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DR. A. K. GHOSH
Director
Zoological Survey of India

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DR. A. K. GHOSH
Director
Zoological Survey of India

RECORDS OF THE ZOOLOGICAL SURVEY OF INDIA

Vol. 93 (3—4)

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Pages : 313-564

CONTENTS

PAGE

YADAV, B. E.—A Report on some species of the Genera <i>Digitipes</i> and <i>Ethmostigmus</i> (Chilopoda : Scolopendromorpha : Scolopendridae, Otostigminae) from Maharashtra ...	313
ADHIKARY, C. C. AND GHOSH, A. K.—On the Occurrence of <i>Linognathus vituli</i> (Linnaeus) (Anoplura : Linognathidae) on a Giant Squirrel, <i>Ratufa indica</i> from North Bengal ...	317
YADAV, B. E.—Scolopendridae (<i>Chilopoda</i>) of Western Ghat with some First Records from the State of Maharashtra, India ...	321
SELVAKUMAR, S. AND AJMAL KHAN, S.—Grapsid and Xanthid Crabs of Parangipettai Coast ...	329
MANDAL, AJOY KUMAR, PODDAR, A. K., BHATTACHARYYA, T. P.—Records of <i>Megaerops niphanae</i> Yenbutra & Felten, 1983 (Mammalia ; Chiroptera : Pteropodidae), <i>Hipposideros lankadiva</i> Kelaart, 1850 and <i>Hipposideros armiger armiger</i> (Hodgson, 1835) (Chiroptera Rhinolophidae) from Manipur, India with Taxonomic Notes. ...	355
BASTAWADE, D. B.—Spiders as Larval Food of <i>Sceliphron violaceum</i> (Dahlb.) (Hymenoptera : Sphecidae) ...	361
RAMAKRISHNA—Biomonitoring of Inland Water : Physical, Chemical and Biological Parameters of River Musi at Hyderabad Andhra Pradesh, India ...	367
MARY BAI, M.—Ecological Studies on the River Cooum with Special Reference to Pollution ...	393
VASANTH, M.—Avifauna of Kalakad Wildlife Sanctuary, Tamil Nadu, India ...	417
MURTHY, T. S. N.—First Record of the Uropelt <i>Teretrurus Sanguineus</i> (Beddome 1887) (Reptilia) Serpentes from the Nilgiris, South India ...	447

NAGABHUSHANAM, A. K. AND KRISHNAN, S.—Observations on the Distribution of some of the Marine Organisms Inhabiting the Intertidal Zone Along the Western Continental Shelf of the Bay of Bengal, with Particular Reference to the Tamil Nadu Coastal Strip	...	449
RAMAKRISHNA, G. AND SINHA, BHANUDEB—Systematic Status of the Genera <i>Adinda</i> , <i>Periscyphis</i> , <i>Paraperiscyphis</i> and <i>Toradjia</i> Crustacea—Isopoda—Oniscoidea—Armadillidae	...	491
HAFEEZULLAH, M.—Cestodes of Vertebrates of Rajasthan	...	507
YADAV, B. E. AND KAMBLE, R. H.—A note on the Temperature Preference in <i>Mesobuthus tamulus tamulus</i> (Fabr.) (Order : Scorpionida, Family : Buthidae)	...	529
HAFEEZULLAH, M.—Trematodes of Vertebrates of Rajasthan	...	537
MUKHERJEE, R. P., CHAUDHURI, S. AND MURMU, A.—Population Survey of Non-Human Primates (Mammalia) of Tripura	...	557

A REPORT ON SOME SPECIES OF THE GENERA *DIGITIPES* AND
ETHMOSTIGMUS (CHILOPODA : SCOLOPENDROMORPHA :
SCOLOPENDRIDAE, OTOSTIGMINAE) FROM
MAHARASHTRA

B. E. YADAV

Zoological Survey of India
Western Regional Station, Pune-411 005

INTRODUCTION

During the course of general faunistic survey of Kolhapur, Sindhudurg and Pune districts, some interesting specimens of centipedes of the genera *Digitipes* and *Ethmostigmus* belonging to tribe Otostigmini were collected under stones, which constitute their first record from Maharashtra.

I. Genus ; *Digitipes* Attems, 1930

The Old World genus of Congo origin, was first recorded in Deccan by Jangi and Dass (1984).

Diagnosis : The claw of 2nd maxilla without spur, nine pairs of oval undivided spiracles present above alternate legs from 3rd onwards except 7th ; anal legs possess postero-medial femoral process in males.

