species of Collembola of which three belonging to suborder Symphyleona and eight to Arthropleona were found to occur predominantly in the studied agroecosystem.

The most abundant and ubiquitous were *Isotomurus balteatus* (Reuter), *Cryptopygus thermophilus* (Axelson), *Lepidocyrtus* (*Lepidocyrtus*) sp., *Cyphoderus javanus* Börner and *Brachystomella* sp. occurring during cultivation of all the three crops while the rest were found to remain restricted to a specific type of crop.

METHODOLOGY

Soil samples, drawn from the field, were extracted through modified Tullgren funnels by using a 60-watt electric lamp for the purpose of dessication. The examples were collected in rectified alcohol and were subsequently mounted on slides for the purpose of identification.

Analysis was made of various species of Collembola, occurring in the agricultural fields of Barrackpore, with reference to their occurrence according to months and specific crop.

Choudhuri, *et al.* (1971a, b, 1972, 1975), Mitra, *et al.* (1977, 1981, 1983a, b, 1986, 1993) and Singh, *et al.* (1971) contributed to the knowledge of Collembola both from cultivated and uncultivated fields of West Bengal and Uttar Pradesh.

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QUALITATIVE ANALYSIS OF COLLEMBOLA WITH REFERENCE TO CROPS

Qualitative analysis of total Collembola, obtained from the experimental plots during cultivation of all the three crops, reveal the presence of eleven species of which six species were crop-specific while others were present during cultivation of all the three crops. Three species, viz., *Seira indica*, *Sminthurus* sp. and *Isotomodes* sp. occurred during cultivation of jute while *Sminthurides appendiculatus*, *Sphaeridia cornuta* and *Acherontiella* sp. were remain associated with paddy only.

An analysis of species, remaining associated with all the three crops, reveals that *Isotomurus balteatus* reached its population-maxima during wheat cultivation and its lowest population occurred during jute cultivation *Cryptopygus thermophilus* and *Lepidocyrtus (Lepidocyrtus)* sp. exhibited their peaks during paddy cultivation and minimum for the former was during wheat cultivation while for the later during jute cultivation and its minimum population occurred during jute cultivation. *Brachystomella* sp. reached its peak of population during wheat cultivation and its minimum population during paddy cultivation.

Qualitative composition of Collembola, obtained during cultivation of each crop, reveals that eight species of Collembola remain associated with both jute and paddy while five species with wheat. *I. balteatus*, *C. thermophilus*, *Lepidocyrtus (Lepidocyrtus)* sp., *C. javanus* and *Brachystomella* sp. occurred during wheat cultivation of which the bulk of the population was of *I. balteatus* and the least was that of *Brachystomella* sp.

During jute cultivation, *C. thermophilus* was most dominant followed by *C. javanus*, *I. balteatus*, *Sminthurus* sp., *S. indica*, *Brachystomella* sp., *Isotomodes* sp. and *Lepidocyrtus (Lepidocyrtus)* sp.

During paddy cultivation, *I. balteatus* was most predominant followed by *C. thermophilus*, *Lepidocyrtus (Lepidocyrtus)* sp., *S. appendiculatus*, *C. javanus*, *S. cornuta*, *Acherontiella* sp. and *Brachystomella* sp.

Occurrence of Collembolan species according to vegetation type

Species	Vegetation		
	Wheat	Jute	Paddy
<i>Isotomurus balteatus</i>	****	**	***
<i>Cryptopygous thermophilus</i>	**	**	**
<i>Lepidocyrtus (Lepidocyrtus)</i> sp.	*	*	**
<i>Cyphaderus javanus</i>	*	**	*
<i>Seira indica</i>	—	*	—
<i>Sminthurides appendiculatus</i>	—	—	*

Table Cont'd.

Species	Vegetation		
	Wheat	Jute	Paddy
<i>Brachystomella</i> sp.	*	*	*
<i>Sminthurus</i> sp.	–	*	–
<i>Sphaeridia cornuta</i>	–	–	*
<i>Isotomodes</i> sp.	–	*	–
<i>Acherontiella</i> sp.	–	–	*
**** Most predominant	** Frequent	– Absent	
*** Predominant	* Infrequent		

QUALITATIVE ANALYSIS OF COLLEMBOLA WITH REFERENCE TO MONTHS

Four species of Collembola viz. *I. balteatus*, *C. thermophilus*, *C. javanus* and *Brachystomella* sp. occurred during January with the highest population of *I. balteatus* followed by others as arranged above in graded sequence. During February, *I. balteatus* continued to dominate the population with four other species, viz. *C. thermophilus*, *Lepidocyrtus* sp., *C. javanus*, *Brachystomella* sp. *I. balteatus* was absent during March and the entire population obtained during this month was represented by *C. thermophilus* only. During April, *I. balteatus* continued to remain absent and *C. thermophilus* constituted half of the population followed by *C. javanus* (5.56%), *Sminthurus* sp. (38.89%) and *Isotomodes* sp. (5.56%). *I. balteatus* was also absent during May with *C. thermophilus* representing the highest population (64.29%) followed by *C. javanus* (14.29%), *S. indica* (7.14%), *S. appendiculatus* (7.14%) and *Isotomodes* sp. (7.14%). *I. balteatus* reappeared during June with 15.79% of the population for this month. The population for this month was, however, dominated by *C. javanus* (42.11%) followed by *S. indica* (21.05%), *C. thermophilus* (15.79%) and *Sminthurus* sp. (5.26%). During July, *I. balteatus* dominated the population with 51.52% followed by *C. javanus* (36.36%), *Brachystomella* sp. (9.09%) and *Lepidocyrtus* sp. (3.03%). *C. thermophilus* was noticeably absent during this month. During August, *I. balteatus* continued to dominate the population with 41.67% followed by *C. javanus* (25%), *S. appendiculatus* (16.67%), *Lepidocyrtus* sp. and *S. cornuta* each with 8.33%. *C. thermophilus* remained unrepresented during this month. During September, *I. balteatus* dominated the population with 51.72% followed by *S. appendiculatus* (34.48%) and *Lepidocyrtus* sp. (6.9%). *C. thermophilus* reappeared in this month constituting 6.9% of the population. During October, *I. balteatus* continued to dominate the population with 44.26% of the population followed by *C. thermophilus* (36.07%), *Lepidocyrtus* sp. (14.75%), *C. javanus* (3.28%) and *Acherontiella* sp. (1.64%). During November, *C. thermophilus* dominated the population with 39.47% followed by *I. balteatus* (26.32%), *Lepidocyrtus* sp. (26.32%),

C. javanus (5.26%) and *Brachystomella* sp. (2.63%). During December, both *I. balteatus* and *C. thermophilus* was represented by the same population (33.33% each) followed by *C. javanus* (25%) and *Brachystomella* sp. (8.33%).

SUMMARY

In the studied fields, altogether eleven species of Collembola were found to occur. *Isotomurus balteatus* was found to be most predominant during cultivation of all the three crops followed by *Cryptopygus thermophilus* which was moderately predominant. Other species occur indifferently and the rarest being *Sminthurides appendiculatus*, *Sminthurus* sp., *Sphaeridia cornuta*, *Isotomodesi* sp., *Acherontiella* sp. and *Salina indica*.

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STATUS OF *MICROPARONELLA* CARPENTER, 1916 (COLLEMBOLA : ENTOMOBRYIDAE : PARONELLINAE)

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INTRODUCTION

The genus *Microparonella* includes smaller species hardly exceeding the length of 1 mm. The genus was established by Carpenter (1916) with the type-species *Microparonella caerulea*. In the same paper he also described the other new species viz., *Microparonella flava*. *Microparonella* is distinct from *Paronella* and *Dicranocentrua* owing to its relatively smaller size, absence of extra ocular structure, less than 8 ocelli on each side, structure and nature of ungues and unguiculi, 2 rows of minutely ciliated dental spines and nature of mucrones. Further, the species of *Paronella* and *Metaparonella* possess the larger rounded or oval body scales with visible striations in contrast to *Microparonella* where the scales are always smaller and completely hyaline like the scales of some genera under Cyphoderinae. Salmon (1964a, b) synonymised the genus *Microparonella* with *Paronella*. The present investigation proves it to be a genus distinctly related to *Paronella* or *Dicranocentrua* and is distinct from the above mentioned genera in every detail. Denis (1925) considered *Microparonella* visibly more evolved and distinct from *Paronella*. He further commented that *Microparonella* possesses more evolved mucrones than *Paronella*. *Microparonella* is very distantly related to *Pseudoparonella* in having more differences than resemblances. Carpenter (1932), however, was misguided by the diagnosis of *Pseudoparonella* given by Handschin (1924) and he (Carpenter, 1932) attributed importance only on the character like bidentate mucro of the species *doveri* for placing it under the genus *Pseudoparonella*. Diagnosis of *Pseudoparonella*, as it has already been mentioned, was based actually on the species like *setigera* and *incerta*. Handschin (1924) fixed *P. appendiculata* (Schott) of the as the type-species of *Pseudoparonella*. *Microparonella* is distinct from *Bromacanthus* in the nature of dental spines (which are minutely ciliated and transiting distally in *Microparonella* vs. smooth, usually non-transiting stout spines in *Lepidonella* and *Bromacanthus*), number and nature of arrangement of ocelli, nature of scales clothing body and in the relative length of body and body facies. Nature of ungues and unguiculi with its teeth also exhibit distinct differentiation in the two genera. Yosii (1966) described a new species viz., *Microparonella ceylonica* from Ceylon which should better be included under *Lepidonella* in view of the nature of its mucrones, ungues and unguiculi, dental spines and in the number and nature of arrangement of ocelli. Moreover, the body facies of the species is more lepidocyrtiform than cyphoderiform. The species of the

genus exhibit a sort of cavernicolous or euedaphic adaptation which is indicated by its usually non-pigmented, cyphoderiform body facies, tendency towards the reduction in the number of ocelli, nature of foot complex, specially in the tendency of enlargement of unguual teeth (sometime reduction also) and in the modification of tenent hair as shown by Christiansen (1965) for the cave-forms. Variable number of ocelli and unguual teeth together with the enlargement or reduction of the paired inner basal unguual teeth indicate that the species of the genus are plastic with the abilities to adapt to various ecological niches.

Redefinition : Body covered with smaller, rounded to oval, hyaline typical scales without visible striations; antennae shorter, rarely sub-equal to the length of body; ocelli reduced; ungues and unguiculi elongate, slender, paired inner unguual teeth enlarged or reduced, unpaired distal teeth present or absent, external basolateral teeth vestigial; unguiculi lanceolate, nondentate; tenent hair slender, usually setaceous; manubrium without spines, dentes with two rows of stiff, minutely ciliated spines (Carpenter in his original diagnosis mentioned only one inner row of spines); mucro slender, elongate, with two prominent ridges, reduced with 2 teeth or well developed with 4 teeth, inner lateral tooth separated and runs parallel with antepical tooth in the form of a separate ridge; Th. II not elevated; in body facies the species of the genus come close to members of Troglodetini under Cyphoderinae.

Type-species : *Microparonella caerulea* Carpenter, 1916, by original designation.

DESCRIPTION OF THE TYPE-SPECIES

Microparonella caerulea Carpenter, 1916

1916. *Microparonella caerulea* Carpenter, *Proc. Roy. Irish Acad.*, **33B** : 1-70.

1929. *Paronella caerulea* Handschin, *Trans. Ent. Soc., London*, **77** : 15-28; Salmon, 1964b, *Bull. Roy. Soc. N. Z.*, (7) **2** : 145-644.

Material : Syntype mounted on a slide from the British Museum (Natural History), London, labelled as "Mahé, Seychelles, Forêt Noire. X.1908. B.M. 1916-183 [P. V. A; J. T. S., 8. 1951]"

Colouration : Violet blue (as mentioned by the author), the syntype examined totally non-pigmented; ocellar fields reduced, faintly pigmented (Text figs. 1. A, B; PL. 1. A).

Clothing : Clothed with smaller hyaline scales, scales with rounded apices, oval or elongate in outline without darker striations (typical scales); flexed macrochaetae absent on the general surface of body (achaetotic); Th. II on anterior margin and Abd. IV occasionally with a few setae; appendages clothed with ciliated acuminate setae.

Head : Ocelli 3 + 3 (as mentioned by the author), in the syntype examined, however, it appears to be 4 + 4 (Text figs. 1. A, B); in the syntype Ants. II, III and IV broken, from Ant. I it appears, antennae shorter than body; relative length index of Ants. I II : III : IV (as given by Carpenter) = 5 : 9 : 9 : 12.

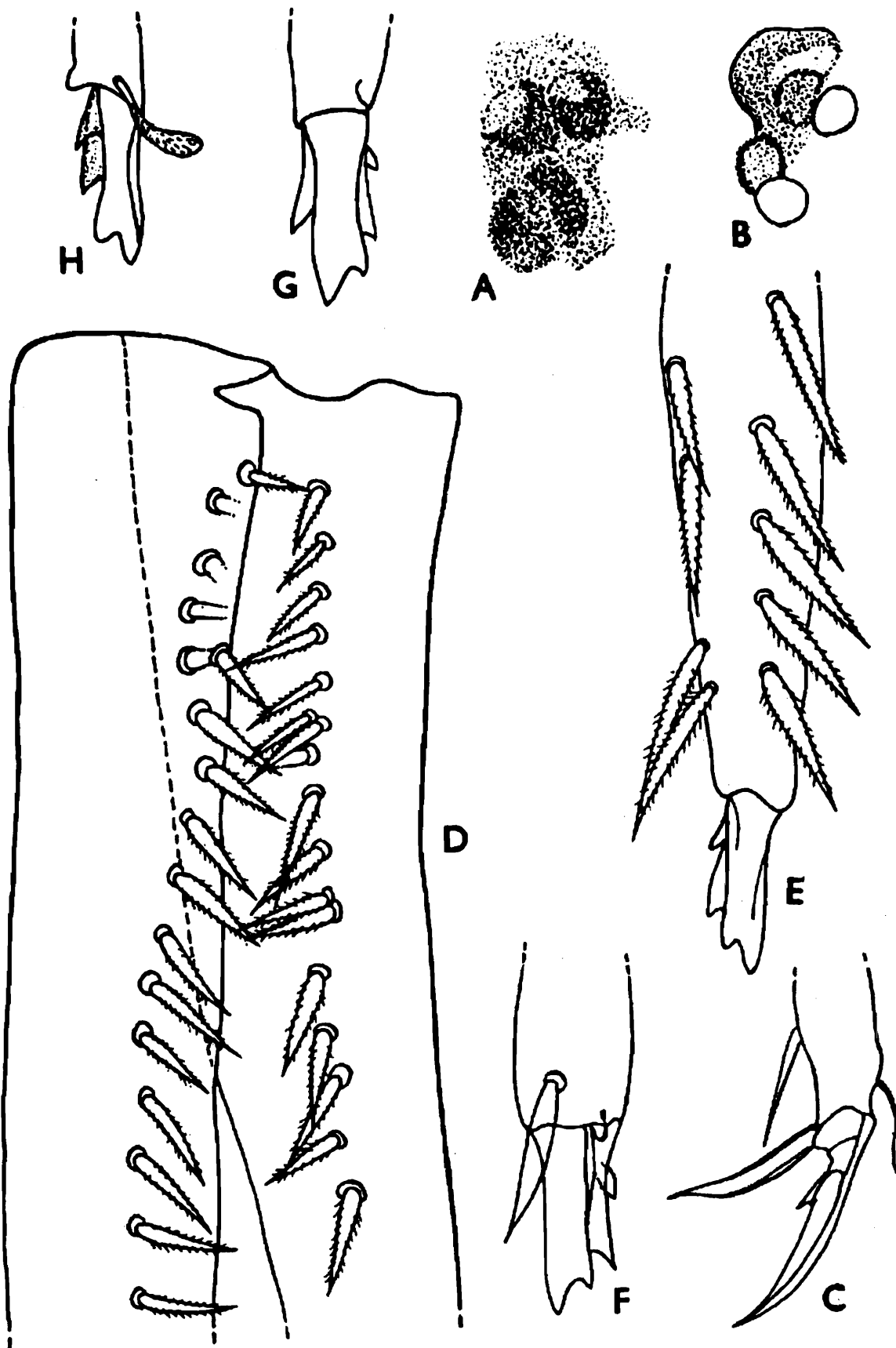


Fig. 1. *Micropaonella caerulea* Carpenter : (A) left ocellar field; (B) right ocellar field; (C) footcomplex of leg II; (D) proximal portion of dentes showing arrangement of spines; (E) distal portion of dentes with mucrone showing arrangement of spines; (F-G) mucrones in different views (All drawn from a syntype).

Thorax : Metathorax longer than mesothorax; legs all similar, unguis slender, with paired inner basal teeth, of which the outer basal tooth enlarged, distal unpaired inner teeth absent; unguiculi long, slender, lanceolate and non-dentate; tenent hair present (Carpenter, 1916, considered it as absent), setaceous (Text fig.1,C).

Abdomen : Abd. IV thrice and a half the length of Abd. III; furcula well developed, dentes longer than manubrium with two rows of minutely ciliated spines (Text fig.1, D, E); mucro elongate with 4 teeth, viz., apical, antepical, inner lateral and basolateral, i.l. runs parallel with ant.ap. (Carpenter, 1916, in his description mentioned 5 teeth in mucro and he depicted a relatively shorter mucro than what is seen in the syntype; he depicted a tooth, termed as "ventral" which is nothing but the terminal thickening of the apical tooth and the tooth he had mentioned and depicted as "lateral", not observed in the syntype examined) (Text figs.1. F, G, H).

Length (excluding appendages) : 1 mm

Type-specimens : Syntypes in the British Museum (Natural History), London.

Type-locality : Mahé, Forêt Noire, Seychelles.

Comparisons : The species can be discriminated from the other species by the reduced number of ocelli and in the nature of its mucrones and foot complex.

Interrelationships : Phylogenetically *Microparonella* appears to be quite an aberrant group in the absence of striking resemblance to any genus under Paronellinae. It, however, possesses certain characteristics which resemble more to the genera under the tribe Troglopedetini. Thus the nature of mucrones (in certain species) and the presence of spines on dentes together with the reduction in the number of ocelli make the genus apparently related to some genera of Troglopedetini and specially to *Cyphoderopsis* Carpenter (1917). Its smaller size, reduced pigmentation, body facies and other features are similar to those of euedaphic or cave species.

Distribution : The genus, as the present knowledge stands, is restricted in the Oriental Region. Thus three species viz., *Microparonella caerulea* Carpenter, *Microparonella flava* Carpenter and *Microparonella doveri* (Carpenter) are known from the Oriental Region. One species viz., *Paronella berlandi* Denis 1925, described from South America, may be a member of this genus.

Species included

Though, *M. flava* and *M. berlandi* resemble to the other species of the genus in many salient features, the exact number of ocelli present in them needs verification. They are, therefore, tentatively included in this genus.

Microparonella caerulea Carpenter, 1916.

Microparonella flava Carpenter, 1916.

Microparonella berlandi (Denis) 1925, new combination.

Microparonella doveri (Carpenter) 1932, new combination.

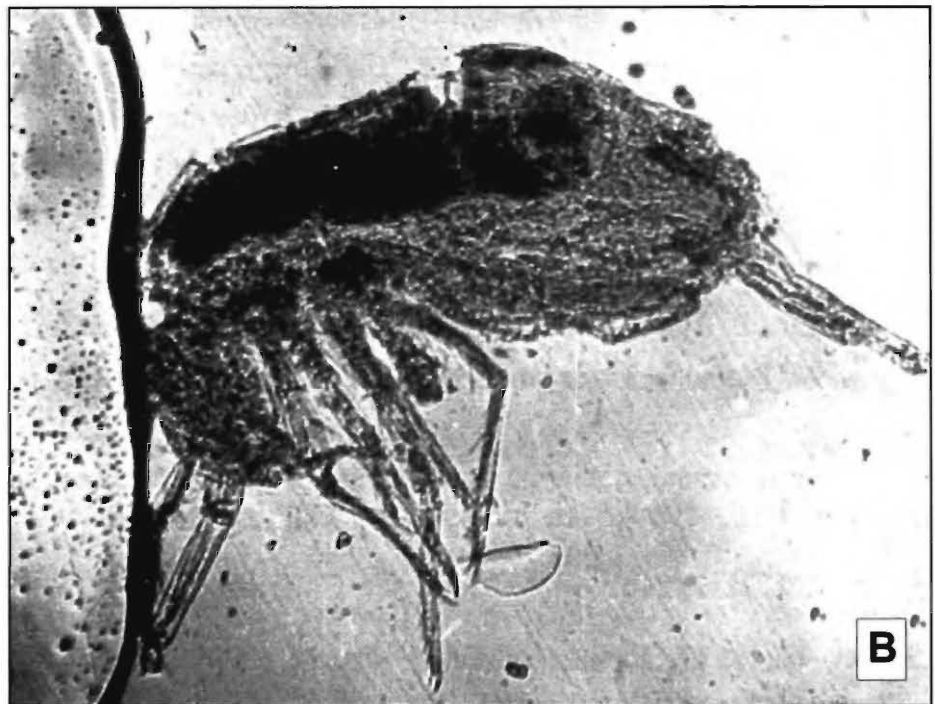
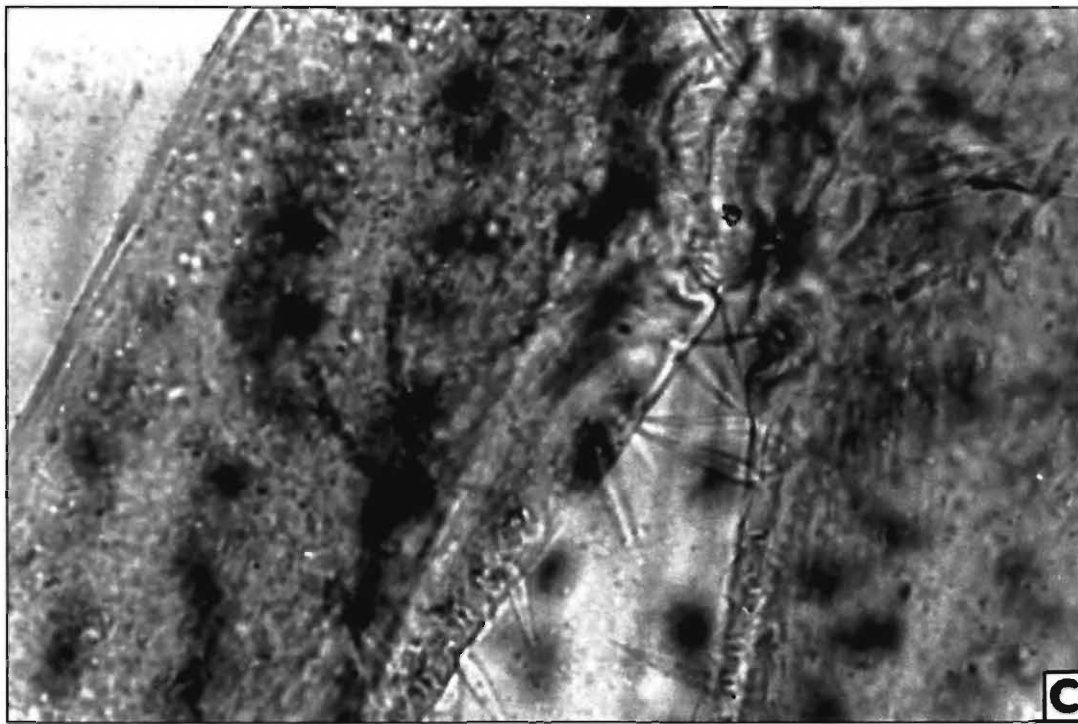


PLATE 1. Photomicrographs showing profile and structural details of *Microparonella caerulea* Carpenter and *Microparonella doveri* (Carpenter), new combination.
(A) profile of *M. caerulea* (syntype);
(B) profile of *M. doveri* (Carpenter) [paralectotype];
(C) proximal portion of denticles showing spines in *M. doveri* (lectotype).

SUMMARY

The concept of *Microparonella* Carpenter, 1916 is precised on the basis of examination of the type specimens of the type-species and other species included under *Microparonella* in this study.

ACKNOWLEDGEMENTS

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Thanks an also done to Dr. J. R. B. Alfred, Director and Dr. G. K. Srivastava, Additional Director of this organization for numerous courtesies.

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**NEW LOCALITY AND HOST RECORD FOR *SOUTHWELLINA*
HISPIDA (VAN CLEAVE, 1925) WITENBERG, 1932
(*ACANTHOCEPHALIA* : *POLYMORPHIDAE*) FROM CHILKA,
ORISSA, AND A NEW HOST RECORD FOR *SOUTHWELLINA SACRA*
N. SP. FROM ANDAMAN**

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INTRODUCTION

The polymorphid worms in aquatic and fish-eating birds are reported mostly from Noth. The species of the genera under the family Polymorphidae viz. *Polymorphus*; *Filicollis*; *Corynosoma*; *Arhythmorhynchus*; *southwellina* etc. have been reported mainly from USSR, USA, and Europe. Some juvenile forms in amphibians and adults in birds have been reported from Japan. Very little is known about the occurrence of the species of these genera in India.

While dealing with the collections, the authors have come across some acanthocephalan parasites from Ichthiophagus birds of Chilka, Orissa and Port Blair, Andaman. The parasites have been identified as *Southwellina hispida* (Van Cleave, 1925) Witenberg, 1932 from *Haliastur indus* (Brahmini kite) and *Nycticorax nycticorax* (Night heron) at Chilka, and *Southwellina sacra* n.sp. from *Egretta sacra* (Reef heron) at Port Blair, Andaman. *S. hispida* has broad geographical distribution as opined by Van Cleave (1940) while reporting the species in heron from Galápagos Islands.

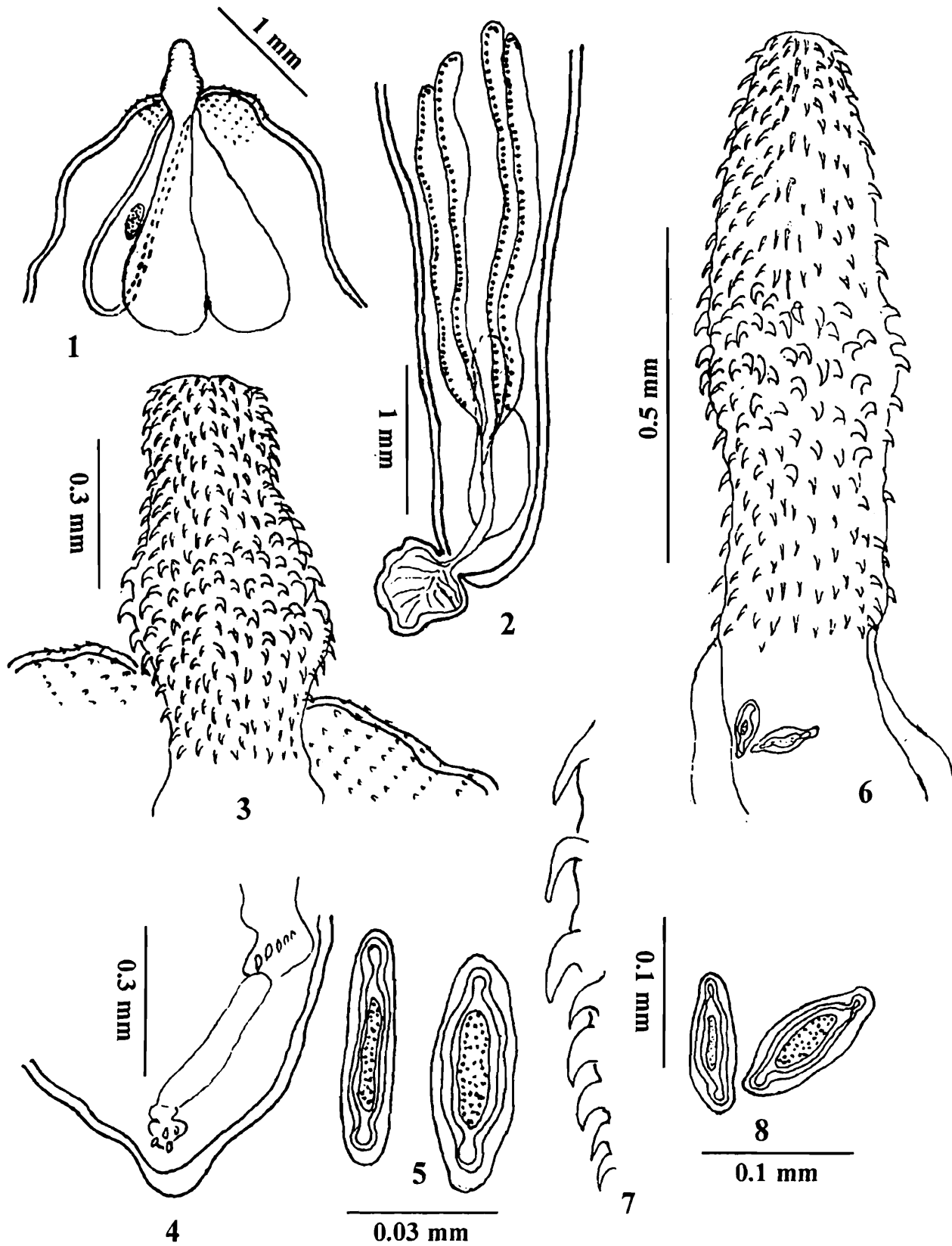
The description of *Southwellina hispida* with its new locality and new host record as well as that of *Southwellina sacra* n.sp. with its new host record is the subject of this paper. *Arhythmorhynchus tigrinus* Moghe and Das, 1953 from India is considered as a synonym of *S. hispida*.

MATERIAL AND METHOD

The specimens are killed in distilled water to allow the probosces to come out of the peoboscis sheaths. The specimens are then pressed and fixed in 70% alcohol. After fixation and staining in borax carmine, permanent whole mounts on slides are prepared. The specimens are drawn under camera lucida. All the measurements are in mm unless otherwise stated.

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PLATE 1



Figs.1-8. *Southwellina hispida* (Van Cleave, 1925) Witenberg, 1932 (Figs.1-5 from *Haliastur indus*; Figs.6-8 from *N.nycticorax*). : 1. Anterior of male; 2. Posterior of male; 3. Proboscis enlarged; 4. Posterior of female; 5. Eggs (*H.indus*); 6. Proboscis enlarged (*N.nycticorax*); 7. Hooks; 8. Eggs (*N.nycticorax*).

Hemiechinoma ponticum Petrotschenko et al, 1972 as synonyms of *S. hispida*. Later, Amin (1985) justified Schmidt's observation and considered *Southwellina* as a valid genus with type species *S. hispida*.

One male and two female specimens from *H. indus* and three female specimens from *N. nycticorax* at Chilka, Orissa have been recovered. The description of *S. hispida* from *H. indus* is as under :

Description :

Male : Body medium, spinose, anterior trunk broad with hypodermic nuclei, posterior trunk short, narrow and devoid of spines, trunk spines anterior, minute, sparse, bare zone between the fields not found. Proboscis spindle shaped, swollen at the middle. 20–22 longitudinal rows with 16–17 hooks in each row, 2–3 hooks per row at mid-proboscis stout and broad, hooks gradually increasing in size from tip toward middle of row. pH – 0.0249–0.0498 X 0.0083 (Ant & Post.) 0.0415–0.0498 X 0.0166–0.0249 (mid proboscis) Pr. Root – 0.033–0.066 X 0.0083 (Ant.) 0.066–0.0664 X 0.0166–0.0249 (mid-proboscis). Neck wider than long. Proboscis sheath cylindrical, double walled, ganglion at the centre. Lemnisci leaf-like. Testes two, at broad anterior trunk region, ruptured. Cement gland four, tubular, long. Seminal vesicle long. Cement reservoir long. Bursa protruded.

Female : Body medium, spinose, anterior trunk broad with hypodermic nuclei, posterior trunk short narrow and devoid of spines, trunk spines anterior, minute, sparse, bare zone between the fields not found. Proboscis spindle shaped, swollen at the middle, 20–22 longitudinal rows with 16–17 rows in each row, 2–3 hooks per row at mid proboscis stout and broad. pH as in male. Neck wider than long, Proboscis sheath double walled, with ganglion at the centre. Lemnisci leaf-like. Uterine bell long. Uterus slender, long. Genital pore sub-terminal. Eggs elliptical with prominent polar prolongations of the middle shell.

Other measurements given in the Table 1.

Host : *Haliastur indus* (Brahmini kite)

Nycticorax nycticorax (Night heron)

Location : Intestine

Locality : Chilka, Orissa

Date of Collection : December, 1986

ZSI Reg. No. W 8553/1–W8556/1, Calcutta.

Discussion Schmidt (1973) observed weak and unstable distinguishing boundaries between the species and even more so between the genera of the family Polymorphidae. Therefore, he

Table 1. Comparative chart of measurement of *S. hispida**

	<i>S. hispida</i> (After Fukui, 1929 and Scholz et al, 1992)	<i>S. hispida</i> (Chilka, Orissa)	<i>S. hispida</i> (Chilka, Orissa)
Total length	M.5.16-14/1.00-2.11 F.7.65-18/1.00-2.60	F.10.5-12.5/3.00-3.25(Ant.) 1.06-1.2 (Post)	M.14.3/3.12(Ant.)1.65 (Post) F. 13.25-15.6/2.75-3.5 (Ant.) 1.31-1.75 (Post)
Proboscis	M. 0-62-0.89/0.32-0.43 F.0.77-0.93/0.32-0.39	F.0.94/0.3 (Mid-prob.)	M. 0.8/0.375 (Mid.prob.) F. 0 : 675/0.289 (Mid-prob.)
Proboscis hooks	20-24/12-15	20-22/16-17	M. 20-22/16-17 F. 20-22/16-17
Size of hooks	Tip. 52-65/13-18* Mid. 47-62/18-22 Base. 41-59/14-15 *in microns	Tip. 0.0249-0.0498/0.0083 Mid. 0.0415-0.0498/0.0166- 0.0249 Base. 0.0249-0.0498/0.0083	Tip. 0.0249-0.0415/0.0083 Mid. 0.0415/0.0249 Base. 0.0249-0.0415/0.0083
Neck	0.49/0.57	0.45/0.575	2.25/0.55
Proboscis Sheath	1.06-1.77/0.39-0.5	0.996/0.332	0.3/0.55
Lemnisci	0.89-1.77/0.24-0.43	1.875/0.625	1.75/0.825
Testes	Ovoid, two T ₁ .0.52-0.85/0.46-0.67 T ₂ .0.72-1.00/0.46-0.61	-	Two, ruptured
Cement gland	Four 1.3-2.84	-	Four 4.625-5.875
Eggs	0.088-0.108/0.023-0.035	0.1-0.125/0.025-0.05	0.083-0.099/0.0249-0.033
Trunk spines	Two fields Ant. 0.24-0.32 wide 5-7 rows Post 0.37-0.72 wide 9-12 rows	Spines in anterior trunk, Spines minute, sparse, 2 fields not found	Spines in anterior trunk, minute, sparse, 2 fields not found.
Host	<i>Nycticorax nycticorax</i> & <i>Phalacrocorax carbo</i>	<i>Nycticorax nycticorax</i>	<i>Haliastur indus</i>
Locality	Japan, Czechoslovakia	Chilka, Orissa, India	Chilka, Orissa, India

*Measurement in mm unless otherwise stated.

revised the family and suppressed two subfamilies viz. Polymorphinae and Corynosomatinae. He synonymised Filicollidae with Polymorphidae considering 8 genera under the family as valid.

Schmidt (1973) resurrected and redefined the genus *Southwellina* Witenberg, 1932. He accommodated the species bearing anterior trunk spines in two fields in at least in one sex, posterior trunk shorter and four cement glands in the genus. Accordingly, he considered four polymorphid species as synonyms of *S. hispida* and included three species in his key to species. *S. hispida* is the type species for the genus.

With almost all morphological characteristics of the specimens under report correspond with that of *S. hispida* redescribed by Fukui (1929) and Scholz et al. (1992) from Japan and Czechoslovakia respectively. Further, the present specimens conform with *S. hispida* in respect of some diagnostic features such as gradual increase of size of proboscis hooks from tip toward middle of each row, hooks' size not more than 0.065 mm etc. as redefined by Schmidt (1973). The distribution of trunk spines in *S. hispida* does not agree with that of the present form. In this case, the trunk spines are so minute and sparse that two fields of spines cannot be ascertained. Therefore, this feature is considered as an intraspecific variation. Otherwise, it is definite that the specimens belong to the species *S. hispida*. Hence, the species is redescribed as *Southwellina hispida* (Van Cleave, 1925) Witenberg, 1932 with new locality and new host record in India.

***Southwellina sacra* n.sp.**

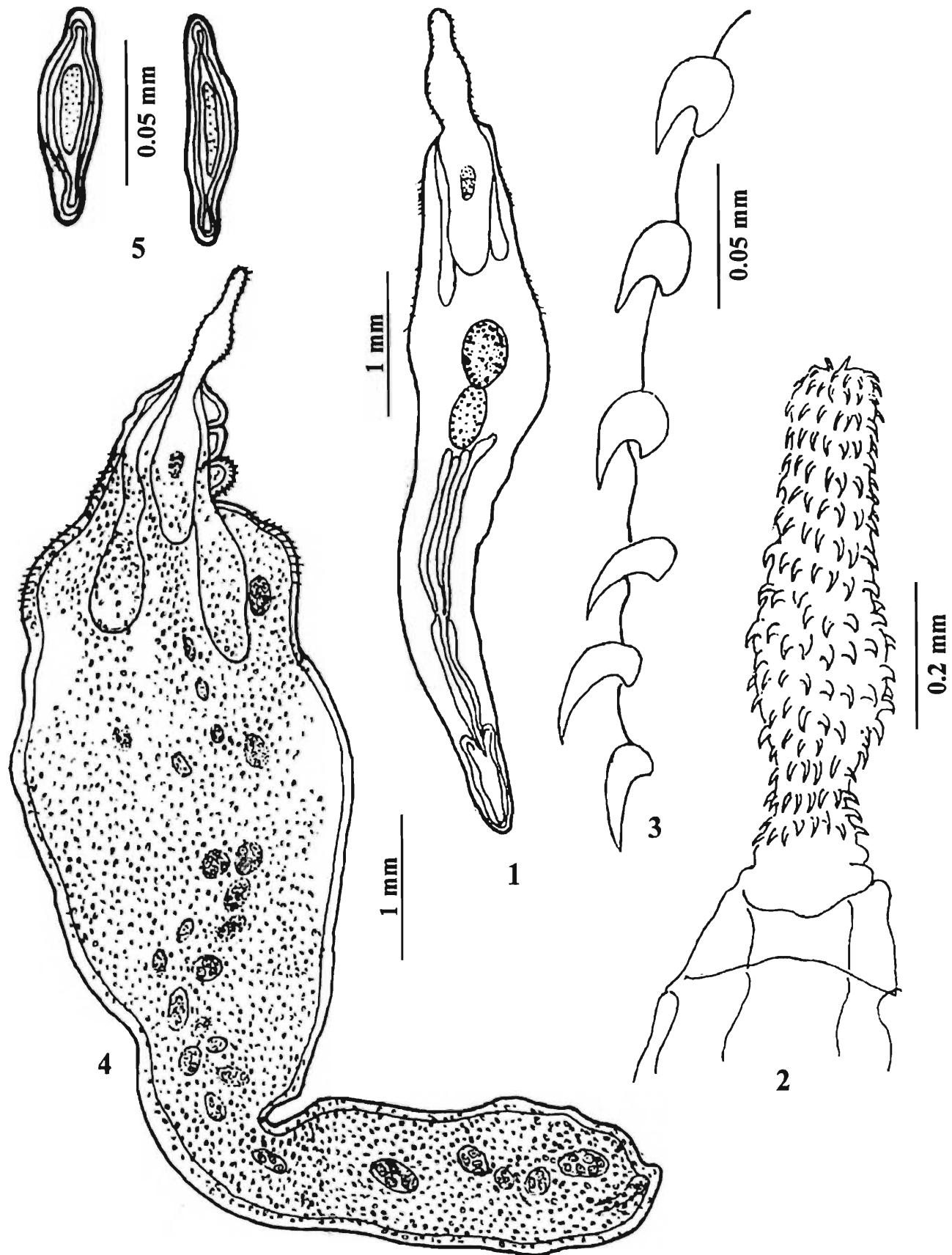
(Plate 2; Figs. 1–5)

Three male and three female specimens are obtained from the intestine of *Egretta sacra* (Reef. heron) from Port Blair, the Andaman. The description is as under :

Description :

Male : Body small, spinose, anterior trunk broad, posterior short, narrow, without spines. Hypodermic nuclei at anterior trunk. Trunk spines in two fields at the broad anterior trunk, 1st. field 0.166–0.182 wide, with 8–10 rows of spines, 2nd. Field 0.248–0.289 wide with 8–12 rows of spines. Proboscis spindle shaped, mid-proboscis broad. Proboscis hooks in 14 longitudinal rows with 15 hooks in each row, 2–3 hooks per row at mid-proboscis stout and broad, hooks gradually increase in size from tip toward middle of row. pH – 0.03–0.036 X 0.004–0.01 (Ant.), 0.036–0.042 X 0.018 (Mid-proboscis), 0.036–0.052 X 0.01–0.012 (Post). Pr. Root 0.02–0.024 X 0.004 (Ant.), 0.036 X 0.008 (Mid-proboscis). Neck short, wider than long, proboscis sheath within broad anterior trunk, double walled, ganglion near centre. Lemnisci leaf like, unequal, Testes two, contiguous, within broad anterior trunk but below the posterior field of trunk spines. Cement gland four, long, tubular, bursa not protruded.

PLATE 2



Figs.1-5. *Southwellina sacra* n.sp. : 1. Male; 2. Proboscis enlarged; 3. Hooks; 4. Female; 5. Eggs.

Female : Body small, spinose, anterior trunk broad, posterior short, narrow, without spines. Hypodermic nuclei at anterior trunk. Trunk spines in two fields at the broad anterior trunk, 1st. field 0.166–0.199 wide with 8–12 rows of spines, 2nd field 0.496–0.512 wide with 8–12 rows of spines. Proboscis spindle shaped, mid-proboscis broad, proboscis hooks in 14 longitudinal rows with 15 hooks in each row, 2–3 hooks per row at mid-proboscis stout and broad, hooks gradually increase in size from tip toward middle of row, hook size as in male. Neck wider than long. Proboscis sheath within broad anterior trunk. Lemnisci leaf-like. Body cavity full of eggs with a few ovarian follicles. Eggs elliptical, prominent polar prolongations of the middle shell present. Genital pore sub-terminal.

Other measurements given in the Table 2.

Host : *Egretta sacra* n.sp.