Species and distribution : Out of six species known from Deccan Plateau, *Digitipes barnabasi* Jangi and Dass is fairly well known from Maharashtra while *D. chhotanii* Jangi and Dass, *D. indicus* Jangi and Dass and *D. coonoorensis* Jangi and Dass form the first record, the details of which are given below—

1. *Digitipes chhotanii* Jangi and Dass, 1984

Material examined : INDIA : MAHARASHTRA, Pune District, Khandala Ghat, 68 kms NW of Pune, 1-X-1988, 2 ♂♂, 1 ♀, Dr. G. M. Yazdani.

Remarks : The 21st sternite longer than broad, (*vs* broader than long). Anal leg tarsi smooth (*vs* pilose).

2. *Digitipes indicus* Jangi and Dass, 1984

Material examined : INDIA, MAHARASHTRA, Sindhudurg Dist, Phonda Ghat, 10-IX-1987, 1 ex, Dr. D. B. Bastawade ; Pune District, Khandala Ghat, 1-X-1988, 1 ♀, Dr. G. M. Yazdani.

Remarks : The specimen from Sindhudurg exhibited variation : 2nd—5th and 13th—20th tergal segments slightly overlapping the preceeding ones ; 6-12 normal ; 10th—20th broader than long.

3. *Digitipes coonoorensis* Jangi and Dass, 1984

Material examined : INDIA : MAHARASHTRA, Sindhudurg Dist., 30 kms. W. of Amboli Ghat, 19-IX-1987, 1 ♀, Dr. D. B. Bastawade.

Remarks : Lateral tergal emargination starts on 6th instead of 8th, and 15th—20th tergal segments broader than long.

II. Genus *Ethmostigmus* Pocock, 1898

The genus *Ethmostigmus*, having worldwide distribution, is represented by five species in India.

Diagnosis : Maxillipedes in the genus lack median dental process but possess 10 pairs of spiracle, including one above the 7th pair of walking legs, the 1st pair of spiracle is large, elliptical and sieve like.

Species and distribution : *Ethmostigmus pygomegas* (Kohlraush) is known to occur in Himalaya (Gravely, 1912) *E. coonooranus* Chamberlin from Nilgiri Hills (Tamil Nadu), *E. platycephalus spinosus* (Newport) from Maharashtra, Karnataka, Tamil Nadu, *E. P. cribrifer* (Gervais) from Mysore (Karnataka) while *E. p. platycephalus* (Newport), the only record from Malabar coast (Kerala).

1. *Ethmostigmus p. platycephalus* (Newport) 1845

Diagnosis : Four basal antennal segments glabrous, median dental plate having 3 teeth, posteriomedial spiny process of anal leg prefemur is of normal size, anal leg prefemur with 3 ventrolateral spines and coxopleural process tipped with 2-4 spines ; bearing dorsally 0-1 spine.

Material examined : INDIA : MAHARASHTRA, Kolhapur District, 60 km. N. of Pundra on Ajra Road, 28-IX-1986, 1 ex, Dr. D. B. Bastawade.

Remarks : Coxopleural process tipped with 2 spines (vs 2-4) and 1 lateral (vs 0-1 dorsal). Body length—110 mm.

SUMMARY

Three species belonging to genus *Digitipes* viz. *D. chhotanii* Jangi and Dass, *D. coonoorensis* Jangi and Dass and one to the genus *Ethmostigmus*, *E. p. platycephalus* (Newport) collected from Western Ghats, Pune, Kolhapur, and Sindhudurg districts are reported for the first time from Maharashtra.

ACKNOWLEDGEMENTS

I am grateful to the Director, Zoological Survey of India, Calcutta, and Dr. G. M. Yazdani Sci-SE, O/C of W. R. S. Pune, for the laboratory facilities.

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ON THE OCCURRENCE OF *LINOGNATHUS VITULI* (LINNAEUS)
(ANOPLURA : LINOGNATHIDAE) ON A GIANT SQUIRREL,
RATUFA INDICA FROM NORTH BENGAL

C. C. ADHIKARY AND A. K. GHOSH

Zoological Survey of India, Calcutta.

INTRODUCTION

Linognathus vituli was first described by Linnaeus (1758) as a species of *Pediculus*. Later on various workers placed its under *Haematopinus* and *Trichaulus*. It was Enderlein (1905) who first rightly considered as a number of *Linognathus* and since then the generic status of the species has been in use. The lice was reported to infest the domestic cattle of Europe, North America, India (Ferris, 1932, 1951) and Wild Boar from Hungary (Dudich 1923). There had been no record on the occurrence of this species in mammal other than Cattle and Boar. During this investigation, the lice have been collected from giant squirrel from Jalpaiguri, North Bengal, India. The squirrel hosting this parasites in fair number should be considered as a new host of *Linognathus vituli* in India. In this paper, the revision of the description of the species has been made with addition of some new characters of taxonomic importance. The general morphology and usages in describing lice follows Kim and Emerson (1978).