Location : Intestine

Locality : Port Blair, the Andaman

Date of coll : June, 1969

ZSI Reg. No. W8557/1-W 8560/1, Calcutta

Discussion : Schmidt (1973) revalidated *S. hispida* (Van Cleave, 1925) Witenberg, 1932 as the type species of *Southwellina* Witenberg, 1932. He considered only three species as valid viz., *S. dimorpha* Schmidt, 1973 from US; *S. macracantha* (Ward & Winter, 1932) Schmidt, 1973 comb. n. from U.S. and *S. hispida*, circumboreal. Moghe and Das (1953) described *Arhythmorhynchus tigrinus*, a juvenile form in *Rana tigrina* from India which was considered as valid by Yamaguti (1963) but Schmidt (1973) left it out without comments.

Arhythmorhynchus tigrinus Moghe and Das, 1953 has been considered as a synonym of *S. hispida* as discussed below :

The present specimens under study have been compared with all the three existing species under the genus *Southwellina*. The present form basically differs from *S. dimorpha*, *S. macracantha*, and *S. hispida* in having lowest number of longitudinal rows of proboscis hooks and number of hooks in each row. Secondly, it differs from these species in having shorter length of proboscis hooks and roots. Finally it differs in having less number of rows of trunk spines in both the fields. Table 2 shows the comparison between the Indian species.

The specimens under study have also been compared with its nearest species of the genera viz, *Hexaglandula*, *Arhythmorhynchus* and *Corynosma* under the family Polymorphidae and have been found that the species is independent of all its nearest allies.

Hence, the authors consider the species as new to science and designate it *Southwellina sacra* n. sp. The new species forms a new record for its locality and host.

Table 2. Comparative chart of measurement of Indian species*.

	<i>S. hispida</i> (From <i>N. nycticorax</i> & <i>Haliastur indus</i> Chilka, Orissa)	<i>S. tigrina</i> (Moghe & Das, 1953) Comb. n. (From <i>Rana tigrina</i> in India)	<i>S. sacra</i> n.sp. (From <i>Egretta sacra</i> Port Blair, the Andaman)
Total Length	M.14.3/3.12 (Ant.) 1.65 (Post.) F.10.5-15.6/2.75-3.5 (Ant.) 1.06-1.75 (Post)	0.25/0.55	M.4.875/0.75 (Ant.) & 0.27 (Post) F.4.5-5.5/1.00-1.75 (Ant.)
Proboscis	M. 0.182-0.8/0.375 (Mid.Prob.) F.0.675-0.94/0.289-0.3 (Mid prob)	0.7/0.25 (Mid-prob.)	M.0.625-0.696/0.2 (Mid Prob.) F. same as male.
Probosis hooks	20-22/16-17	17-18/14-15	14/15
Size of books	Tip. 0.0249-0.0498/0.0083 Mid. 0.0415-0.0498/0.0116-0.0249 Base.0.0249-0.0498/0.0083	Tip. 0.03 Mid. 0.04 Base 0.03	Tip. 0.03-0.036/0.004-0.01 Mid. 0.036-0.042/0.018 Base 0.036-0.052/0.01-0.012
Neck	0.49/0.57		0.2/0.325
Probosis Sheath	0.3-0.996/0.332-0.55	0.06	0.85/0.225
Lemnisci	1.75-1.875/0.625-0.825	1.00/0.15	L ₁ -0.75/0.125 L ₂ -1.05/0.225
Testes	Two, ruptured	T ₁ -0.15 T ₂ . 0.15	T ₁ – 0.375/0.25 T ₂ – 0.347/0.207
Cement glands	Four 4 625-5.875	Number, not given. long, tubular	Four 0.375 long
Eggs	0.083-0.125/0.0249-0.05		0.083-1.00/0.024-0.033
Trunk Spines	Spines in anterior turnk, minute, sparse, 2 fields not found.	2 fields 1 st 0.12 wide, 40-44 rows 2 nd 0.2 wide, 48-52 rows	M- 2 fields 1 st 0.166-0.182 wide, 8-10 rows 2 nd 0.248-0.289 wide, 8-12 F-rows 1 st 0.166-0.190 wide, 8-12 rows 2 nd 0.0496-0.512 wide, 8-12 rows.

*Measurement in mm unless otherwise stated.

Status of *Arhythmorhynchus tigrinus* Moghe & Das, 1953

Moghe and Das (1953) described *Arhythmorhynchus tigrinus*, the larval form in frogs, *Rana tigrina* from India. At the same time crow and kite were experimentally fed with the larvae of the species. The authors found positive result in them and established that the final hosts for *Arhythmorhynchus* were birds.

After careful study, it is observed that *A. tigrina* with all its characteristic features fit with that of *S. hispida* (after Schmidt, 1973 and Scholz et al., 1992) except the features viz, number of cement glands and size of eggs (lacking in their description). Other variations such as length of lemnisci, size of proboscis sheath, number of rows of spines in both the fields of the trunk (40-44 rows and 48-52 rows respectively) etc. may be deemed as variation due to juvenility. This number of longitudinal rows of proboscis hooks from tip toward mid-proboscis etc, are very much in agreement with the range of number and size of different organs as found in *S. hispida*.

Having compared the description of *A. tigrinus* with that of juveniles of *S. hispida* and *A. duocinctus*, it is opined that *A. tigrinus* and *S. hispida* are the same species.. Therefore, we propose *A. tigrinus* as a synonym of *S. hispida*. Hence, it is *Southwellina tigrina* (Moghe & Das, 1953) Comb. n.

SUMMARY

The paper deals with redescription of *Southwellina hispida* (Vanceleave, 1925) Witenberg, 1932 from *Haliastur indus* (Brahmini kite) and *Nycticorax nycticorax*{Night heron} at Chilka, Orissa. The former host forms a new host record in India and the latter forms a new locality record. *Arhythmorhynchus tigrinus* Moghe & Das, 1953, a juvenile form in *Rana tigrina* from India has been proposed to be the synonym of *S. hispida* by the present authors. Some parasites collected from *Egretta sacra* (Reef heron) at Port Blair, the Andaman, have also been described as *Southwellina sacra* n.sp. The host, *Egretta sacra* claims to be a new host record for the species.

ACKNOWLEDGEMENT

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IMPACT OF THE POLLUTION OF RIVER BURHI GANDAK ON PLANKTON AND MAICOFAUNA AT MEHSI, NORTH BIHAR CAUSED BY SUGAR MILLS AND MOTHER OF PEARL BUTTON INDUSTRIES

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INTRODUCTION

River Burhi Gandak, constitutes an important freshwater resource of North Bihar passing through several districts like Champaran, Muzaffarpur, Darbhanga and Begusarai and is a part of the major riverine system of the region—the Kosi-Gandak. Because of the availability of bivalve shells in huge quantities in the river, several important mother of pearl button and lime cottage industrial centres have developed alongside the river. Besides the belt has several sugar mills. These industries discharge their untreated effluents and wastes directly into the river. With the result, certain stretches of the river got polluted.

Although some reports are available on the pollution of main river Ganga and some other tributaries like Daha in North Bihar, particularly by Sugar and distillery wastes (David and Ray, 1966, Sahay *et al.*, 1994), practically no information is available on the pollution and its impact on the biota in the tributaries of Gandak -Kosi river system. An earlier report (Datta Munshi and Datta Munshi, 1991) on the ecology of the rivers of this system gives only a general idea of their physiography. With this in mind, the present studies were undertaken to assess the impact of pollution on the diversity and density of plankton and molluscan fauna of this river near polluted sites in Mehsi block of East Champaran district. Mehsi Township (Fig 1) is an important centre for the mother of pearl button and lime industries. Besides, there are three sugar mills also located in the area. These discharge their wastes into the river causing pollution of the river in the vicinity of the township.

DESCRIPTION OF THE STUDY AREA

The impact of the pollution on the biota of the river was studied by fixing following stations/sites as shown schematically in Fig. 1.

**Zoological Survey of India, Kolkata-700 020.*

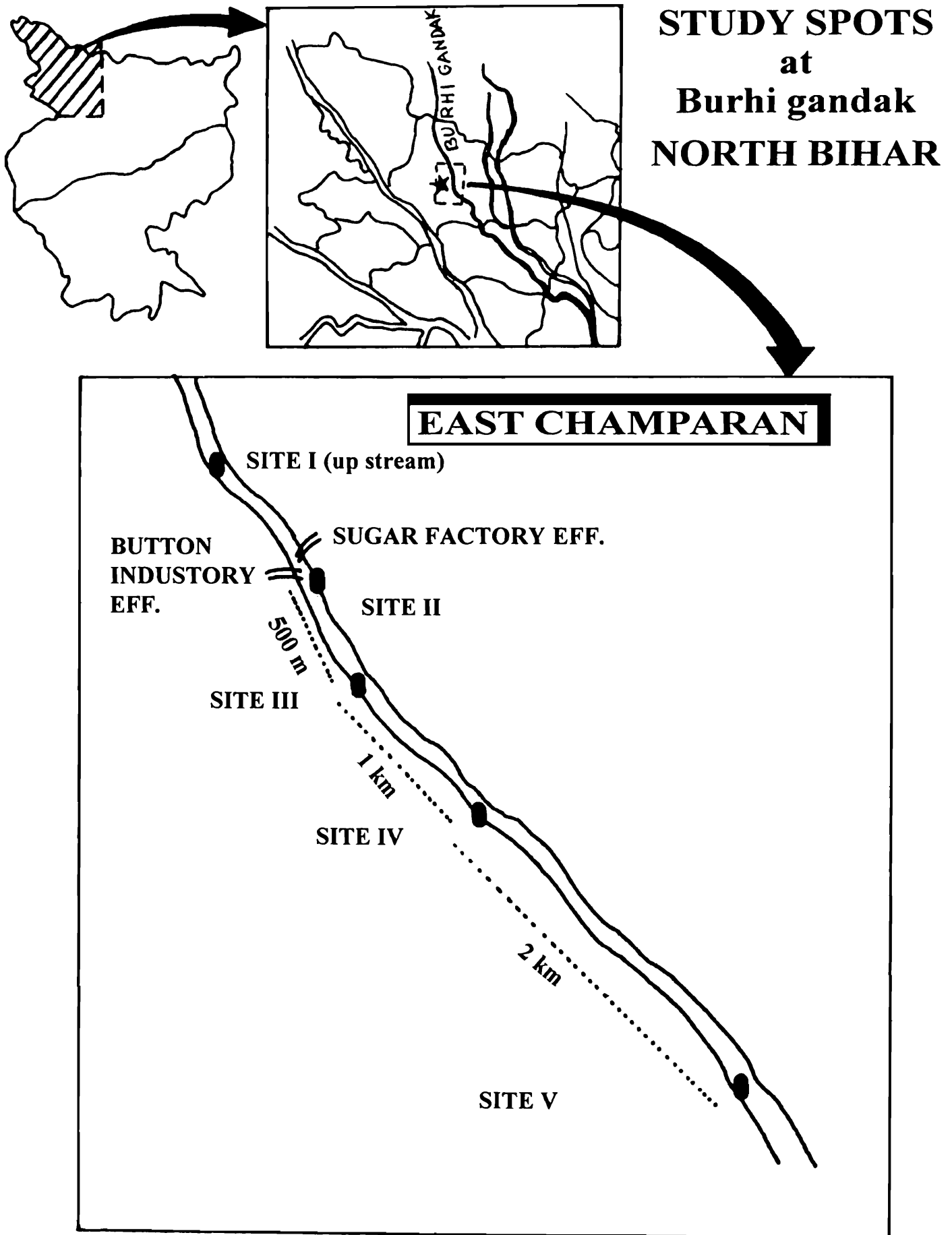


Fig. 1. Study spots at Burhi gandak, North Bihar.

- Site I. above outfall.** This site was fixed nearly 1 km above Mehsi Town where no industrial effluents were discharged. This has been considered as standard unpolluted site.
- Site II. Outfall.** The station was situated near Mehsi Town ship where the solid and liquid wastes are discharged into the river.
- Site III. Approximately 500 m below the outfall.** This site was situated nearly 500 m from the Mehsi Town
- Site IV. Approximately 1.5 km below the outfall.**
- Site V. Approximately 2 km below the outfall**

MATERIAL AND METHODS

Surface water samples for physico-chemical analysis were collected from atleast three places at each site. The analysis of temperature, pH, dissolved oxygen and hardness were done in the field itself and samples for B.O.D., C.O.D., Silicate and Ca⁺⁺ were brought to the laboratory. Standard Methods (A.P.H.A., 1991) were followed for the analysis. Only those parameters which showed significant impact are included here.

Phytoplankton samples were collected by filtering 1-2 lit of water through Whatman filter paper No. 4 and preserved in Lugol's solution. Zooplankton samples were collected with the help of plankton net made of bolting nylon No. 20 (mesh size 0.075 mm). For relative composition and qualitative studies samples were collected randomly from several places by throwing and towing the net from the shore. The filtered zooplankton were preserved in 4% formalin. The quantitative molluscan fauna for the determination of density were collected with the help of a wooden quadrat net (area 0.25 sqm, height of the frame 3"), attached with a bag of fine meshed mosquito net cloth. For bottom fauna, the quadrat was placed on the bottom of littoral zone and all shells live and dead alongwith the mud /sand upto the depth of 2" was collected. There after the quadrat was pulled up slowly collecting all the macrophytes falling with the quadrat. For qualitative studies, thorough search of the bottom of littoral zones and macrophytes were done and specimens were collected. Dead shells were discarded and live ones preserved in 6% formalin.

Although studies were carried out for all the seasons, summer (March-June) monsoon (July-October) and winter (November-February), the data collected during winter and summer are analysed and presented. Due to heavy rains and flooding of the river during monsoon months, location of the stations were disturbed and sampling was also difficult. Further due to considerable dilution the impact was also not visible.

RESULTS

1. Physico-chemical properties of water

The physico-chemical condition around outfall at different sites during winter and summer are shown in Table 1. There was a sudden alteration in almost all parameters studied except water temperature at Site-II, (outfall) as compared to Site-I (above outfall). The conditions started improving soon after outfall. The most important effect was on the pH, which dropped considerably near the outfall in both seasons. During summer, the dissolved oxygen concentration dropped from 7.2 mg/l at site-I to 2.4 mg/l at Site-2. Although recovery started immediately from site-III onwards, its rate was comparatively slower. While the recovery in respect of B.O.D. was comparatively faster, C.O.D. decreased gradually. The recovery of hardness was very slow and even at Site-V, the values were much higher than those of Site-I. Silicate and Ca⁺⁺ also showed the initial increase that was followed by considerable recovery at sites-III and IV and the values returned to normal at Site-V. Almost similar trends were noticed during winter season.

Table 1. Physico-chemical conditions of river water at different sites around outfall.

Parameters	WINTER					SUMMER				
	Site-I	Site-II	Site-III	Site-IV	Site-V	Site-I	Site-II	Site-III	Site-IV	Site-V
	I	II	III	IV	V	I	II	III	IV	V
Water										
Temperature °C	23.2	23.4	22.8	22.7	23.3	31.5	31.9	31.8	31.6	32
pH	5.8	5	5.5	5.7	5.9	6	5.2	5.8	5.9	6.1
Dissolved oxygen										
mg/l	8.4	2.8	3.6	6.5	8.4	7.3	2.4	3.2	3.9	8.2
B. O. D. mg/l	10	105	63	49	25	328	446	413	392	327
C. O. D. mg/l	250	1102	593	301	228	1709	2430	2329	2190	1805
Total hardness										
mg/l	102	239	231	209	117	104	328	309	283	178
Silicate (mg/l)	12	16.5	15.8	14.6	12.7	12.2	34.3	27	21.9	12.8
Ca ⁺⁺ mg/l	37.5	59.6	51.2	37.2	38	17.5	24	22.5	21.6	18

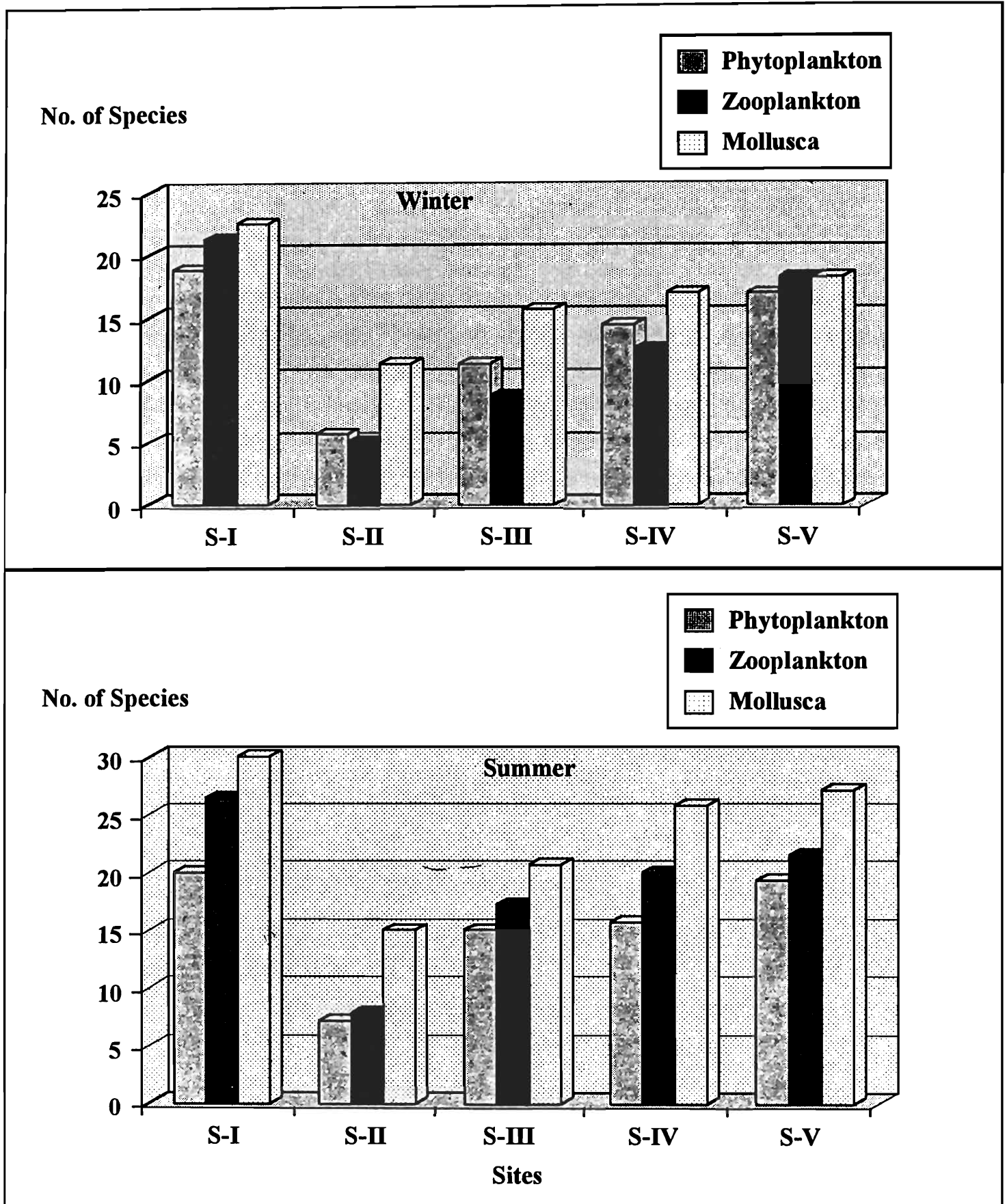
2. Plankton

Impact on species richness and abundance of both phyto and zooplankton was severe near the outfall. The number of phytoplankton taxa during summer dropped from 20 to 8 between Sites-I and II (Table 2, Fig. 2) revealing a reduction of 60% (Table 3). Similarly number of species of zooplankton also decreased from 26 above the outfall to 9 at the outfall, exhibiting a reduction of 65% (Fig. 2). However recovery in both cases was rapid as station 3 harboured 15 and 17 species of phyto and zooplankton showing an improvement of 75.0 and 65.33 percent respectively.

The decrease and increase in the numerical density of both phytoplankton and zooplankton at different sites was almost similar to the species richness (Table 2, Fig 3) However, the rate of reduction between Sites-I and II was of slightly lesser magnitude than the species richness. In case of phytoplankton the reduction between Sites I and II was about 52% but the recovery between sites II and III was rapid (87.12%). Similarly the reduction in zooplankton density between Sites-I and II was of the order of 63.55% and recovery between Sites I and III was 77.02% (Table 3). The conditions returned to almost normal at site-V, both for phytoplankton and zooplankton. Not much variation in the pattern was observed during winter season.

Table 2. Species richness and density of phytoplankton, zooplankton and malacofauna at different sites.

	WINTER					SUMMER				
	Site-I	Site-II	Site-III	Site-IV	Site-V	Site-I	Site-II	Site-III	Site-IV	Site-V
	above outfall	outfall	500 m below outfall	1 km below outfall	2 km below outfall	above outfall	outfall	500 m below outfall	1 km below outfall	2 km below outfall
No. of Phyto-plankton species	19	6	12	14	17	20	8	15	16	19
Density of Phyto-plankton (no/l)	3648	1382	2402	2554	3179	4015	1925	3489	5667	3894
No. of Zooplankton species	21	5	8	12	19	26	9	17	20	22
Density of Zoo-plankton (no/l)	229	66	189	207	219	557	203	429	468	499
No. of Molluscan species	22	12	16	17	19	30	15	21	26	27
Density of Mollusca (no/sqm)	538	177	485	487	491	616	413	529	541	558



S-I—above outfall, S-II—outfall, S-III—500 m below outfall, S-IV—1 km below outfall, S-V—2 km below outfall.

Fig. 2. Species richness of phytoplankton, zooplankton and malacofauna at different sites during summer and winter.

Table 3. Percentage of reduction (between sites I and II) and recovery (between sites I and III) of biotic components around outfall.

PARAMETGERS	WINTER					SUMMER				
	Site-I above outfall	Site-II outfall	Percent reduc- tion	Site-IV 500 m below outfall	Percent reco- very	Site-I above outfall	Site-II outfall	Percent reduc- tion	Site-IV 500 m below outfall	Percent reco- very
Species Richness										
Phytoplankton	19	6	68.42	12	63.15	20	8	60	15	75
Zooplankton	21	5	76.2	8	57.14	26	9	65.3	17	65.3
Gastropoda	10	7	30	9	90	15	9	40	10	66.66
Bivalvia	12	5	58.33	7	58.33	15	6	60	11	73.33
Total Mollusca	22	12	44.5	16	72.72	30	15	50	21	73.33
Density										
Phytoplankton	3648	1382	62.1	2404	63.15	4015	1925	52.05	3489	87.12
Zooplankton	229	66	71.12	189	82.53	557	203	63.55	429	77.02
Gastropoda	250	120	52	265	106	280	201	28.21	255	91.07
Bivalvia	288	57	80.2	220	76.39	336	112	66.66	274	81.55
Total Mollusca	538	177	67.1	485	90.14	661	313	52.64	529	80.03

3. Mollusca

Species richness : Detailed studies were carried on the impact of pollution on the diversity, density and composition of molluscan fauna. A total of 31 species was recorded from the unpolluted Site-I, which included 16 species of gastropods and 15 species of bivalves (Table 4). The number reduced drastically at site-II, near the outfall where only half of the number of species was present as compared to unpolluted Site-I during summer. However, 21 species were recorded from site-III and 28 from site-IV showing quick recovery (Table 2, Fig 2). This was also evident from the analysis of the reduction and recovery rates (Table 3). The reduction in species richness between Sites I and II was 52%. The recovery was very quick as nearly 80% of the species reappeared at Site-3. During winter also only 12 species were at site-II as compared to 22 at site-I exhibiting a reduction of 44.5%. The immediate recovery (72.72%) was significant.

Table 4. Species richness and density of gastropods and bivalves at different sites.

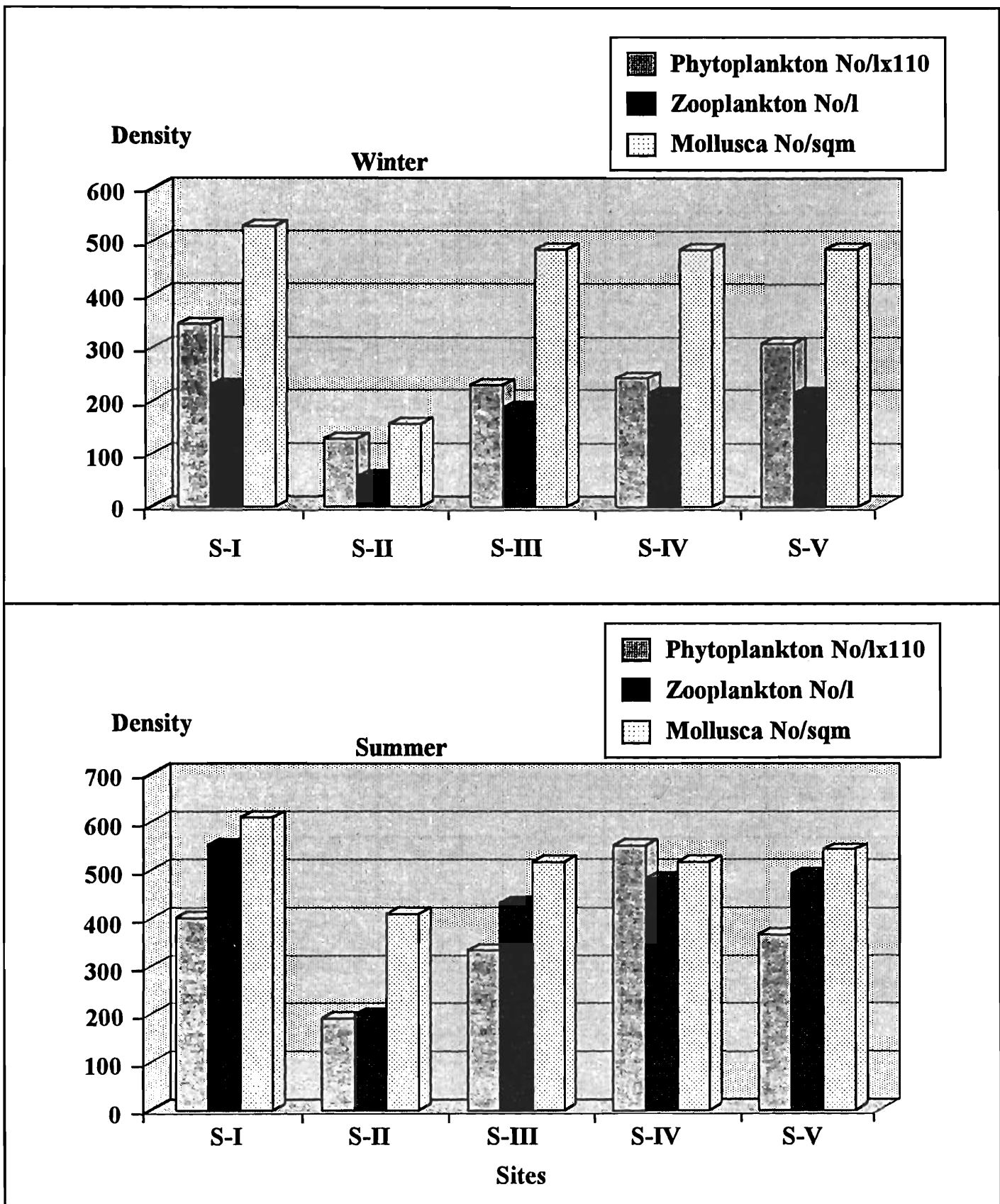
	WINTER					SUMMER				
	Site-I	Site-II	Site-III	Site-IV	Site-V	Site-I	Site-II	Site-III	Site-IV	Site-V
	above outfall	outfall	500 m below outfall	1 km below outfall	2 km below outfall	above outfall	outfall	500 m below outfall	1 km below outfall	2 km below outfall
No of Gastro- pod species	10	7	9	9	10	15	9	11	14	14
Number of bivalve species	12	5	7	8	9	15	6	10	12	13
Density of gastro- pods (no/sqm)	250	120	265	250	230	280	230	255	260	235
Density of bivalves (no/sqm)	288	57	220	237	261	336	183	274	281	323

Abundance : The total molluscan density at site-I during summer was 616/sqm, which was reduced to 413/sqm at the outfall site-II. Like species diversity the recovery in case of density was also quick and the mean density at site-III was 529/sqm. (Table 2, Fig. 3). This resulted in the reduction of 52.64% between sites-I and II and recovery of 80% at site-III (Table 3). During winter the reduction between sites II and I and recovery between Sites II and III were 67.10 and 90.14% respectively showing comparatively lesser impact during the season.

Composition : Table 5 and Fig. 3 show the relative impact of pollution on the species richness and density of the two major molluscan groups viz. gastropods and bivalves. It is abundantly clear that bivalves were much more affected than gastropods. During summer at unpolluted site-I, there were 30 species of mollusca, 15 of gastropods and 15 of bivalve. At the outfall, Site-II, only 6 species of bivalves were present as compared to 9 of gastropods. This resulted in a decrease of only 28.21% in case of gastropods between sites-I and II but the reduction in case of bivalves was of the magnitude of 66.66%. The recovery between sites-I and III was also slower in case of bivalves (Table 3) than gastropods.

DISCUSSION

From the results, it is quite clear that the river Burhi Gandak near Mehsi was polluted as evident from generally altered conditions of both physicochemical and biological characteristics of the water around the outfall region. The lower value of pH near the outfall was probably due



S-I—above outfall, S-II—outfall, S-III—500 m below outfall, S-IV—1 km below outfall, S-V—2 km below outfall.

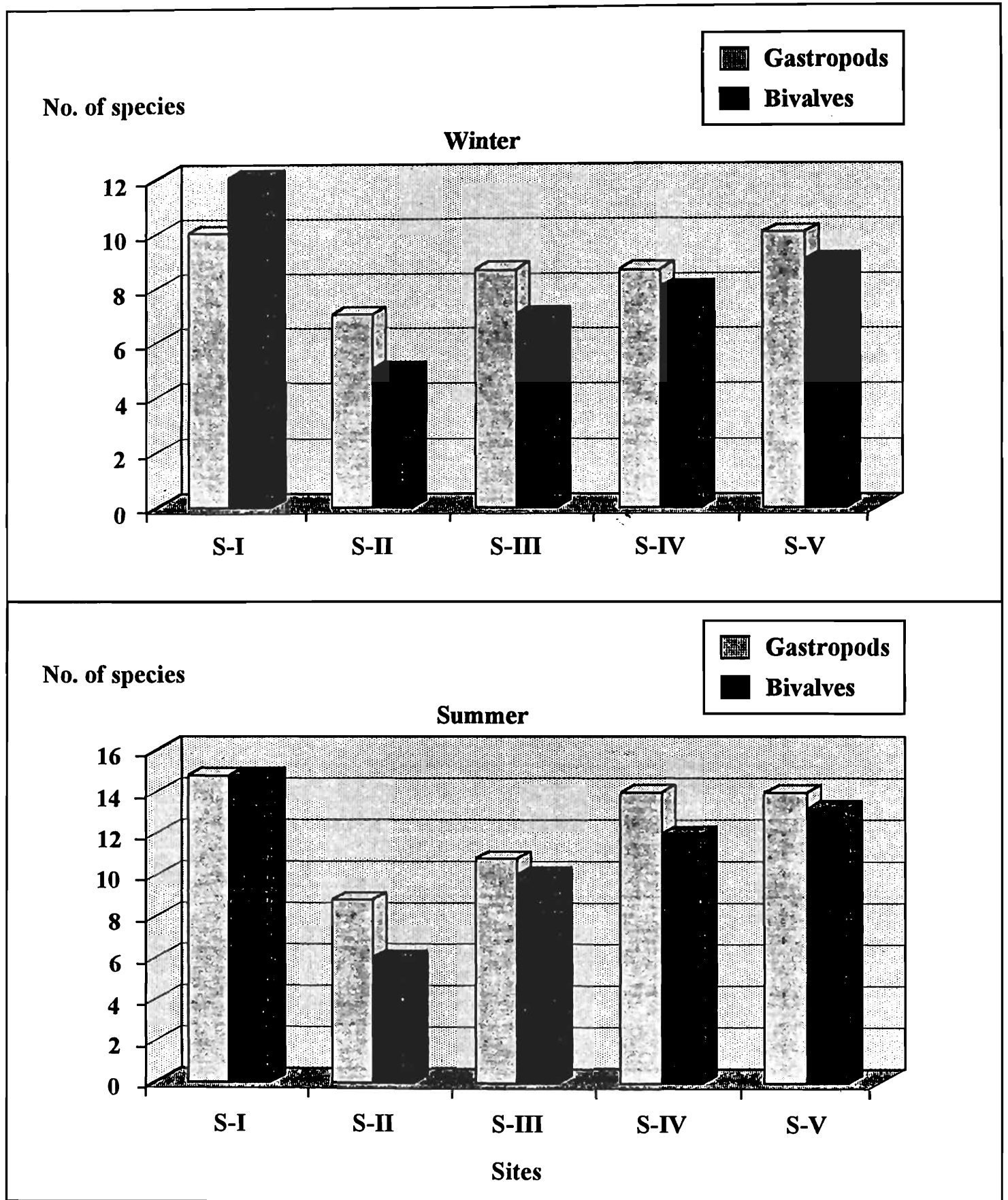
Fig. 3. Density of phytoplankton, zooplankton and malacofauna at different sites during summer and monsoon.

Table 5. Occurrence of molluscan species at different sites around outfall during winter and summer.

Species	WINTER					SUMMER				
	Site-I	Site-II	Site-III	Site-IV	Site-V	Site-I	Site-II	Site-III	Site-IV	Site-V
Gastropoda										
Family : Viviparidae										
<i>Bellamyia bengelensis</i> (Lamarck)	+	+	+	+	+	+	+	+	+	+
<i>Bellamyia crassa</i> (Benson)	-	-	-	-	-	+	+	+	+	+
<i>Bellamyia dissimilis</i> (Mueller)	-	-	-	-	-	+	-	-	+	+
Family : Pilidae										
<i>Pila globosa</i> (Swainson)	+	-	+	+	+	+	-	+	+	+
Family : Bithyniidae										
<i>Gabbia orcula</i> (Frauenfeld)	+	+	+	+	+	+	+	+	+	+
<i>Digoniostoma ceraneopoma</i> (Benson)	+	-	+	+	+	+	-	-	-	-
<i>Digoniostoma pulchella</i> (Benson)	-	-	-	-	-	+	-	-	+	+
Family : Thiaridae										
<i>Thiara (Thiara) scabra</i> (Muller)	+	+	+	+	+	-	-	-	-	-
<i>Thiara (Thiara) lineata</i> (Gray)	-	-	-	-	-	+	+	+	+	+
<i>Thiara (Melanoides) tuberculata</i> (Mueller)	+	+	+	+	+	+	+	+	+	+
<i>Bortia (Antimelania) co.</i> Costula Rafinesque	+	-	-	-	+	+	-	+	+	+
Family : Lymnaeidae										
<i>Lymnaea (Pseudosuccinea) acuminata</i> (Lamarck)	+	+	+	+	+	+	-	-	+	+
<i>Lymnaea (P) lt (P) lufeola</i> (Lamarck)	-	-	-	-	-	+	+	+	+	+
Family : Planorbidae										
<i>Indoplanorbis exustus</i> (Deshayes)	+	+	+	+	+	+	+	+	+	+
<i>Gyraulius convexluscus</i> (Hutton)	+	+	+	+	+	+	+	+	+	+
<i>Gyraulius tabiatus</i> (Benson)	-	-	-	-	-	+	+	+	+	+

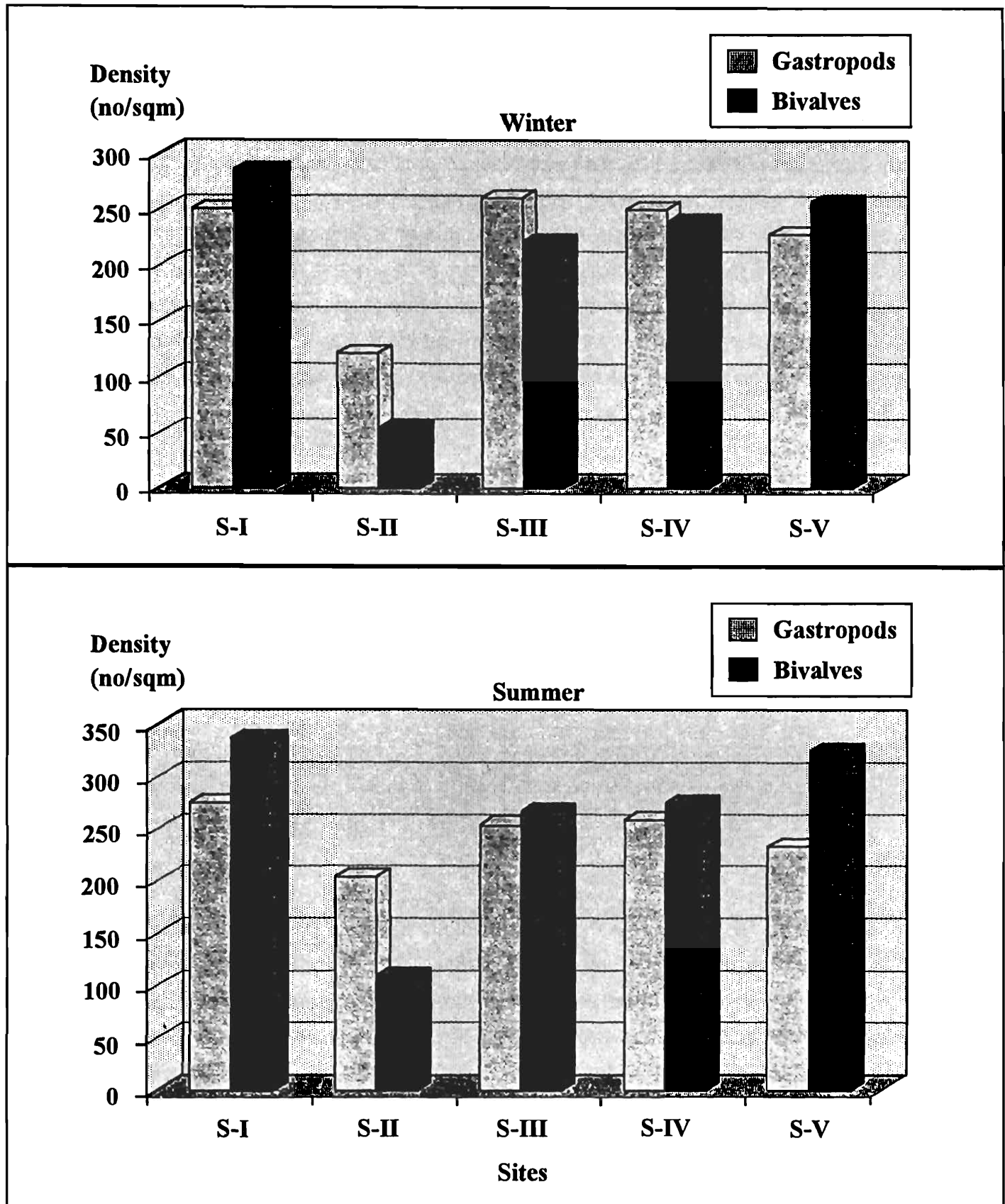
Table 5. Cont'd.

Species	WINTER					SUMMER				
	Site-I	Site-II	Site-III	Site-IV	Site-V	Site-I	Site-II	Site-III	Site-IV	Site-V
Gastropoda										
Class : Bivalvia										
Family : Unionidae										
<i>Lemellidens corrianus</i> (Lea)	+	+	+	+	+	+	+	+	+	+
<i>Lammellidens jenisianus</i> (Benson)	-	-	-	-	-	+	-	-	+	+
<i>Lammellidens marginalis</i> (Lamarck)	-	-	-	-	-	+	-	+	+	+
Family : Amblemidae										
<i>Parreysia (Parreysia)</i> <i>corrugata</i> (Mueller)	+	+	+	+	+	+	+	+	+	+
<i>Parreysia (P.) favidens</i> (Benson)	+	+	+	+	+	+	+	+	+	+
<i>P. (P.) favidens</i> <i>assamensis</i> Preston	+	-	+	+	+	+	+	+	+	+
<i>P. (P.) favidens</i> <i>chrysis</i> (Benson)	+	-	+	+	+	+	-	+	+	+
<i>P. (P.) favidens</i> <i>deltae</i> (Benson)	-	-	-	-	-	+	-	-	+	+
<i>P. (P.) viridula</i> (Benson)	+	-	-	-	-	+	-	-	+	+
<i>P. (P.) triembolus</i> (Benson)	+	-	-	-	-	+	-	-	+	+
<i>Parreysia (Radiatula)</i> <i>andersoniane</i> (Nevill)	+	+	+	+	+	+	-	+	+	+
<i>P. (R.) caerulea</i> (Lea)	+	-	-	-	+	+	-	-	+	+
<i>P. (R.) lima</i> (Simpson)										
Family : Corbiculidae										
<i>Corbicula bensoni</i> (Deshayes)										
Family : Pisidiidae										
<i>Pisidium (Afropisidium)</i> <i>clarkeanum</i> (G & H Nevill)										
NUMBER OF SPECIES	22	12	16	17	19	30	15	21	26	27



S-I—above outfall, S-II—outfall, S-III—500 m below outfall, S-IV—1 km below outfall, S-V—2 km below outfall.

Fig. 4. Relative species richness of gastropods and bivalves at different sites during summer and winter.



S-I—above outfall, S-II—outfall, S-III—500 m below outfall, S-IV—1 km below outfall, S-V—2 km below outfall.

Fig. 5. Density (no/sqm) of gastrodods and bivalves at different sites summer and winter.

to acidic nature of the organic wastes. The organic nature of some of the pollutants was also visible from increased load of B.O.D and rapid decrease in dissolved oxygen contents at the outfall. At the same time sudden increase in C.O.D, hardness, silicates and Ca^{++} at the outfall region also indicate the inorganic nature of some pollutants. Although no detailed studies on the nature of effluents from different discharge sources were made, it can be assumed that the effluents discharged by sugar mills were of highly organic nature. The increase in hardness, silicate and Ca^{++} was probably due to the mother of pearl button and lime manufacturing activities. The analysis further revealed that the impact of pollution was restricted only to a short distance near the outfall and conditions started improving rapidly from Site-III onwards. The impact of pollution on physico-chemical nature of water was almost invisible at site-V, nearly 2 km downstream. Even during summer months when dilution ratio was low due to comparatively reduced flow of water, the impact on the physicochemical quality of the water was not severe at site-V. This revealed a limited nature of the physico-chemical impact of pollution on the river. It is well known that the impact of pollution on running waters is mostly governed by the nature and amount of pollutants added and inflow of freshwater from upstream. At Mehshi, the flow of the river was moderate which brought sufficient amount of water needed for dilution. Further the nature of wastewater generated by neither the sugar mills nor by button industries were toxic and therefore their impact was also not severe. Generally in case of organic pollution created by food/ beverage industries the recovery is rapid because of quick decomposition of organic matter. Similarly coarse sized suspended inorganic particles also settle quickly.

As compared to the physico-chemical nature of water, the impact of pollution was much severe on the biota. Although conditions improved significantly at Site V, neither the species richness nor numerical abundance of different groups, excepting the sudden abundance of phytoplankton at Site-3 during summer returned to their original numbers recorded from unpolluted upstream Site-I, showing that the recovery was still underway. The sudden increase of the phytoplankton at Site-IV was probably due to increased availability of nutrients liberated by the decomposition of huge quantity of organic matter as observed by Khan (1995) in case of the discharge from a paper and pulp mill in the Hugly river. The slower recovery of biota as compared to physico-chemical nature of water pointed out towards the long lasting impact of pollution on living material. This confirms the viewpoints expressed by a number of workers (Cook, 1976) that the physico-chemical parameters of water indicate the impact of pollution as long as pollutants remain in the particular area. Once flushed, these parameters do not indicate the deterioration of the quality in the past. Contrary to this, the biota once affected, take a long time to recover and return to their normal biological activities.

Among the three groups of biota studied, phytoplankton, zooplankton and malacofauna, only the last groups was either sessile or very slow moving and could not escape from the impact of changing condition of environment quickly by moving elsewhere. Due to this reason, benthic/

macrophytes associated sessile or slow moving animals have been considered as most reliable indicator of the impact of pollution. (Wilhms, 1970, Chandler, 1970, Cook, 1976).

Among the two molluscan groups, the bivalves appeared to be considerably more sensitive to pollution than gastropods. The reduction in both species number and density of bivalves at outfall was much higher than gastropods. While several species of gastropods like *Bellamyia bengalensis*, *Gabbia orcula*, *Thiara tuberculata*, *Indoplanorbis exustus* and *Gyraulus convexiusculus* were remained almost unaffected near the outfall, none of the bivalve species were comfortable at this site and a few species which occurred, had their densities greatly reduced.

SUMMARY

The present studies were undertaken to assess the impact of pollution on the physico-chemical nature of water and diversity and density of phytoplankton, zooplankton and molluscan fauna of river Burhi Gandak near polluted sites in Mehsi block of East Champaran district. Mehsi Township (Fig 1) is an important centre for the mother of pearl button and lime industries. Besides, there are three sugar mills also located in the area which discharge their wastes into the river causing pollution in the vicinity of the outfall. The impact of the pollution was studied by fixing 5 sites (sites I-V), starting from nearly one km above the outfall to nearly 2 km below the outfall.

There was a sudden alteration in almost all the physico-chemical parameters studied near the outfall but conditions started improving soon after and the recovery was nearly complete within a short distance of 2 km. Impact on species richness and abundance of both phytoplankton and zooplankton was severe near the outfall. Species richness near the outfall (as compared to site above the outfall) decreased by 60% and 65% in case of phytoplankton and zooplankton respectively. However recovery in both cases was rapid as the site-III (500 m below the outfall) showed improvement of 75.0 % and 65.33 % for phyto and zooplankton respectively. The pattern of reduction and recovery for their densities was almost similar to that of species richness.

Although similar pattern of impact was noticed on the diversity and density of molluscan fauna, the recovery was comparatively slower and neither species richness nor density recovered completely at site V, which indicated the greater impact of pollution on these organisms. Bivalves were found to be more affected than gastropods.

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A CHECKLIST OF AQUATIC AND SEMI AQUATIC HEMIPTERA (INSECTA) OF RAJASTHAN, INDIA

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INTRODUCTION

Aquatic and semi aquatic bugs play a vital role and form an important component in food webs of fresh water ecosystems. Studies also indicate that the quality of aquatic environment is partially dependent on aquatic bug population dynamics (Thirumalai & Raghunathan, 1988; Ramakrishna, 2000). Jansson (1977) demonstrated that members of the family Corixidae are used as indicators of water quality. Further, certain families of the bugs may be utilised in the biological control of mosquito larvae (Jenkins, 1964). Because of their diverse habitats and poor dispersal capability, these water bugs serve as zoogeographical indicators (Jordon, 1951; Hungerford & Matsuda, 1958). Some of the aquatic bugs are key stone predators; their abundance is essential to the existence of animal communities in an aquatic habitat (Murdoch *et al.*, 1984).

Out of 285 genera and about 3558 species distributed all over the world, aquatic bug fauna in India is represented by 78 genera and about 269 species under 15 major families. (Thirumalai, 1999). Perusal of literature indicates paucity of information on water bugs of Rajasthan except for the reporting of 12 species under 9 genera accommodated in 7 families of aquatic and semi aquatic bugs (Bhargava, 1985) and 6 species under 4 genera accommodated in 2 families of semi aquatic bugs (Thirumalai, 2001).

The present checklist includes the collection of aquatic and semiaquatic Heteroptera made available to the authors from various aquatic habitats of Rajasthan. The list comprises of 25 species accommodated under 16 genera and in 8 families. Under each species, the citation for the original description and other accompanying work necessary to understand the taxon or its occurrence in India is given.

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AQUATIC AND SEMI AQUATIC HEMIPTERA OF RAJASTHAN

Infraorder GERROMORPHA

Family GERRIDAE

Subfamily EOTRECHINAE

Genus *Onychotrechus* Kirkaldy, 19031. *Onychotrechus rhexenor* Kirkaldy, 1903

Onychotrechus rhexenor Kirkaldy, 1902. *Entomologist*, **36** : 44.

Onychotrechus rhexenor Kirkaldy : Distant, 1903. *Fauna British India*, **2** : 183.

O. rhexenor Kirkaldy : Anderson, 1980. *Steenstrupia*, **6**(10) : 128.

Genus *Amemboa* Esasi, 1925Subgenus *Amemboa* Esaki, 19252. *Amemboa (Amemboa)* sp.

Subfamily GERRINAE

Genus *Aquarius* Schellenberg, 18003. *Aquarius adelaidis* (Dohrn, 1860)

Aquarius adelaidis Dohrn, 1860. *Stettin. ent. Ztg.*, **21** : 408.

Aquarius adelaidis (Dohrn) : Andersen, 1990. *Steenstrupia*, **16**(4) : 61.

Gerris spinolae Leth. & Ser., 1896. *Cat. gen. Hemiptera*, **3** : 63.

Gerris spinolae (Leth. & Ser.) : Distant, 1903. *Fauna British India*, **2** : 180.

Genus *Limnogonus* Stal, 1868Subgenus *Limnogonus* Stal, 18684. *Limnogonus (Limnogonus) fossarum fossarum* (Fabricius, 1775)

Cimex fossarum Fabricius, 1775. *Syst. Ent.*, 727.

Gerris fossarum Fabricius, 1794. *Ent. Syst. emen. aucta*, **IV** : 188.

Limnogonus fossarum Stal, 1868. *K. Svenska Vetensk. Akad.*, **7** : 133.

L. (Limnogonus) fossarum (Fab.) : Hungerford & Matsuda, 1959. *J. Kans. Ent. Soc.*, **32**(1):40.

L. (L.) fossarum (Fab.) : Andersen, 1975. *Ent. Scand. Suppl.*, **7** : 30.

5. *Limnogonus (Limnogonus) nitidus* (Mayr, 1995)

Hydrometra nitida Mayr, 1865. *Verh. zool. bot. Ges. Wien*, **15** : 443.

Gerris nitida (Mayr) : Distant, 1903. *Fauna British India*, **2** : 178.

Limnogonus nitidus (Mayr) : Kirkaldy, 1908. *Wissenschaftl. Ergebn. der Schwed. Zool. Exped. nach dem Kilimandjaro*, **12** : 21.

L. (Limnogonus) nitidus (Mayr) : Matsuda, 1960. *Kans. Univ. Sci. Bull.*, **41** : 198.

L. (Limnogonus) nitidus (Mayr) : Andersen, 1975. *Ent. Scand. Suppl.*, **7** : 62.

Family VELIIDAE

Subfamily MICROVELIINAE

Genus *Microvelia* Westwood, 1834

Subgenus *Microvelia* Westwood, 1834

6. *Microvelia (Microvelia) douglasi* Scott, 1874

Microvelia douglasi Scott, 1874. *Ann. Mag. nat. Hist.*, **14** : 448.

Microvelia (Microvelia) douglasi Distant : Andersen, 1995. *Cat. Het. Palaearctic Region*, **1** : 87.

Microvelia douglasi Scott : Thirumalai, 1994. *Misc. Occ. Pap., Rec. zool. Surv. India*, **165** : 40.

Microvelia repentiana Distant, 1903. *Fauna British India*, **3** : 174

M. kumaonensis Distant, 1909. *Ann. Mag. nat. Hist.*, **3(8)** : 500.

Family MESOVELIIDAE

Subfamily MESOVELIINAE

Genus *Mesovelialia* Mulsant & Rey, 1852

7. *Mesovelialia vittigera* Horvath, 1895

Mesovalia vittigera Horvath, 1895. *Revue. ent.*, **14** : 160.

Mesovelialia mulsanti White : Distant, 1903. *Fauna British India*, **2** : 169.

Mesovelialia orientalis Kirkaldy, 1901. *Annali Mus. civ. Stor. Nat. Giacomo Doria*, **20** : 1908.

Mesovalia vittigera Horvath : Thirumalai, 1994. *Misc. Occ. Pap., Rec. zool. Surv. India*, **165** : 28.

Family HYDROMETRIDAE

Subfamily HYDROMETRINAE

Genus *Hydrometra* Latreille, 1796

8. *Hydrometra greeni* Kirkaldy, 1898.

Hydrometra greeni Kirkaldy, 1898. *Entomologist*, **31** : 2.

Hydrometra greeni Kirkaldy : Thirumalai, 1994. *Misc. Occ. Pap., Rec. zool. Surv. India*, **165** : 29.

Hydrometra greeni Kirkaldy : Polhemus & Polhemus, 1995. *Bishop. Mus. Occ. Pap.*, **43** : 22.

Hydrometra vittata (Stal) : Distant, 1903. *Fauna British India*, **2** : 170.

Infraorder NEPOMORPHA

Family NOTONECTIDAE

Subfamily ANISOPINAE

Genus *Anisops* Spinola, 1837

9. *Anisops barbatus* Brooks, 1951

Anisops barbata Brooks, 1951. *Kans. Univ. Sci. Bull.*, **34** : 387.

A. barbata Brooks : Thirumalai, 1994. *Misc. Occ. Pap., Rec. zool. Surv. India*, **165** : 13.

10. *Anisops bouvieri* Kirkaldy, 1904

Anisops bouvieri Kirkaldy, 1904. *Wiener Ent. Zeit.*, **23** : 116.

11. *Anisops cavifrons* Brooks, 1951

Anisops cavifrons Brooks, 1951. *Kans. Univ. Sci. Bull.*, **34** : 418.

12. *Anisops sardeus* Herrich-Shaffer, 1850

Anisops sardea Herrich-Shaffer, 1850. *Die wanzennartigen Insecten*, **9** : 41.

Anisops sardea Herrich-Shaffer, Thirumalai, 1989. *Misc. Occ. Pap., Rec. zool. Surv. India*, **118** : 19.

Subfamily NOTONECTINAE

Tribe NOTONECTINI

Genus *Enithares* Spinola, 183713. *Enithares ciliata* (Fabricius, 1798)

Notonecta ciliata Fabricius, 1798. *Suppl. Ent. Syst.*, 524.

Enithares indica Spinola : Distant, 1906. *Fauna British India*, 3 : 42.

Enithares paviana Distant, 1910. *Fauna British India*, 5 : 329.

E. lacta Paiva, 1919. *Rec. Indian Mus.*, 19 : 155.

E. abbreviata (Kirby) : Hafiz and Mathai, 1938. *Rec. Indian Mus.*, 40 : 210.

Family NEPIDAE

Subfamily RANATRINAE

Tribe RANATRINI

Genus *Ranatra* Fabricius, 179014. *Ranatra elongata* Fabricius, 1790.

Ranatra elongata Fabricius, 1790. *Skrif. Nat. Selesk.*, 1 : 228.

Ranatra elongata Fabricius : Thirumalai, 1994. *Misc. Occ. Pap., Rec. zool. Surv. India*, 165 : 22.

15. *Ranatra filiformis* Fabricius, 1790.

Ranatra filiformis Fabricius, 1790. *Skrit. Nat. Selsk.*, 1 : 228.

Ranatra filiformis Fabricius : Thirumalai, 1994. *Misc. Occ. Pap., Rec. zool. Surv. India*, 165 : 22.

Subfamily NEPINAE

Tribe NEPINI

Genus *Laccotrephes* Stal, 186616. *Laccotrephes griseus* (Guerin-Meneville, 1835).

Nepa griseus Guerin, 1844. *Iconogr. Regne. Anim.*, 352.

Laccotrephus griseus (Guerin) : Distant, 1910. *Fauna British India*, 5 : 314.

L. griseus (Guerin) : Thirumalai, 1994. *Misc. Occ. Pap., Rec. zool. Surv. India*, 165 : 22.

17. *Laccotrephes ruber* (Linnaeus, 1764).

Nepa ruber Linnaeus, 1764. *Mus. Lud. Ulr.*, 165.

Laccatrephes ruber (Linn.); Distant, 1906. *Fauna British India*, 3 : 18.

L. ruber (Linn.) : Thirumalai, 1994. *Misc. Occ. Pap., Rec. zool. Surv. India*, 165 : 22.

Family BELOSTOMATIDAE

Subfamily BELOSTOMATINAE

Genus *Diplonychus* Laporte, 183318. *Diplonychus rusticus* (Fabricius, 1781).

Nepa rustica Fabricius, 1781. *Ent. Sept.*, 4 : 62.

Sphaerodema rusticum (Fab.) : Distant, 1906. *Fauna British India*, 3 : 36.

D. rusticus (Fab.) : Lauck & Menke, 1961. *Ann. Entomol. Soc. Amer.*, 54 : 649.

D. rusticus (Fab.) : Thirumalai, 1994. *Misc. Occ. Pap., Rec. Zool. Surv. India*, 165 : 25.

Diplonychus indicus Venkatesan & Rao, 1980. *J. Bombay nat. Hist. Soc.*, 88 : 299.

Subfamily LETHOCERINAE

Genus *Lethocerus* Mayr, 1853Subgenus *Lethocerus* Mayr, 185319. *Lethocerus indicus* (Lepeletier & Serville, 1825).

Belostoma indicum Lepeletier & Serville, 1825. *Encyclopedia Methodique Paris*, 10 : 272

B. indicum (Lepeletier & Serville) : Distant, 1906. *Fauna British India*, 3 : 38.

Lethocerus indicus (Lep. & Serv.) : Lundblad, 1933. *Arch. Hydrobiol. Suppl.*, 12 : 52.

Lethocerus indicus (Lep. & Serv.) : Polhemus, 1995. *Cat. Het. Palaerctic region*, 1 : 23.

Family PLEIDAE

Genus *Paraplea* Esaki & China, 192820. *Paraplea buenoi* (Kirkaldy, 1904).

Plea buenoi Kirkaldy, 1904. *Wien. ent. Zeit.*, 23 : 128.

P. buenoi Kirkaldy : Distant, 1906. *Fauna British India*, 3 : 48.

P. buenoi Kirkaldy : Bhargava, 1985. *Proc. Nat. Sympos. Evalu. Environ.*, (1981), 319.

21. *Praplea frontalis* (Fieber, 1844).

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Plea pelopea Distant, 1910. *Fauna British India*, 5 : 336.

P. (Paraplea) frontalis (Fieber) : Hafiz & Pradhan, 1947. *Rec. Indian Mus.*, 45 : 349.

Praplea frontalis (Fieber) : Thirumalai, 1999. *IAAB*, 7 : 34.

Family CORIXIDAE

Subfamily CORIXINAE

Tribe AGRAPTOCORIXINI

Genus *Agraptocorixa* Kirkaldy, 1898

22. *Agraptocorixa hyalinipennis hyalinipennis* (Fabricius, 1803)

Sigara hyalinipennis Fabricius, 1803. *Syst. Rhya. Brusvigae*, 105.

Corixa unicolor Paiva, 1918. *Rec. Indian Mus.*, 14 : 30.

Corixa paivana Paiva & Dover, 1922. *Rec. Indian Mus.*, 24 : 333.

Agraptocorixa. hyalinipennis (Fab.) : Jaczewski, 1926. *Ann. Zool. Mus. Polon Warsw.* 5 : 18.

Agraptocorixa. hyalinipennis (Fab.) : Thirumalai, 1994. *Misc. Occ. Pap., Rec. zool. Surv. India*, 165 : 8.

Genus *Sigara* Fabricius, 1775

Subgenus *Tropocorixa* Hutchinson, 1940

23. *Sigara promontoria* (Distant, 1910).

Corixa promontoria Distant, 1910. *Fauna British India*, 5 : 341.

Corixa (Tropocorixa) promontoria Distant : Hutchinson, 1940. *Trans. Connecticut Acad. Art. Sci.*, 33 : 437.

Subfamily MICRONECTINAE

Genus *Micronecta* Kirkaldy, 1897

Subgenus *Basilonecta* Hutchinson, 1940

24. *Micronecta scutellaris scutellaris* (Stal, 1858).

Sigra scutellaris Stal, 1858. *Vetens akad. Forh.*, 15 : 339.

Micronecta dione Distant, 1910. *Fauna British India*, 5 : 348.

Micronecta malabarica Kirkaldy, 1908. *Canad. Ent.*, **40** : 209.

Micronecta malabarica Kirkaldy : Distant, 1910. *Fauna British India*, **5** : 347.

Micronecta proba Distant, 1910. *Fauna British India*, **5** : 348.

M. scutellaris pseudostriata Hutchinson, 1940. *Trans. Connecticut Acad. Art. Sci.*, **33** : 371.

M. (Basilonecta) scutellaris scutellaris (Stal) : Hutchinson, 1940. *Trans. Connecticut Acad. Art. Sci.*, **33** : 365.

M. (Basilonecta) scutellaris scutellaris (Stal) : Thirumalai, 1994. *Misc. Occ. Pap., Rec. zool. Surv. India*, **165** : 9.

Subgenus *Sigmonecta* Wroblewski, 1962

25. *Micronecta quadristrigata* Breddin, 1905.

Micronecta quadristrigata Breddin, 1905. *Soc. Ent. Zurich*, **20** : 57.

M. minthe Distant, 1910. *Fauna British India*, **5** : 347.

Micronecta quadristrigata Breddin : Lundblad, 1933. *Arch. Hydrobiol. Supp.*, **12** : 87.

Micronecta (Basileonecta) quadristrigata Breddin : Hutchinson, 1940. *Trans. Connecticut Acad. Art. Sci.*, **33** : 376.

Micronecta (Sigmonecta) quadristrigata Breddin : Wroblewski, 1962. *Bull. Acad. Pol. Sc. II. Warszawa*, **10** : 176.

M. (Sigmonecta) quadristrigata Breddin : Thirumalai, 1994. *Misc. Occ. Pap., Rec. zool. Surv. India*, **165** : 8.

NOTE : Jansson (1995) regarded *M. minthe* as a separate species found in Sri Lanka. However, certain forms of *minthe* are *quadristrigata*.

SUMMARY

The aquatic and semi aquatic groups of Insects represent a significant level of diversity (Ghosh, 1996). As checklists of provincial areas are of immense value in diversity studies, (Daniels, 1977; Ananthakrishnan, 1999) this account presents base line data to the functional aspects of fresh water communities and to dispel taxonomic uncertainties existing at various levels. While studying the diversity of water bugs in India, Thirumalai & Krishnan (2000) stated that more than 50% of the semi aquatic bugs are from the states through which the Western Ghats run. Though Karnataka ranks first in total area of wetlands availability, the number of species so far reported (56) is less than Tamilnadu (95) which ranks eighth in India. On the contrary, Arunachal Pradesh

that ranks fifteenth in the wetland area availability, the total species is 42. The present study area is twelfth and the report of 25 species so far invites more effort for systematic exploration of this group intensively.

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**A NEW GENUS AND NEW SPECIES OF GALL MIDGE
[CECIDOMYIIDAE : DIPTERA] INFESTING *GARUGA PINNATA*
ROXB., [BURSERACEAE] FROM INDIA**

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INTRODUCTION

In years 1993 to 1995 Cecidomyiid flies were bred by one of us [THS] from leaf galls of *Garuga pinnata* Roxb., at Bhokar Dist. Nanded, Maharashtra, India. The leaf gall is the first Indian record of cecidomyiid gall from the host plant. On the closer observation of these flies a new genus *Garugadiplosis* and a new species *Garugadiplosis brevivalpis* are described as under.

Key Words : Diptera, Nematocera, Cecidomyiidae, *Garugadiplosis brevivalpis*, new genus and new species.

***Garugadiplosis* gen. nov.**

Eyes confluent above. Trophi normal. Palpi short, biarticulate. Antenna : 2+12 segmented in both sexes; in male flagellate segments binodose with short stems, two whorls of long setae, one on each enlargements, two whorls of short and regular circumfila, one each on basal and apical enlargements; in female flagellate segments cylindrical, with short stems, two whorls of long setae, circumfila low, third and fourth segments confluent; vein R5 reaching wing margin well beyond its apex and interrupting at its union, vein Cu forked; claws simple on all legs, empodium shorter than the claw. Genitalia : basal clasp segment globose, with small blunt apical lobe, terminal clasp segment stout, ending in a thooth apically, dorsal plate deeply incised, lobes round, subdorsal plate longer than the dorsal, bilobed, lobes triangular, aedeagus longer than the subdorsal plate, truncated apically. Ovipositor protractile, lamellae thick, rod shaped.

[Type species : *Garugadiplosis brevivalpis* sp. nov.]

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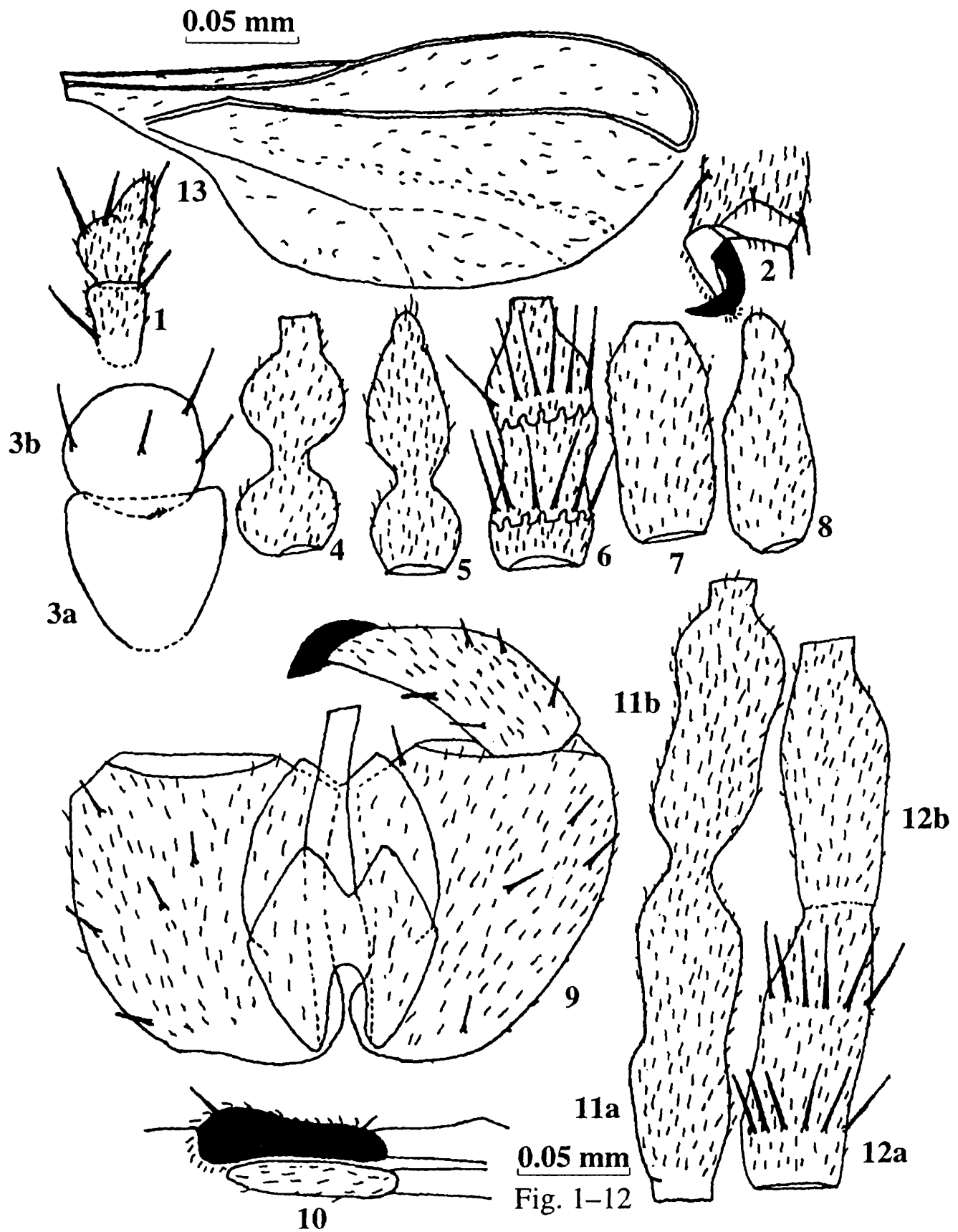
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Garugadiplosis brevipalpis sp. nov.

(Figs. 1–13)

Male : Body 0.85 mm long. Palpus short, biarticulate, sparsely setose, first segment [10 : 6] cylindrical, broad apically, length $1.66 \times$ its maximum thickness; second segment [12 : 7] longer and broader than first, flattened medially, $1.71 \times$ its maximum thickness. Antenna : 0.39mm, shorter than body, with 2+12 segments, segments with binodose enlargements and short stems, with two whorls of long setae, one on each enlargement, two whorls of regular and short circumfila, one each on basal and apical enlargements; scape [18 : 17] cup shaped, broader at apex than at base; pedicel [16 : 16] globose; third segment [37] confluent with and longer than fourth, with a small basal prolongation [2 : 7], basal enlargement [15 : 11] 0.45 the length of the segment and $1.36 \times$ as long as its maximum thickness, apical enlargement [15 : 11] similar to the basal, apical stem [5 : 5] 0.55 the length of the apical enlargement and as long as thick; fourth segment [30] 0.85 the length of the third, without basal stem, basal enlargement [13 : 11] 0.43 the length of the segment and $1.81 \times$ its maximum thickness, apical enlargement as long as the basal, apical stem [4 : 5] 0.37 the length of the apical enlargement; penultimate segment [27] shorter than the fifth, basal enlargement [10 : 10] 0.37 the length of the segment; and as long as thick, basal stem [2 : 3] 0.2 the length of the basal enlargement, apical enlargement [10 : 9] 0.37 the length of the segment and $1.1 \times$ as long as thick; terminal segment [29] longer than the penultimate, basal enlargement [9 : 9] 0.33 the length of the segment and as long as thick, basal stem [2 : 3] 0.22 the length of the basal enlargement and thicker than long, apical enlargement [14 : 9] $1.55 \times$ as long as the basal and 0.64 the length of the segment, apical stem in the form of a round tip. Wing hyaline, $2.7 \times$ as long as broad [70 : 26], vein R5 reaching wing margin well beyond its apex and interrupting costa at its union, vein Cu forked. Legs : long, densely hairy, claws simple on all legs, evenly curved, empodium shorter than the claw [10 : 12]. Genitalia : basal clasp segment sparsely setose, globose, $1.13 \times$ as long as broad [34 : 30], with a small subapical blunt lobe; terminal clasp segment stout, thicker at base, little more than thrice as long as broad [28 : 9], ending in a tooth; dorsal plate incised in middle, lobes round, broader than long [20 : 23]; subdorsal plate incised, lobes triangular apically, longer than dorsal, $1.5 \times$ its maximum breadth [30 : 20]; aedeagus rod shaped, broad basally, truncated apically, longer than basal clasp segment length $7 \times$ its maximum thickness [35 : 5].

Female : Body 0.85 mm long [including ovipositor]. Palpus biarticulate, sparsely setose, first segment [15 : 7] cylindrical, length $2.14 \times$ its maximum thickness; second segment [10 : 8] shorter and broader than the first, flattened medially, length $1.25 \times$ its maximum thickness. Antenna : 0.75 mm long, shorter than the body, with 2+12 segments, enlargements cylindrical, with short apical stems, low circumfila and two whorls of long setae; scape cup shaped, broader than long [13 : 18]; pedicel [15 : 17], subglobose, longer than the scape, broader than long; third segment [32], longest of all, confluent with fourth, enlargement 0.90 the length of the segment [30 : 32]



Garugadiplosis brevivalpis ♂ ♀

Figs. 1-13. *Garugadiplosis brevivalpis* : 1. Palpus [♂]; 2. Claw [♂]; 3a. Scape [♂]; 3b. Pedicel [♂]; 4. Penultimate segment [♂]; 5. Terminal segment [♂]; 6. 5th antenna segment [♂]; 7. Penultimate segment [♀]; 8. Terminal segment [♀]; 9. Genitalia; 10. Ovipositor; 11a. 3rd antenna segment [♂]; 11b. 4th antenna segment [♂]; 12a. 3rd antenna segment [♀]; 12b. 4th antenna segment [♀]; 13. Wing [♂].

and $2.72 \times$ as long as thick [30 : 11], stem thicker than long [2 : 7]; fourth segment [30], shorter than the third, enlargement 0.86 the length of the segment [26 : 30] and $2.16 \times$ as long as thick [26 : 12], stem thicker than long [4 : 6]; penultimate segment [22] without stem, $2 \times$ its maximum thickness [22 : 11]; terminal segment [26], longer than penultimate, enlargement 0.76 the length of the segment and $2 \times$ its maximum thickness [20 : 10], apical stem in the form of a nipple [6 : 5]. Wing and legs as in male. Ovipositor : exerted, lamellate; dorsal lamella stout, rod shaped [21 : 6]; basal lamella shorter and thinner than the dorsal, elongated oval [18 : 5].

Material examined :

Holotype : Male dissected and mounted on slide labelled, "emerged from leaf galls of *Garuga pinnata* Roxb., Bhokar, Dist. Nanded. T. H. Shaikh coll.", dated 01.VIII.1993.

Allotype : Female dissected and mounted on slide, labelled as in holotype.

Paratype : Two males and two females dissected and mounted on slides, data as in holotype.

Etymology : Generic name is associated with the host plant and species name pertains to the short 2-segmented palpus.

Type material is retained in first author's collection at Nanded for the time being.

REMARKS

Garugadiplosis appeals close to *Amradiplosis* Mani (1947) but differs in having short two segmented palpus; inconspicuous circumfila; simple claws; vein R5 reaching wing margin well beyond wing apex; basal clasp segment with a small subapical lobe; ovipositor long and exerted [In *Amradiplosis* palpi long three segmented, circumfila loops long and regular; claws dentate; vein R5 reaching wing margin at wing apex; basal clasp segment without lobe; ovipositor short and not exerted.]

Description of Leaf gall

Epi-hypophyllous, more pronounced on the lower side of the leaf-blade, sessile, simple, ovoid or globose, smooth, persistent gall, occurs on midrib, veins and veinlets, initially pale green but turns reddish brown as grows old. Gall cavity unilocular enclosing one or two larvae inside. Full grown gall measures 7–8 mm in diameter, 3–7 galls may arise on a single leaf. Exit hole circular. The gall formation starts in June and adults emerges in July/August.

A psyllid, *phacopteron lentigenosum* Buckton (Homoptera) is well known to cause leaf galls on the same host plant [Mani 1973]. But a Cecidomyiid causing gall on *Garuga pinnata* is reported for the first time from India.

ACKNOWLEDGEMENTS

We take this opportunity to thank the Principal, Science College, Nanded for providing necessary laboratory facilities. One of us (RMS) is grateful to the Director, Zoological Survey of India, Kolkata and the Officer-in-charge, ZSI (Pune) for permitting him to study the material.

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**PARASARCOPHAGA (LIOSARCOPHAGA) CHOUDHURYI SP. NOV.
(DIPTERA : SARCOPHAGIDAE) FROM SAGAR ISLAND,
SUNDARBANS BIOSPHERE RESERVE, INDIA**

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INTRODUCTION

Very little is known about the sarcophagid flies from Sagar Island. Nandi (2001) reported only 8 species from this Island. The authors made several trips for collection of this flies from different parts of the Island and found an interesting species described now as new to the Indian sarcophagid fauna.

Types will be deposited in National Collection of Zoological Survey of India, Kolkata in due course.

ABBREVIATIONS USED IN THE TEXT

ac–acrostichal bristles, *dc*–dorsocentral bristles, *h*–humeral bristles, *hpl*–hypopleural bristles, *ia*–intraalar bristles, *mpl*–mesopleural bristles, *np*–notopleural bristles, *pa*–postalar bristles, *ph*–posthumeral bristles, *ps*–presutural bristles, *sa*–supraalar bristles, *st*–sternopleural bristles.

ABBREVIATIONS USED IN THE FIGURES

AP–apical plate of paraphallus, *LP*–lateral plate of paraphallus, *P*–paraphallus, *S*–styli of glans, *T*–theca of penis, *V*–ventralia of penis, *PA*–process of apical plate of paraphallus, *K*–seventh tergite, *F*–sixth sternite, *G*–seventh sternite, *H*–eighth sternite, *AS*–anal sternite.

***Parasarcophaga (Liosarcophaga) choudhuryi* sp. nov.**

(Text figures 1–6)

Male : Body length 8–9 mm.

Head : Width of frons about two-thirds that of one eye; frontal vitta blackish, its width at narrowest point of frons about twice that of each parafrontal; parafrontal and parafacial black with golden pollen, the former with short scattered hairs, the latter with a row of short black hairs near

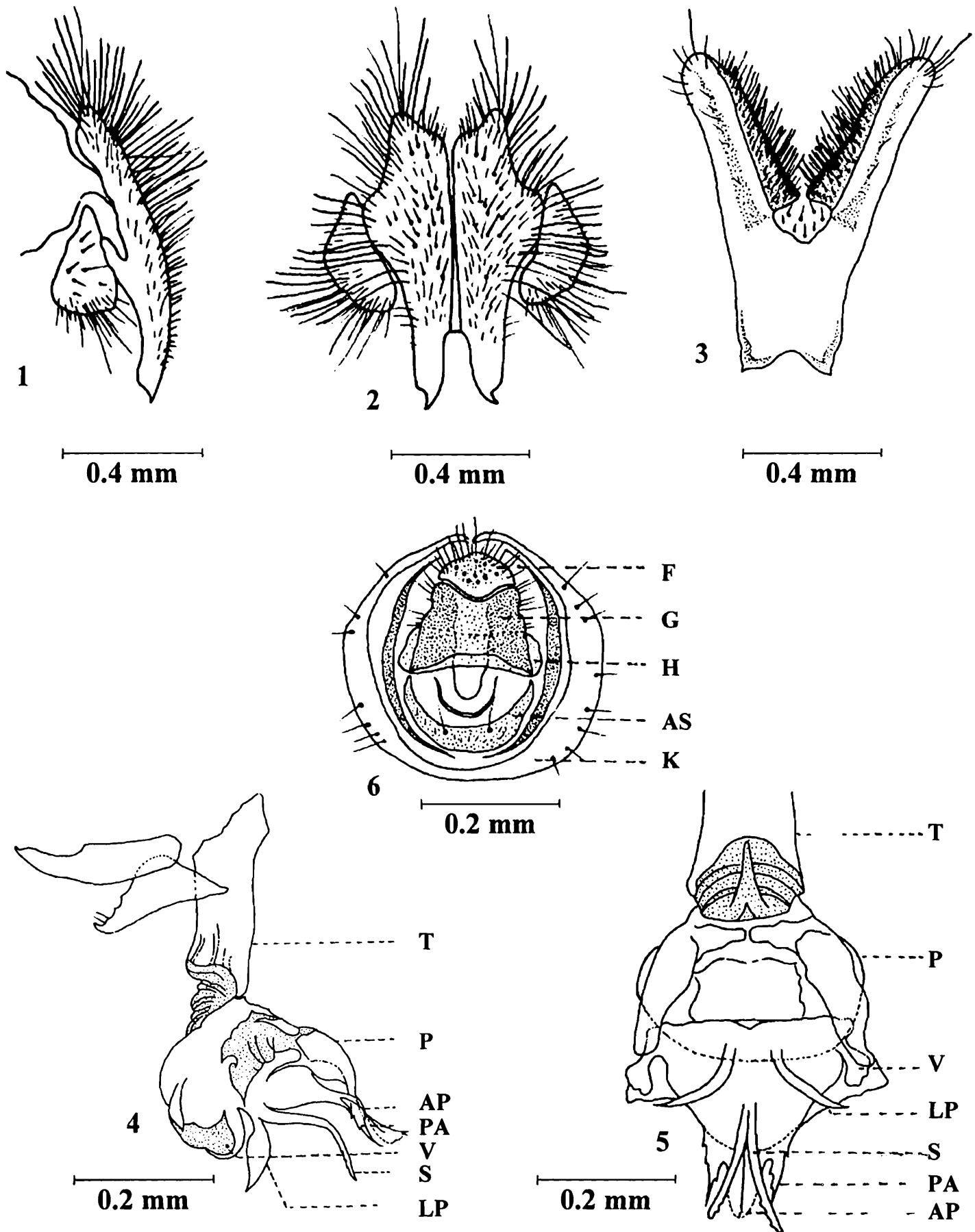
the eye margin of which lower 3 stouter; antennae brownish with silvery pollen, reaching up to about 0.8 distance to vibrissae, first and second segments blackish, third segment brownish with silvery pollen and its length about more than twice that of the second; arista long, plumose along basal half; facial ridge brown with silvery pollen; vibrissae long, distance between vibrissae about three times that of parafacial width; frontal bristles 9, arranged in a row on parafrontal and reaching half of second antennal segment, upper 2 reclinate, lower 3 below base of antennae; gena black with greyish hairs; postgena black with silvery hairs; outer vertical bristle short, inner vertical well developed and about three times that of the outer vertical, post vertical moderately developed; ocellar and postocellar bristles short; a row of regular postocular setae besides postocular cilia, rest of the area with short hairs; palpi black; proboscis blackish-brown.

Thorax : Grey with three black longitudinal stripes; *ac* 0+1; *dc* 4+5 (posterior 2 *dc* stout); *ia* 1+2; *ps* 1; *h* 2; *ph* 2; *np* 2; *pa* 2; *sa* 4; *st* 1+1+1; *mpl* 7-8; *hpl* 6-7; upper part of propleura bare with silvery pollen; prostigmatic and propleural bristles well developed and accompanied with short hairs; pro- and mesothoracic spiracles brown; apicoscutellar and discoscutellar bristles 1 pair each; lateroscutellar bristles 2 pairs.

Wings : Hyaline with brown veins; R_1 bare; R_{4+5} with a row of short setae located dorsally, extending half from the basal node to r-m and several short setae along ventral surface of basal node of R_{4+5} ; fifth costal segment slightly greater than the third, the former with short spines along basal half of its anterior margin; costal spines stout; epaulet brown with short spines; basicostal scale yellowish; squama whitish; halter brown.

Legs : Black; fore femur with a pair of rows of bristles along posterodorsal surface and a row of bristles along posterior margin of ventral surface; fore tibia with a row of 3 bristles along basal one-third of anterodorsal surface and 1 bristle on posterodorsal surface at about one-third the distance from the distal end; mid femur with a row of bristles along middle portion of anterodorsal surface, a row of short setae each along distal half of anteroventral and posteroventral surfaces, a row of short bristles along basal half of anteroventral surface, 2 bristles on posterolateral surface distally and numerous long hairs along basal one-third of posteroventral surface; mid tibia with a row of bristles along posterodorsal surface, 2-3 bristles along anterodorsal surface on distal half and 1 bristle each on distal one-third of anteroventral and posteroventral surfaces; hind femur with a pair of rows of bristles along anterodorsal surface, a row of bristles along anteroventral surface and 2 bristles on distal part of posteroventral surface; hind tibia with 2 bristles apart medially on anterodorsal surface, 1 bristle each on posterodorsal surface at about one-third and two-thirds the distances from the basal end.

Abdomen : Greyish with golden checkered pattern; median marginal bristles on second and third abdominal tergites absent but both with a pair of lateral marginal bristles, fourth with a pair of median and three lateral marginal bristles, fifth with a row of about 14-16 marginal bristles; sternites first to fourth with short hairs; fifth sternite Y-shaped with stout spines on inner sides and



Figs. 1-6. Genitalia σ^7 ; 1. inner and outer forceps, lateral view; 2. same, posterior view; 3. fifth sternite; 4. penis, lateral view; 5. same, ventral view; 6. genitalia q , ventral view.

long hairs terminally on arms; first and second genital segments without marginal bristles; inner forceps slightly curved with grooved at the apex; outer forceps almost oval with few hairs terminally; anterior paramere elongated and wide; posterior paramere gradually pointed apically with 2 short hairs anteriorly; theca shorter than paraphallus, both are sclerotised; apical plate of paraphallus slightly curved backwards with anterior membranous region and elongated apical processes; lateral plate of paraphallus elongated, wide at middle and pointed apically; styli of glans slightly longer than apical plate of paraphallus and with serrations at tip; ventralia almost oval with wide trilobed, posterior lobe with curved chitinous area and the others almost membranous.

Female : Almost similar to male excepting for the following differences :

Body length : 6 mm.

Head : Width of frons more wider than male and about twice that of male; frontal bristles 7; 2 proclinate fronto-orbital bristles; frons showing two black stripes; palpi orange with brown hairs.

Thorax : *ac* non visible; *dc* 1+3.

Wings : Fifth costal segment about twice that of the third; M_{1+2} not bent forward to R_{4+5} .

Legs : Fore tibia with 4 bristles along middle portion of posteroventral surface; mid femur with a row of short bristles along ventral surface; hind tibia with 2 bristles on mid dorsally and 1 bristle on ventral surface.

Abdomen : Second to fourth sternites each with 4 bristles, fifth with 6 bristles, sixth wider than the others and with numerous short hairs, peripheral parts of seventh sternite deeply pigmented, concave anteriorly and overlapped to the eighth sternite and its median portion transparent, eighth membranous, less wide and without hairs; anal sternite well developed, cup-like and with 2 long and few short hairs; seventh tergite entire with short bristles and hairs.

Female described here was collected in couple.

Holotype : 1♂, Sagar Island; Bani Jungle, 24.xi.2000, B. C. Nandi and Shuvra Kanti Sinha; 2♂♂, *Paratypes*, same data as *Holotype*; *Allotype* 1♀, Bani Jungle, 24.xi.2000, B. C. Nandi and Shuvra Kanti Sinha; 1♂, Fraserganj, 26.xi.2000, B. C. Nandi and Shuvra Kanti Sinha.

Distribution : India : Sundarbans Biosphere Reserve; Bani Jungle and Fraserganj.