***Linognathus vituli* (Linnaeus)**

Female : (Fig. 1) Total body length 2.46 mm. **Head :** (Fig. 2) Without eyes, elongate the forehead acutely conical, slightly shorter than hind head, which has the later margins straight and parallel ; entire head quite strongly sclerotic and pigmented with a darker longitudinal band long the lateral margin of the hind head. All typical head setae present ; ventral setae large, larger than dorsal side, ventral pre-antennal head setae (VPaHS) long, sutural head setae (SHS) 2 pairs ; supra antennal central head setae (SPAtCHS) small, dorsal Principal head setae (DPHS) long, dorsal marginal head setae (DMHS) 2-3 pairs. Antennae 5 segmented ; occipital apophyses (OA) not developed. Pharynx without brushes ; mouth parts reaching nearly to the posterior border of the thorax.

Thorax : Meso and meta thoracic phragmata well developed, notal pit indistinct. Sternal plate absent. **Legs :** Forelegs small and slender with acuminate claws, mid and hind legs subequal and larger than forelegs ; each with stout claw, tibial thumbs highly developed ; each with a spiniform seta ; one pair of mesothoracic spiracle. Dorsal principal thoracic setae (DPTS) medium sized, one pair. **Abdomen :** Membraneous, with no sternal and targal plates except genital and terminal segments. Paratergites

absent. Central abdominal setae (CAS) in two rows both dorsal and ventral side. In dorsal, anterior row having 3-5 setae, terminal with 2 setae, rest having 7-9 setae each. In ventral, anterior having 2-4 setae and remaining 9-11 setae each. 6 pairs of spiracles, with distinct internal ledges ; a pair of each on segments 3-8.