Discussion : Provisionally, we are placing this species under the genus *Parasarcophaga* Johnston and Tiegs, 1921 on account of long third antennal segment, serrated styli of glans and well developed and complex apical plate of paraphallus. The structure of ventralia is more massive here than in any other species of the genus. This species is almost similar to *Parasarcophaga (Liosarcophaga) angarosinica* Rohdendorf, 1937, but differs from it by the structures of ventralia and lateral plate of paraphallus. Moreover, the styli of glans are more elongated here.

This species is named in honour of Prof. Amalesh Choudhury, renowned scientist and mangrove specialist and former Prof. and Head of the Department of Marine Science, Calcutta University, Kolkata.

Bionomics : This species was collected from bushes near dead mollusca.

SUMMARY

A new species of *Parasarcophaga (Liosarcophaga) choudhuryi* is described from Sagar Island and male and female genitalia are figured.

ACKNOWLEDGEMENTS

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**THE SPECIES OF *METASTENUS* WALKER AND *ACROCLISOIDES*
GIRAULT & DODD (HYMENOPTERA : CHALCIDOIDEA :
PTEROMALIDAE) FROM INDIA**

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INTRODUCTION

Metastenus Walker and *Acroclisoides* Girault & Dodd are two Pteromalid genera poorly known from the Indian subcontinent.

The type specimens of the new species are deposited in Zoological Survey of India, Western Ghats Field Research station, Calicut, India.

The morphological terminology used in this paper generally follows that of Boucek (1988). The following abbreviations are used : F1-F5—funicular segments 1 to 5; MV—marginal vein; OOL—ocellocular distance; PMV—postmarginal vein; POL—post ocellar distance; SMV—submarginal vein; STV—stigmal vein; T1-T5—gastral tergites 1 to 5; BMNH-British Museum (Natural History), London, U.K.

Genus *Metastenus* Walker

Metastenus Walker, 1834 : 301-302. Type species : *Metastenus concinnus* Walker by monotypy.

Symnophagus Ashmead, 1904 : 319, 321. Type species *Symnophagus townsendi* Ashmead by monotypy and original designation. Syn. by Graham, 1956 : 256.

Tripolycystus Dodd in Girault 1915 : 337. Type species *Tripolycystus sulcatus* Dodd, by original designation. Syn, by Boucek, 1988; 440.

Boucek (1988) stated that probably only one species of *Metastenus* occur from Europe to China and India, two species in Africa and one species in Australia. According to Boucek *et al.* (1979) *Metastenus* is known from the region by the type species *M.concinnus* Walker recorded from Kerala, India. Though we have made extensive collections of Pteromalidae from Kerala we couldn't collect *M.concinnus* Walker so far. However we could collect a new species of

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Metastenus from Kerala which is described here. Since the original description is inadequate for identification, a redescription of *M. concinnus* Walker is provided here based on the study of the lectotype (lectotype selected by Graham, 1956). A key to separate the two species of *Metastenus* is also provided.

The genus belongs to the subfamily Pteromalinae and can be distinguished by the following characters :

Diagnosis : Gena with a hollow above base of the mandible extending fully one third up the malar space; female flagellum with 3 very short anelli and 5 funicular segments with dense longitudinal sensillae; propodeum tapering to nucha; MV of forewing only moderately widened; parallel sided; gaster sessile.

Biology : parasites of coccidophagous and aphidophagous coccinellid beetles.

Key to the Indian species of Metastenus

1. Propodeum (Fig.3) with nucha moderate and coarsely reticulate; plicae raised and distinct; antennae (Fig. 1) inserted centre of face, body moderately reticulate
 *M. concinnus* Walker
- Propodeum (Fig. 7) with nucha short, finely reticulate; plicae very fine almost indistinct; antennae (Fig. 5) inserted below middle of face, reticulation of body finer especially on head and propodeum *M. indicus* sp. nov.

1. *Metastenus concinnus* Walker

(Figs. 1-3)

Metastenus concinnus Walker, 1834 : 302. Lectotype. F. designated by Graham (1956 : 256) (examined).

Redescription : Lectotype : Female : Length 1.5 mm. Black; antennae dark brown; coxae concolrous with mesosoma; remainder of legs brown; tegulae brown; wings hyaline; veins brown.

Head : (Fig. 1) uniformly and moderately reticulate; clypeus finely striate; anterior margin shallowly emarginate. In dorsal view head width 2x length; temple length 0.43x eye length; POL : OOL = 5 : 4; eye height 1.3x width in profile; malar space length 0.6x eye height; posterior margin of gena sharp; scrobe locally deep; antennae inserted middle of face; scape length 0.7x eye height; pedicel longer than F1, clava 1.2x as long as two preceding segments combined.

Mesosoma : moderately reticulate; pronotal collar almost shiny, anteriorly carinate. Mesoscutum width 2.1x length. Scutellum medially slightly longer than mesoscutum (9.5 : 9); frenum clearly separated. Propodeum (Fig. 3) with median area coarsely reticulate, nucha moderately long, plicae

sharp and complete; spiracles small, oval, touching hind margin of metanotum. Forewing (Fig. 2) with relative lengths of SMV 19; MV 9; PMV 9.25; STV 5.5.

Gaster : (Fig. 3) 2x as long as wide in dorsal view and as long as head plus mesosoma combined.

Host : A widespread parasite of coccinellid beetles especially on those predatory on coccids (Boucek & Rasplus 1991). Recorded from India with coccids (Boucek *et al.*, 1979).

Material examined : Lectotype : Female : England (grass fields near London) det. Graham (BM type Hym. 5.2225.)

Distribution : India (Kerala), Europe.

2. *Metastenus indicus* sp. nov.

(Figs. 4-8)

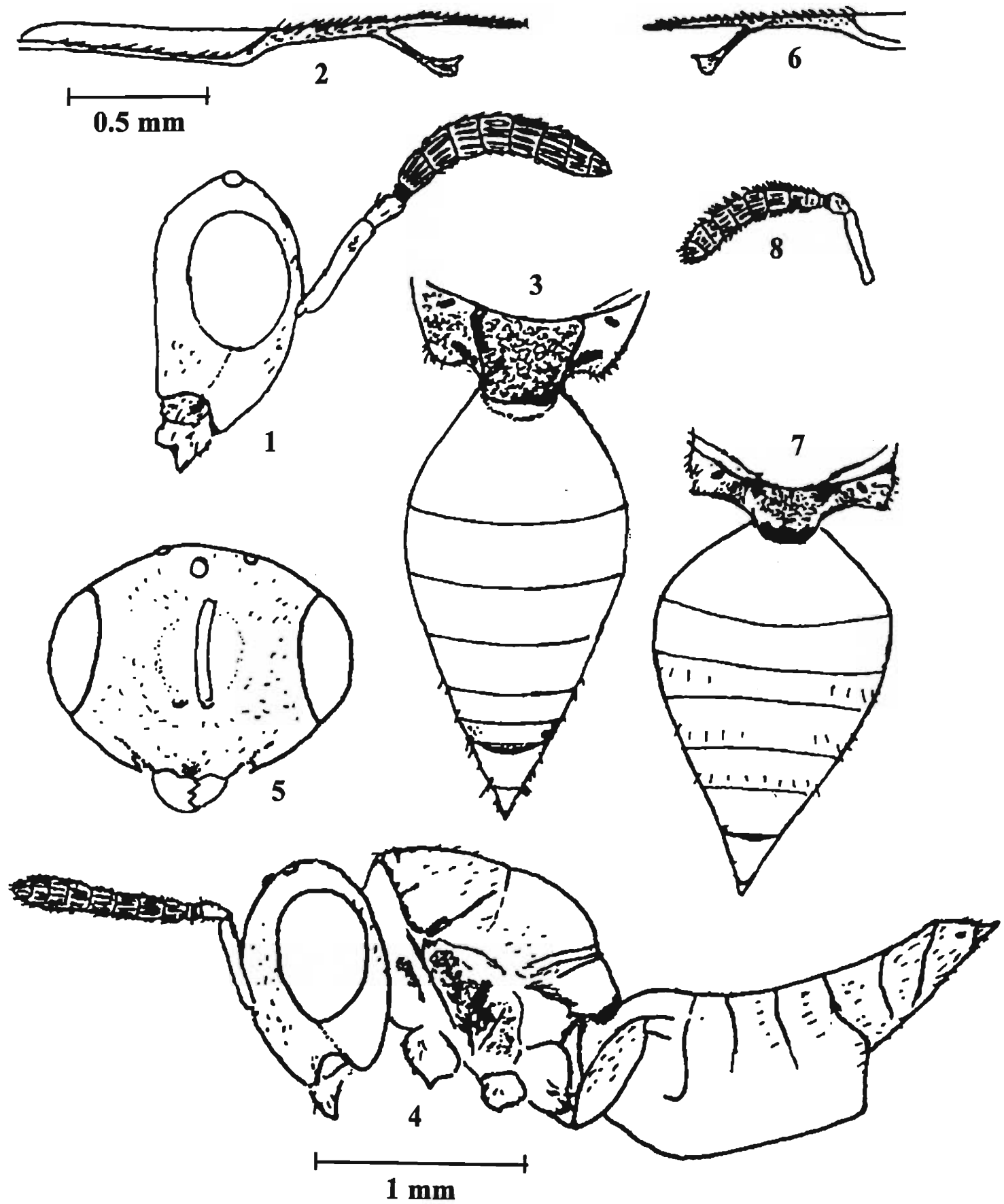
Holotype : Female : Length 1.6–1.8 mm. (Holotype 1.8 mm) Black; gaster with brownish tinge; antennae testaceous; fore and hind coxae concolrous with mesosoma, mid coxae and all femora dark brown; hind tibiae and tarsi yellow; fore and mid tibiae and tarsi testaceous except proximal two third part of former brown. Tegulae brown; wings hyaline; veins pale brown.

Head : (Figs. 4, 5) Uniformly finely reticulate; pubescence small; clypeus similarly sculptured as on rest of face except anteriorly shiny, anterior margin slightly projecting. In dorsal view head width 2.1x length and 1.2x that of mesosoma; temple length 0.4x eye length; POL little longer than OOL (7 : 6.25); in front view head width 1.2x height; eye height 1.6x width in profile; malar space length 0.6x eye height. Both mandibles with four teeth. Antennae inserted below middle of face, little above lower margin of eyes, scape length 0.7x eye height; pedicel plus flagellum length 0.7x head width; pedicel as long as F1; clava 1.2x as long as two preceding segments combined.

Mesosoma : (Fig. 4) closely and moderately reticulate, anterior margin of pronotal collar not carinate. Mesoscutum width 2.2x length. Scutellum without frenalium, medially as long as mesoscutum. Propodeum (Fig. 7) with nucha short, medially 0.5x as long as scutellum; median carina vaguely indicated in some specimens; median area finely reticulate, plicae very fine, almost indistinct; spiracles moderate, oval. Forewing (Fig. 6) length 2x width, basal part almost bare. Relative lengths of SMV 22, MV 13, PMV 12, STV 7.

Gaster (Figs. 4, 7) little longer than head plus mesosoma combined (31 : 28) and 2x as long as wide in dorsal view, sometimes dorsally collapsing.

Male : (Fig. 8) length 1.2–1.3 mm. Resembles female but differs in the nature of antenna with 2 anelli and 6 funicular segments with very long pubescence.



Figs. 1-8. 1-3. *Metastenus concinnus* Walker, Female : 1. Head and antenna in profile; 2. Forewing venation; 3. Propodeum and gaster in dorsal view. 4-8. *Metastenus indicus* sp. nov. Female; 4. Body in profile; 5. Head in front view; 6. Forewing venation; 7. Propodeum and gaster in dorsal view; 8. Male antenna.

Material examined : *Holotype* : Female : INDIA : Kerala, Kannur district, Kottiyoor R.F. 3.ii.1995, Coll. P. M. Sureshan; *Paratypes* : 2 female, 1 male, Kerala, Pathanamthitta district, Konni, 26.xi.1988; 2 male, 1 female, Kerala, Alapuzha district, Kayamkulam, 21.ii.1989; 3 female, Kerala, Ernakulam, 9.ii.1989; 1 female, 2 male, Kerala, Palakkad district, Anakkatty, 12.xii.1987; 3 female, Kottayam district, Kumarakom, 29.xi.1988; 2 female, Athirampuzha, 28.xi.1988; 1 female, Pathanamthitta district, Achankoil, 25.ii.1997; 1 female, Pamba, 21.ii.1997, Coll. P. M. Sureshan; 3 male, Malappuram district, Chelari, 10.x.1981; 2 female, Palghat district, Silent valley, iii.1985; 1 male, Malampuzha, 11.xii.1987; 2 female, Calicut University campus, ix. 1985; Coll. T C. Narendran & Party.

Remarks : This species differs from the only known species from the region, *M.concinus* Walker as given in the key.

Genus *Acroclisoides* Girault

Acroclisoides Girault & Dodd, in Girault, 1915 : 334. Type species *Acroclisoides megacephalus* Girault & Dodd by original designation.

The genus *Acroclisoides* is found distributed in Africa, South Asia, New Guinea and Australia (Boucek, 1988). The genus is known by one species *A.indicus* Ferriere from the India and Myanmar (Boucek *et al.*, 1979). A new species of *Acroclisoides* is described here from India. *A.indicus* Ferriere is redescribed here based on the study of specimens from Kerala. A key to separate the two species of *Acroclisoides* from Indian subcontinent is also provided.

Members of the genus are parasites in eggs of Pentatomid Heteroptera and by the following combination of characters the genus can be easily distinguished.

Diagnosis : Head unusually broad; occipital carina distinct; clypeal margin not produced, rather straight; antennae inserted high above centre of face with two anelli and six funicular segments; mesoscutum with notauli complete; gaster petiolate, petiole subquadrate; T1 often narrowed basally so that gaster is prolonged behind the petiole; MV of forewing widened.

Key to the Indian species of *Acroclisoides*

1. Forewing (Fig. 13) with a broad brown spot beneath STV; gaster (Fig. 12) long, 0.8x as long as head plus mesosoma combined; head in dorsal view 2.2x as wide as long; lower posterior corner of gena developed in to a sharp spine; antennal flagellum dark brown
..... *A.maculatus* sp. nov.
- Forewing (Fig. 10) hyaline, without brown spot beneath STV; gaster short (Fig. 9), length 0.6x as long as head plus mesosoma combined; head in dorsal view 1.9x as wide as long; lower posterior corner of gena developed in to a short spine; antennal flagellum pale brown
..... *A.indicus*. Ferriere

1. *Acroclisoides indicus* Ferriere

(Figs. 9–11)

Acroclisoides indicus Ferriere, 1931 : 279. M. India : Dehra Dun (BMNH).

Since the original description of the species is based on a male specimen, a redescription is provided here based on the study of female specimen.

Female : Length 1.4 mm. Head and mesosoma dark metallic blue, lower face bright metallic blue with golden green reflection; gaster dark blue dorsally and brown ventrally; antennae with scape, pedicel and anelli testaceous, remainder pale brown; fore and hind coxae concolrous with mesosoma except tips testaceous with tips of tarsi brown. Tegulae pale brown; wings hyaline, veins pale brown.

Head : (Figs. 9, 10) closely reticulate; clypeus almost closely reticulate, clearly separated from rest of the face, anterior margin wavy. In dorsal view head width 1.4x that of mesosoma and 1.9x length; temple length almost half of eye length; POL 0.8x OOL; In front view head width 1.5x height; malar space length 0.7x eye height; eye height 1.3x width in profile; eyes separated by 2.4x their height. Antennae with scape as long as eye, pedicel plus flagellum almost as long as head width; F1–F3 equal, other segments gradually decreasing in length; clava shorter than two preceding segments combined.

Mesosoma : (Fig. 9) pronotal collar dorsally shiny behind anterior carina. Mesoscutum width 2.4x length, mid lobe moderately reticulate, reticulation finer on side lobes. Scutellum medially slightly longer than mesoscutum (11 : 10); propodeum with median area moderately reticulate, lateral areas finely reticulate; median carina complete; plicae indicated anteriorly. Forewing (Fig. 10) length 2.3x width; PMV only little longer than MV. Relative lengths : SMV 19; MV 7; PMV 8.5; STV 5.

Gaster : (Fig. 9) short, compressed, 0.6x as long as head plus mesosoma combined.

Male : Length 1.6 mm. Similar to female but differs in having gaster more compressed and antennae with funicular segments elongated and with long hairs.

Material examined : 1 Female, INDIA : Kerala : Calicut University campus, v.1989; 1 Male, Calicut University campus, vii.1989, Coll. P. M. Sureshan (in ZSIC).

Distribution : India (Kerala; Tamil Nadu; Uttar Pradesh), Myanmar.

Host : ex. Pentatomid eggs (Boucek *et al.*, 1979).

2. *Acroclisoides maculatus* sp. nov.

(Figs. 12–15)

Holotype : Female : Length 1.5 mm. Head and mesosoma dark metallic blue, lower face with golden green reflection; gaster including petiole brown with metallic blue reflection beyond middle.

Antennae with scape pedicel and anelli testaceous, remainder brown. Fore and hind coxae except distal tip concolrous with mesosoma; distal tip of fore and hind coxae, mid coxae and remainder of legs testaceous with tips of tarsi brown. Tegulae yellow. Forewing with a broad brown spot beneath STV; veins and pubescence brown.

Head : (Figs. 12, 14) reticulation as in *A. indicus*. In dorsal view head width 2.2x length and 1.4x as wide as mesosoma; anterior margin of clypeus wavy; temple length 0.73x eye length; POL 0.7x OOL. In front view head width 1.7x height; malar space length 0.7x eye height; eye height 1.3x width in profile; lower posterior margin of gena with a distinct tooth. Antennae with scape little shorter than eye (11 : 12); pedicel little wider than long; F1–F3 equal in length; F4–F5 little shorter.

Mesosoma : (Fig. 12) pronotum moderately reticulate, shiny behind anterior carina. Mesoscutum width 2.4x length., similarly sculptured as in *A. indicus*. Scutellum similarly sculptured as on mid lobe of mesoscutum, medially slightly longer than mesoscutum (12 : 11). Propodeum medially 0.6x as long as scutellum; median carina complete; plicae indicated anteriorly. Forewing (Fig. 13) length 2.3x width; basal cell and speculum closed below; basal hair line indicated. Relative lengths SMV 26; MV 9.5; PMV 14; STV 8.

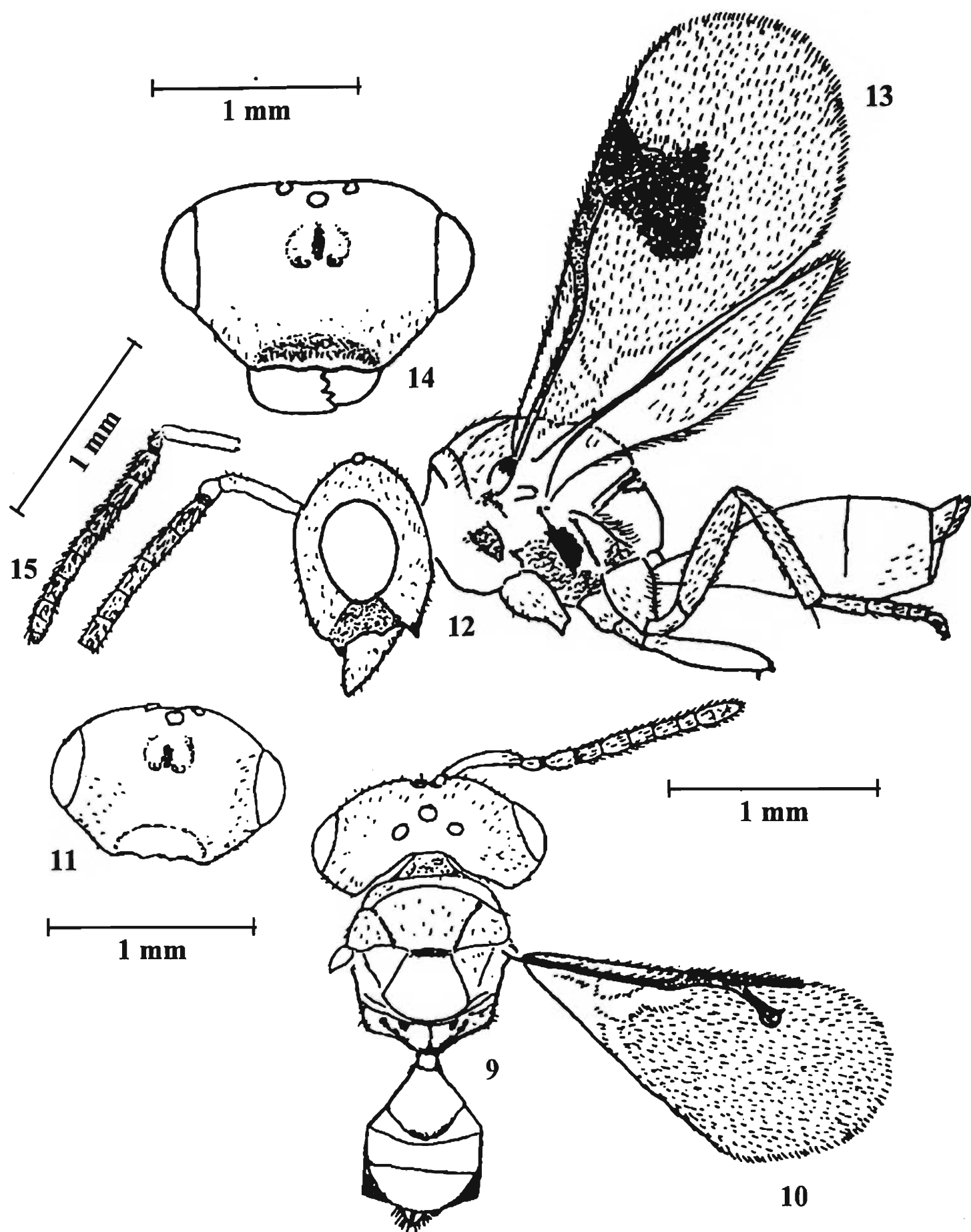
Gaster : (Fig. 12) elongate, ovate, 0.8x as long as head plus mesosoma combined (without petiole).

Male : (Fig. 15) Length 1.7 mm. Resembles female but differs in having antennae thicker and gaster short and compressed.

Material examined : Holotype : Female (without tip of antennae) : INDIA : Kerala : Calicut District, Kotooli, 20.vii.1995, Coll. P. M. Sureshan. Paratypes : 1 Male, INDIA : Tamil Nadu, Coimbatore, ix.1987, Coll. Narendran & party; 8 male, Kerala : Calicut University campus, 10.i.2001, ex. eggs on leaf of *Ficus drupaceae* var *pubescence* (Roth), Coll. T C. Narendran. (in ZSIC).

Remarks : This species closely resembles *A. indicus* Ferriere in general morphology but differs as given in the key.

In the nature of forewing, antenna and in having wider head this species resembles *A. megacephalus* Girault & Dodd but differs from it in having gaster with T4 not occupying half of gaster (excluding petiole) body dark metallic blue and middle coxae testaceous (in *megacephalus* T4 of gaster occupying half of its length, body dark metallic green and first two pairs of coxae concolrous with body).



Figs. 9-15. 9-11. *Acroclisoides indicus* Ferriere, Female : 9. Body in dorsal view; 10. Forewing; 11. Head in front view. 12-15. *Acroclisoides maculatus*, sp. nov. Female : 12. Body in profile; 13. Forewing; 14. Head in front view; 15. Male antenna.

SUMMARY

Two new species of Pteromalidae, one each under the genera *Metastenus* Walker (*M. indicus* sp. nov.) and *Acroclisoides* Girault & Dodd (*A. maculatus* sp. nov.) are described from India. *M. concinnus* Walker and *A. indicus* are redescribed based on the study of the lectotype and determined material respectively. Diagnosis and key to the species from India of both the genera are provided.

ACKNOWLEDGEMENTS

The first author is grateful to the Director, Zoological Survey of India, Kolkata and the Officer-in-charge Zoological Survey of India, Western Ghats Field Research Station, Calicut for providing facilities and encouragement. We are thankful to Dr. Chris Burwell, Queensland Museum, Australia and Dr. John S. Noyes, and Miss. Suzanne Lewis, BMNH, London for providing various type material on loan and relevant literature on Pteromalidae.

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NOTES ON THE DERMAPTERA (INSECTA) OF LAKSHADWEEP WITH THE DESCRIPTION OF A NEW SPECIES

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INTRODUCTION

Srivastava (1991) recorded two species of Dermaptera, namely, *Euborellia stâli* (Dohrn) now treated as synonym of *Euborellia annulata* (Fabricius) and another *Euborellia* sp. Besides, *Anisolabis annulipes* Lucas was reported on a Male from Minikoi by Burr (1902) which may be treated with reserve since it was determined before the concept of male genitalia was fully introduced in the taxonomy of the Order.

Three more species are reported from the area including an undescribed species.

ANISOLABOIDEA

ANISOLABIDIDAE

ANISOLABIDINAE

Euborellia annulipes (Lucas)

Anisolabis annulipes; Burr, 1902, *The Fauna and Geography of the Maldive and Laccadive Archipelagos*, 1(2) : 235 (1 Male; Lakshadweep, Minikoi).

Distribution : World wide.

Euborellia sp.

Euborellia sp. Srivastava, 1991. *State Fauna Series 2 : Fauna of Lakshadweep* : 259, figs. 3-6 (Male, 1 Female, 1 nymph : Lakshadweep, N of Agatti Isl.).

Remarks : The above male, female were not named due to the poor condition of male specimen which represent an undescribed species. The brief description and figures were given for the future workers to recognise the species when additional material is available.

***Euborellia annulata* (Fabricius)**

Forficula annulata Fabricius, 1793, *Ent. Syst.*, II : 4 (Sex ?; America Merdionale).

Euborellia annulata; Brindle, 1981, *Entomologists' Rec. J. var.*, **93** : 14 (*Forcinella stâli* Dohrn, 1864—treated as a synonym).

Euborellia stâli; Srivastava, 1991, *State Fauna Series 2: Fauna of Lakshadweep* : 259, figs. 1–2 (Females; Kavaratti and Amini Isls).

Distribution : World wide.

FORFICULOIDAE

SPONGIPHORIDAE

LABINAE

***Circolabia curvicauda* (Motschulsky)**

(Fig.1)

Material examined : India : Lakshadweep, Minicoy Isl, 1 Male, 1 Female, ex rotten banana stem, 26.ii.2001 (*G.K.Srivastava* coll.).

Distribution : World wide. First record from the area.

***Chaetospania nigriceps* (Kirby)**

(Figs. 2-3)

Material examined India : Lakshadweep, Minicoy Isl, 1 Male, 2 Females, ex rotten banana stem, 26.ii.2001 (*G.K.Srivastava* coll.).

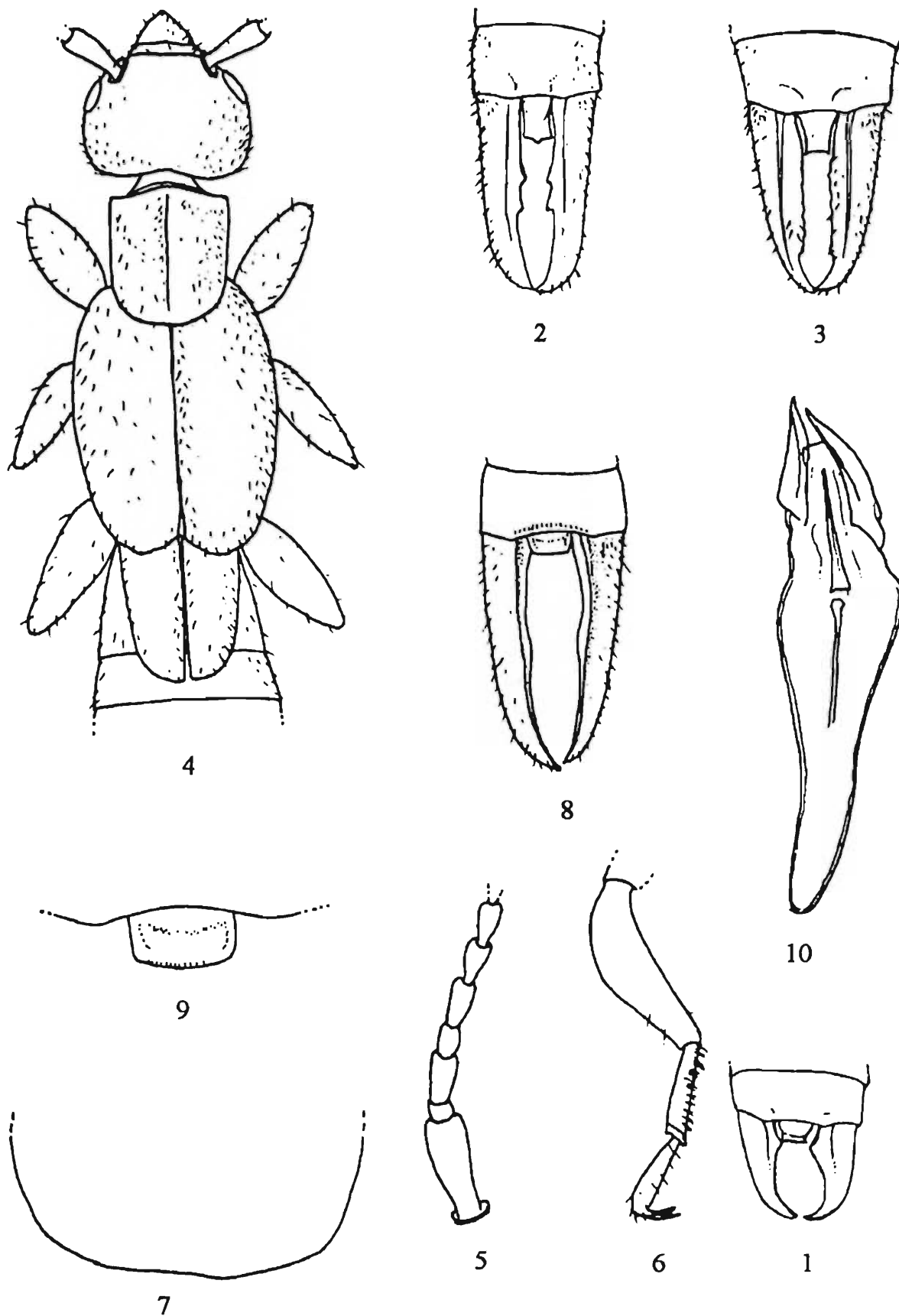
Distribution : India (Andaman & Lakshadweep), Myanmar, Celebes, New Guinea and Solomon Islands.

Reported for the first time from Lakshadweep.

***Chaetospania alfredi* sp.n.**

(Figs. 4-10)

Male: General colour blackish brown; antennae, ultimate tergite and forceps a little lighter in colour; mouth parts, tibiae basally and apically and whole of tarsi yellow. Finely pubescent, sides of abdominal segments and forceps with long pubescence.



Figs. 1-10. *Circolabia curvicauda* (Motschulsky), Male, 1. Ultimate tergite and forceps; *Chaetospania nigriceps* (Kirby), Male, 2. Ultimate tergite and forceps; Female, 3. Ultimate tergite and forceps; *Chaetospania alfredi* sp. n., Holotype Male, 4. Anterior portion of body; 5. A portion of antennae with seven basal segments; 6. Hind tibia & tarsus; 7. Hind portion of penultimate sternite; 8. Ultimate tergite and forceps; 9. Pygidium, enlarged; 10. Genitalia.

Head slightly broader than long, depressed, smooth, postero-lateral angles rounded, hind margin feebly emarginate in middle, sutures obsolete. Eyes shorter than post-ocular area. Antennae 12-segmented, stout, narrowed basally, slightly shorter than the distance between antennal bases; 2nd short, about as long as broad; 3rd long, cylindrical; 4th shorter than 3rd, slightly longer than broad; 5th about as long as 3rd but gently stout, 6th onwards gently stouter, gradually increasing in length and each narrowed at base, segments 11 & 12 thin, rod shaped. Pronotum slightly longer than broad, smooth, sides straight, parallel, depressed, hind margin rounded, median sulcus fine, prozona weakly raised and poorly differentiated from depressed metazona. Elytra and wings well developed, smooth, former with humeral angle prominent, meeting along the median line, hind margin convex; latter about half as long as the elytra, meeting along the median line. Legs short, stout, femora stout, swollen especially fore and hind pair; hind tibia about as long as tarsi; tarsi with first segment slightly longer than third; second segment broader than long, short; claw without an arolium. Abdomen weakly convex, smooth, narrowed at base, gradually enlarging posteriorly. Penultimate sternite transverse, hind margin briefly rounded, scarcely emarginate in middle. Ultimate tergite quadrate, smooth, weakly depressed, gently widened posteriorly, hind margin incrassate, emarginate in middle, above bases of forceps oblique. Pygidium vertical, transverse, subtruncate posteriorly. Forceps separated at base by pygidium, branches tapering apically, almost straight in basal 2/3, afterwards gently incurved in apical one third, tip gently hooked, inner margin with dorsal border sharp, straight, ventral border in middle a little projecting. Genitalia with parameres narrowed apically with tip acuminate; virga stout.

Female : Unknown.

Measurements : (in mm) :

	Holotype
	Male
Length of body	4.6
Length of forceps	1.5

Material examined: India: Lakshadweep, Minicoy Isl, Holotype Male, (genitalia mounted between two coverslips and pinned with the specimen), ex rotten banana stem, 26.ii.2001 (*G.K.Srivastava* coll.); deposited in the Zoological Survey of India, Kolkata.

The species is named after Dr.J.R.B.Alfred, Director, Zoological Survey of India, in recognition of his contributions to Indian zoology.

Remarks : Amongst the Oriental species of the genus this species comes close to *Chaetospania andersoni* Brinde, 1971, from Sri Lanka but differs in having the head, pronotum, elytra and wings smooth (*vs* head & pronotum punctured; elytra more strongly punctured, almost rugose and wings less closely punctured in *C. andersoni*); pronotum slightly longer than broad, parallel sided (*vs* as broad as long, slightly narrowed posteriorly) and parameres narrow, tip acuminate (*vs* broader in most part, tip acute).

GENERAL REMARKS ON FAUNA

Fauna of the area, on the basis of present studies, appears to be mainly Oriental having close relationship with that of Peninsular India and Sri Lanka. Two species viz. *Euborellia stâli* (Dohrn) and *E. annulipes* (Lucas) have world wide distribution but more common in warmer parts of the globe. Most likely unnamed species of *Euborellia* may be endemic to the area. The closeness of new species, *Chaetospania alfredi* to a Sri Lankan species reveals that it is a derivative of essentially Deccan Plateau and Sri Lankan faunal element which has diversified in space and isolation. The other two Spongiphorid species, namely *Circolabia curvicauda* (Mostchulsky) and *Chaetospania nigriceps* (Kirby) commonly occur under bark of dead and decaying trees and stems of banana. Most likely the distribution of above plants and animals may be inter-linked. The former has world wide distribution whereas the latter is occurring extensively in the Oriental and Australian (Papua New Guinea & Solomon Isls) Regions.

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**NOTES ON THE GENUS *PAREPARCHUS* BURR (INSECTA :
DERMAPTERA) WITH THE DESCRIPTION OF A NEW SPECIES
FROM INDIA**

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INTRODUCTION

This genus was erected by Burr (1911) for the reception of *Opisthocosmia minuscula* Bormans (1984) described on a female from Sumatra and figured the ultimate tergites and forceps of male, besides head and pronotum, antennae and tarsus. The locality record is mentioned as Sumatra and Borneo and the said male should be from latter area.

Pareparchus can be separated from other genera of Opisthocosmiinae by comparatively shorter and thicker antennal segments, semicircular transverse pronotum and transverse ultimate tergite.

At present, besides type species, *P. pelvimeter* Hebard (1923) from India is included under the genus. The described species differs from both the known species in general colouration and the forceps, in males, having branches regularly incurved, cylindrical and with a triangular inwardly direct tooth near base.

***Pareparchus* Burr**

Pareparchus Burr, 1911, *Genera Insect.*, **122** : 92 (Type species : *Opisthocosmia minuscula* Bormans, 1884); Townes, 1945, *Ann. ent. Soc. Am.*, **38** : 353; Popham & Brindle, *Entomologist*, **98** : 135; Kapoor, 1967, *Agra Univ. J. Res. (Sci.)*, **16**(1) : 34; Popham, 1968, *Entomologist*, **101** : 277; Sakai, 1970, *Dermapterorum Cat. Prael.*, **7** : 49; Sakai, 1982, *Bull. Daito Bunka Univ.*, **20** : 46; Sakai, 1994, *Dermapterorum Cat.*, **26** : 5483, Srivastava, 1976, *Rec. zool. Surv. India, Occ. pap.*, **2** : 69; Steinmann, 1989, *World Catalogue of Dermaptera* : 719; Steinmann, 1993, *Das Tierreich*, **108** : 267.

Size small to medium; slender. Antennae multi-segmented, basal segment shorter than the distance between antennal bases; 3rd and 4th sub-equal, former slender and latter stouter, 5th onward segments gradually increasing in length, not slender. Eyes shorter than post-ocular area.

Pronotum transverse and semicircular. Elytra and wings well developed, former not keeled along the costal margin. Legs slender, hind tarsi with 1st segment equal to 3rd; 2nd briefly lobed, claw without an arolium. Ultimate tergite transverse, sloping backwards. Forceps, in males, stout, elongated.

Type species : *Opisthocosmia minuscula* Bormans 1884.

Distribution : Oriental Region.

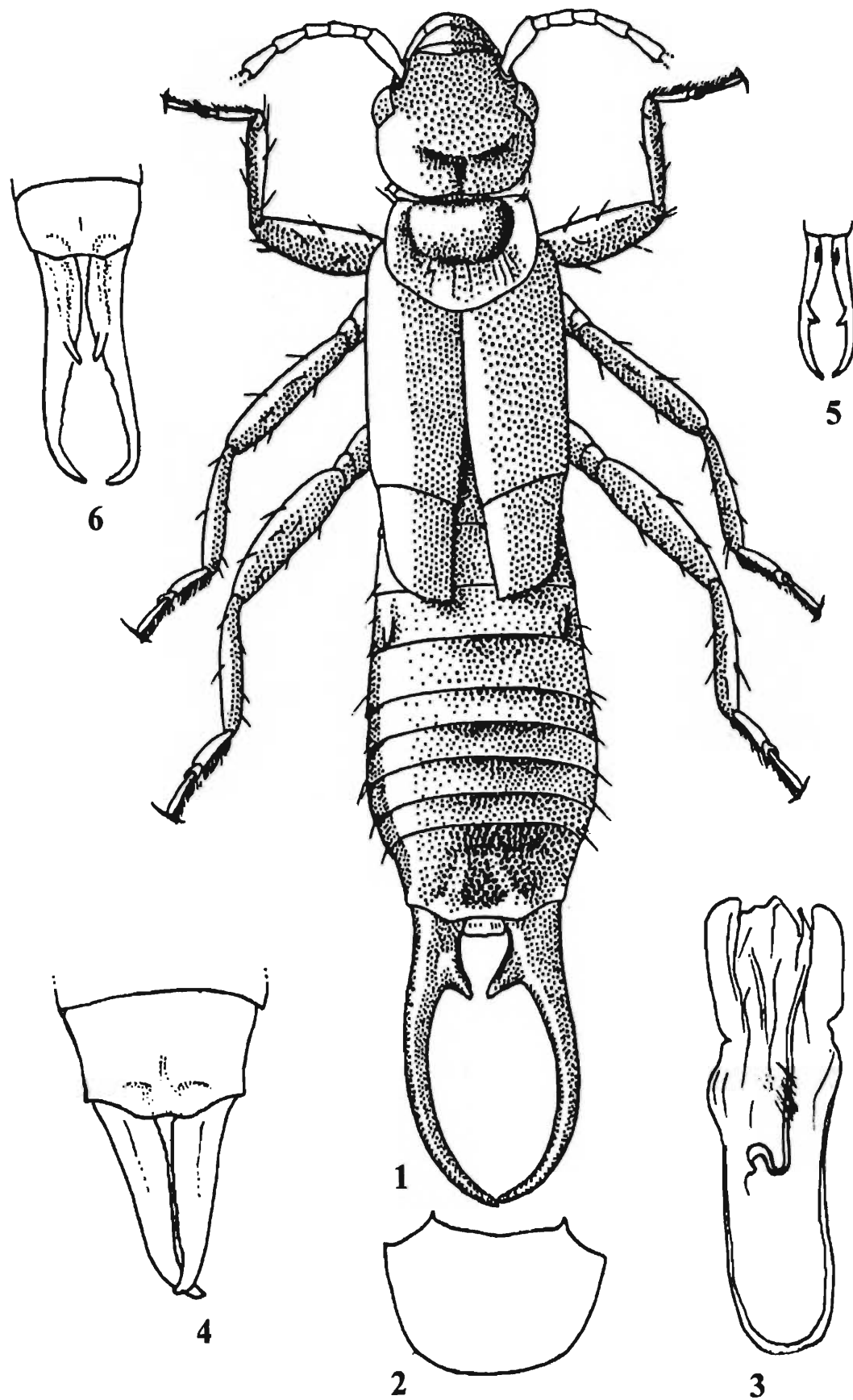
Key to species (basal on males only)

- 1(4). Size smaller (7.0 to 7.4 mm, including forceps)
- 2(3). Abdominal tergites strongly punctate; forceps regularly incurved from base to apex, at base close to inner dorsal border with a sharp, triangular, inwardly and posteriorly directed tooth (figs. 1-4). *P. pillai* sp. n.
- 3(2). Abdominal tergites weakly punctate; forceps with branches sub-contiguous in basal $\frac{1}{4}$, afterwards incurved enclosing oblong space, at base above with a short vertical crest and in apical $\frac{1}{3}$ a triangular tooth directed inwards (fig. 5)..... *P. minusculus* (Bormans)
- 4(1). Size larger (11.1–13.5 mm, including forceps) (fig. 6)..... *P. pelvimeter* Hebard

Pareparchus pillai sp.n.

Male : General colour chocolate brown with shades of black; pronotum on sides and posteriorly, legs and basal two antennal segments yellow; elytra with a yellow oblong patch near shoulder, wings yellow with a faint stripe of brown in middle.

Head about as long as broad, smooth, hind margin scarcely emarginate in middle, frons convex, sutures faint. Antennae 12-segmented, stout, basal segment stout, gently expanded apically, shorter than the distance between antennal bases; 2nd about as long as broad; 3rd long, slender; 4th a trifle shorter than preceding, stouter, expanded apically; 5th stouter, longer than 3rd; remaining gradually increasing in length. Eyes distinctly shorter than post-ocular area. Pronotum transverse, smooth, sides alongwith hind margin semicircular, median sulcus distinct, prozona tumid; metazona depressed. Elytra and wings well developed and smooth. Legs typical of the genus, hind tarsi with 1st segment compressed, equal to 3rd; 2nd briefly lobed, clad on underside with pubescence. Abdomen long, gently enlarged in middle, tergites convex, blackish brown, along the hind margin yellowish brown, shining, punctate. Penultimate sternite transverse, shallowly punctate, hind margin rounded. Ultimate tergite transverse, weakly convex, gently narrowed and sloping backwards,



Figs. 1-6. *Pareparchus pillaii* sp.n., Holotype Male, 1. Dorsal view; 2. Penultimate sternite; 3. Genitalia; Paratype Female, 4. Ultimate tergite and forceps; *Pareparchus minusculus* (Bormans), Male, 5. Ultimate tergite and forceps; *Pareparchus pelvimeter* Hebard, Male, 6. Ultimate tergite and forceps.

(Fig. 5 after Burr, 1911)

punctures deeper than on the other abdominal tergites, posteriorly in middle faintly depressed, hind margin incrassate, straight in middle, laterally oblique above bases of forceps. Pygidium vertical, transverse, posterior margin in the middle with a small triangular point. Forceps cylindrical, tapering apically, regularly incurved, with tip gently hooked, internal margin unarmed, at base a sharp, triangular tooth directed inward and posteriorly close to inner dorsal border present. Genitalia with parameres flat, longer than broad, virga thin and tubular.

Female : Agrees with male in most characters except that pronotum is complete yellow; elytra unicolourous with a shade of yellow in middle; abdominal tergites obscurely punctulated; ultimate tergite more narrowed posteriorly, punctation heavier than on the other abdominal tergites but weaker than in Male; forceps simple and straight.

Measurements : (in mm).

	Holotype	Paratypes	
	Male	2 Male	1 Female
Length of body	– 5.5	5.3-5.4	7.0
Length of forceps	– 1.5	1.6-1.7	1.7

Material examined : Holotype Male, India : Kerala, Kayapara Forest, 1160 m, 24.xii.1980; 1 nymph, with same data; Paratypes : 1 Male, 1 Female, 2 nymphs, Silent valley and Kayapara Dam site, 9.xii.1980 (*R.S.Pillai* coll.); 1 Male (genitalia mounted between two coverslips and attached to the pin of specimen), Nilgiri Hills, Devala, 3200 ft,...x.1980 (*P.S. Nathan* coll.).

Remarks : Some variations are noted in the colour. In the paratype Male from Nilgiri Hills, Devala the elytra and wings are almost unicolourous brown. Posterior margin of tergites is however lighter in colour.

This species is close to *Pareparchus pelvimeter* Hebard, but differs by its smaller size, i.e., 7.0–7.1 in Males (vs 11.0-13.0 mm in *Pareparchus pelvimeter* Hebard); heavier punctation on abdominal tergites (vs obscurely punctulated) and forceps cylindrical, regularly incurved from base to apex, internal margin armed with a triangular tooth, directed posteriorly and inwards, situated near base (vs branches depressed and contiguous in basal 1/3, afterward compressed, incurved, enclosing broadly oblong space, internal margin serrated, a vertical, triangular tooth directed posteriorly inwards situated at basal 1/3).

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I am thankful to Dr. J. R. B. Alfred, Director, Zoological Survey of India, Kolkata for providing necessary facilities.

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DIVERSITY AND COLONIZATION OF THE TERRESTRIAL INVERTEBRATE FAUNA AT SCHIRMACHER OASIS, EAST ANTARCTICA

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INTRODUCTION

The knowledge about Antarctic invertebrate fauna in general and East Antarctic in particular specially on the limnology bio-ecology, faunal diversity, species richness, distribution pattern of invertebrate fauna is still fragmentary (Somme, 1985). The fresh water lakes of the Antarctic continent representing a biological integration of an entire drainage area, are particularly attractive ecological unit for basic study (Priddle and Heywood, 1980).

Keeping these in view, the scientists of the Zoological Survey of India have been undertaking a continuing programme to explore the terrestrial invertebrate fauna of the Schirmacher Oasis of East Antarctic with special reference to bio-ecological studies since 1990. The present communication is an attempt to deal with the distribution pattern of different invertebrate faunal groups occurring in about 36 sites, on the embankment of various lakes particularly on the moss turf habitats during the period from January to February 1996. An attempt has also been made to incorporate the ecology of some dominant nematode species studied during the period from January to February 1990.

LITERATURE REVIEW

A perusal of literature reveals that lakes of maritime and sub Antarctic islands were more intensively surveyed than continental Antarctica particularly Schirmacher Oasis.

Bardin and Leflat (1965) are the first workers to study the chemical characteristics of Schirmacher Oasis. Komarek and Ruzicka (1966) are pioneers in studying freshwater algae of the area. Matonkdar and Gomes (1983) are the first Indian to conduct biological studies on lakes, while Ingole and Parulekar (1987, 1990, 1993) dealt with composition and spatial distribution of microfauna of 10 fresh water lakes. A review on the biological studies carried out from I to VIth Indian Scientific expedition to Antarctic waters (Dhargalkar, 1988) shows that the data collected during summer to

*The paper was presented by the first author in the VIIth SCAR Biology Symposium, Christchurch, New Zealand (27.8.98 to 8.9.98).

not show continuity. Thus lacunae that exists, can be removed in by taking up systematic and biological programmes. Richter *et al* (1990) reported some unidentified mites and springtail from Schirmacher Oasis. During the above mentioned investigation Ingole and Parulekar (Opcit) reported 7 microfaunal groups, viz. Protozoa, Turbellaria, Nematoda, Oligochaeta, Tardigrada, Rotifera, Acarina and identified only 8 species upto generic level. Hazra (1994) recorded and studied the ecology of 5 genera of soil nematodes of this region. Arif (1995) reported some groups of invertebrate fauna without proper taxonomic identity. Venkataraman (1998) reported Tardigrada (2 spp.), Nematoda (3 spp.), Rotifer (1 sp.), Mitra (1999) reported six microfaunal groups viz., Protozoa (17 spp.), Nematoda (5 spp.), Rotifera (1 sp.), Tardigrada (2 spp.), Collembola (2 spp.) and Acarina (2 spp.) from different lake water system of Schirmacher Oasis.

PHYSIOGRAPHY : CLIMATE & VEGETATION

The core of the Antarctic is the high ice covered continent which is subdivided into two broad divisions : East and West. There is a sharp contrast between these two divisions both geologically and physically. East Antarctica contains part of an ancient continental shield, overlain by younger rocks, whereas West Antarctica contains continental material that has been joined to the East Antarctic shield late in its history. The term 'Oasis' was first used by 'Stephenson' (a member of British Antarctic expedition team, 1934–1937) to cover both dry and wet snow free areas on the Antarctic continent. The Schirmacher Oasis of east Antarctic was discovered by a German expedition team 1939. It is situated in between shelf and land ice having an ice free area of 36 sq. km with lakes, lagoons, ponds and water streams. It lies in between 70°34' S and 70°77' S latitudes and 11°22'E and 11°55'E longitudes and 90 km south of Princess Astrid Coast. The Schirmacher Oasis of East Antarctica is a group of low lying, dome shaped hills, essentially snow- and ice free high polar rock deserts in the eastern Dronning Maud land. It is about 100 km away from the Antarctic shore.

The climate is relatively mild due to low altitude, with air temperature over the glacier ice between -7.7 and $+8.2^{\circ}\text{C}$ during mid summer (December to January) when melt water is abundant. Fresh water lakes, ponds and pools cover approximately 3.4 km² of Oasis area. The altitude lies in between the local Zero level and 228 metre with an average of 100 metre. Its surface is rough and undulated. January is the warmest month (monthly mean air temperature 0.7°C , maximum 8.2°C) and August the coldest (monthly mean air temperature -16.3°C , minimum -34.5°C). The average wind velocity over the year is around 9.7 m/s. The wind at Schirmacher Oasis are normally easterly, south easterly during summer. Extreme air temperature recorded at the Maitri station was -34°C and $+0.8^{\circ}\text{C}$.

Despite the fact that scientists have been visiting Antarctica for nearly 100 years, there are still gaps in what is known of Antarctic plants. Best studied are the mosses, liverworts and lichens, but little is known about the algae, fungi and bacteria. The distribution of plants are controlled by a

number of factors such as temperature, availability of water, wind, heat from the sun, and the influence of animals such as birds and seals. The most common large plants found around greater Antarctica are mosses and lichens. These are distributed chiefly around the edge of the continent, as well as on the Antarctic peninsula. Mosses have been reported from as far south as 84°42' S and lichens from 86°69' S at a height of 1980 metres.

MATERIAL AND METHODS

A total of 36 sites (33 lakes and 3 swampy areas) were chosen for the present investigation (Map 1). A total of 135 sample were collected of which 120 samples from floating, submerged mosses and mosses of marginal areas of the lakes and 15 moss sample were collected from 3 swampy areas as stated.

Soil samples were drawn at the rate of 3 samples per site on different dates, during the period from January 1990 to February 1990. January 1992 to February 1992 and January to February 1996. The samples were drawn by using stainless steel corers (e.s. diameter 8.55 cm) from a depth of 5 cm. Separate sample units were drawn on several dates from different sites to study the vertical distribution of nematodes. The 3 samples per plot were drawn from a depth of 10 cm and sub-divided into two 5 cm sub samples as per method described by Curry (1971). The soil inhabiting microarthropod fauna were extracted by Macfadyen's (1953) expedition funnel apparatus with slight modifications.

The protozoans, tardigrades and rotifers were extracted from the freshly collected moss sample by floating this on a 50 ml glass Jar by following standard methods for each group. The methodology followed by Cobb's (1918) for sieving and decantation the Bermann funnel technique of Christic and Perry (1951) were used for extraction of nematodes.

LOCATION AND CHARACTERISTICS OF SAMPLING SITES

The sampling sites were located at Schirmacher Oasis, east Antarctica, where the Indian station 'MAITRI' is present (Lat. 70°44' 30"–70°46' 30" S and Long. 11°22' 44 "–11°54' 44" E). There are over 58 fresh water lakes at different sizes within the Oasis. 36 such lakes were chosen for the present study. Each sampling plot of moss turf was measured 5 m × 5 m areas in the periphery of the lakes. The lakes and the swampy areas have been categorised according to their location (Table 1) in respect of closeness to Polar ice caps (A) – 14 sites; Shelf ice (B) – 7 sites; and in between A & B (C) – 15 sites. The position in respect of Indian station such as east of Maitri (E) – 19 sites; west of Maitri (W) – 13 sites and north of Maitri (N) – 4 sites. The swampy areas have designated in this study it means this sites having a very little depth of water and smaller in size in comparison to the true lake areas.

Table 1. Showing the location, position of the collection sites and presence of fauna in different lake water systems.

Site	Location			Position			Fauna
	A	B	C	E	W	N	
1	+				+		+
2			+		+		+
3			+		+		+
4			+		+		+
5		+				+	
6			+		+		+
7	+				+		+
8			+		+		+
9	+				+		+
10	+				+		+
11			+		+		+
12			+		+		
13			+	+			
14			+	+			+
15			+	+			+
16			+	+			
17		+		+			
18		+		+			
19			+	+			
20	+			+			+
21	+			+			
22	+			+			+
23	+			+			
24	+			+			
25	+			+			
26	+			+			
27	+			+			+
28			+			+	+
29	+				+		
30			+	+			
31	+			+			
32		+				+	+
33		+				+	
34			+		+		+
35		+		+			+
36		+		+			+

Abbreviations used : A = Near to Polar ice cap; B = Near to Shelf; C = In between A & B; E = East of Maitri; W = West of Maitri; N = North of Maitri.

RESULTS

Faunal composition

It is evident from table 1, the invertebrate fauna were obtained from 20 localities out of 36 lake sites sampled during the investigation. The invertebrate fauna obtained from all the sites of Schirmacher Oasis are given in table (2).

The protozoans were most dominant and represented by 17 species followed by Nematoda comprising of 5 genera species. The Collembola, Acarina and Tardigrada each was represented by two genera species. The Rotifera was represented by only one species, viz., *Philodina gregarina*.

In connection with the analysis of Protozoan distribution in different lake system (Table 2) it has been observed that the maximum number of testacid protozoans (7 species) were obtained from the lake no. 28 followed by six species were recorded from the lake no. 34. *Oxytricha fallax* Stein and *Stylonychia* sp. (Ciliates) were recorded only from the lake no. 1. while *Assulina muscorum* Greef was most widely distributed species which obtained from seven different localities. The only rotifer species *Philodina gregarnia* was obtained from six different sites. From the Schirmacher Oasis only 2 species of tardigrades viz. *Hipsibius chilensis* (Plate) (3 localities) and *Macrobotus polaris* (Murray) (2 localities) have been collected so far during the present study. The Acarina was obtained from two localities (11 and 27) and the Collembola were also found in two localities (8 and 11) (Table 2).

Ecology of nematode population

The nematode fauna obtained from different sites of Schirmacher Oasis are shown in fig. 1. The genus *Tylenchorhyncus* was most dominant and its representation was 41% of the total nematode fauna obtained. The genus *Dorylaimoides*, *Drylaimellus* and *Paramylonchulus* contributed 27.87%, 18.83% and 12.52% respectively of total nematode fauna.

Population fluctuation

Fig. 2 showed that datewise changes in number of total nematode fauna recorded from different sites. The total nematode fauna had its highest peak on 27th January followed by 3rd January and minimum population were obtained during 25th February. The species wise fluctuation are given in Fig. 1. *Paramylonchulus* showed a steady population up to the end of January and declines gradually until it reaches minimum in the end of February. *Tylenchorhyncus* showed two clear peaks are on 3rd January and others on 27th January thereafter the population declines sharply from 1st February. *Dorylaimoides* and *Drylaimellus* were similar each with an early January and a late January peak in numbers.

Table 2. Contd.

SPECIES	L			A					K					E				S			
	1	2	3	4	6	7	8	9	10	11	14	15	20	22	27	28	32	34	35	36	No. of sites
<i>Stylopychis sp.</i>	+																				1
GR. B : ROTIFERA			+						+			+				+	+	+			6
<i>Philodina gregarina</i>			+						+			+				+	+	+			6
GR. C : TARDIGRADA			+					+								+	+				4
<i>Hypsibius chilensis</i> (Plate)			+					+								+					3
<i>Macrobiotus polaris</i> (Murray)			+														+				2
GR. D : ACARINA										+					+						2
<i>Tyrophagus sp.</i>										+											1
Fam : Scutacaridae										+					+						2
GR. E : COLLEMBOLA							+			+											2
<i>Cryptopygus sp.</i>							+														1
<i>Unidentified sp.</i>										+											1
GR. F : NEMATODA	+	+	+	+	+	+		+	+		+		+	+	+	+			+	+	15
<i>Drylaimellus sp.</i>	+															+			+		3
<i>Dorylaimoides sp.</i>				+								+	+								3
<i>Paramylonchulus</i>											+										1
<i>Tylenchorhynchus sp.</i>			+		+	+		+	+						+					+	7
<i>Aporcelaimellus sp.</i>		+																			1
No. of Species	5	6	6	5	1	1	1	5	4	6	5	1	1	1	4	10	5	7	6	1	

Vertical distribution

Depth wise distribution of mean population of nematodes obtained from different study sites reveals that maximum nematode fauna (76.65%) was recorded from upper most layer (0–5 cm). Monthly variation in the vertical distribution of nematode showed maximum in upper most layer during the month of January and February. *Paramylonchulus* was not found on 15.1.90 from both the layers. *Dorylaimellus* sp. were not found in 5–10 cm layer and the genus *Tylenchorhynchus* was absent in 5–10 cm layer. It is interesting to know that the relative abundance of nematode in the upper layer was associated with preponderance of immature forms (Fig. 3–5).

DISCUSSION

The results presented here are based on sample survey of 36 sample sites of Schirmacher Oasis.

The invertebrate fauna encountered in this study belong to 6 different groups, viz., Protozoa, Rotifera, Tardigrada, Nematoda, Acarina and Collembola. The protozoans were the most dominant invertebrate fauna in the present study. It was represented by 17 genera/species and occurred from 13 different localities. The genera like *Parmulina*, *Diffugia* (1 & 2), *Nebella*, *Oxytricha*, *Stylonychia* were obtained from a single site of different lake system. Therefore these species are highly restricted in their distribution pattern. On the contrary, *Assulina muscorum* and *Arcella arenaria* were found to be widely distributed in different localities of the lake system and may be termed as ubiquitous. This might be due to their capacity to utilize different food sources and microhabitats for survival (Addison, 1980). No ciliate species including the cosmopolitan soil inhabiting genus *Colpoda* has been recorded from swampy areas. The testacids *Corythion dubium* was found to be most dominant and cosmopolitan followed by *Assulina muscorum* and *Arcella* spp. This is worth mentioning here that all but one genus (*Parmulina* Penard) of Protozoa identified so far from Schirmacher Oasis are cosmopolitan soil and moss dwelling forms which are not only reported from maritime Antarctic and Sub-Antarctic zones but also from other parts of the globe. The Rotifera, Tardigrada, Acarina and Collembola were extracted significantly low in number. The distribution of these species were also restricted to only few sites. Rotifera were obtained from six different lakes, Tardigrades were collected from four sites and the Acarina and Collembola were obtained only from two sites (Table 2). This might be due to the fact that these groups are able to withstand extreme microfloral changes in the habitat.

The nematode fauna encountered in this study belong to 5 genera and obtained from 15 different localities of which *Tylenchorhynchus* sp. was most dominant species. Some genera markedly differ in this abundance from one site to other as well as one date to other date. The maximum nematode population were recorded at the end of January when the surrounding temperature were high and moss vegetation were in full grown stage. Thereafter, the population

starts declining and reached to a minimum number in the last week of February when low temperature was recorded. These findings are compatible to the observations of Maslen (1979, 1981) from Signi Island. He also observed maximum population density of nematodes during austral summer and low in winter.

It is evident from the table 1 that sixteen sites were devoid of any faunal components during the present investigation. This is presumably due to the presence of poor vegetational cover as most of these site were nearer to polar ice caps. This corresponds with the observation of Block (1966) who suggested direct correlations amongst the vegetational cover microflora and Acarina.

The changes in vertical disatribution pattern of nematode population showed higher proportion on the upper 5 cm layer of moss soil in the present study (Fig. 3–5). This is in consistence with the result of the earlier works of sub-Antarctic islands (Spaull, 1973 B and Maslen 1981). But it was not possible to ascertain in the present study whether the vertical distribution pattern was the same throughout the year as this study has been conducted during the limited period of summer months only. The reason for maximum aggregation of population in the upper layer during summer in Antarctic region might be related to the density of texture of moss which acts as a source of food for nematodes and other invertebrate fauna (Maslen, 1981) and the numerical variation of nematodes in different strata in different dates might be due to effects of temperature in the present study.

In general it is evident from the tables 1 and 3 that maximum number of invertebrate groups were obtained from lake no. 3 and 28. This might be due to the fact that, both the sites were located in area C (in between Polar ice cap and Shelf ice). It can be concluded from the present investigation that the nematodes were widely distributed invertebrate fauna and recorded from 15 different sites on the contrary the protozoans showed high species diversity with 17 genera/species distributed over 13 localities. This might be due to the reason that the colonization of Antarctic terrestrial environment considers habitat favourability as a function of its heterogeneity in both space and time (Walton, 1984).

Lastly, it might be inferred that the factorial components considered here, in conjunction with the other biotic and abiotic components not considered in this study, collectively contributed to the distribution and colonization of invertebrate fauna in Schirmacher Oasis.

ACKNOWLEDGEMENTS

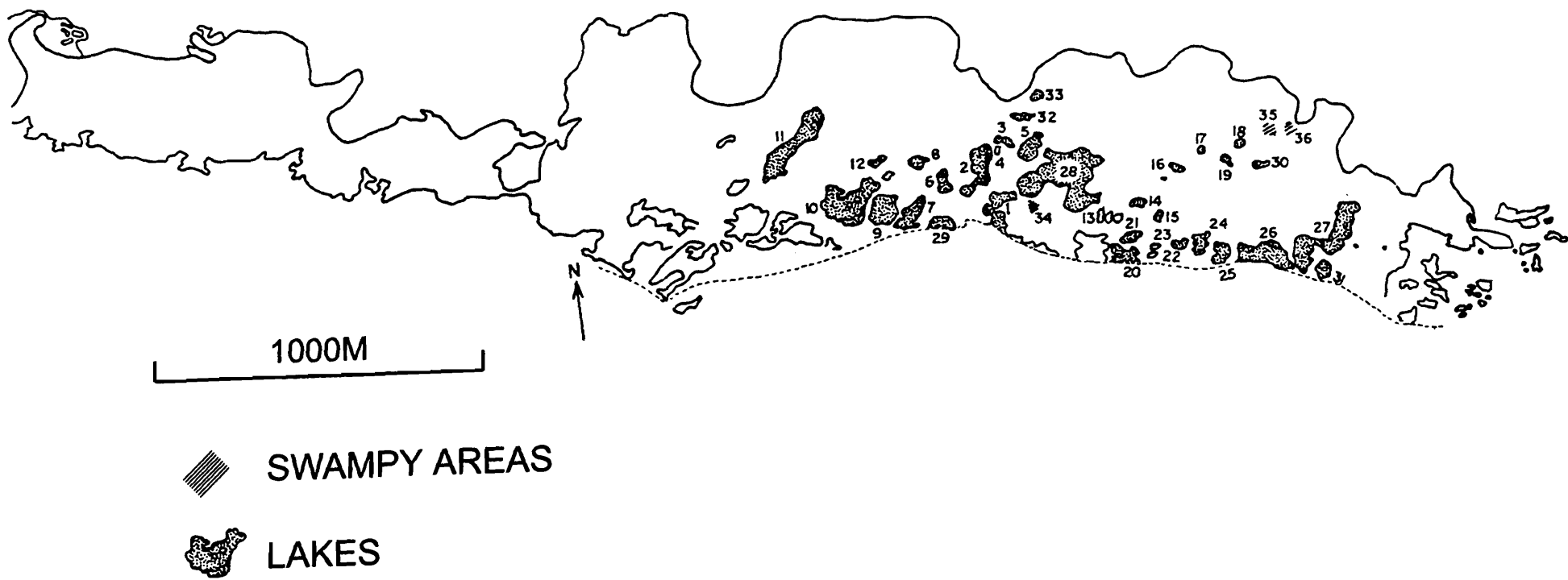
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Map 1. Sampling sites at Schirmacher Oasis.

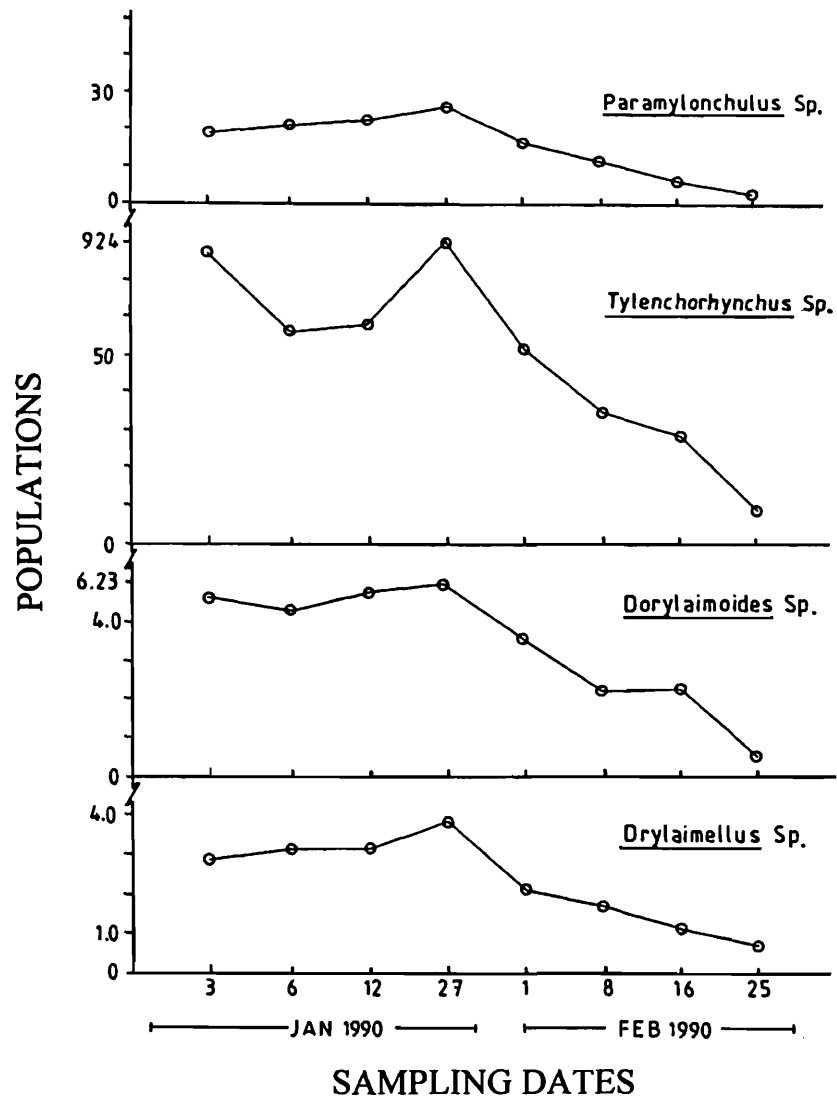


Fig. 1. Fluctuations of population of each nematode genus at Schirmacher Oasis (%).

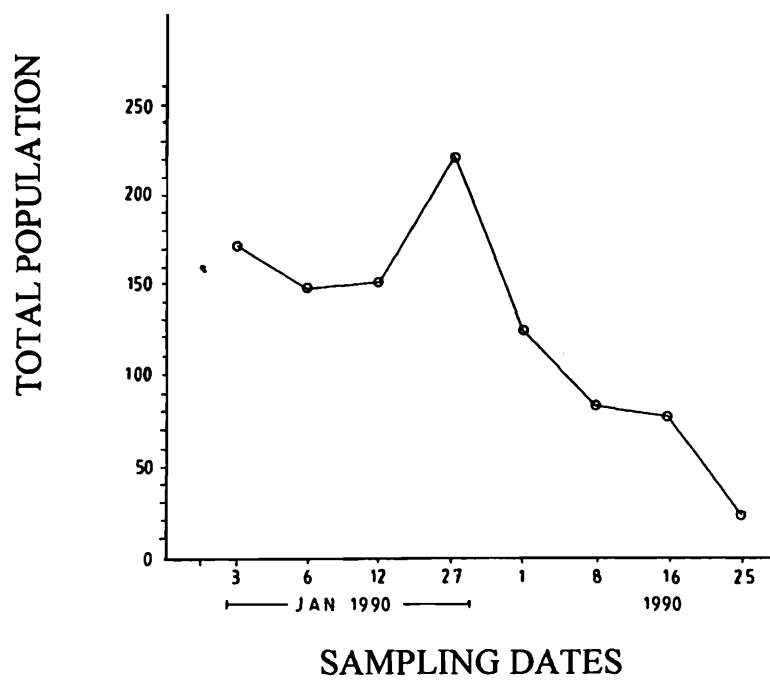


Fig. 2. Fluctuation of total nematode population at Schirmacher Oasis (%).

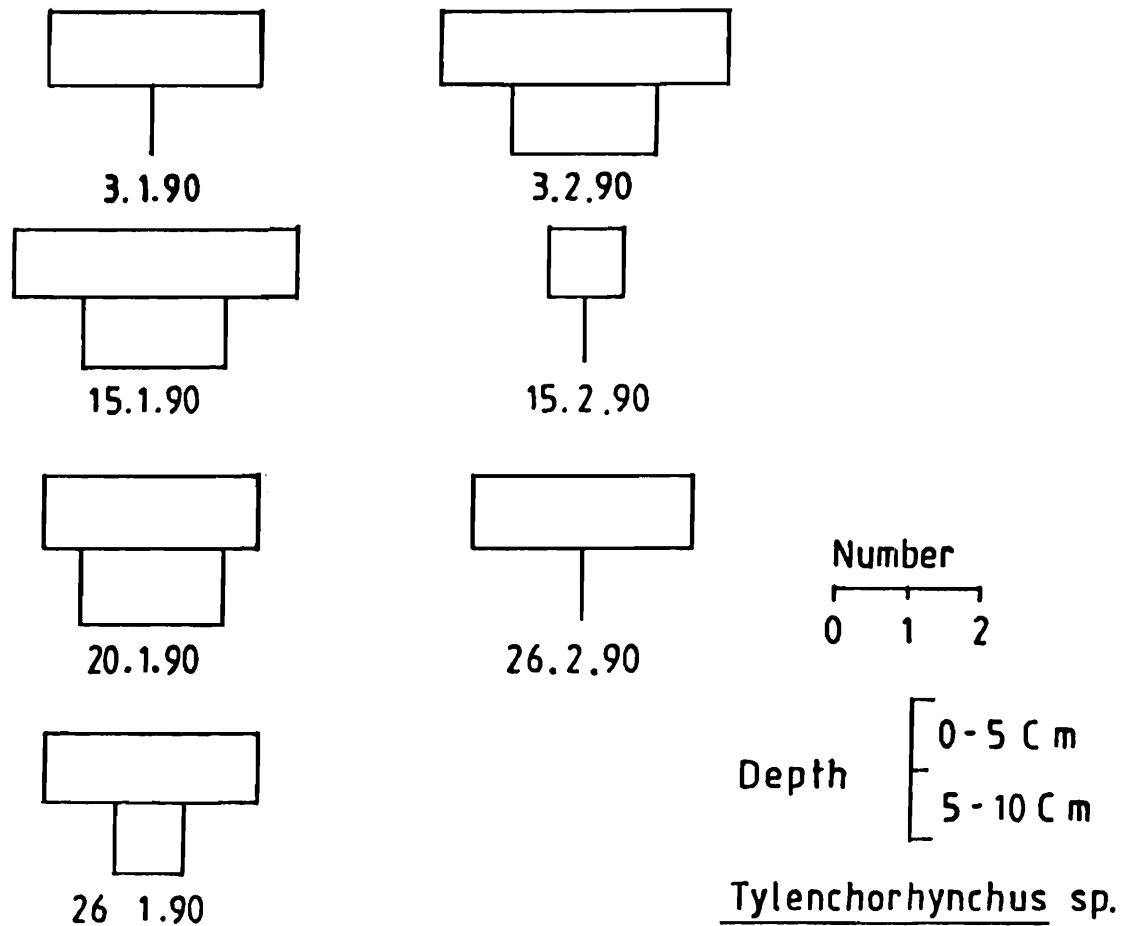


Fig. 3. Vertical distribution of *Tylenchorhynchus* at Schirmacher Oasis.

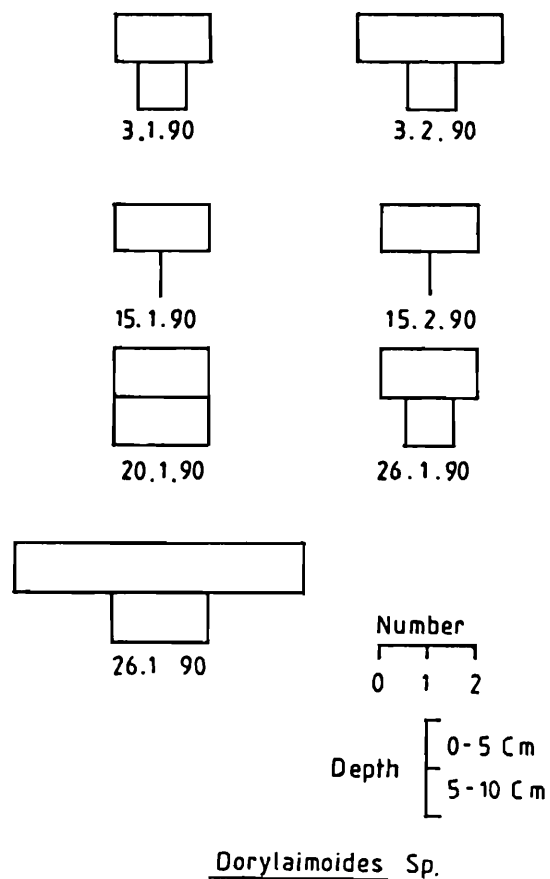


Fig. 4. Vertical distribution of *Dorylaimoides* at Schirmacher Oasis.

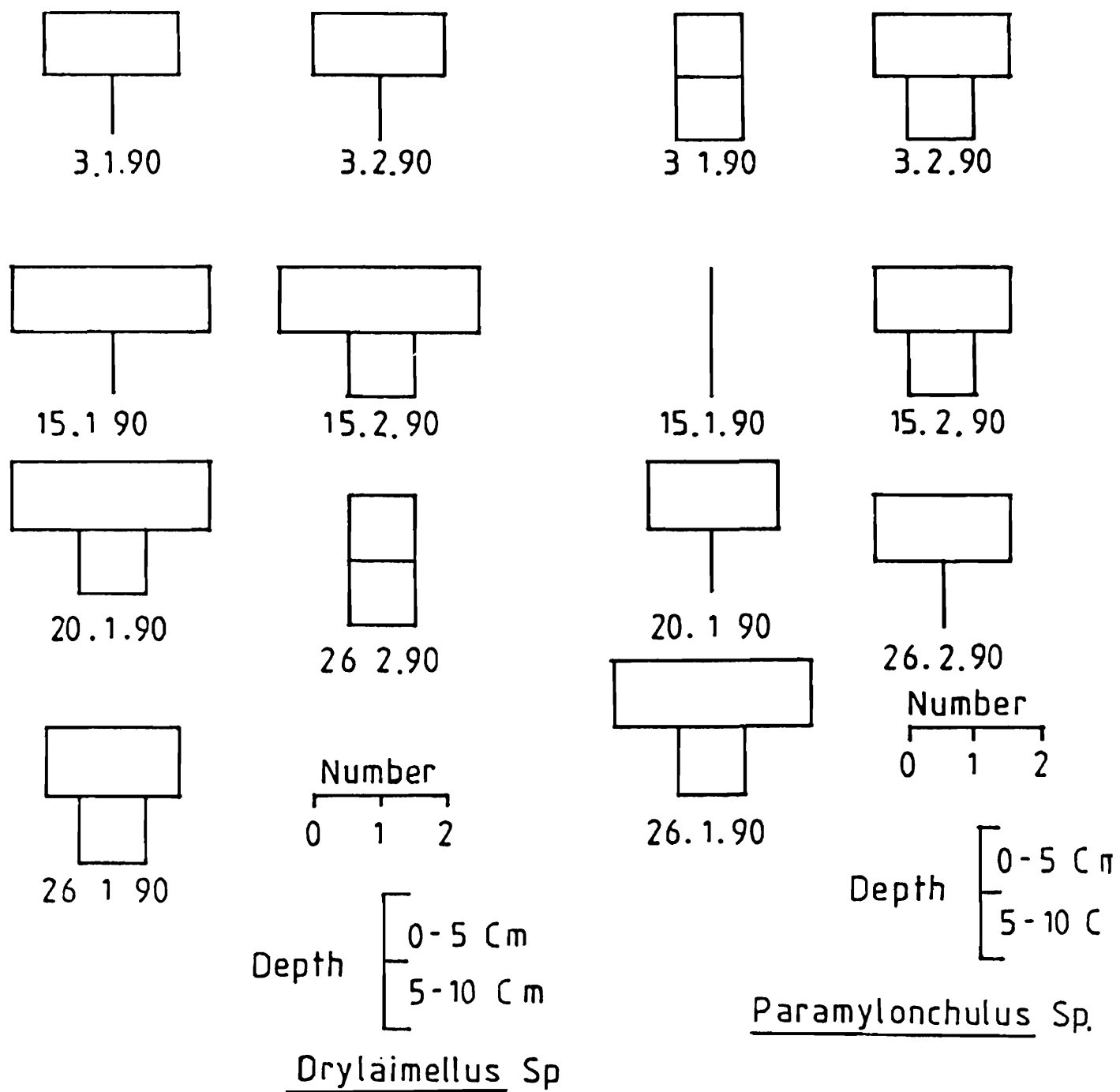


Fig. 5. Vertical distribution of *Dorylaimellus* and *Paramylonchulus* at Schirmacher Oasis.

PLATE I



A



B

A = Lake near to Polarice Cap
B = Lake near to sheef

ASSESSMENT OF THE HABITAT AND DIVERSITY OF MALACO-FAUNA OF KOSI RIVER SYSTEM, NORTH BIHAR

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INTRODUCTION

During recent years, there has been a growing recognition for better understanding of freshwater macroinvertebrate communities due to the important role played by them in the ecosystem dynamics, particularly at secondary trophic level. This has led to an increased effort to study their diversity, density and relationship with the physicochemical and biological characteristics of the habitat. Molluscs, which constitutes an important component of macroinvertebrate communities of both lotic and lentic habitats, not only form the food of many commercially important fishes but are also utilised by mankind in several ways.

In Bihar, although several studies have been carried out during recent past on physico-chemical and biological characteristics of some rivers (David and Ray, 1966; Pashwa and Mahrotra 1966; Nasar and Munshi, 1971; Bilgrami & Munshi, 1979 and 1985) and also on some aspects of molluscan ecology/ biology in lake and ponds (Rai *et.al.* 1981, Singh and Roy, 1991 Sinha, 1995), no attempt has been made to study the molluscan fauna with reference to physicochemical and biological properties of rivers of Kosi-Burhi Gandak System which are important rivers of North Bihar and major tributaries of River Ganga (Datta Munshi and Datta Munshi, 1991). Therefore, an attempt has been made during present investigations to study the general physico-chemical and biological characteristics of the water of the two rivers and the qualitative diversity of malacofauna at some selected site.

STUDY AREA :

The Kosi river system in North Bihar comprises of several smaller rivers, rivulets, dhars, flood plain lakes (*chaurs* and *mans*) and swamps. Samples for the study were collected from the following four selected stations of Rivers Burhi Gandak and Kosi as indicated in Fig 1.

Station I. Siluri Ghat (District Begusarai) : it is situated nearly 15 km away from Begusarai town, just below the Manjhaul bridge over river Budhi-Gandak.

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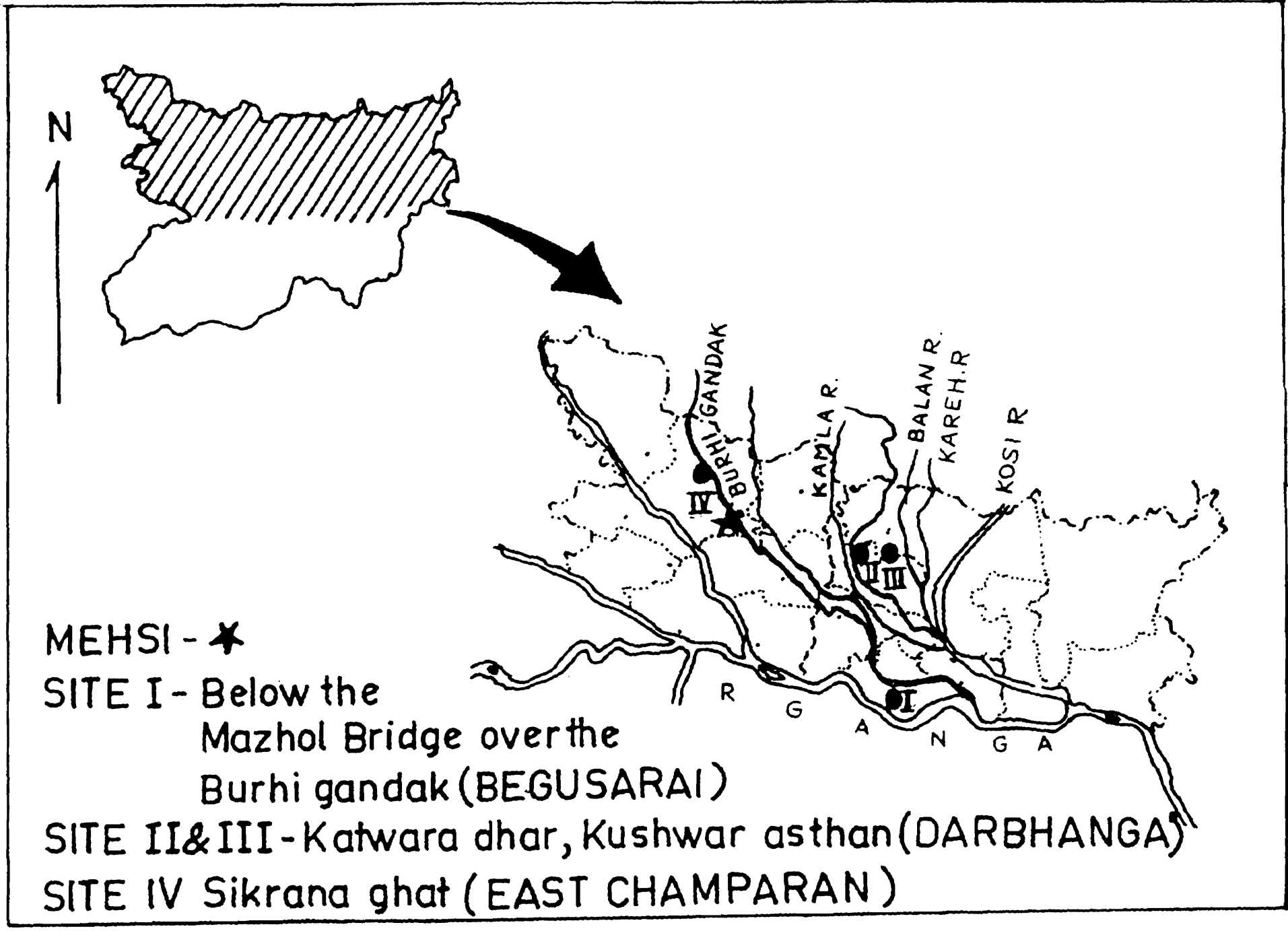


Fig. 1 : Map showing location of study sites, North Bihar drainage system.

Station II. Katwara Dhar (District Darbhanga) : It is about 50 km away from Darbhanga town on way to Kusheshwarsthan on river Jiwach, a comparatively smaller tributary of the Kosi system. This station was characterized by the occurrence of a diverse malacofauna.

Station III. Kusheshwarsthan (District Darbhanga) : This was an important site, situated nearly 60 km from Darbhanga town. This huge *chaur* (Ox-bow Lake) covers an area of about 500 acres. This is a perennial *chaur* receiving large quantities of water from several smaller tributaries of the river Kosi like Kamla, Balan, Kareh and Bagmati, beside Kosi.

Station IV. Sikrahana Ghat (District. East Champaran) This is situated about 145 km north-west of Kusheshwarsthan in the Mehshi block on Burhi Gandak river. This is an important site for the commercial shell fish collection as there are several Mother of Pearl button industries located here.

MATERIAL AND METHODS

The studies were conducted on seasonal basis during 1995-96. There are three defined seasons in this part of the country viz. summer (March-June), Monsoon (July – October) and winter (November-February). Samples were collected during different season from all the three sites. Samplings were done from the slow flowing zones of rivers having less current and from pools/ oxbow lakes/ beels and chaur. Data for the respective seasons of the two annual cycles are pooled together in order to have mean values.