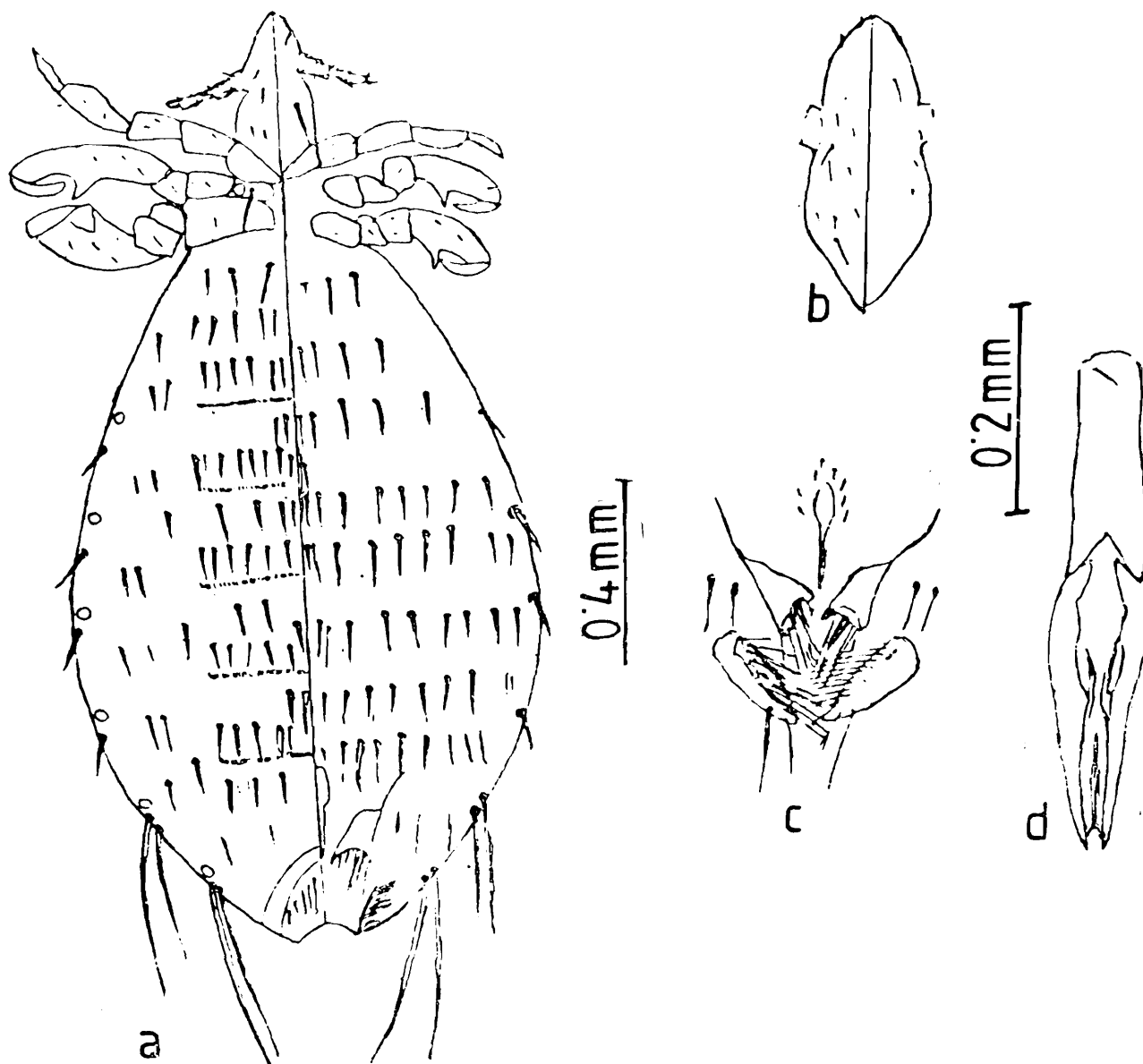


Fig. a. *Linognathus vituli* (Linnaeus), b. Head, c. Genitalia of Female, d. Genitalia of Male.

Genitalia : (Fig. 3) Gonopods very distinctive form, set close together, broad, with posterior margin emarginate and bearing a sclerotic hook at its inner angle.

Male : In general very similar to female. **Genitalia :** (Fig. 4) Parameters long and acutely tapering, almost entirely concealing the delicate, elongate, ring-like endodermal piece, basal apodeme longer than terminal complex ; Pseudopenis small with slender arms, apex of the apodemes terminating in a single point.

Nymphs : Unknown.

Material examined : 5 ♀ ♀, 4 ♂ ♂.

Host : Giant squirrel, *Ratufa indica* (Erxleben).

Place of collection : Jainti, Jalpaiguri, 10.12.84.

Remarks : The present specimens correspond with those described by Ferris, 1932, 1951 from Europe, N. America, India and Wild Boar from Hungary by Dudich, 1923, but with following differences ; Head : VPahs long, SHS 2 pairs, SPAtCHS small, DPHS long ; DMHS 2-3 pairs. Thorax : MDHS one pair ; medium sized. Abdomen : CAS in two rows both dorsal and ventral side. In dorsal, anterior 3-5 setae, terminal with 2 setae, remaining having 7-9 setae each. In ventral, anterior 2-4 setae, remaining having 9-11 setae each.

SUMMARY

A new host Giant squirrel, is recorded from *Linognathus vituli* (Linnaeus) a parasite of common cattle for the first time. The morphology of the lice has also been described in details in this paper.

ACKNOWLEDGEMENTS

The author is thankful to Sri A. K. Mondal, Scientist 'B', Zoological Survey of India, for identification of mammal and to Dr. P. K. Chaudhuri, Reader in Zoology, Burdwan University, for going through the manuscript. Sincere thanks to Shri S. Ghosh, Zoological Survey of India, for collection of specimees.

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SCOLOPENDRIDAE (*CHILOPODA*) OF WESTERN GHAT WITH SOME FIRST
RECORDS FROM THE STATE OF MAHARASHTRA, INDIA

B. E. YADAV

Zoological Survey of India
Western Regional Station
Pune-411 005

INTRODUCTION

Western Ghat, a rich heritage of biodiversity, forms a vast array of tropical evergreen forests, with the patches of mixed to dry deciduous, having red laterite and black soil, provides the unique home-sites for centipedes, in the moist soil as well as in the semi-arid zones and habitats at hill ranges. However, as a result of human invasion, through urbanization and rapid constructions, centipedes are under threat.

The Scolopendridae, in India, is represented by two subfamilies, 3 tribes, 8 genera comprising about 70 species.

During the course of faunistic survey of Ahmad Nagar, Raigad, Kolhapur, Sangli and Pune districts, specimens of *Scolopendra* (*Trachycormocephalus*) *indiae* (Chamberlin),* *S. (T) mirabilis* (Porat)* and *Scolopendra andhrensensis* Jangi and Dass, were collected. Hitherto the first two species were restricted to Indo—Gangetic belt (Khanna, 1977, Vazirani and Khanna 1977, Jangi and Das 1984) and the last was originally described by Jangi and Dass (1984) from Vishakhapatnam district, Andhra Pradesh. The present account constituting the first record of three species adds significantly to the Scolopendrid Fauna of Western Ghat, and thus raising the number of species for W. G. to 41. The details of the specimens collected, are given below.

1. *Scolopendra indiae* (Chamberlin) 1914

Material examined : INDIA, MAHARASHTRA, Raigad district, 50 kms E. of Mangaon, 6-XII-1987, 1 ex. Dr. D. B. Bastawade, Ahmad Nagar district, Chincholi Village, 8-IX-1988, 1 ex., Dr. R. H. Kamble.

Diagnostic characters : Lateral emargination only on the 21st tergite.