Water samples for physicochemical analysis were collected from the surface (1 ft depth) manually with the help of a fisherman by filling the water slowly in a 250-ml glass bottle from the desired depth and lifting slowly after tightly fitting the stopper. Generally all samplings for both physico-chemical and biological parameters were done at sites of approximately 5ft depth. Sampling at all stations were done in the morning around 9.00 A.M. Temperature was measured by a glass thermometer, light intensity by a Lux meter and pH by a battery operated pH meter. Other parameters were determined following Standard method (APHA, 1991).

Quantitative samples of phytoplankton, collected by filtering 1 lit of water on a Whatman filter paper, were preserved in Lugol's solution. Counting was done major group wise by taking one-ml sample in the Sedgwick Rafter counting chamber and observing under a microscope.

Zooplankton was collected by plankton net made of No. 21 bolting cloth. Random tows were made several times and all samples collected were preserved in 4% formalin. Counting was done major group wise with the help of Sedgwick rafter counter under a stereo binocular.

Molluscan fauna was collected qualitatively both from littoral as well as benthic zones with the help of a drag net made of a rectangular iron frame of 0.5 x 0.5 m attached with a loose bag made of mosquito net cloth. The drag net was operated at the littoral zone and also in the bethic zones of the river in areas where depth did not exceed 5 ft, for a distance of about 5 meters and

all material collected were taken out. This procedure was repeated several times at different places. Samples from the deeper areas of the rivers were collected with the help of a fisherman who brought bottom soil in a cloth bag by diving. Live molluscan specimens were picked up from the macrophytes as well as soil. All samples from one site were mixed and preserved in 5% formalin. Dead shells were not taken into consideration. Samples were brought to the laboratory and sorted group-wise. Species identification was done following Subba Rao (1989).

Seasons were divided as summer (March-June) Monsoon (July-October) and winter (November-February).

RESULTS

1. Physicochemical characteristics of water quality

The mean seasonal values of different physicochemical parameters are given in Table 1. At Station 1 (River Burhi Gandak), the mean atmospheric temperature varied between 33.0 °C and 26.0 °C, lowest in winter and highest in summer. There was not much difference with surface water temperature excepting during winter season. Light intensity in surface zone ranged between 780 Lux (summer) and 230 Lux (monsoon) and varied between 480 and 260 at deeper zone. Light measurements during winter could not be carried out. pH of both, surface as well deeper zone were always acidic and ranged from 5.5 (summer) to 6.5 (winter) in surface water. Not many differences were noticed in the values of pH between surface and depth water. Conductivity ranged between 270 and 439 micromhos. Dissolved oxygen concentration ranged from 4.56 to 5.2 mg/l. Free carbon dioxide were also recorded in significant quantities and values ranged from 24.0 to 34.0 mg/l. While Carbonate alkalinity was recorded only from surface waters during winter season. Bicarbonates were recorded almost throughout the year. Exorbitantly high values (296 mg/l) were recorded during winter and only 16.0 mg/l was observed during monsoon. The values of chloride were comparatively low and fluctuated between 8.0 and 27.0 mg/l. The values were lowest during monsoon. The hardness of surface water during winter was about 169.6 mg/l, which decreased during following monsoon season (135 mg/l). The concentration of the nutrients, phosphate (PO₄-P) and Nitrate (NO₃-N) were moderate throughout the year. Highest values of phosphates were recorded during monsoon month (0.145 mg/l) and lowest during summer (0.03 mg/l). Contrary to these nitrates was high during summer (1.42 mg/l) and lowest during monsoon (0.05 mg/l). Calcium and magnesium ions were present in moderate quantities.

The physicochemical characteristics at Stations II, III and IV, barring few parameters, did not vary much (Tables 1). The value of silicates varied widely at different stations during different season. Exceptionally high values were recorded from Station I during monsoon (100 mg/l), which was accompanied by very high values of PO₄-P (0.145 mg/l). pH values were comparatively high at Station IV during summer (7.3), otherwise it ranged between 5.5 and 6.8 at different stations during different seasons.

Table 1. Physicochemical characteristics of the Surface water quality at different Stations of River Kosi/Burhi Gandak.

Parameters	Station I : Slurighat			Station II : Katwara Dhar			Station III : Kusheshwarsthan			Station IV : Sikhrana Ghat		
	Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter
Air												
Temperature °C	33	33	26	33	28	26.5	34	31	20.5	31	-	23.2
Water												
Temperature °C	32	32	22	32	31	22.5	29	30	22.5	29	-	21.5
Conductivity (umhos)	-	270	439	-	190	350	-	240	-	-	-	460
Ligh intensity (Lux)	780	230	-	660	260	-	1025	240	320	-	-	-
pH	5.5	5.5	6.5	6.8	6	5.2	6.1	6.5	6.5	7.3	-	5.5
Dissolved												
oxygen (mg/l)	4.8	4.56	5.2	6	3.6	5.2	2.2	4.48	9.2	5.6	-	6.9
Free CO ₂ (mg/l)	24	34.1	-	-	9.2	4.4	10.8	12.6	-	7.2	-	2
Carbonate (mg/l)	-	-	16.6	15	-	-	-	-	3	-	-	-
Bicarbonate (mg/l)	1.16	16	296	164	82	194	138	84	184	108	-	278
Chloride (mg/l)	27	8	11.6	14	9	11.2	12	6	7	29.48	-	7.6
Silicate (mg/l)	35.71	100	4.1	3.8	12.5	12	11.36	27.7	5.5	16.6	-	8
Phosphate,												
PO ₄ -P (mg/l)	0.03	0.145	0.06	-	0.14	0.18	-	0.01	0.2	0.02	-	0.28
Nitratate,												
NO ₃ -N (mg/l)	1.42	0.05	1.35	1.12	0.04	1.85	2.18	0.06	0.35	1.73	-	1.33
Total Hardness												
(mg/l)	-	135	169.6	-	85	103.6	-	125	170.8	-	-	120
CaH mg/l	-	105	120	-	55.5	72	-	100	115.2	-	-	-

2. Macrophytes

Table 2 shows the occurrence and relative abundance of various macrophytic species at different stations based on approximate eye estimation. The macrophytes were found to grow profusely, particularly in the slow flowing littoral region of the rivers, side pools and chauras. Eight important taxa of submerged/floating macrophytes were recorded which were present at all the stations. Although water hyacinth (*Eichhornia sp.*) was present at all stations during all seasons, it was found in great abundance in Kusheshwarasthan chaur (Station III). The other important flora was *Vallisneria sp.*, *Hydrilla sp.*, *Potamogeton sp.*, *Najas SP*, *Ceratophyllum sp.*, *Ipomea sp.*

Table 2. Occurrence and relative abundance of different macrophyte taxa at different stations of Kosi river system.

Taxa	Station -I Siurighat			Station-II Katwara Dhar			Station-III Kusheshwarsthan			Station-IV Sikhrana Ghat		
	S	M	W	S	M	W	S	M	W	S	M	W
<i>Eichhornia crassipes</i>	++	-	+	+++	+	++	+++	++++	+++	+++	+++	+
<i>Vallisneria sp.</i>	++	+	-	+++	+	+++	++	++	++	-	-	+
<i>Hydrilla sp.</i>	++	-	++++	++	++	+++	++	++	+++	+	++	+++
<i>Potamogeton sp.</i>	+	+	++	+	+	++	+	-	++	++	+	++
<i>Najas sp.</i>	++	-	++	+	-	++	-	++	++	-	-	-
<i>Ceratophyllum sp.</i>	+	+	++	-	-	++	++	-	++	-	-	++
<i>Jussia sp.</i>	-	-	+	+	+	+	+	+	+	+	+	++
<i>Scripus sp.</i>	+	+	-	+	-	++	++	+	-	+	+	+
<i>Ipomea sp.</i>	+	+	+	++	++	+	++	+	++	+	+	+

++++ Abundant; +++ - fairly common ; ++ Common, recorded in moderate numbers; + occasional; - absent.

3. Phytoplankton

The phytoplankton community of the river system was comprised of Chlorophyceae (green algae), Myxophyceae (blue green algae) and Bacillariophyceae (diatoms). Table 3 gives a combined list of various taxa recorded from different stations. A total of 32 taxa were recorded during the entire course of the study. There were not many differences in the qualitative diversity of phytoplankton either at different stations or during different seasons. The green algae were

Table 3. List of Phytoplankton taxa recorded from different study stations of rivers Kosi river system.

Chlorophyceae	Myxophyceae	Bacillariophyceae
<i>Chlorococcus sp.</i>	<i>Microcystis aeruginosa</i>	<i>Cymbrella cymbiformis</i>
<i>Volvox sp.</i>	<i>Oscillatoria sp.</i>	<i>Nitzschia sp.</i>
<i>Chlorella vulgaris</i>	<i>Spirulina sp.</i>	<i>Gomphonema sp.</i>
<i>Scenedesmus quadricula</i>	<i>Anabaena sp.</i>	<i>Melosira ambiguans</i>
<i>Eudorina sp.</i>	<i>Aphanizomenon sp.</i>	<i>Pinnularia sp.</i>
<i>Panorina sp.</i>	<i>Phormidium sp.</i>	<i>Synedra sp.</i>
<i>Cosmarium sp.</i>	<i>Nostoc sp.</i>	<i>Diatomella sp.</i>
<i>Closterium monoliferum</i>	<i>Gleotrichia sp.</i>	<i>Naviculla sp.</i>
<i>Zygnema sp.</i>		<i>Tabellaria sp.</i>
<i>Mougeotia sp.</i>		<i>Asterionella sp.</i>
<i>Hydrodictyon sp.</i>		<i>Fragilaria sp.</i>
<i>Oedogonium sp.</i>		
<i>Spirogyra sp.</i>		

represented by 13 taxa, followed by diatoms -11 taxa-and lowest number belonged to blue green algae (8 taxa).

The phytoplankton density (number /l) ranged from 84/l to 2082/l at station I, 113/l –2061/l at Station II and 105/l-2471/l at Station III. Plankton sampling from Station IV, Sikhrana Ghat was done only during winter and mean density for the season was recorded as 1473/l (Table 4). Highest density was recorded during summer seasons and lowest during monsoon at all stations from where samplings were done for all seasons. While green algae dominated at Station-I in all seasons, blue green algae were the dominant component during summer at Stations II and III. During monsoon season diatoms were in abundance at both Station I and II. Highest concentration of blue green algae was recorded from the slow flowing chaur of Kusheswarsthan (Station-III).

4. Zooplankton

The zooplankton community of the rivers were composed of four important groups viz. Protozoa, Rotifera, Cladocera (Crustacea) and Copepoda (Crustacea). Altogether 27 taxa were recorded during the course of the study from all stations (Table 5). The Rotifers, represented by the largest number of species (13), were dominated by the species belonging to brachionid genera *Brachionus* and *Keratella*. Protozoan was represented by 6 species belonging to genera *Arcella*, *Diffugia* and *Centropyxis*. Only few taxa-5 and 3 represented the Cladocera and Copepoda respectively.

Table 4. Seasonal variations in mean density (no/l) and relative composition (%) of major groups of phytoplankton at different stations of Kosi river system (*S- Summer, M- Monsoon, W- Winter*) - *indicates no sampling.*

	Station -I Siurighat			Station-II Katwara Dhar			Station-III Kusheshwarsthan			Station-IV Sikhrana Ghat		
	S	M	W	S	M	W	S	M	W	S	M	W
Numerical												
Density (no/l)												
Myxophyceae	260	11	60	836	11	60	1691	26	510	-	-	640
Chlorophyceae	1041	45	452	557	34	452	130	17	432	-	-	385
Bacillariophyceae	781	28	113	668	68	113	650	62	240	-	-	448
TOTAL	2082	84	625	2061	113	625	2471	105	1182	-	-	1473
Relative composition(%)												
Myxophyceae	12.5	13.1	9.6	40.6	9.0	9.6	5.3	24.8	43.2	-	-	43.4
Chlorophyceae	50.0	53.6	72.3	27.0	30.1	72.3	26.3	16.2	36.5	-	-	26.1
Bacillariophyceae	37.5	33.3	18.1	32.4	60.2	18.1	26.3	59.0	20.3	-	-	30.4

The zooplankton density ranged between 33/l -470/l at Station-I, 50/l -2454/l at Station II and 27/l -1953/l at Station III, highest during summer and lowest in monsoon at all the three stations. The mean density at Station-IV during winter was 403/l. The highest density was at Station-II during all seasons. Except during monsoon season at Station-II, Rotifers dominated the zooplankton composition at all stations during all seasons and their percentage composition was above 32%. Rotifers were followed by Cladoceran, which contributed, between 26-46% to the total zooplankton. The contribution of Copepods was also moderate Table 7.

5. Malacofauna

A total of 32 species of Mollusca comprising 16 species each of Gastropoda and Bivalvia were recorded from all the stations during the entire course of study. Table 8 enlists various species recorded from different stations during different seasons. Gastropods were represented by the families Viviparidae (3 species), Pilidae (1 species), Bithynidae (3 species), Thiariidae (4 species), Lynnaeidae (2 species) and Planorbidae (3 species). Bivalves were represented by the families Unioidea ((3 species), Amblemidae (11 species/subspecies), Corbiculidae (1 species) and Pisidiidae (1 species). The number of species at various stations during different seasons varied between 14 and 29. Highest number was recorded from Station II and lowest from Station III. Overall highest

Table 5. List of Zooplankton taxa recorded from different study stations of Kosi river System.

Protozoa	Rotifera	Cladocera	Copepoda
<i>Arcella megastoma</i> Penard	<i>Brachionus angularis</i> Gosse	<i>Diaphanosoma sp.</i>	<i>Diaptomus sp.</i>
<i>Arcella discoides</i> Ehrenberg	<i>Brachionus caudatus</i> Fadeev	<i>Daphnia carinata</i> King	<i>Cyclops sp.</i>
<i>Diffugia lebes</i> Penard	<i>Brachionus diversicornis</i> (Daddy)	<i>Bosminopsis sp.</i>	<i>Mesocyclops edex</i>
<i>Diffugia lobostoma</i> Leidy	<i>Brachionus forficula</i> Wierzejski	<i>Chydorus sphaericus</i> (O.F.Muller)	
<i>Centropyxix ecornis</i> (Ehrenberg) Leidy	<i>Brachionus plicatus</i> Muller	<i>Alona sp.</i>	
<i>Centropyxix arcelloides</i> Penard	<i>Keratella cochlearis</i> (Gosse)		
	<i>Keratella quadrata</i> (Muller)		
	<i>Keratella tropica</i> (Apstein)		
	<i>Lecane (L) luna</i> (Muller)		
	<i>Filinia longiseta</i> (Ehrenberg)		
	<i>Hexarthra sp.</i>		
	<i>Polyarthra sp.</i>		

species richness was observed during winter months at all stations and lowest during monsoon. There were not much significant differences in the species richness of different stations during any particular season. Both, Gastropods and Bivalves appeared to contribute almost equally in term of number of species at all stations (Fig. 2).

The approximate qualitative estimation of the abundance (eye estimation) of various species revealed the dominance of *Bellamya bengalensis*, *Pila globosa*, *Thiara (M.) tuberculata*, *Bortia costula* and *Gyraulus convexiusculus* among Gastropods and *Lamellidens corrianus*, *L. jenkinsianus*, *L. marginalis*, *Parreysia (P.) favidens* and *P. (P.) corrugata* among Bivalves at almost all the stations throughout the year.

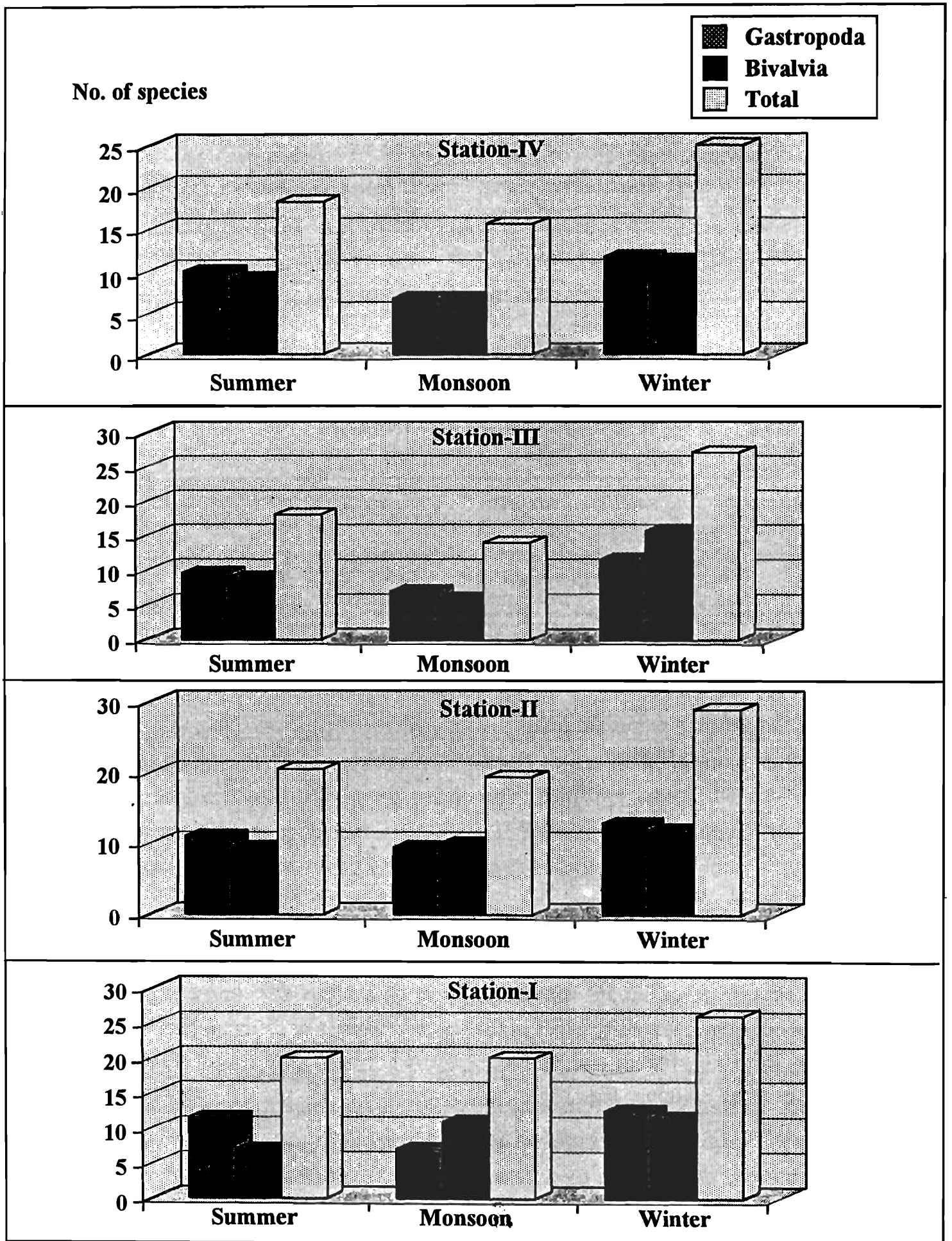


Fig. 2. Seasonal variations in the molluscan species richness at different Stations of Kosi river system.

Table 6. Seasonal variations in mean density (no/l) and relative composition (%) of major groups of phytoplankton at different stations (*S*–*Summer*, *M*–*Monsoon*, *W*–*Winter*)—*indicates no sampling*.

	Station -I Siurighat			Station-II Katwara Dhar			Station-III Kusheshwarsthan			Station-IV Sikhrana Ghat		
	S	M	W	S	M	W	S	M	W	S	M	W
Numerical Density (no/l)												
Myxophyceae	260	11	60	836	11	60	1691	26	510	–	–	640
Chlorophyceae	1041	45	452	557	34	452	130	17	432	–	–	385
Bacillariophyceae	781	28	113	668	68	113	650	62	240	–	–	448
TOTAL	2082	84	625	2061	113	625	2471	105	1182	–	–	1473
Relative composition(%)												
Myxophyceae	12.5	13.1	9.6	40.6	9.0	9.6	68.4	24.8	43.2	–	–	43.4
Chlorophyceae	50.0	53.6	72.3	27.0	30.1	72.3	5.3	16.2	36.5	–	–	26.1
Bacillariophyceae	37.5	33.3	18.1	32.4	60.2	18.1	26.3	59.0	20.3	–	–	30.4

Table 7. Seasonal variations in mean density (no/l) and relative composition (%) of major groups of zooplankton at different stations of Kosi river system. *S*–*Summer*, *M*–*Monsoon*, *W*–*Winter*—*indicates no sampling*.

	Station -I Siurighat			Station-II Katwara Dhar			Station-III Kusheshwarsthan			Station-IV Sikhrana Ghat		
	S	M	W	S	M	W	S	M	W	S	M	W
Numerical Density (no/l)												
Protozoa	40	–	–	260	5	–	390	4	43	–	–	35
Rotifera	260	16	45	991	11	45	781	11	60	–	–	280
Cladocera	130	11	23	591	23	23	521	6	48	–	–	58
Copepoda	40	6	11	612	11	11	261	6	32	–	–	30
TOTAL	470	33	79	2454	50	79	1953	27	183	–	–	403
Relative composition(%)												
Protozoa	8.5	–	–	10.6	10.0	–	20.0	14.8	23.5	–	–	8.6
Rotifera	55.3	48.5	57.0	40.4	22.0	57.0	40.0	40.7	32.8	–	–	69.5
Cladocera	27.7	33.3	29.1	24.1	46.0	29.1	26.7	22.2	26.2	–	–	14.5
Copepoda	8.5	18.2	13.9	24.9	22.0	13.9	13.3	22.2	17.5	–	–	7.4

DISCUSSION

Rivers, lakes, floodplain wetlands (beels , chaur, Mans) and ponds etc with suitable water quality and luxuriant growth of macrophytes possess diverse assemblage of macroinvertebrate fauna, particularly insects and molluscs. In fact, the health of an aquatic ecosystem can be judged by the variety of macrophyte associated and benthic macroinvertebrate communities. Molluscs, which are an integral component of both types of habitats viz., macrophyte associated as well as littoral benthic, play an important role in the trophic dynamics of the ecosystem by forming a sizable component of food for a variety of fishes.

From the analysis of general physico-chemical parameters of water quality at different study stations of Kosi River system, it was fairly evident that the quality was reasonably good at most of the stations throughout the year. This was quite expected as there were no apparent sources of any pollution / degradation excepting the profuse growth of water hyacinth at certain points which might have prevented the oxygen assimilation. However, the impact was not visible. Similarly all stations were characterised by the abundant growth of diverse macrophytes. The running water of the river system had sufficient vegetation, even during monsoon months when most of the macrophytes are uprooted, though in reduced density. This has resulted in diverse assemblage of molluscan fauna throughout the year at all stations. High species richness of malacofauna in clean or unpolluted freshwaters of this region has also been reported by several earlier workers (Rai *et al.*, 1981; Baruah, 1995; Sinha, 1995). Singh and Roy (1991) reported the abundance of molluscs in Kowar Lake, Bihar, which was related to abundant growth of macrophytes. Thick strands of *Ceratophyllum*, *Eichhornia*, *Hydrilla*, *Potamogeton* and *Phragmites* are known to harbour a variety of Gastropod fauna because of their bushy roots. The bushy roots and submerged leaves provide shelter and suitable space for Gastropods to remain attached. These also act as spawning places for many species of Gastropods.

Besides macrophytes, the distribution and abundance of molluscan fauna in freshwater habitat has been related to several other physico-chemical and biological factors, like temperature, rainfall, flooding, dissolved oxygen, nature of bottom sediment and availability of food (Macon, 1950; Peter, 1968; Roy *et al.*, 1988; Subba Rao, 1989). The moderate temperature, pH, alkalinity, carbonates, hardness, nitrate, phosphate and availability of Ca⁺⁺ in sufficient quantity together with abundant phyto and zooplankton were definitely responsible for the flourishing populations and communities of molluscs at all stations.

There were significant differences in the habitat preferences of Gastropods and Bivalves at all stations, both lotic as well as lentic (Station-III, Kusheshwarsthan-a Chaur). While most of the Gastropods adults as well juveniles, except large sized *Bellamya* and *Pila*, preferred macrophytes strands, most of Bivalves preferred the sandy soil of the littoral zones.

It was observed that most of the species of both Gastropods and Bivalves occurred in littoral regions and their availability at the bottom of open water was markedly poor. This phenomenon

could be observed in the deep *chaur* of Kusheshwarsthan. The dredge samples from open and comparatively deeper waters had very few Bivalves. This indicated the suitability of littoral zones of both running as well as confined freshwaters for the growth of the natural molluscan population. Further, in *dhars* and rivers too Bivalves were caught with dredges in considerable numbers at the banks. However, the bottom of the macrophytes choked littoral zones at certain places in relatively confined waters, were not found to be a very suitable habitat as these harboured very few species. Other workers have also observed such phenomenon. Peter (1968) observed that in the eutrophic waters of weed choked shallow basin, the benthic fauna usually leave the bottom due to hypoxic or anoxic conditions prevailing therein. In such zones faunal assemblage increases considerably at macrophyte strands (Kumar, 1985). Thus it can be concluded that diversity and density of molluscs depend upon not only macrophyte biomass but also the extent and quality of littoral zones. Another reason why littoral macrophytic zones harboured greater variety and density of malacofauna was the abundant availability of phyto and zooplankton, which formed the basic food of most of the species.

As reported by some workers (Macon, 1950), it was also observed during present investigations that atmospheric temperature exerted a great influence on the seasonal variations in the diversity and density of molluscan community which in turn controlled their metabolic and reproductive activities. The seasonal variation in the distribution and abundance of malacofauna of this river system was well defined because of clearly demarcated temperature regimes during different seasons. Maximum number of species and relatively higher numerical density and biomass were observed during winter season at all stations. Significant lowering of atmospheric temperature, which in turn created optimum environmental conditions, facilitated this. The macrophytes also flourished during this season, which had direct impact on molluscan diversity and density.

SUMMARY

The Assessment of physicochemical and biological properties of some important riverine stretches and floodplain lakes (Chaur) of Kosi River system in North Bihar, India in relation to the distribution and abundance of molluscan fauna was carried out during 1995-96. Four sites, viz. Siuri Ghat, and Sikrana Ghat on river Burhi Gandak, Katwara Dhar on river Jiwach (a small tributary of Kosi) and a floodplain wetland, Kusheshwarsthan *Chaur* located between tributaries Jiwach and Balan were selected for the study. Samplings were done on seasonal basis. The physico-chemical quality of water was reasonably good at most of the stations throughout the year as there was no apparent source of any pollution/degradation. The macrophytes were found to grow profusely, particularly in the slow flowing littoral region of the rivers, side pools and chaur. Eight taxa of submerged/floating macrophytes were recorded which were present at all study stations. The phytoplankton of the river system was comprised of 32 taxa belonging to Chlorophyceae, Myxophyceae and Bacillariophyceae. The density (number /l) ranged from 84/l to 2471/l. The zooplankton community was composed 27 taxa belonging to of Protozoa,

Rotifera, Cladocera and Copepoda. The Rotifers, represented by the largest number of species (13), were dominated by the species of brachionid genera *Brachionus* and *Keratella*. The Cladoceran and Copepods were represented by only few taxa. The zooplankton density ranged between 33/l–2454/l, highest during summer and lowest during monsoon. A total of 32 species of Mollusca comprising 16 species each of Gastropoda and Bivalvia were recorded during the entire course of study. The number of species at various stations during different seasons varied between 14 and 29. Highest at Station II and lowest at Station III. Overall highest species richness was observed during winter months at all stations and lowest during monsoon. The approximate qualitative estimation of the relative abundance of various species revealed the dominance of *Bellamyia bengalensis*, *Pila globosa*, *Thiara (M.) tuberculata*, *Bortia costula* and *Gyraulus convexiusculus* among Gastropods and *Lamellidens corrianus*, *L. jenkinsianus*, *L. marginalis*, *Parreysia (P.) favidens* and *P.(P.) corrugata* among Bivalves at almost all the stations throughout the year. The considerably good water quality and abundance of varied macrophytes were responsible for the diverse assemblage of malacofauna in sufficient numbers at all stations.

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POPULATION DENSITY, BIOMASS AND CALORIFIC VALUES OF FRESHWATER BIVALVE, *PARREYSIA FAVIDENS* (BENSON) OF KOSI RIVER BASIN, NORTH BIHAR, INDIA

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INTRODUCTION

Freshwater bivalves, which are an important component of the macroinvertebrate fauna, play a very significant role in the trophic dynamics of the ecosystem. They occupy almost a middle position in the food chain and transfer energy from primary producers to the consumers of higher order at secondary productivity level. Because of this, it is extremely important to assess their density, biomass and calorific values in order to understand their specific role in the energy dynamics of the ecosystem.

Although studies on the population and production ecology of freshwater bivalves are considerably meagre as compared to marine bivalves, several important reports are available from temperate region (Negus, 1966; Magnin and Stanczykowska, 1971; Ravera and Sprocati, 1997). In India practically no work has been done on freshwater bivalves and there is a general dearth of literature, particularly from this part of the country excepting the report of Sharma *et al.* (1996) on the biomass of molluscs of Katwara lake wetland, Bihar. However, some reports on the bioenergetics of other freshwater insects are available (Roy and Datta Munshi, 1983; Prakash *et al.* 1996).

The bivalve fauna of the river of North Bihar belonging to Kosi-Gandak River System is very rich, both qualitatively and quantitatively. Several species of bivalves occur abundantly in rivers, rivulets, channels, floodplain wetlands (*Chauras, Mauns*), and rainwater impoundments. These bivalves are commercially utilised by local population since time immemorial for making mother of pearl button, ornaments and other decorative material. Besides these are also used for making medicine, poultry feed, lime etc.

Keeping in view their importance in the region and paucity of information, detailed long-term studies on their biology, ecology and productivity were undertaken. The present paper, which is a part of the detailed work, deals with the population density, biomass and calorific values of an

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important bivalve species, *Parreysia favidens* (Benson) from two rivers of Kosi River System viz. Budhi Gandak and Jiwach.

MATERIAL AND METHOD

The sampling was done from one site of the river Budhi Gandak, **Siuri Ghat** (Begusarai District) and one site of river Jiwach, **Katwara Dhar** (Darbhanga district) in Kosi river basin, during summer (March–June) and winter (November–February) seasons of 1997. The details of the study stations have already been described (Begum and Khan, 2002). Qualitative and quantitative collection of bivalves were done by placing a wooden frame of 30 cm x 30 cm in the littoral zone of the river in slow flowing zones. All bivalves in the frame were hand picked and live specimens of *P. favidens* were separated and brought to laboratory, cleaned thoroughly, counted and weighed individually with shell. The shells were then removed and the flesh were weighed to obtain shell free wet weight. They were then dried in an oven for several hours at 60 °C till constant weights were obtained. The loss in weight between the dry weight and wet weight represented the amount of water.

For the determination of calorific value, the dried samples were homogenized with a mortar and pestle and the homogenate was mixed with distilled water and a semidried paste was prepared. Pellets were made from this paste using a pellet-forming machine, which were again dried in oven for at least 24 hours before burning in an oxygen bomb calorimeter. Three replicate determinations were done for each sample. The ash contents in the sample were determined by weighing the residual in the cup left after burning. Before pressurization, the bomb was flushed with oxygen to remove the nitrogen from the bomb. Taking into account the ash content of the sample, the ash free energy values were calculated.

The energy contents of the sample was determined according to following formula derived from the heat balance equation :

$$W_g = \frac{W_w(t_n + C - t_o) - b}{G}$$

Where,

W_g = Calorific value of the sample

W_w = Net calorific value of the calorimeter system, i.e. water equivalent of the calorimeter
= 2390

T_n = Final temperature of the control period

C = Correlation for radiation = 0.79

G = Weight of the sample in GM.

RESULTS AND DISCUSSION

Population Density and Biomass

The population density of *Parreysia favidens* was found to 28.80/sqm in summer and 54.40/sqm in winter at Siuri Ghat. At Katwara Dhar the respective values for summer and winter were 37.28/sqm and 41.62/sqm (Table 1).

The dry weight biomass values for summer and winter at Siuri Ghat were 120.96 g/sqm and 16.59 g/sqm respectively. At Katwara Dhar the values were 156.57 g/sqm during summer and 12.68 g/sqm during winter (Table 1).

The pattern of both density and biomass was similar, low density and high biomass during summer and high density and low biomass during winter. Low density and high biomass during summer was due to the abundance of bigger sized individuals as the period coincided with the maturity of gonads and breeding season. Contrary to this higher density and lower biomass during winter was due to the abundance of newborn individuals in the population.

Calorific value

The calorific values *P. favidens* was found to be 6.55 kcal/g dry weight. The calorific value for ash free dry weight was worked out to be 7.0306-kcal/g dry weight. At Siuri Ghat calorific values per unit area were found to be 793.255 kcal/sqm during summer and 108.797 kcal/sqm during winter. At Katwara Dhar, the respective values for summer and winter were 1026.786 kcal/sqm and 83.155 kcal/sqm. The calorific value for ash free dry weight was found to vary between 847.613 and 119.955 at Siuri Ghat and between 1132.160 and 91.727 kcal/g ash free dry weight (Table 1).

Working on the productivity of insects, Roy and Munshi (1993) reported that the calorific values of these animals depend considerably on their fat contents and to a lesser extent on non-fatty substance. The higher calorific value of *P. favidens* during summer was also due to stored

Table 1. Density, biomass and calorific values of *Parreysia favidens* in rivers Burhi Gandak and Jiwach of Kosi river basin during summer and winter.

Sites	Season	Density (no/sqm)	Dry weight Biomass (g/sqm)	Calorific value Dry weight (kcal/sqm)	Calorific value ash free dry weight (kcal/m ²)
Siuri Ghat	Summer	28.80	120.96	793.355	874.613
Budhi Gandak River	Winter	54.40	16.59	108.770	119.955
Katwara Dhar	Summer	35.28	156.57	1026.786	1132.160
Jiwach river	Winter	40.60	12.68	83.155	91.727

food material specially lipids and proteins, which the mussels accumulate in their body during the maturation and breeding phase. The high productivity of the macro-invertebrates in general at Katwara Dhar during summer has been reported by Singh (1993) who found the highest productivity during Summer (May and June) and lowest during monsoon (July and August). Since no sampling was done in monsoon month during present investigations, the conclusion of Singh (*op.cit.*) seems applicable for *P. Favidens* too.

SUMMARY

Population density, biomass and calorific values of an important bivalve species, *Parreysia favidens* (Benson), from two rivers of Kosi River Basin. North Bihar, viz. Budhi Gandak and Jiwach, were worked out during summer and winter seasons of 1997. The density was found to be 28.80/sqm in summer and 54.40/sqm in winter at Siuri Ghat and 37.28/sqm in summer and 41.62/sqm in winter at Katwara Dhar. The dry weight biomass values for summer and winter at Siuri Ghat were 120.96 g/sqm and 16.59 g/sqm respectively. At Katwara Dhar these values were 156.57 g/sqm for summer and winter respectively. Low density and high biomass during summer was due to the abundance of bigger -sized individuals as the period coincided with the maturity of gonads and breeding season. Contrary to this higher density and lower biomass during winter was due to the abundance of newborn individuals in the population. The calorific values *P. favidens* was found to be 6.55 kcal/g dry weight and 7.0306 kcal/g ash free dry weight. The higher calorific value during summer was due to stored food material specially lipids and proteins, which the mussel accumulates in their body during the maturation and breeding phase.

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NOTE ON ZOOGEOGRAPHY OF ODONATA (INSECTA) OF NICOBAR ISLANDS, INDIAN OCEAN

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INTRODUCTION

The Nicobar group of islands is comprised of twenty two islands with an area of total landmass of about 1840 sq. km. The extreme length of space occupied by this group of islands is about 210 km. and the extreme width is about 60 km. Among these islands the Great Nicobar is the largest with an area of about 1045 sq. km. The distance between the northern point of these islands and the southern point of the Andaman group of islands is about 135 km.; similarly the distance of the southern tip of the Great Nicobar from the northern tip of Sumatra is also approximately 135 km.

Physically these islands are young fold mountains, with Cretaceous rocks, a continuation of Arakan-Yoma of Burma (Myanmar). According to geological records these islands first appeared from the ocean-bed about 110 million years ago in the Mesozoic period, and have undergone several periods of partial submergence and elevation since their appearances. So that the terrestrial fauna has never been wiped out. The islands experience hot and dry tropical climate, and are largely covered by evergreen rain forests. But they actually lack fresh surface waters which usually act as breeding grounds of odonates.

The object of the paper is to report a list of Odonata known so far from these islands, with a note on the composition of odonate fauna and their affinities with the fauna of different zoogeographical regions and nearby lands.

HISTORICAL REVIEW

Selys (1853) first reported Odonata fauna from Nicobar islands. Later Hagen (1858, 1867), Selys (1863, 1877), Brauer (1864, 1865, 1867), Laidlaw (1917), Fraser (1933, 1934, 1936), Chhotani *et al.* (1983), Tikader and Das (1985), Mitra and Maiti (1992), Lahiri and Mitra (1993), Mitra (1995) and Hämäläinen *et al.* (1999) contributed on various aspects of odonatology of the Nicobar islands.

LIST OF ODONATA OF NICOBAR ISLANDS

Order ODONATA

Suborder ZYGOPTERA

Family *Chlorocyphidae**Libellago aurantiaca* (Selys)*Libellago lineata blanda* (Selys)Family *Platycnemididae**Copera vittata serapica* HagenFamily *Coenagrionidae**Pseudagrion pruinatum pruinatum* (Burmeister)*Pseudagrion williamsoni* Fraser*Pseudagrion andamanicum* Fraser*Ceriagrion olivaceum* Laidlaw*Ceriagrion auranticum auranticum* Fraser*Ceriagrion* sp. indet.*Agriocnemis femina femina* (Brauer)*Agriocnemis pygmaea* (Rambur)*Ischnura senegalensis* (Rambur)

Suborder ANISOPTERA

Family *Aeshnidae**Anaciaeschna jaspidea* Burmeister*Gynacantha dravida* Lieftinck*Gynacantha subinterrupta* RamburFamily *Libellulidae**Agrionoptera insignis insignis* (Rambur)*Nesoxenis lineata* (Selys)*Orthetrum sabina sabina* (Drury)

Brachydiplax chalybea chalybea Brauer
Diplacodes trivialis (Rambur)
Acisoma panorpoides panorpoides (Rambur)
Neurothemis intermedia intermedia (Rambur)
Neurothemis fluctuans (Fabricius)
Brachythemis contaminata (Fabricius)
Pantala flavescens (Fabricius)
Tholymis tillarga (Fabricius)
Tramea virginia Rambur
Tramea transmariana euryale Selys
Rhyothemis variegata variegata (Linn.)
Rhyothemis phyllis (Sulzer)
Camacinia gigantea (Brauer)
Zyxomma obtusum Albarda

DISCUSSION

Composition of the fauna : The fauna of the Nicobars is composed of thirty two species and subspecies spread over twenty two genera and five families, and two suborders.

Relationship of the fauna : Number of species is not large and the fauna is separated from other zoo-centres. But from the data available at hand it appears that Odonata of the Nicobars bear affinities with Indian mainland fauna, Burma (Myanmar), Indonesia, Andamans, in addition to the fauna of several zoogeographical regions. Affinities are as follows (Table 1).

Table 1.

Name of the country / zoogeographical regions	Number of species
India (main land)	23
Myanmar (Burma)	22
Indonesia	21
Cuba	1
Australian region	9
Palearctic region	16
Ethiopean region	3
Nearctic region	2

Note on the affinities of the fauna with the fauna of the Andaman islands : The fauna of Nicobar group of islands bears close affinities with the fauna of the Andamans. It is interesting to note that although they share eighteen species, which could cross the Andaman sea; and the only endemic form in the Nicobars, *Libellago lineata blanda* (Selys) could not cross the sea, likewise five endemics of the Andamans also could not cross 135 km. to reach the Nicobars. Kiauta (1984) opined that members of the family Chlorocyphidae (*Libellago* is a genus in the family) have originated and radiated from the Indonesian region. Hence it is conjectured that probably *Libellago lineata blanda* of the Nicobars and *Libellago lineata andamanensis* (Fraser) of the Andamans have originated independently. According to Fraser (1934) most of Indian species of *Libellago* originated from *Libellago lineata* occurring in Myanmar (Burma).

Forms in the direct line of emigration : Several species, viz. *Pseudagrion p. pruinatum* (Burmeister), *P. williamsoni* Fraser, *Libellago aurantiaca* (Selys), *Agrionoptera i. insignis* (Rambur) occur from Myanmar (Burma) to Malayasia which lie in the direct line of emigration to the islands.

Subspecies and link-populations : In addition to the common forms between the nearby lands fauna of the Nicobars has some link-populations in nearby lands. For example, *Pseudagrion pruinatum ranaunse* Schmidt, is endemic to Sumatra and it is a link-population of *Pseudagrion p. pruinatum*; *Agrionoptera insignis dorothea* Fraser occurs from North-East India to Myanmar and other subspecies of *Agrionoptera insignis* complex occur from Myanmar to Malayasia, are all link-populations of *Agrionoptera i. insignis*; similarly *Neurothemis intermedia excelsa* Lieft., a purely Javan population of *Neurothemis intermedia* complex, is a link-population of *Neurothemis i. intermedia*.

SUMMARY

The article deals with a check-list of Odonata fauna of Nicobar islands, short history on odonatology of the Nicobars, affinities with the fauna of certain countries and zoogeographical regions, subspecies and link populations in other areas.

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ENDEMIC ODONATA OF INDIA

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INTRODUCTION

The Order Odonata, popularly known as dragonflies and damselflies, is a primitive group of insects and occurs in different ecosystems. In India about five hundred species and subspecies occur. India has a landmass with an area of approximately 32,67,500 sq. km. including the arcuate chain of Andaman and Nicobar Islands; the Laccadives (Lakshadweeps) and Minicoy islands in the Arabian sea. The main landmass is divided into the Himalayan mountain chain in the North, isolating the country from the rest of Asia; this is followed by the monotonous highly populated Indo-Gangetic plain which ends in the Bay of Bengal. The last is a triangular plateau of old peninsular upland.

ZOO-CENTRES AND ENDEMISM

Endemics occur only in a particular area. According to Roonwal and Verma (1977) endemic species have evolved locally; and Hutchinson (1957) has considered that endemics remain confined in their 'fundamental niche' where they can survive for indefinite period. According to Emerson (1955) endemic genera occur in a vast zoogeographic area. Indian odonate fauna although largely borrowed from Malaysian subregion but some forms *viz.* *Zygonyx* of Ethiopian region and *Hemicordulia* of Australian region have made their way to India. Kiauta (1984) has opined that members of the family Chlorocyphidae have reached India from their place of origin at Malaysian subregion. India has also zoo-centres of its own (Mitra 2000b). For example according to Lieftinck (1984) members of the genus *Calicnemia* Strand have originated and radiated from the Himalayan region.