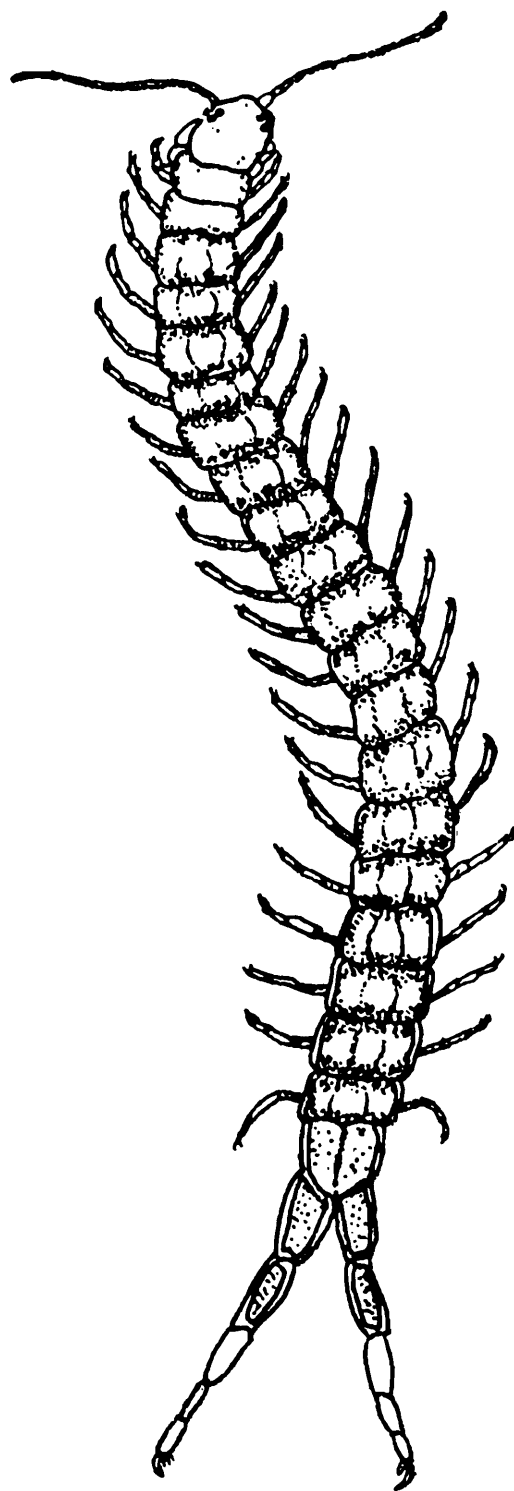
Variations noticed : Length 50 mm. (Vs. 23 mm.). The claw of anal legs without tarsal spur.

Distribution : ORISSA : Jeypore dist. RAJASTHAN ; Jodhpur dist. MAHARASHTRA : Ahmad Nagar and Raigad dist.

* Lewis (1986) Synonymised the genus *Trachycormocephalus* under *Scolopendra*.

2. *Scolopendra mirabilis* (Porat) 1876

Material examined : INDIA, MAHARASHTRA, Sangli district, Machundi Village, 20 kms. E. of Jat-Umadi Road, 19-X-1984, 1 ex., Dr. A. S. Mahabal.



Scolopendra amazonica Bucherl

FIG. 1

Diagnostic characters : Lateral emargination on the tergites 17th-21st.

Variations noticed : The claw of anal legs with a spur.

Distribution : RAJASTHAN : Nagpur dist. Jodhpur ; Asop Village, Bharatpur, MAHARASHTRA : Sangli district.

The base of dental plate on the coxosternum of *S. indiae* (Chamberlin) and *S. mirabilis* (Porat) noticed hairy with median longitudinal furrows as was observed by Khanna (1977),

3. *Scolopendra andhrehis* Jangi & Dass 1984

Material examined : INDIA, MAHARASHTRA, Kolhapur district, Kadamkai khind, near village Tamdalge, 15-VIII-1989, 1 adult female, Dr. S. G. Patil ; Pune district, Vetil hill, 22-IX-1983, 1 ex, Dr. D. B. Bastawade.

Diagnostic characters : The cephalic plate bearing coarse pit like puncta, lack of tarsal spur on the 20th pair of walking legs, prefemur of anal legs ventrally having 1-6 spines.

Variations noticed : Length 80 mm. (Vs. 26 mm.)

Antennae : Composed of 19 articles instead of 17, six basal segments glabrous. **Cephalic plate :** In Kolhapur specimen, puncta, on anterior 1/3 portion (Vs 2/3). **Tergites :** Lateral emargination starts on 15th (Vs 18th). **Maxillipedes :** out of six median teeth, inner 2 (Vs 3) partly united. **Toothed femoral process** present only at one side in the Kolhapur specimen.

Distribution : ANDHRA PRADESH : Visakhapatnam district, MAHARASHTRA : Kolhapur and Pune districts.