Among the zoo-centres, the North-East India-East India—the meeting area of Tibeto-Chinese, Indo-Chinese and Old peninsular forms, is very important; the Western Ghats, which are separated from other zoo-centres are rich in endemics. The North-west India is a zone where forms get opportunities for a considerable admixture of mediterranean elements with Turkmenian and some Ethiopian derivatives including the fauna of old peninsular India. The South Indian forms bear affinities with the fauna of Sri Lanka (Ceylon). The group of Andaman and Nicobar Islands is an arcuate chain in the Bay of Bengal. These islands are formed by the summits of submerged ranges

connected with the Arakan yoma of Burma (Myanmar) to which the meridian 92°E forms a tangent between cape Negaris and Sumatra (Achin head).

List of endemics : (a) *Genera* : *Caconeura* Kirby, *Esme* Fraser, *Melaneura* Fraser, *Phylloneura* Fraser, *Calocypha* Fraser, *Davidioides* Fraser, *Dubitogomphus* Fraser.

(b) *Species and subspecies* (excluding some recently described controversial taxa), number of species in family are in parenthesis.

Suborder ZYGOPTERA

Family PLATYSTICTIDAE

1. *Drepanosticta anandalei* Fraser
2. *Platysticta decannensis* Laidlaw
3. *Protosticta antelopoides* Fraser
4. *Protosticta davenporti* Fraser
5. *Protosticta fraseri* Kennedy
6. *Protosticta gravelyi* Laidlaw
7. *Protosticta hearseyi* Fraser
8. *Protosticta mortoni* Fraser
9. *Protosticta rufostigma* Fraser
10. *Protosticta sanguinostigma* Fraser

Family PROTONEURIDAE

1. *Caconeura gomphoides* (Rambur)
2. *Caconeura obscura* (Fraser)
3. *Caconeura ramburii* (Fraser)
4. *Caconeura risi* (Fraser)
5. *Caconeura t-coerulea* (Fraser)
6. *Disparoneura quadrimaculata* (Rambur)
7. *Disparoneura apicalis* (Fraser)
8. *Disparoneura canningi* (Fraser)
9. *Elattoneura atkinsoni* (Selys)
10. *Elattoneura campioni cacharensis* (Fraser)

11. *Elattoneura nigerrima* Laidlaw
12. *Elattoneura souteri* (Fraser)
13. *Elattoneura tetrica* (Laidlaw)
14. *Elattoneura nihari* Mitra
15. *Esme cyaneovittata* Fraser
16. *Esme longistyla* Fraser
17. *Esma mudiensis* Fraser
18. *Melaneura billineata* Fraser
19. *Phylloneura westermanni* (Selys)
20. *Prodasineura verticalis andamanensis* (Fraser)
21. *Prodasineura verticalis anandalei* (Fraser)

Family COENAGRIONIDAE

1. *Aciagrion hisopla krishna* Fraser
2. *Aciagrion approximans* (Selys)
3. *Agriocnemis corbeti* Kumar and Prasad
4. *Agriocnemis keralensis* Peters
5. *Agriocnemis pieris* Laidlaw
6. *Agriocnemis splendidissima* Laidlaw
7. *Ceriagrion coeruleum* Laidlaw
8. *Enallagma immsi* Laidlaw [Tsuda (1991) separated it from *E. parvum* Selys]
9. *Enallagma insula* Fraser [Mitra (2000a) considered its doubtful status]
10. *Ischnura dorothea* Fraser
11. *Ischnura inarmata* Calvert
12. *Ischnura patricia* Fraser
13. *Ischnura rubiolio* Selys
14. *Ischnura rufostigma rufostigma* Selys
15. *Mortonagrion varalli* Fraser
16. *Pseudagrion andamanicum* Fraser
17. *Pseudagrion indicum* Fraser
18. *Pseudagrion hypermelas* Selys

Family PLATYCNEMIDIDAE

1. *Calicnemia carminia pyrrhosoma* Lieftinck
2. *Calicnemia mukherjeei* Lahiri
3. *Calicnemia sudhaae* Mitra
4. *Coeliccia dorothea* Fraser
5. *Coeliccia prakritiae* Lahiri
6. *Coeliccia sarbottama* Lahiri
7. *Coeliccia rossi* Asahina
8. *Coeliccia schmidtii* Asahina
9. *Coeliccia fraseri* Laidlaw
10. *Copera vittata decanensis* (Laidlaw)
11. *Copera vittata serapica* (Selys)

Family SYNLESTIDAE

1. *Megalestes irma* Fraser
2. *Megalestes lieftincki* Lahiri
3. *Megalestes raychaudhuri* Lahiri

Family LESTIDAE

1. *Indolestes assamicus* Fraser
2. *Indolestes pulcherrimus* Fraser
3. *Indolestes davenporti* (Fraser)
4. *Orolestes durga* Lahiri
5. *Lestes garoensis* Lahiri
6. *Lestes malabaricus* Fraser
7. *Lestes nigriceps* Fraser
8. *Lestes praemorsus sikkima* (Fraser)
9. *Sympecma annulata kashmirensis* Ander

Family MEGAPODAGRIONIDAE

1. *Burmargiolestes laidlawi* Lieftinck

Family CHLOROCYPHIDAE

1. *Calocypha laidlawi* (Fraser)
2. *Libellago lineata andamanensis* (Fraser)
3. *Libellago lineata blanda* Selys
4. *Rhinocypha bisignata* Selys
5. *Rhinocypha perforata beatifica* Fraser
6. *Rhinocypha vitrinella* Fraser
7. *Rhinocypha hilaryae miaoa* Lahiri and Sinha

Family EUPHAEIDAE

1. *Anisopleura subplatystyla* Fraser
2. *Anisopleura lieftincki* Prasad and Ghosh
3. *Anisopleura vallei* St. Quentin
4. *Bayadera hyalina* Selys
5. *Bayadera kali* Cowley
6. *Dysphaea ethela* Fraser
7. *Euphaea cardinalis* (Fraser)
8. *Euphaea dispar* Rambur
9. *Euphaea fraseri* (Laidlaw)

Family CALOPTERYGIDAE

1. *Echo margarita tripartita* Selys
2. *Vestalis apicalis apicalis* Selys
3. *Vestalis apicalis submontana* Fraser
4. *Vestalis gracilis montana* Fraser

Suborder ANISOPTERA

Family GOMPHIDAE

1. *Acrogomphus fraseri* Laidlaw
2. *Anormogomphus heteropterus* Selys

3. *Asiagomphus nilgiricus* (Laidlaw)
4. *Asiagomphus odoneli* (Fraser)
5. *Burmagomphus cauvericus* Fraser
6. *Burmagomphus hasimaricus* Fraser
7. *Burmagomphus sivalikensis* Laidlaw
8. *Burmagomphus laidlawi* Fraser
9. *Cyclogomphus heterostylus* Selys
10. *Cyclogomphus vesiculosus* Selys
11. *Cyclogomphus wilkinsi* Fraser
12. *Cyclogomphus ypsilon* Selys
13. *Davidius aberrans senchalensis* Fraser
14. *Davidius davidi assamensis* Fraser
15. *Davidius kumaoensis* Fraser
16. *Davidius malloryi* Fraser
17. *Davidius zallorensis zallorensis* Selys [Type locality cited by Selys is untraceable]
18. *Davidioides martini* Fraser
19. *Dubitogomphus bidentatus* Fraser
20. *Gomphidia ganeshi* Chhotani, Lahiri and Mitra
21. *Gomphidia kodagunensis* Fraser
22. *Gomphidia leonora* Mitra
23. *Gomphidia platyceps* Fraser
24. *Gomphidia t-nigram* Selys
25. *Heliogomphus promelas* (Selys)
26. *Heliogomphus spirilus* (Fraser)
27. *Ictinogomphs atrox* (Selys)
28. *Ictinogomphs kishori* Ram
29. *Macrogomphus abnormis* Selys
30. *Macrogomphus wynaadicus* Selys
31. *Macrogomphus annulatus annulatus* (Selys)
32. *Megalogomphus bicornuatus* (Fraser)
33. *Megalogomphus flavicolor* (Fraser)
34. *Megalogomphus hannyingtoni* (Fraser)

35. *Megalogomphus superbus* Fraser
36. *Merogomphus longistigma longistigma* (Fraser)
37. *Merogomphus longistigma tamaracherriensis* Laidlaw
38. *Merogomphus martini* (Fraser)
39. *Microgomphus souteri* (Fraser)
40. *Microgomphus torquatus* (Selys)
41. *Microgomphus verticalis* (Selys)
42. *Nihonogomphus indicus* Lahiri
43. *Onychogomphus acinaces* Laidlaw
44. *Onychogomphus cacharicus* (Fraser)
45. *Onychogomphus grammicus* (Rambur)
46. *Onychogomphus malabarensis* Fraser
47. *Onychogomphus meghalayanus* Lahiri
48. *Onychogomphus nilgiriensis anaimalaicus* (Fraser)
49. *Onychogomphus nilgiriensis nilgiriensis* Fraser
50. *Onychogomphus thienemanni* Schmidt
51. *Paragomphus echinoocipitalis* (Fraser)
52. *Phaenandrogomphus aureus* (Laidlaw)

Family AESHNIDAE

1. *Aeshna flavifrons* Lichtenstein
2. *Gynacantha apicalis* Fraser
3. *Gynacantha arnaudi* Asahina
4. *Gynacantha bainbriggei* Fraser
5. *Gynacantha biharica* Fraser
6. *Gynacantha odoneli* Fraser
7. *Gynacantha rammohani* Mitra & Lahiri
(Appears to be abnormal variety of *G. dravida* Lieftinck)
8. *Gynacantha rotundata* Asahina
9. *Oligoaeschna speciosa* Karube
10. *Oligoaeschna andamani* Chhotani, Lahiri and Mitra

11. *Oligoaeschna khasiana* Lieftinck
12. *Periaeschna flinti assamensis* Asahina
13. *Periaeschna lebasii* Navas
14. *Petaliaeschna fletcheri* Fraser

Family CORDULEGASTERIDAE

1. *Chlorogomphus brittoi* Navas
2. *Chlorogomphus campioni* (Fraser)
3. *Chlorogomphus fraseri* St. Quentin
4. *Chlorogomphus preciosus fernandi* Asahina
5. *Chlorogomphus schmidti* Asahina
6. *Chlorogomphus xanthoptera* (Fraser)
7. *Chlorogomphus parvistigma* (Selys)

Family CORDULIIDAE

1. *Epophthalmia frontalis binocellata* (Fraser)
2. *Epophthalmia vittata vittata* Burmeister
3. *Idionyx corona burliyarensis* Fraser
4. *Idionyx corona corona* Fraser
5. *Idionyx galeata* Fraser
6. *Idionyx imbricata* Fraser
7. *Idionyx intricata* Fraser
8. *Idionyx minima* Fraser
9. *Idionyx nadaganensis* Fraser
10. *Idionyx nilgiriensis* (Fraser)
11. *Idionyx periyashola* Fraser
12. *Idionyx rhinoceroides* Fraser
13. *Idionyx saffronata* Fraser
14. *Idionyx travancorensis* Fraser
15. *Macromia anaimalaiensis* Fraser
16. *Macromia bellicosa* Fraser
17. *Macromia ellisoni* Fraser
18. *Macromia flavotittata* Fraser

19. *Macromia ida* Fraser
20. *Macromia indica* Fraser
21. *Macromia irata* Fraser
22. *Macromia miniata* Fraser
23. *Macromia whitei* Selys
24. *Macromidia donaldi* Fraser
25. *Somatochlora daviesi* Lieftinck

Family LIBELLULIDAE

1. *Hylaeothemis fruhstorferi apicalis* Fraser
2. *Hylaeothemis gardeneri* Fraseri
3. *Orthetrum martensi* Asahina
4. *Zygonyx iris davina* Fraser
5. *Zygonyx iris intermedia* Lahiri
6. *Zygonyx iris metallica* Fraser
7. *Zygonyx torrida isis* Fraser
8. *Zygonyx iris malabarica* Fraser
9. *Epithemis mariae* Laidlaw

DISCUSSION

About five hundred species and subspecies of odonates occur in India* Of these two hundred one (or 40%) are endemics and 5% genera are endemics. This high rate of endemism is due to diversified ecosystems in the main landmass. Certain areas in North-East India, Himalays, Western Ghats are politically sympatric but divided into ecologically allopatric areas. Hence population of Odonata have been divided into subpopulations and finally new taxa (Mitra 1999). Distribution of species and subspecies as per genus has been cited by Mitra (2000b); and as per family has been indicated in the present list of endemics. Following will demonstrate the causes of high rate of endemism.

Peculiarities in the distribution of endemics : It is well known that dragonflies have great powers of flight. In spite of this, several species have got peculiar local distribution. In the Himalayas,

*Tsuda (1991) reported 494 species and subspecies from India; Tsuda (2000) reported 497 species and subspecies from the country but he omitted four species, of them one endemic *Elatoneura nihari* Mitra) has been cited here. Hence the total number of odonate species occur comes to 501.

hills of North-East India, Western Ghats, and Andaman and Nicobar islands, several species which are usually rare are confined to a small stretch of river-bed or in a patch of marshy land. In addition to their localized distribution, there are several species which are very seasonal and are usually single-brooded and live for a few weeks only. Among the endemics *Echo margarita margarita* is confined in the North-East India; *Megalestes irma* in Eastern Himalayas; *Gomphidia leonorae* in the Susunia hill of West Bengal; *Epithemis mariae* in the Western Ghats; *Libellago lineata andamanensis* in the Andamans; *Libellago lineata blanda* in the Nicobars. Some taxa occur in several parts of India. For instance, *Onychogomphus duaricus* occurs in West Bengal, Meghalaya and Uttar Pradesh; *Epophthalmia vittata vittata* occurs in the peninsular India, West Bengal and Uttar Pradesh.

Barriers in the distribution of Indian Odonata : India is practically isolated from the whole of the world. It has been made possible after the break of Panagea, due to which India has become surrounded by seas and oceans. After the rise of the Himalayas and extension of the Thar desert the isolation has been completed. It has great influence on native culture as well as fauna and flora. Therefore the high rate of endemism in the biological world is due to barriers—Thar desert, Himalayas, oceans and seas. Moreover within the country hills, streams as well as forest provide different ecosystems for different taxa and isolate them from others in the same political or administrative area. The high rate of endemism in a small state, Meghalaya, (33 out of 148 species and subspecies) indicate that political or administrative areas apparently appear sympatric but are ecologically divided into several allopatric zones. Occurrence of three subspecies—*Neurothemis intermedia intermedia*, *N.I. degener* and *N. I. atalanta* in Sikkim, proves the above facts. Lack of perennial water source is the cause for less number of species in Andamans than that of Arunachal Pradesh, although both are areas of rain forests. Occurrences of *Libellago lineata andamanensis* in South Andaman and *Libellago lineata blanda* in Great Nicobar clearly shows that they are unable to cross 135 kms. wide sea. A few species can cross the high altitudes of the Himalayas and the Thar desert but not all.

SUMMARY

The paper deals with a list of endemic genera (7) and endemic species and subspecies (201), zoo-centres and faunal affinities of Indian Odonata as well as peculiarities in the distribution of endemics and barriers in the distribution.

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STRUCTURAL AND FUNCTIONAL ANATOMY OF STOMACH OF A FRESHWATER BIVALVE *PARREYSIA FAVIDENS* (BENSON) OF KOSI RIVER OF NORTH BIHAR

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INTRODUCTION

Different members of the bivalves show considerable variations in structure and function of the stomach (Graham, 1949; Owen, 1956; Purchon, 1960a; Bernard, 1973; Judd, 1979). *Parreysia favidens* is one of them found commonly in freshwater system belonging to the family Unionidae. The alimentary canal of *Parreysia favidens* like other bivalves is peculiar due to the presence of many specialized characters which suits their specific mode of feeding. *P. favidens* is a deposit and suspension filter feeder, feeding chiefly on phytoplankton, zooplankton and detritus. Several works have been done on the structure and function on the stomach of molluscs. Morton, 1953; George, 1952; Owen, 1956; Millar, 1955; But no adequate knowledge is available on the Structural and functional anatomy of stomach of *P. favidens*. The present paper deals with the structural and functional anatomy of a freshwater bivalve *Parreysia favidens*.

Key Words : Structural, Functional Anatomy, Stomach, *P. favidens*.

MATERIALS AND METHODS

Live specimens of *P. favidens* were collected from different rivulets and channels of the river Burhi Gandak of North Bihar. The collected specimens were fixed in 5% formalin. Now the alimentary canal of the specimens were taken out and cut into small pieces. The small pieces of stomach were dehydrated in graded alcohol and xylene and specimens transferred for 2 hrs in wax at 60-62°C. Three changes were made and specimens were embedded. The embedded materials were trimmed and section (5-7 µm thick) and were stained with haematoxylin. For analysis of enzymes, analysis test of lipase, Protease and amylase were made by mixing the extract with an

emulsion of olive oil and subsequently staining a small sample with Nile blue sulphate (George, 1952). Camera lucida sketches of the specimens were drawn.

RESULT AND DISCUSSION

The alimentary canal of *Parreysia favidens* consists of a mouth, a relatively short and flattened oesophagus, a complex stomach, a midgut and rectum opening outside by the anus. The stomach is surrounded by a deep brownish or greenish digestive gland or diverticula. From the stomach arises a number of openings into the digestive diverticula. (Fig. 1). The stomach receives digestive enzymes (Proteases and lipases, Mansour Bek; 1948. Rose; 1949 and George; 1952) from diverticula through ducts. An outgrowth is found at the junction of stomach and intestine which is called "style sac" Style sac secretes a still gelatinous rod of mucoprotein termed "crystalline style" which contains mucous and powerful amylolytic anzyme (Fig. 1).

The stomach of *P. favidens* is relatively a thin walled sac and extensively ciliated. The ciliated areas are typically formed into a complex pattern of fold and ridges to create sorting areas. There are three main sorting regions out of which first region sorts fine food particles from the mucous string by means of ciliary sorting areas and rejects debris or indigestible matters into the intestine, second region carries part of digestible food which is to be passed into the digestive gland for intracellular digestion and third conveys waste materials returned from the digestive gland to the intestine (Reid, 1965). The grooves and redges of gastric shield really corresponds to those present on the inner wall of the stomach. The food particles remain present towards the ventral side in the lumen of the stomach hence the midgut takes its origin. Gastric shield constitutes an inert structure which is a chitinous, protective lining of the stomach against which the style rotates. It appears to be present upto greater or lesser extent in all the bivalves and hold the head of the styles assisting in the mortar trituration of the stomach contents by a type of mortar and pestle action (own, 1956, shaw and Battle, 1959). The shield overlay a ciliated epithelium. The cilia are infact attached on its free surface. The crystalline style sac is completely filled by a gelatinous crystalline style. It is solid but flexible rod (Fig. 2). Morphologically the style sac separately develops from the midgut. In *P. favidens* the particulate matter forming the bottom deposits includes sand grains, living organisms and organic detritus (Table 1, 2). It is collected by the palp proboscis and injected in considerable quantity, so that in freshly caught animals the stomach is invariably distended. The presence of sphincter muscle at the junction of the style sac with the intestine prevents the scope of material from the stomach except by the intestinal groove. Enzymes are secreted into the lumen by the style sac epithelium and by the digestive diverticula and food and enzymes are thoroughly mixed with food enzyme rotatary action by the action by the specialized cilia of the style sac. The pressure exerted by the distended wall of the stomach, aided by muscular action, serves to evaluate

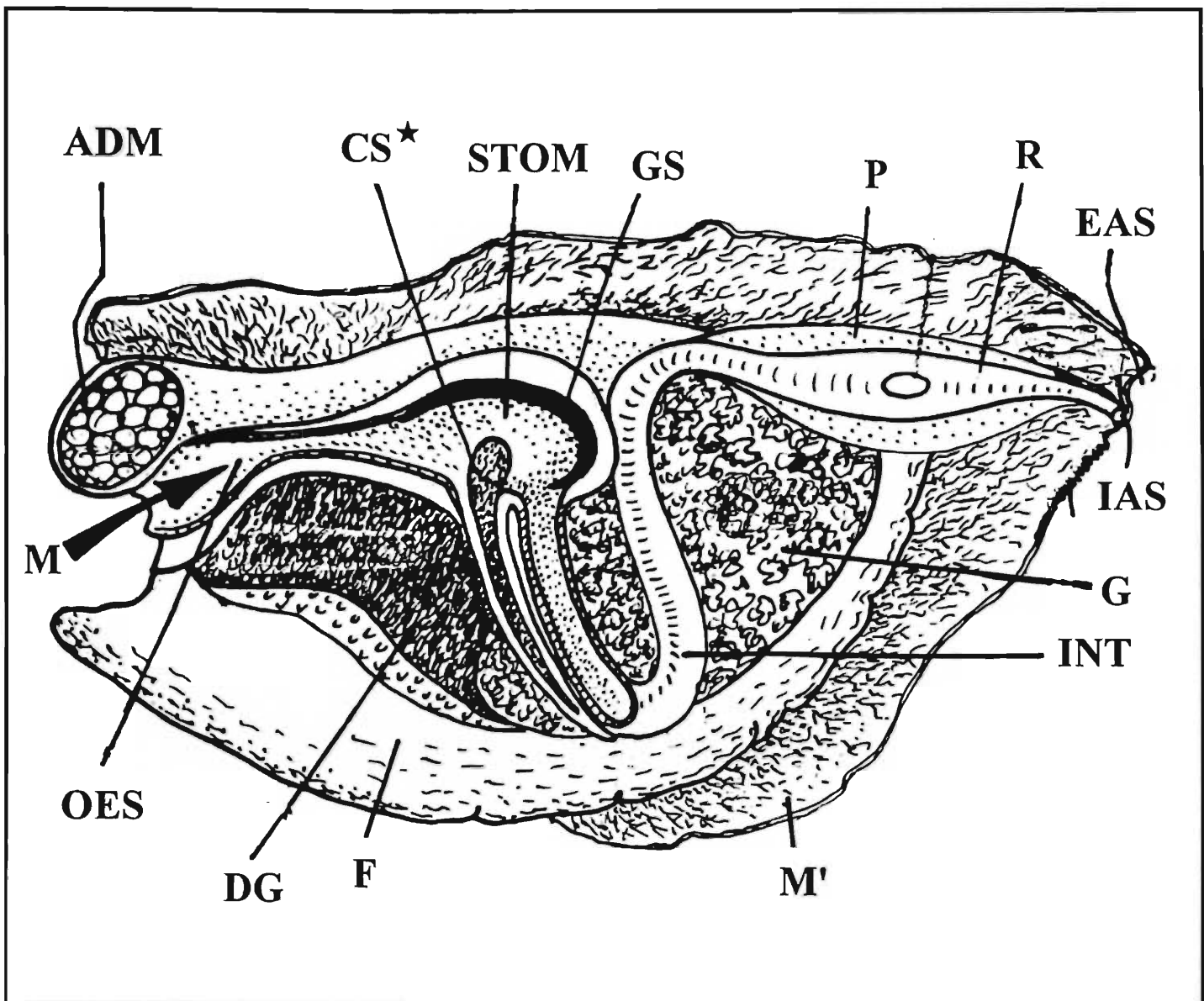


Fig. 1. Diagrammatic representation of internal anatomy of *Parreysia favidens* showing the position of stomach along with crystalline style (CS) and gastric shield (GS).

the soluble products of digestion out of the contained mass and these are absorbed by the lining epithelium. Finally, relaxation of the sphincter muscle allows the compacted faecal mass contained in the style sac to enter the intestine (own, 1956). The secretory spheres produced by the fragmentation of the tubule cells may contain proteases and lipases, whose traces could be liberated into the stomach (Morton (1953) suggested for the gastropod, *structio Laria*) presumably serve to drive fluid out of the ducts, while at the same time preventing material from entering the diverticula.

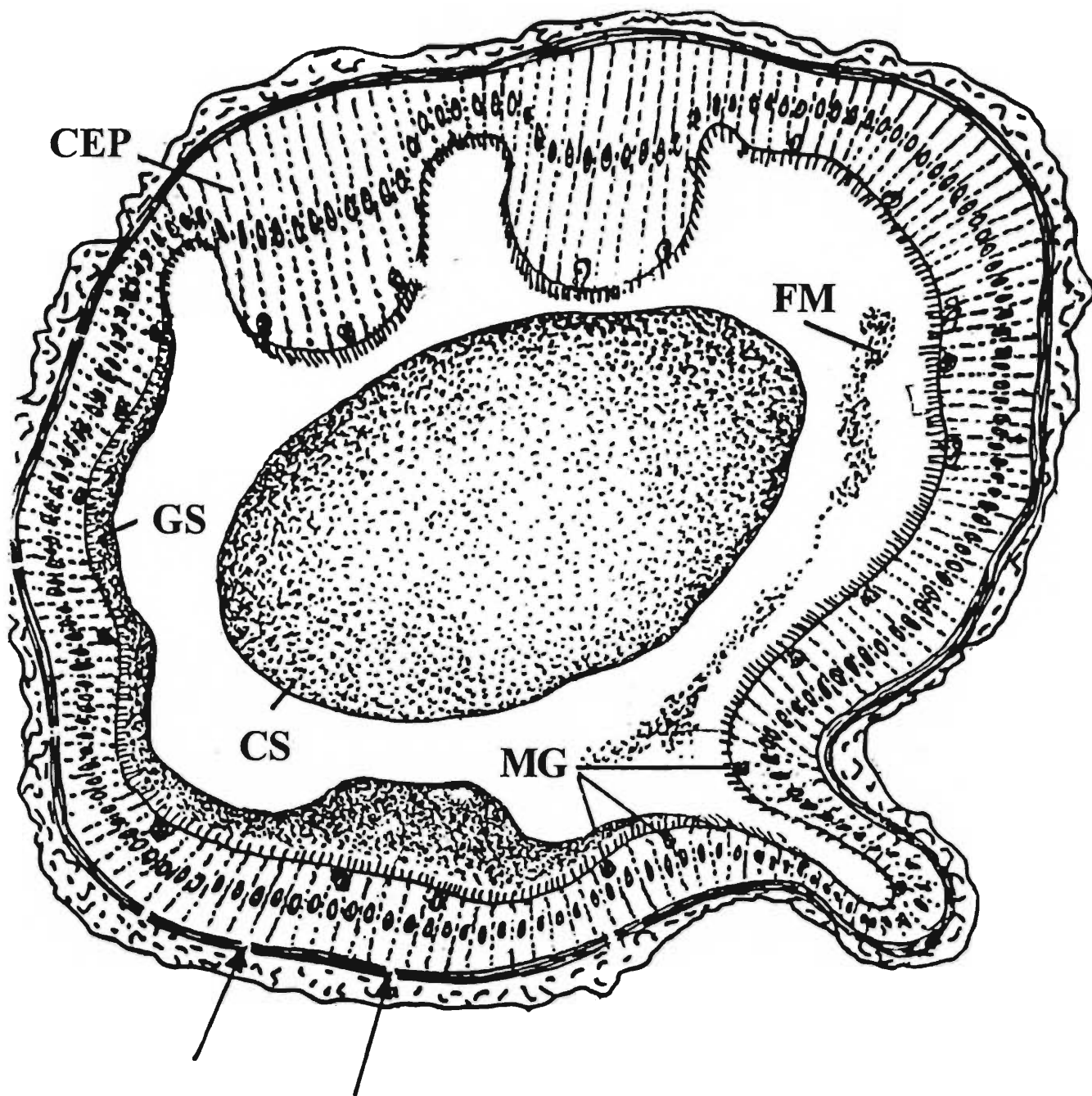


Fig. 2. Showing the camera lucida sketch of T.S. of stomach of *Parreysia favidens*. Note asterisk shows the position of crystalline style (CS) and gastric shield (GS) of *P. favidens*.

ABBREVIATIONS

ADM	..	Adductor muscle	M	..	Mouth
CS	..	Crystalline style	MG	..	Mucous gland
DG	..	Digestive gland	R	..	Rectum
EAS	..	Exhalant	OES	..	Oesophagus
FM	..	Faecal matter	STOM	..	Stomach
GS	..	Gastric shield	P	..	Pericardium
G	..	Gonad	M'	..	Mantle
IAS	..	Inhalant siphon	F	..	Foot
INT	..	Intestine			

Table 1. Intensity of feeding in *Parreysia favidens* in different periods (Values in %).

Months	No. of stomach	Georged	Full	3/4 Full	1/2 Full	1/4 Full	Little	Empty
MAR	20	8.2	26.6	26.4	17.6	9.2	7.8	2.2
APR	23	21.4	30.3	13.7	14.4	8.4	6.5	5.3
MAY	19	15.4	39.6	11.4	13.7	6.3	7.9	5.7
JUN	21	13.4	28.1	20.6	20.6	10.7	4.2	2.4
JUL	17	02.4	06.6	11.7	20.8	32.6	20.8	5.1
AUG	18	01.9	04.3	10.7	20.8	30.7	28.7	2.9
SEP	14	–	–	07.4	16.3	40.3	16.9	19.1
OCT	11	–	–	10.4	18.3	38.6	25.8	5.9
NOV	16	02.0	04.0	27.3	29.3	30.4	07.0	–
DEC	19	08.1	21.4	20.3	21.4	14.8	13.8	0.2
JAN	21	09.9	20.4	22.6	23.7	16.3	08.7	0.4
FEB	13	10.4	23.4	27.6	20.4	10.3	06.2	1.7

Table 2. Plankton community (%) in gut contents of *Parreysia favidens* and water samples of Siurighat (Begusarai) during March 1995 to February 1996.

SEASONS	Gut contents of <i>Parreysia favidens</i>									Plankton in water sample of Siurighat							
	Phytoplankton				Zooplankton				Miscellaneous	Phytoplankton				Zooplankton			
	Bac.	Chl.	Myx.	Tot.	Pro.	Rot.	Cl.	Tot.		Bac.	Chl.	Myx.	Tot.	Pro.	Rot.	Cl.	Tot.
Summer	31	23	17	71	14	06	05	25	04	36	31	13	80	12	05	03	20
										(1062)	(625)	(396)	(2000)	(286)	(113)	(71)	(500)
Monson	32	23	18	73	13	04	04	21	06	35	24	21	80	11	06	03	20
										(42)	(28.8)	(25.2)	(96)	(13.2)	(7.2)	(3.6)	(24)
Winter	28	24	18	70	15	09	01	25	05	28	32	19	79	14	06	01	21
										(196)	(224)	(133)	(533)	(98)	(42)	(7)	(147)

(Values in brackets are densities in U/L)

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WATER QUALITY STUDIES RELATED TO FISHES OF KONDAKARLA LAKE, ANDHRA PRADESH

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INTRODUCTION

Studies on pisciculture of different water bodies in India were carried out by Das (1945), Alikunhi (1957), Banerjee (1967), Swingle (1967), Sreenivasan (1967), Sharma and Dutta Munshi (1995) ... *etc.* Jhingran (1991) dealt with the ecological aspects of water bodies for pisciculture. As nothing is known on the suitability of water quality for pisciculture in Kondakarla lake, the present investigation was undertaken to ascertain the same.

MATERIAL AND METHODS

Kondakarla lake is situated about 50 km south-west of Visakhapatnam in Andhra Pradesh between latitudes 17°35'30" and 17°36'02" N and longitudes 82°59'27" and 83°01'0" E. It covers an area of 6.5 sq. kms. Water samples were collected from the lake during three different seasons of the year 1997 and their analysis was done with the help of A.P.H.A. (1989). Fish fauna of the lake was collected from fishermen's catches.

RESULTS AND DISCUSSION

The physico-chemical parameters of the lake water and the ranges for fish growth are given in Table-I. According to Jhingran (1991) a depth of about 2 metres is congenial for fish productivity in a pond. In shallow ponds, sun light penetrates upto the bottom, warms up the water and facilitates the increase in productivity. This proved true in the case of Kondakarla lake which is a shallow with a depth of about 2 metres with light penetrating to the bottom. Das (1945) stated the upper lethal temperatures for fishes like *Anabas testudineus*, *Channa punctatus*, *Heteropneustes fossilis*, *Clarius batrachus*, *Puntius ticto*, *Rasbora daniconius* and *Glossogobius giuris* lying between 39°–41°C. All these fishes are also found in Kondakarla lake, with the water temperatures ranging between 22° and 32°C. The suggested ranges of this parameter for fish growth is 20°–14°C.

Table I. Physico-Chemical Parameters of Kondakarla Lake.

Ser no.	Parameter	Cheemanapalle			Avasomavaram			Rajam			Centre Point			Kondakarla Village			Vadrepalle			Haripalem			Ranges in which fish grows
		S	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S	M	W	
1	Temperature Air (°C)	32	31	23	32		25.5	32	31	26	32	31	26.5	31	31	23	32	31	28	32	31	29	
2	Temperature Water (°C)	29	29	22.5	29		24	29	29	24	29	31	24	29	29	22	29	30	25	29	30	25	20 - 41
3	pH	7.5	8.5	7.5	7.2		7.5	7.4	8.5	7.5	6.9	8.5	7.0	7.3	8.9	7.0	7.2	8.5	7.0	7.1	8.5	8.0	6.5 - 8.5
4	E. Conductivity (m. mhos/cm)	840	1340	780	730		630	810	860	540	520	1640	80	560	960	830	430	1090	510	960	720	830	430 - 1200
5	Turbidity (NTU)	6	60	8	540		6	5	50	8	6	60	6	5	50	8	20	10	8	4	60	8	5 - 300
6	Dis. Oxygen (mg/litre)	7.5	8.2	3.2	7.2		5.8	7.9	12.2	6.6	9.4	16.2	0.8	2.4	5.6	3.0	2.8	9.2	6.0	3.4	9.8	5.0	4 - 9
7	Total Alkalinity (mg/litre)	190	185	295	200		135	155	255	230	120	160	165	430	290	300	235	210	80	280	315	350	100 - 300
8	Total Hardness (mg/litre)	140	80	165	125		155	135	210	155	110	145	110	185	430	200	120	230	150	175	295	270	15 - 250
9	Calcium (mg/litre)	46	17	48	38		40	40	34	42	31	32	27	59	92	61	40	52	40	36	50	59	25 - 80
10	Magnesium (mg/litre)	7	10	12	9		15	10	31	13	9	17	11	11	51	13	6	38	13	22	38	32	5 - 40
11	Chloride (mg/litre)	149	170	110	142		80	142	175	75	146	115	45	184	210	70	156	145	55	160	185	70	70 - 180
12	Nitrate N (mg/litre)	1	2	2	1		2	1	1	2	1	2	2	1	4	3	1	3	3	1	5	3	0.2 - 4.0
13	Phosphorus (mg/litre)	NIL	15	10	Traces		15	NIL	10	5	Traces	5	5	NIL	5	10	Traces	40	5	Traces	10	10	0.5 - 4.0

S = SUMMER

M = MONSOON

W = WINTER

Turbidity forming a limiting factor in the productivity of a water body, varies with the nature of the basin of the water body, degree of exposure, nature of inflowing sediments...*etc.* Lakes with clay bottom are likely to have more turbidity, restricting the penetration of sun light and reducing the photosynthetic activity, which in turn influence the productivity of water mass. Turbidity tolerance of different cultivable fishes have not anywhere been studied systematically, but it is found that fish grows between the range of 5–300. Indian major carps and other culturable plain-dwelling fishes are known to tolerate the prevailing high ranges of turbidity (Jhingran, 1991).

Light penetration depends on the intensity of light which varies with geographic location of the water body between latitudes, while the shade provided by the surrounding vegetation, however, affects the incidence of light on the water body (Jhingran, 1991). Kondakarla lake being a shallow one, light penetrates to the bottom. Sreenivasan (1967) studied electric conductivity of a number of fish ponds and reported that above 400 micromhos/cm. The range of this parameter in Kondakarla lake water varied from 430–1640 micromhos/cm, favouring productivity. A good fish growth in a water body, occurs between 430–1200 of the factor.

Lake water receives oxygen either by absorption from atmosphere at the surface or from photosynthesis of chlorophyll bearing organisms inhabiting the water body (Jhingran, 1991). The animal community inhabiting the water body requires dissolved oxygen for respiration and releases carbon-di-oxide as catabolic product. Oxygen is consumed by respiration of animal and aquatic plants as well as the putrefication of organic matter and other causes. The dissolved oxygen at Kondakarla lake ranged from 0.8 to 16.2 mg/lit. Dissolved oxygen between 4–9 is favourable for fish production as the ecosystem is able to support the development of large fishes with high metabolic rate in this range. Low dissolved oxygen level is responsible for abundance of small sized weed fishes with low metabolic rate. In the case of Kondakarla lake, dissolved oxygen was noticed within this range at majority of the spots investigated yielding fishes of larger size.

Swingle (1967) stated that waters having pH range of 6.5 to 8.5 as recorded before day-break are congenial for pisciculture, while those having pH values more than 9.5 are unsuitable due to non-availability of carbonates. Fish mortality generally takes place at about 11 pH. Most of the pH values of Kondakarla lake water recorded during morning hours were found in the above range, favouring fish production.

According to Alikunhi (1957), highly productive waters will have alkalinity more than 100 mg/lit., but it is found that 100–300 is favourable for its augmentation. Total alkalinity of Kondakarla lake water varied between 120 and 430 mg/lit., indicating its suitability for pisciculture.

The total hardness in the lake water recorded from 80 to 430 mg/lit., is suitable for satisfactory growth of fishes. Swingle (1967) observed that more than 15 would be congenial for the purpose. The author suggests that upto 250 mg/lit. of this factor is permissible for fish growth and in majority of the spots of the ecosystem, the value is found within this range.

Banerjee (1967) reported that 0.2 mg/lit. of Nitrate is required for fish production. Nitrate component in the ecosystem was recorded from 1 to 5 mg/lit., indicating favourable condition for fish production. Proper fish growth rate needs 0.2 to 4.0 mg/lit. of this parameter in any water body.

Phosphorus is also stated to be an important factor for pond fertility, even though it occurs in a small quantity. It varied from 0 to 15 (exceptionally 40) in the present study. Sreenivasan (1967) stated that phosphorus less than 0.5 mg/lit. is indicative of poor productivity. According to the author, the factor between 0.5 to 4.0 is congenial for fish production.

From the above discussion, it is evident that most of the water properties of Kondakarla lake are favourable for fish production, while other factors as phosphorus do not have any inhibitory effect on pisciculture.

Out of the 17 species of fishes recorded from the lake (Table-II), *Notopterus noptopterus*, *Mystus vittatus*, *M. bleekeri* and *Salmostoma bacaila* are larvivorous and can suitably be employed for pest and vector control. *Rasbora daniconius* and all the *Puntius* species have ornamental value and suitable for aquaria. *Clarius batrachus* is a food fish and can also be used as a test animal for

Table II. Fishes recorded from Kondakarla lake.

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1. *Notopterus noptopterus* (Pallas)
 2. *Salmostoma bacaila* (Ham-Buch)
 3. *Rasbora daniconius* (Ham.)
 4. *Puntius* sp.
 5. *P. ticto* (Ham-Buch)
 6. *P. sophore* (Ham.)
 7. *Mystus vittatus* (Bloch)
 8. *M. bleekeri* (Day)
 9. *Clarius batrachus* (Linn)
 10. *Heteropneustes fossilis* (Bloch)
 11. *Channa punctatus* (Bloch)
 12. *Ambassis* sp.
 13. *Chanda nama* (Ham.)
 14. *Glossogobius giuris* (Ham.)
 15. *Oreochromis mossambica* (Peters)
 16. *Anabas testudineus* (Bloch)
 17. *Mastacembalus pancalus* (Ham.)
-

the biological assay of pituitary hormones. *Heteropneustes fossilis* is commercially important due to its invigorating quality of flesh. Although *Ambassis* is not suitable for eating, some of its species are used as a manure, while others are of ornamental value for aquaria. *Chanda nama* is used not only as food but also in the control of guinea worms for malaria control. It also contributes largely to the artisanal fish catches in some states. *Glossogobius giuris* forms minor fishery in some places like Hooghly estuary in West Bengal. Eventhough *Oreochromis mossambica* is a good food fish in India, it is unsuitable for aquaculture along with other major carps due to its depredation on carp fry. *Anabas testudineus* is regarded as highly esteemed for its fine flavour, restorative values and prolonged freshness when kept out of water. It can also be cultured single or in combination with *Heteropneustes fossilis*, which is also suitable for cultivation in ponds and reservoirs. Hence a composite fish culture (also called as **Polyculture**) is suggested for the lake, as its main objective is to grow more number of species with varied feeding habits, utilising all types of food available in the water body.

SUMMARY

Water quality and fish composition were studied in Kondakarla lake during the three seasons of the year 1997 to ascertain suitability of the lake for pisciculture. The ichthyofauna of the water body comprises 17 species of fishes promising rich aquacultural potential. Suitability of the water quality for pisciculture and economic importance of fishes have been discussed.

ACKNOWLEDGEMENTS

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REVIEW OF THE INDIAN SPECIES OF TREMATODE GENUS *PHILOPHTHALMUS* LOOSS, 1899 PARASITES IN THE CONJUNCTIVA OF BIRD'S EYE

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INTRODUCTION

Aquatic, terrestrial and arboreal birds are found to harbour in their conjunctival sac, various species of trematodes, belonging to the genus *Philophthalmus* Looss, 1899. More than thirty species have been described so far from various zoo-geographical region of the world. As many as fifteen species have been described or recorded so far from dove, pigeon, duck, fowl, vulture, eagle and kingfisher from India.

We obtained six specimens belonging to above mentioned genus from conjunctiva of three Black Drongo (*Dicrurus adsimilis*), constituting a new host record and showing some interesting variation of characters of taxonomic importance. A review of the species of the genus *Philophthalmus* described from India forms the subject matter of present communication.

MATERIAL AND METHOD

Six specimens were recovered from eye of Black Drongo (*Dicrurus adsimilis*) shot at Sikkim. These were stained in Borax carmine. Drawings were made with camera lucida. All the measurements used in this paper are in millimeters.

DESCRIPTION

Family : PHILOPHTHALMIDAE Looss, 1899

Subfamily : PHILOPHTHALMINAE Looss, 1899

Genus : *Philophthalmus* Looss, 1899

Philophthalmus nocturnus Looss, 1907

(Fig. 1)

Body aspinose, flattened and clavate with a narrow anterior and broadly rounded posterior end. 5.225 – 5.775 in length and 1.175 – 1.925 in maximum width in equatorial region. Oral sucker terminally

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placed, $0.3 - 0.42 \times 0.475 - 0.5$ and ventral sucker larger than oral sucker, $0.65 - 0.75 \times 0.6 - 0.7$ situated at anterior third of the body.

Mouth leads through a very short prepharynx into a large globular and strongly muscular pharynx, $0.35 - 0.4 \times 0.47 - 0.525$. Oesophagus short, divides into two slender intestinal caeca. Intestinal caeca lateral, extend almost upto hind end.