THE SCOLOPENDRID CENTIPEDES OF WESTERN GHAT

Family : SCOLOPENDRIDAE

Subfamily : SCOLOPENDRINAE

Tribe : Scolopendrini

<i>Sl. No.</i>	<i>Species</i>	<i>Distribution in W. G. Belt</i>
1.	<i>Scolopendra amazonica</i> Bucherl	Maharashtra, Goa, Karnataka, Kelala, T. N.
2.	<i>Scolopendra morsitans</i> Linn.	Maharashtra, Karnataka, Bangalore, Tamil Nadu.
3.	<i>Scolopendra hardwickei</i> Newport	Maharashtra, Karnataka, Karwar, Mysore.
4.	<i>Scolopendra subspinipes</i> Leach	Tamil Nadu : Cochin.

Sl. No.	Species	Distribution in W. G. Belt
5.	<i>Scolopendra subspinipes dehani</i> Brandt	Karnataka : Karwar.
6.	<i>Scolopendra andhrensensis</i> Jani & Dass,	Maharashtra : Pune, Kolhapur.
7.	<i>Scolopendra punensis</i> Jangi & Dass	Maharashtra, Pune.
8.	<i>Scolopendra ellorensis</i> Jangi & Dass	Maharashtra, Aurangabad, Ellora.
9.	<i>Scolopendra indiae</i> (Chamberlin)	Maharashtra, Ahmad Nagar, Raigad.
10.	<i>Scolopendra mirabilis</i> (Porat)	Maharashtra, Sangli.
11.**	<i>Arthrorhabdus jonesii</i> Verhoeff	Kerala : Trivendrum.
12.	<i>Cormocephalus westwoodi dispar</i> Porat	Deccan area.
13.	<i>Cormocephalus macrosestrus</i> Attems	Maharashtra.
14.	<i>Cormocephalus pygmaeus</i> (Pocock)	Maharashtra : Nasik, Karnataka : Kanara.
15.	<i>Cormocephalus nudipes</i> Jangi & Dass	Karnataka : Mangalore, Karwar.
16.	<i>Cormocephalus pilosus</i> Jangi	Maharashtra, Karnataka, Goa.
17.	<i>Cormocephalus denticaudus</i> Jangi & Dass	Maharashtra, Satara, Panchgani.
18.	* <i>Cormocephalus nigrificatus</i> Verhoeff	Kerala : Trivendrum.
19.	<i>Cormocephalus pseudonudipes</i> Jangi & Dass	Maharashtra : Nasik.
Tribe : Asanadini		
20.	<i>Asanada brevicornis</i> Meinert	Maharashtra.
21.	<i>Asanada agharkari</i> (Gravely)	Maharashtra : Satara Koyana Valley.
22.	<i>Asanada sokotrana</i> (Pocock)	Maharashtra : Aurangabad ; Pune ; Kerala : Palghat.
23.	<i>Asanada indica</i> Jangi & Dass	Maharashtra.
Subfamily : OTOSTIGMINAE		
Tribe : Otostigmini		
24.	* <i>Digitipes gravelyi</i> Jangi & Dass	Kerala : Palghat.
25.	<i>Digitipes coonoorensis</i> Jangi & Dass	Tamil Nadu : Nilgiri, Maharashtra : Sindhudurg.
26.	<i>Digitipes indicus</i> Jangi & Dass	Maharashtra, Pune, Khandala Kerala : Palghat, Trichur.
27.	<i>Digitipes chhotanii</i> Jangi & Dass	Maharashtra : Pune, Khandala.

<i>Sl. No.</i>	<i>Species</i>	<i>Distribution in W. G. Belt</i>
28.	<i>Digitipes barnabasi</i> Jangi & Dass	Maharashtra.
29.	<i>Otostigmus orientalis</i> Porat	Maharashtra, Bombay, Pune, Bhorghat.
30.	<i>Otostigmus politus</i> Karsch	Kerala, Palghat.
31.	* <i>Ethmostigmus coonooranus</i> Chamberlin	Tamil Nadu : Nilgiri
32.	* <i>Ethmostigmus tristis</i> (Meinert)	Tamil Nadu : Nilgiri
33.	* <i>Ethmostigmus platycephalus platycephalus</i> (Newport)	Maharashtra, Kolhapur, Kerala : Malbar coast, T. N. Nilgiri.
34.	<i>Ethmostigmus p. spinosus</i> (Newport)	Karnataka : Mysore, Maharashtra : Satara, Mahabaleshwar.
35.	* <i>Ethmostigmus p. cribrifer</i> (Gervais)	Karnataka : Mysore.
36.	<i>Rhysida lithobioides trispinosus</i> Jangi & Dass	Maharashtra, Karnataka.
37.	<i>Rhysida longipes simplicior</i> Chamberlin	T. N. : Coonoor.
38.	<i>Rhysida longipes longipes</i> (Newport)	Goa, Karnataka : Coorg.
39.	<i>Rhysida nuda subnuda</i> Jangi	Maharashtra, Karnataka, Kerala.
40.	<i>Rhysida nuda immarginata</i> (Porat)	Maharashtra : Pune, Khandala.
41.	<i>Rhysida crassispina</i> Kraepelin	Maharashtra : Raigad, Matheran.

Source : Pocock (1892), Gravely (1910), Attams (1930), Jangi & Dass (1980 a, b), Jangi (1966), Jangi & Dass (1984), Khanna & Tripathi (1987), Koch (1984), (Unpublished record).

* Endemic, ** Rare in Asia.

Key to the known Indian species of Scolopendra

- | | | | |
|----|---|---|---|
| 1a | Head with basal plate. | ... | 2 |
| 1b | Head without basal plate. | ... | 4 |
| 2a | Cephalic plate with para median furrows, coxosternal plate of maxillipedes with furrows. | ... | 3 |
| 2b | Cephalic plate bearing coarse pit like puncta, coxosternal plate of maxillipedes without furrow, 20th walking leg without tarsal spur and anal leg prefemur, ventrally having 1-6, spines, (excluding prefemoral process) ... | <i>S. andhrensensis</i>
Jangi & Dass | |

- | | | | | |
|-----|---|-----|--|----|
| 3a | Tergites 17th 21st laterally emarginated. | ... | <i>S. mirabilis</i>
(Porat) | |
| 3b | Only the Tergite 21st laterally emarginated. | ... | <i>S. indiae</i>
(Chamberline)) | |
| 4a | Head with distinct median longitudinal furrow. | ... | | 5 |
| 4b | Head without median longitudinal furrow, grooves or sulci may or may not be present on the head. | ... | | 6 |
| 5a | Coxopleural processes of anal leg segment simply pointed without spinules. | ... | <i>S. maziibii</i>
(Gravely) | |
| 5b | Coxopleural processes of anal leg segment tipped with spines. | ... | <i>S. occidentalis</i>
(Attems) | |
| 6a | Grooves or sulci on the head confined to the posterior half. | ... | | 7 |
| 6b | Grooves or sulci absent on the head, 1st tergite with or without transverse collar sulcus. | ... | | 8 |
| 7a | Coxosternal plate of the maxillipedes with net work of fine sulci on each side, 21st sternite, tapering with straight posterior margin. | ... | <i>S. nudus</i>
(Jangi & Dass) | |
| 7b | Coxosternal plate of the maxillipedes with two posteriorly divergent sulci, 21st sternite tapering with rounded posterior margin. | ... | <i>S. paranudus</i>
(Khanna & Tripathi) | |
| 8a | 1st tergite with transverse collar sulcus. | ... | <i>S. valida</i> H. Lucas | |
| 8b | 1st tergite without transverse collar sulcus. | ... | | 9 |
| 9a | Anal leg prefemur, femur and tibia in adult male dorsally flat and emarginated and prefemur in juveniles and adults of both sexes carrying ventrally 9 spines in 3 longitudinal rows. | ... | | 10 |
| 9b | Anal legs without such secondary sexual character. | ... | | 11 |
| 10a | 20th walking legs with tarsal spur. | ... | <i>S. morsitans</i> Linn. | |
| 10b | 20th walking legs without tarsal spur. | ... | <i>S. amazonica</i>
Bucherl | |
| 11a | Alternate brown or dark green, brownish yellow tergites indicating banded appearance of the trunk, anal leg prefemur without spines. | ... | <i>S. hardwicki</i>
Newport | |
| 11b | No colour pattern, anal leg prefemur with or without spines ventrally. | ... | | 12 |
| 12a | Anal leg prefemur (excluding prefemoral process) bearing 1-6 spines. | ... | | 13 |

- 12b Anal leg prefemur (excluding prefemoral process) bearing as many as 26 spine. ... *S. elloreensis*
Jangi & Dass
- 13 20th walking legs with tarsal spur, cephalic plate smooth or rugose. ... 14
- 14a Cephalic plate smooth. ... *S. subspinipes*
Leach
- 14b Cephalic plate rugose. ... *S. punensis*
Jangi & Dass.

SUMMARY

The present paper deals with an annotated list of the Scolopendrid centipedes of Western Ghat with the first record of three species of the genus *Scolopendra*, collected, during the course of faunistic survey of Ahmad Nagar, Raigad, Kolhapur, Sangli and Pune districts of Maharashtra.

ACKNOWLEDGEMENTS

I am grateful to the Director, Zoological Survey of India, Calcutta, and to Dr. G. M. Yazdani, Sci-SE, O/c, W. R. S, Pune, for the facilities.