Testes tandem in last quarter of body, large, unequal, slightly lobate with smooth margins. Anterior testis larger or smaller than posterior one. Anterior one $0.475 - 0.675 \times 0.7 - 0.925$ and posterior one $0.425 - 0.625 \times 0.725 - 0.925$. Vasa efferentia distinct. Cirrus sac long, club-shaped, $1.325 - 1.5$ in length, placed on the right side of the ventral sucker and extending posteriorly from the level of the intestinal bifurcation, may extend upto or behind the ventral sucker. Oval vesicula seminalis occupies the broad basal part of the cirrus sac, leads through a short narrow tubular part into the ductus ejaculatorius. Long ejaculatory duct, traverses the whole narrow part of the cirrus sac and ultimately terminates into a short eversible cirrus. Genital pore sub-median, on the right side of the caecal arch.

Globular ovary, situated in front of the anterior testis, median or sinistral in position, $0.2 - 0.25 \times 0.22 - 0.275$, partly covered on the ventral side by uterine coils. Tubular extra and intra caecal vitellaria mostly lateral, extends from the level of the posterior end of cirrus sac upto the level of ovary where they turn inwards, crossing the caeca dorsally, intruding into intercaecal field. In some places the vitellaria have a beaded appearance due to agglomeration of yolk cells. Narrow transverse vitelline ducts appear as prolongations of tubular vitellaria and they meet behind the ovary to form a vitelline reservoir, Laurer's canal is present. The complex lies slightly to the left of the median line, close to the postero lateral boarder of ovary and is partly masked by the initial coils of uterus. Receptaculum seminis uterinum present. Utrine coils occupy almost the whole space between anterior testis and cirrus sac, extending laterally into extracaecal field and posteriorly at the sides of testes. Muscular metraterm, wide, near the posterior end of cirrus sac, but distally it narrows and runs straight along cirrus sac to open outside by genital pore. Mature eggs are rather elongated, thin walled, broadened at one end; measures 0.074×0.033 . These eggs contain fully developed miracidia which have two closely apposed cup-shaped eyes. Some of the miracidia are seen lying free in uterus which are possibly released from the eggs during flattening and fixing. Each micacidium is found to contain a well developed sporocyst, often packed with germ cells and germ balls.

Excretory pore is terminal. Excretory bladder appears 'T'-shaped with short transverse limbs from the ends of which arises lateral cornua.

DISCUSSION

Looss, 1899 established the genus *Philophthalmus* with the species *P. palpebrarum* (Fig. 3) collected from *Corvus cornix* and *Milvus parasiticus* from Egypt. Subsequently more than thirty species were added to this genus from Europe, Asia, Africa and America from various aquatic and terrestrial bird's eye.

Fifteen species under the genera *Philophthalmus* have been described so far from India. List of the species along with their host and feeding habit is given in Table 1, to indicate the wide range of the ecological habitats of the hosts in which the species of this genus have established.

Skrjabin, 1947 proposed two subgenera, *Philophthalmus*, for the species with distinctly few isolated large vitelline follicles and *Tubolecithalmus* for those species, not having widely separated follicles but singular tubular or closely placed innumerable follicles. He included *P. nocturnus* Looss, 1907; *P. gralli* Mathis et Leger, 1910; *P. nyrocae* Yamaguti, 1934 and *P. muraschikinzevi* Tretikowa, 1946 in the later subgenus. This, apparently sound basis, proposed by Skrjabin for splitting the species in two subgenera, seems to very much well conceived. All the Indian species so far described have apparently tubular or closely placed small vitelline follicles. Subsequently Karyakarte, 1967 found *Philophthamids*, possessing both the follicular and tubular vitellaria and proposed a third subgenus *Mixophthalmus* for his species *P. chrysomae*.

Ching, 1960 studied the developmental stages of *P. gralli* Mathis et Leger, 1910 in various hosts such as chickens, ducks, rats and rabbits in Hawaii and noted morphological variations in respect of many characters of taxonomic importance. He suggested closer similarity between *P. indicus* Jaiswal and Singh, 1954 (Fig. 7); *P. oculare* Wu, 1938 and *P. mirzai* Jaiswal and Singh, 1954 (Fig. 8) with *P. nocturnus* Looss, 1907. He stated that for specific identification in the genus *Philophthalmus* series of specimens have to be studied since great variations of characters are very common feature. Prokash and Pandey, 1968 after detail observation considered all the Indian species such as *P. indicus* Jaiswal and Singh, 1954; *P. aquilla* Jaiswal, 1955; *P. lucknowensis* Baugh, 1962 (Fig. 10) and *P. halcyoni* Baugh, 1963 (Fig. 9) as synonym of *P. mirzai*. Even about the validity of *P. mirzai*, they opined that, "A truly valid status, distinct from *P. nocturnus*, would need a detailed scrutiny of the specimens described under the genus."

Subsequently many species were added to this genus. Srivastava and Pande, 1971; Varghese and Sundaram, 1975; and Mehra, 1980 on the otherhand considered *P. mirzai* as synonym of *P. gralli* Mathis et Leger, 1910. Mehra, 1980 further listed *P. (Mixophthalmus) chrysomae* Karyakarte, 1967 (Fig. 11) as synonym of *P. gralli*. Srivastava, 1982 also considered *P. gralli* as the only valid species and considered *P. (P.) problematicus* Tubangu, 1932 of Karyakarte, 1967; *P. (P.) columbae* Karyakarte, 1968 and *P. (P.) acridotheres* Karyakarte, 1969 as synonym of *P. gralli*.

Murty, 1966, 1967 initiated life history studies on some specimens of this genus from India. Swarnakumari and Madhavi, 1992 studied the life history stages of *Philophthalmus* cercariae, obtained from naturally infected snail *Thiara tuberculata* at Vishakhapatnam, Andhra Pradesh. They infected Leghorn Chickens with the cercariae and recovered 721 flukes from the eyes of 50 chickens. They observed after detail study and analysing allometric growth that "*P. nocturnus* stands close to *P. gralli* both in growth pattern and in the details of the development of adult form metacercariae. The similarities are also reflected in the morphology of the adults of the two species.

Table 1. Host Parasite list and feeding behaviour of hosts of *Philophthalmus* sp. described from India.

Name of the Parasite	Host		Family of the Host	Feeding habitat of the host	Reference
	Common Name	Scientific Name			
1. <i>P. palpebrarum</i> Looss, 1899	Carrion crow	<i>Corvus cornix</i>	Corvidae	Scavenger	<i>Zool. Jahrb. Syst.</i> 12 : 521-784
2. <i>P. nocturnus</i> Looss, 1907	Little owl	<i>Anthena noctua</i>	Strigidae	Predator	<i>Curr. Sci.</i> 35 : 366-367
	Domestic fowl	<i>Gallus domesticus</i>	Phasianidae	Graminivorous & Insectivorous	
3. <i>P. gralli</i> Mathis et Leger 1910	Black Drongo/ King Crow	<i>Dicrurus adsimilis</i>	Dicruridae	Insectivorous/ Flower nector eater	<i>Bull. Path. Exot.</i> 3 : 245
	Lesser whistling teal	<i>Dendrocygna javanica</i>	Anatidae	Chiefly vegeterian, but also take aquatic animal	
	Domestic duck <i>domesticus</i>	<i>Anas boschas</i>	-do-	-do-	
4. <i>P. anatinus</i> Sugimoto, 1928	-do-	-do-	-do-	-do-	<i>Zool. Mag.</i> 40 : 343-351
5. <i>P. indicus</i> Jaiswal and Singh, 1954	Scanvager vulture <i>percnopterus</i>	<i>Neophron</i>	Accipitridae	Scavanger	<i>J. Helm.</i> 28 (3/4) : 135-142
6. <i>P. problematicus</i> Tubangui, 1932	Domestic fowl	<i>Gallus domesticus</i>	Phasianidae	Graminivorous/Ins	<i>Phillip. J. Sci.</i> 47 : 369-404
7. <i>P. mirzai</i> , Jaiswal and Singh, 1954	Pariah kite <i>govinda</i>	<i>Milvus migrans</i>	Accipitridae Predator	Scavenger/	<i>J. Helm.</i> 28 (3/4) : 135-142
8. <i>P. aquilla</i> Jaiswal, 1955	Towny eagle <i>nipalensis</i>	<i>Aquila rapax</i>	-do-	-do-	<i>Proc. Ind. Sci. cong.</i> 42. IV. : 10
9. <i>P. halcyoni</i> Baugh, 1962	White breasted king fisher	<i>Halcyon smyrnensis</i>	Alcedenidae	Fish/Crustacean eater	<i>J. Helm.</i> 36 (3) : 243-258
10. <i>P. lucknowensis</i> Baugh, 1962	Towny eagle <i>nipalensis</i>	<i>Aquila rapax</i>	Accipitridae Predator	Scavnger/ -do-	
11. <i>P. chrysomae</i> , Karyakarte, 1967	Yellow eyed babbler	<i>Chrysoma sinense</i>	Muscicapidae	Insectivorous	<i>Ind. J. Helm.</i> 18 Seminar supplement 25-28
12. <i>P. (P.) columbae</i> , Karyakarte, 1968	Blue rock pigeon	<i>Columba livia</i>	Columbidae	Graminivorous	<i>Rev. Parasit.</i>
13. <i>P. acredotheres</i> , Karyakarte, 1969	Common myna	<i>Acridotheres tristis</i>	Sturnidae	Grub eaters	<i>Marath. Univ. J.</i> 8 (1) : 79-83
14. <i>P. (T.) alli</i> , Karyakarte, 1971	Indian ring dove	<i>Streptopelia decaocto</i>	Columbidae	Graminivorous	<i>Marath Univ. J.</i> 10 : 71-73
15. <i>P. peteri</i> , Sreekumaran and Peter, 1973	Domestic duck	<i>Anas boschas domesticus</i>	Anatidae	Chiefly vegeterian but also take aquatic animals	<i>Ind. Vet. J.</i> 50 : 946

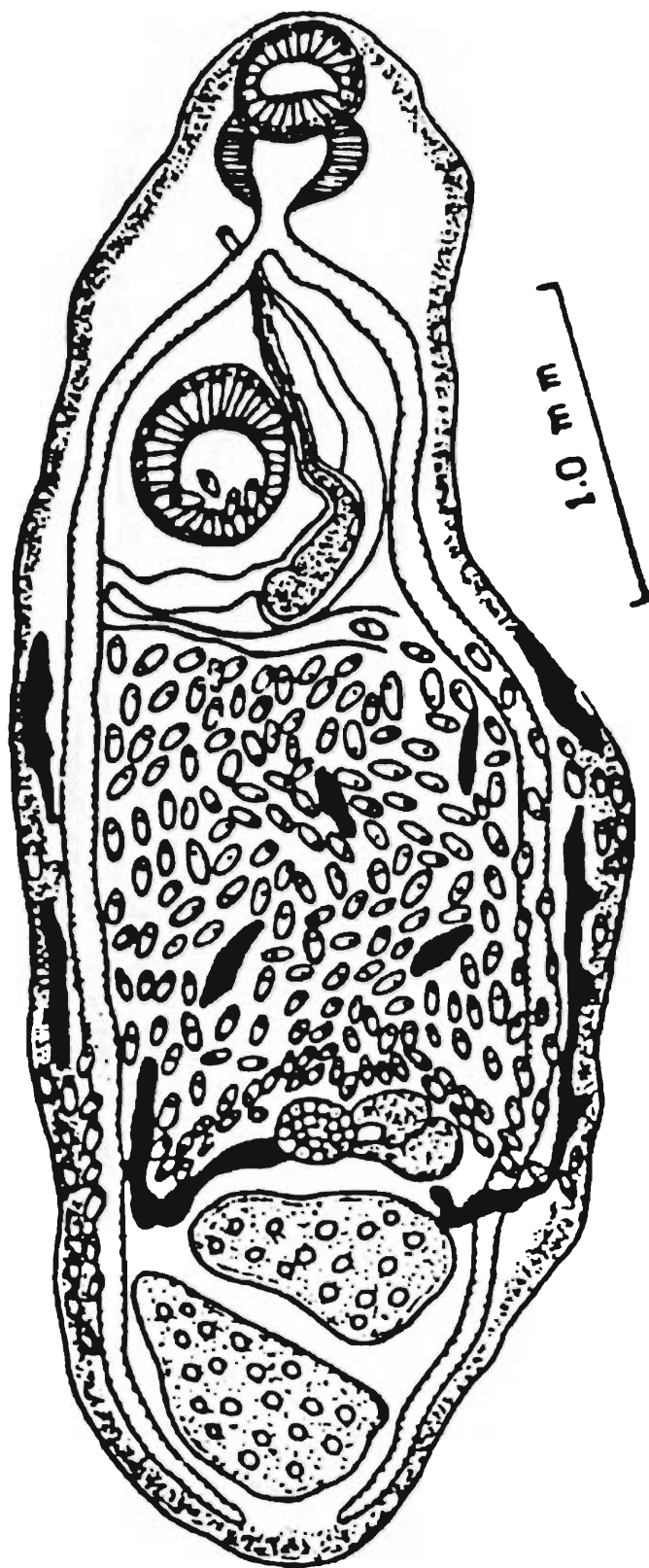


Fig. 1

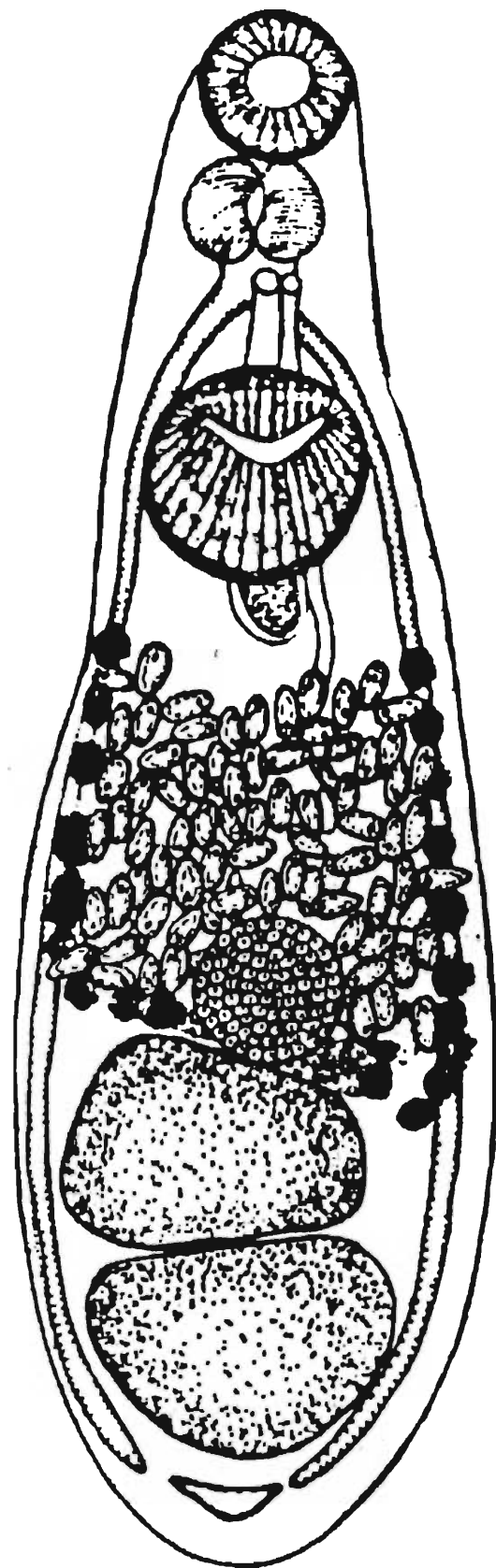


Fig. 2

Fig. 1. *Philophthalmus nocturnus* Looss, 1907 of Ghosh and Chakrabarti, 1994

Fig. 2. *P. nocturnus* Looss, 1907 of Swarnakumari and Madhavi, 1992

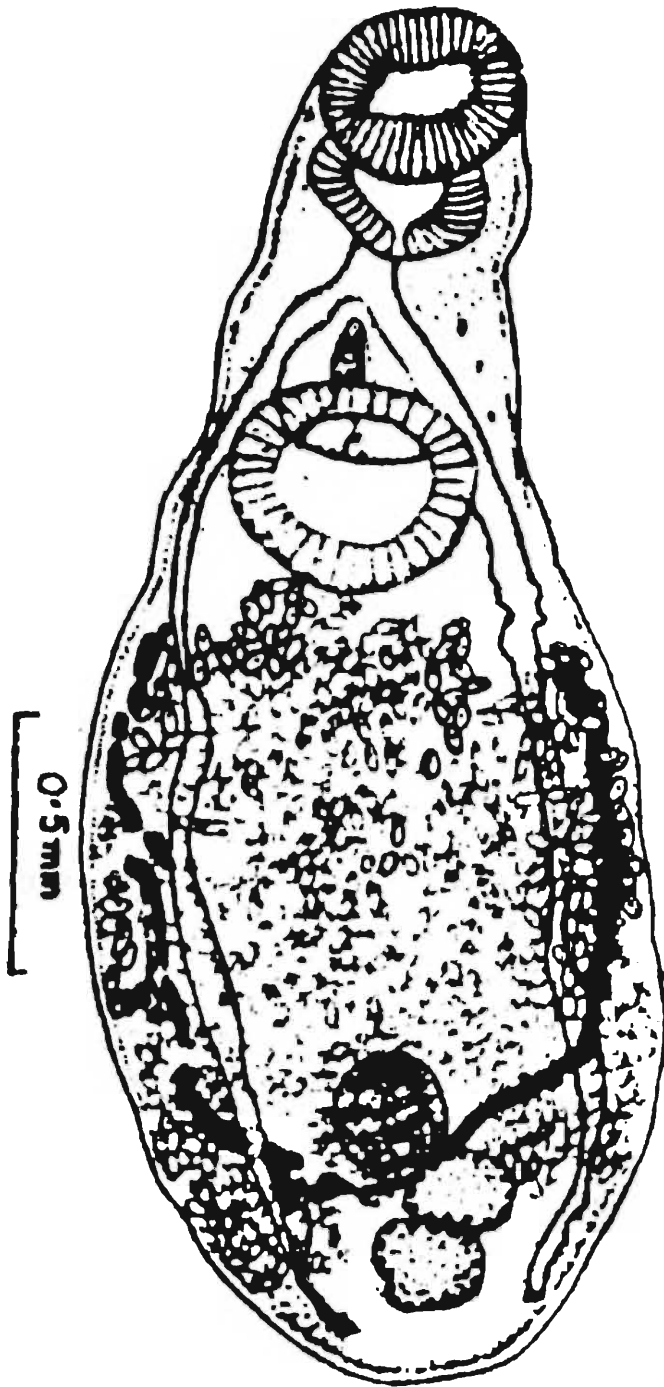


Fig. 5

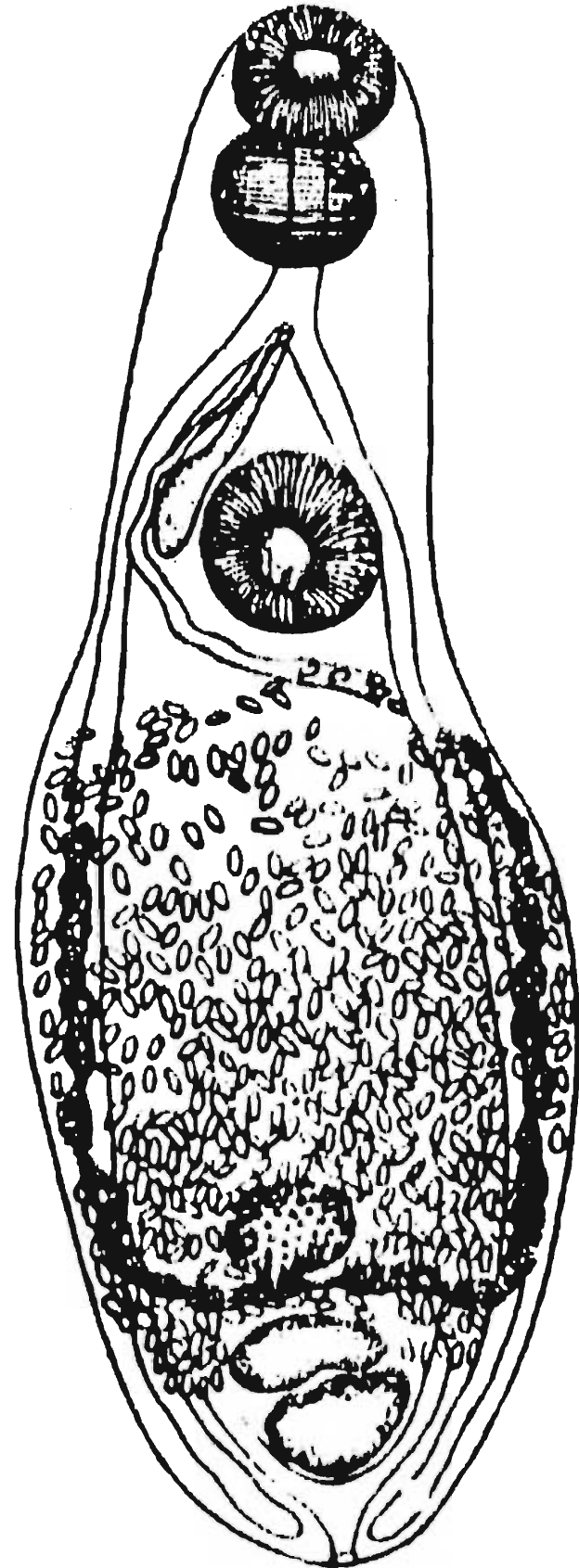


Fig. 6

Fig. 5. *P. gralli* Mathis et Leger, 1910 of Mehra, 1982

Fig. 6. *P. problematicus* Tubangui, 1932

Hence the detailed study of the biology and the host-parasite relationship of the two species may disclose *P. gralli* to be synonym with *P. nocturnus* (Fig. 2).

It may be noted here that most of the Indian species have been described on the basis of few specimens only. Evaluations of various characters relied upon for differentiating species, reveals that the following characters are to be taken into account for correct diagnosis.

Ratio of suckers, length and breadth, nature of vitellaria whether tubular or follicular; extension of vitellaria is a variable character as it is found to vary as per the stage of maturity. Extension of cirrus is also an important character. In some species cirrus sac extends further below to acetabulum or not crossing even half to the length of the acetabulum. Uterine coils appear to be variable to a great extent, possibly depending upon the stage of maturity. Shape and the size of the vesicula seminalis, recepticulum seminis uterinum, are also much variable. Position of the genital pore may be a dependable character, provided observed in large number of specimens.

Thus on the basis of our study along with observations of Murthy, 1966, 1967; Prokash and Pandey, 1968; Swarnakumari and Madhavi, 1992, we consider *P. gralli* as synonym of *P. nocturnus*.

Distinguishing characters of the species *P. anatinus* Sugimoto, 1928, *P. (L) alli* Karyakarte, 1971 (Fig. 12) and *P. peteri* Sreekumaran and Peter 1973 subsequently recorded from India are well within the wide range of variations in *P. nocturnus*. As such they are also considered as synonymous with *P. nocturnus*.

Thus in our opinion *P. nocturnus* stands as the specific trematode parasites of eye, found in different species of birds throughout Indian subcontinent.

Distribution : Europe, Africa, America, Asia.

SUMMARY

Taxonomic status of all the Indian species under the genera *Philophthalmus* described and recorded so far from India have been reevaluated. Critical studies on the extent of variation in respect of genital pore, nature & distribution of vitellaria, genital complex etc., have been made. It has been inferred that *Philophthalmus nocturnus* Looss, 1907 is the only valid species under the genus *Philophthalmus* in Indian subcontinent.

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Fig. 7

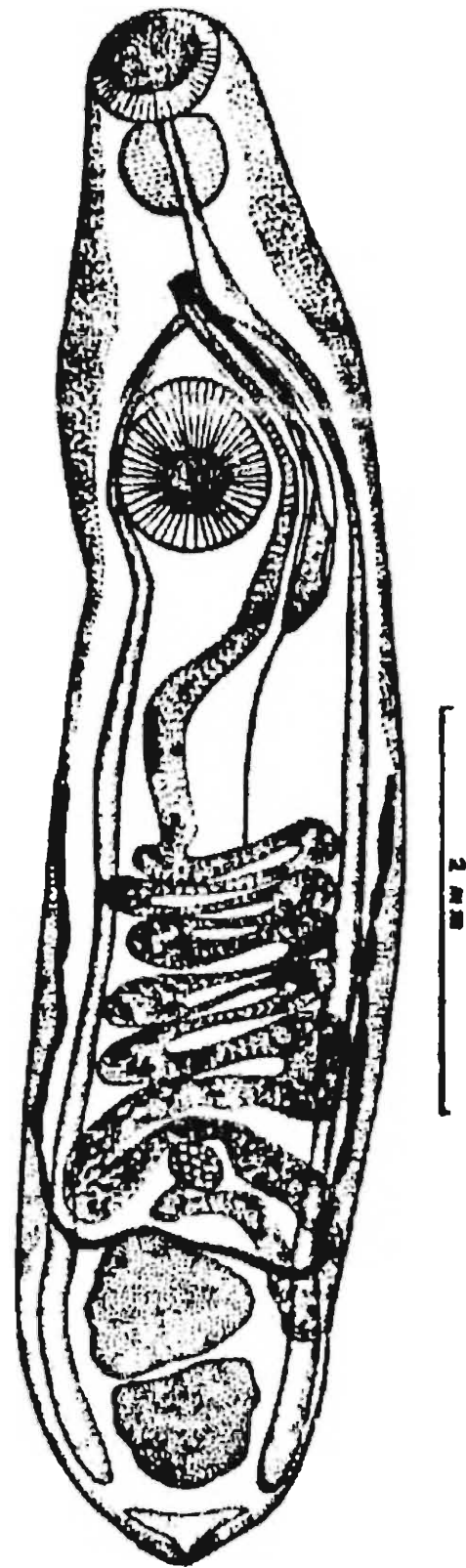


Fig. 8

Fig. 7. *P. inducus* Jaiswal and Singh, 1954

Fig. 8. *P. mirzai* Jaiswal and Singh, 1954

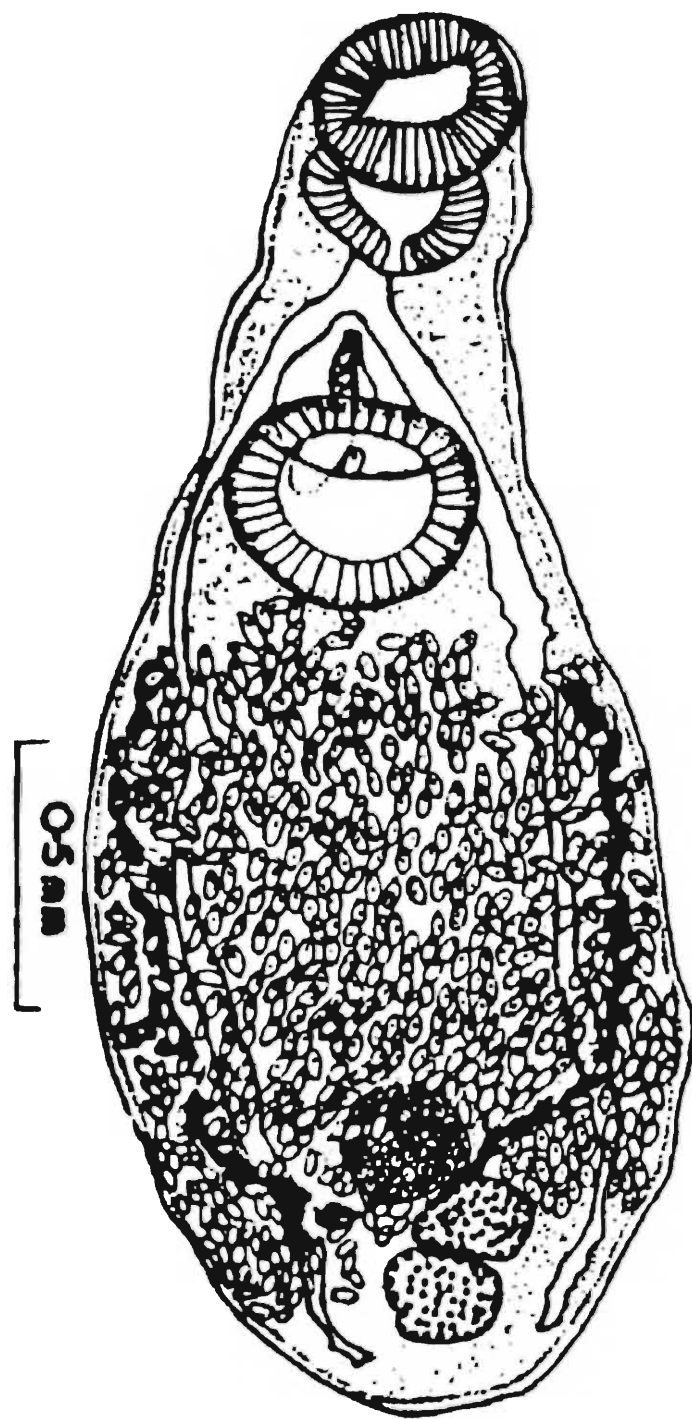


Fig. 9

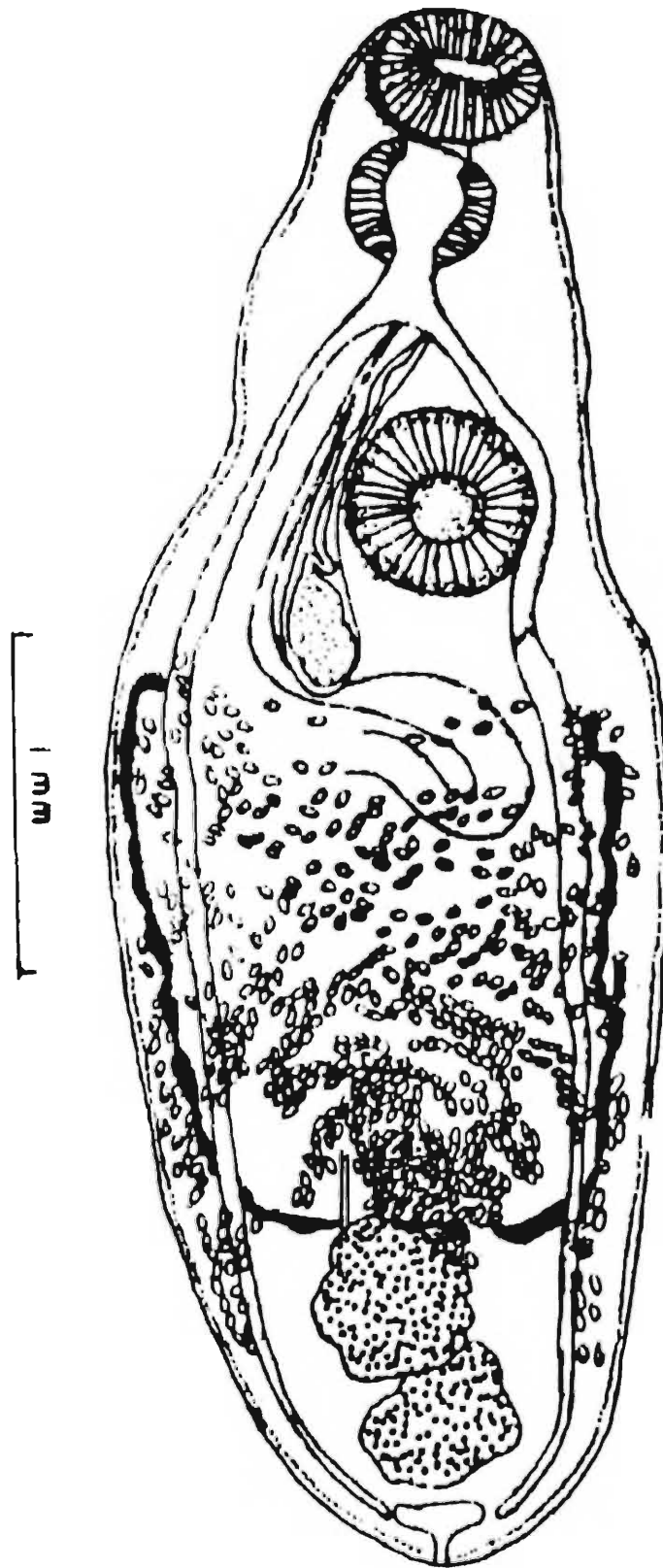


Fig. 10

Fig. 9. *P. halcyoni* Baugh, 1962

Fig. 10. *P. lucknowensis* Baugh, 1962



Fig. 11

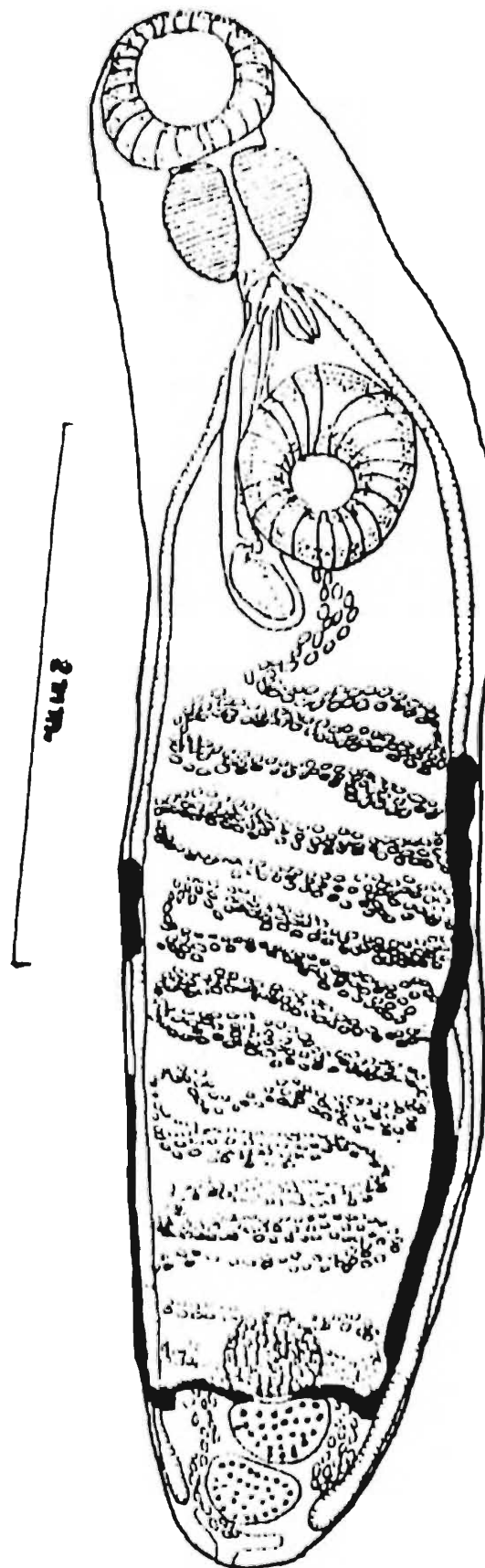


Fig. 12

Fig. 11. *P. (M.) chrysomae* Karyakarte, 1967

Fig. 12. *P. (T.) alli* Karyakarte, 1971

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* Not consulted in original.

Short Communication

**TOPOTYPE OF *BREGMACEROS MCCLELLANDI* THOMPSON
(PISCES : BREGMACEROTIDAE) FROM THE GANGETIC DELTA
WITH A REDESCRIPTION OF THE SPECIES**

INTRODUCTION

While going through the National Zoological Collection of the Zoological Survey of India, Kolkata, three specimens of the genus *Bregmaceros* Thompson, 1840 were found, collected from the Gangetic delta, West Bengal (26°–27° N and 88°–89° E), India. These specimens when examined and compared with the only species under the genus known from the Indian region (Talwar, 1984) identified as *B. mcClellandi* Thompson, 1840. Since the species was not adequately described in the original description and the present species has been collected from its type locality after a long period of 141 years, the species has been proposed here as a topotype of *B. mcClellandi* with a redescription of the species. It may also be mentioned here that the author of this species has not kept the type specimen of the species, therefore, collected of topotype from its type locality with a redescription of the species was long felt.

***Bregmaceros mcClellandi* Thompson**

1840. *Bregmaceros mcClellandi*, Thompson, *Charlesworth Mag. nat. Hist.*, 4 : 184 (Type-locality : Gangetic delta, West Bengal, India).

1984. *Bregmaceros mcClellandi*, Talwar, *Commercially Sea Fishes of India* : 294 (description and distribution).

Materials examined : 3 exs., 62 to 88 mm Total length; Reg. No. : ZSI, Calcutta, F9353/2; Bakkhali, Gangetic delta, South 24 Parganas, West Bengal, India; Coll. : P. Mukherjee Date of coll. 03.02.1981.

Body moderately elongate and compressed. Head length 6.76 to 7.13 and body depth 6.28 to 6.88 in total length. Eye diameter 3.83 to 4.50 in head length. Snout length 3.60 to 4.33 and postorbital length 1.80 to 1.90 in head length. Dorsal fin two, first dorsal consist of a single long ray originated on top of rear portion of head, extending almost up to origin of second dorsal. Second dorsal and anal fins with broad bases almost similar length, the middle rays of both the fins much shorter. Pelvic fins originated under rear part of head, with 5 rays, of which the outer 3 rays long and thick extending far beyond the origin of anal fin. Pectoral fins with 25 rays, inserted just behind the opercular end. Caudal fin forked. Lateral line scales 63 to 65.

Colour : Dorsal surface and upper part of sides light brown, lower sides and abdomen silvery. Entire or upper part of pectoral fin black. Anterior and posterior part of second dorsal and fin black. Caudal fin black. Fins of the young specimens colourless.

Size : This species is known to attain up to 100 mm total length.

Distribution : Indo-West Pacific.

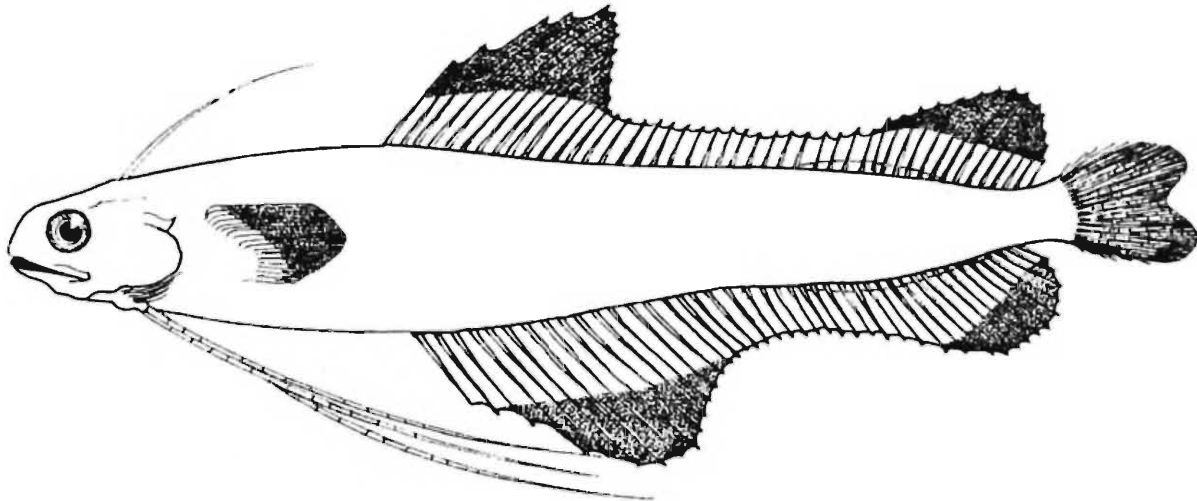


Fig. 1. *Bregmaceros mcClellandi* Thompson.

SUMMARY

Three specimens of *Bregmaceros mcClellandi* Thompson, 1840 were collected from its type locality, the Gangetic delta, West Bengal, India. This species has been designated as a topotype with a redescription of this species in this paper.

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Short Communication

REPORT OF LIVING PEN SHELL, *PINNA (ATRINA) PECTINATA PECTINATA* LINNAEUS (MOLLUSCA : BIVALVIA : PINNIDAE) FROM SHANKARPUR, WEST BENGAL

INTRODUCTION

During the faunistic survey at Digha-Shankarpur area, the authors noticed a number of living pen shells : *Pinna (Atrina) pectinata pectinata* Linnaeus from Shankarpur fishing harbour, which are harvested in trawl-nets along with other fish and nonfish materials.

Only the shells of *Pinna (Atrina) pectinata pectinata* Linnaeus is hitherto reported only from Sandhead (District : South 24 Parganas) in 1928 (Subba Rao *et al.*, 1992). This is the second report of the living species from the West Bengal coast.

A brief description of this species is given below.

MATERIAL AND METHOD

The living specimens were collected from the bycatch, dumped near Shankarpur fishing harbour. The soft parts were removed, washed in 70% alcohol and finally kept in dried condition.

SYSTEMATIC ACCOUNT

Phylum	MOLLUSCA
Class	BIVALVIA
Order	MYTILOIDA
Family	PINNIDAE

Pinna (Atrina) pectinata pectinata Linnaeus.

1767. *Pinna pectinata* Linnaeus, *Syst. nat.*, ed. 12 : 1160.

1891. *Pinna serra* Smith, *Proc. Zool. Soc.* London : 233.

Materials examined : 2 exs. Loc. Shankarpur fishing harbour. Coll. S. Mitra. Regd. no. 2090. Dated 13.xii.99.

Diagnosis : Shell wedge shaped, triangular, outline inflated; heavy; sculptured with radiating ribs, bears short upright spines which open posteriorly; sculpture consists of 5–30 radiating ribs on the posterior slope. Nacreous layer in both valves iridescent, occupying two-third of the valve, posterior adductor scar large, subcircular, located within the posterior border of the nacreous area; anterior adductor scar small, located at the tip of the nacreous area (Subba Rao *et al.*, 1992).

Measurements (in mm) :

Specimens	Length	Height	Width
1	265	63	17
2	250	48	11

Distribution : India : West Bengal : South 24 Parganas, Shankarpur coast, District Midnapore (Present record) and Andaman & Nicobar Islands. Elsewhere : Srilanka, Thailand, Malaya, Korea, Japan, Philippines and Australia.

SUMMARY

This is the second report of the species from West Bengal after 1928. The occurrence of live specimens indicate that further search may reveal more specimens. Since it is collected in fishing trawler (trawlers are operated beyond 50 km from the shore), the species may be occurring offshore at a greater depth.

ACKNOWLEDGEMENTS

The authors wish to express their deep felt gratitude to Dr. J.R.B. Alfred, Director, Zoological Survey of India, Kolkata for providing facilities.

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MITRA *et al* : Report of living pen shell, *Pinna(atrina) Pectinata pectinata* Linnaeus.

PLATE I



Pen shell, *Pinna(Atrina)Pectinata pectinata*.