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GRAPSID AND XANTHID CRABS OF PARANGIPETTAI COAST

S. SELVAKUMAR AND S. AJMAL KHAN

*Centre of Advanced Study in Marine Biology
Annamalai University, Parangipettai-608 502*

INTRODUCTION

Studies pertaining to the infauna of Parangipettai waters have been in progress since the inception of the Marine Biological Station in the year 1956. With the growth of this station as an Advanced Centre in Marine Research, a more extensive knowledge on the local fauna has become imperative. Special emphasis was given to this aspect, so as to get a comprehensive idea of community structure and population dynamics of this area. Brachyuran crabs, the most interesting group of organisms among the decapod crustaceans occur in large numbers in the Vellar estuary, Pitchavaram mangroves and in the trawl catches of local mechanised vessels. Sethuramalingam (1983) studied the portunid crabs of Porto Novo coast. No information is yet available regarding the species composition of grapsid and xanthid crabs. In the present study an inventory was made on species composition of the above groups and the results are given here. The terminology used in the keys conform to those of earlier works. The synonyms given are not to be complete.

CHECK LIST

- Family : Grapsidae Dana, 1851
- Subfamily : Grapsinae Dana, 1851
- Genus : **Grapsus** Lamarck, 1801
- Species : *G. strigosus* Herbst, 1783
G. tenuicrustatus (Herbst, 1783)
- Genus : **Metopograpsus** H. Milne Edwards, 1853
- Species : *M. maculatus* Milne Edwards, 1853
M. messor (Forskal, 1775)
- Subfamily : Varuninae
- Genus : **Ptychognathus** Stimpson, 1858
- Species : *P. altimanus* (Rathbun, 1914)
- Genus : **Pseudograpsus** H. Milne Edwards, 1837
- Species : *P. intermedius* Chhapgar, 1955

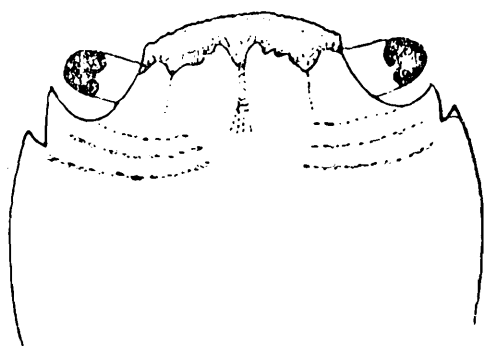
- Subfamily : Sesarminae Dana, 1852
- Genus : **Nanosesarma** Tweedie, 1950
- Subgenus : **Nanosesarma** Serene and Soh, 1970
- Species : *N. (Nanosesarma) minutum* (De Man, 1887)
- Subgenus : **Beanium** Serene and Soh, 1970
- Species : *N. (Beanium) batavicum* (Moriera, 1903)
N. (Beanium) andersoni (De Man, 1887)
- Genus : **Neoepisesarma** Serene and Soh, 1970
- Subgenus : **N. (Neoepisesarma)** Serene and Soh, 1970
- Species : *N. (Neoepisesarma) mederi* (H. Milne Edwards, 1853)
- Subgenus : **Muradium** Serene and Soh, 1970
- Species : *N. (Muradium) tetragonum* (Fabricius, 1798)
- Subgenus : **Selatium** Serene and Soh, 1970
- Species : *N. (Selatium) brockii* (De Man, 1887)
- Genus : **Parasesarma** (De Man, 1890)
- Species : *P. plicatum* (Latreille, 1806)
- Subfamily : Plagusinae Dana, 1851
- Genus : **Plagusia** Latreille, 1806
- Species : *P. depressa tuberculata* (Lamarck, 1818)
P. dentipes (De Haan, 1835)
- Family : Xanthidae Alcock, 1898
- Subfamily : Xanthinae Alcock, 1898
- Genus : **Liagore** De Haan, 1835
- Species : *L. rubromaculatus* (De Haan, 1835)
- Genus : **Leptodius** A. Milne Edwards, 1863
- Species : *L. crassimanus* A. Milne Edwards, 1867
- Genus : **Demia** Laurie, 1906
- Species : *D. buccalipes* Alcock, 1898
- Genus : **Halimede** De Haan, 1835
- Species : *H. ochtodes* (Herbst, 1783)
- Genus : **Galene** De Haan, 1833

- Species : *G. bispinosa* (Herbst, 1783)
 Subfamily : Piluminae Ortmann, 1893
 Genus : **Heteropanope** Stimpson, 1858
 Species : *H. indica* De Man, 1887

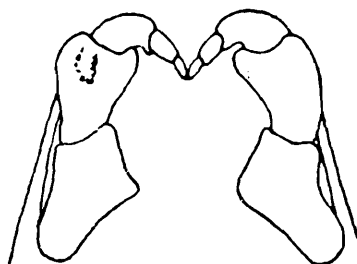
KEY FOR IDENTIFICATION

Key to Grapsidae

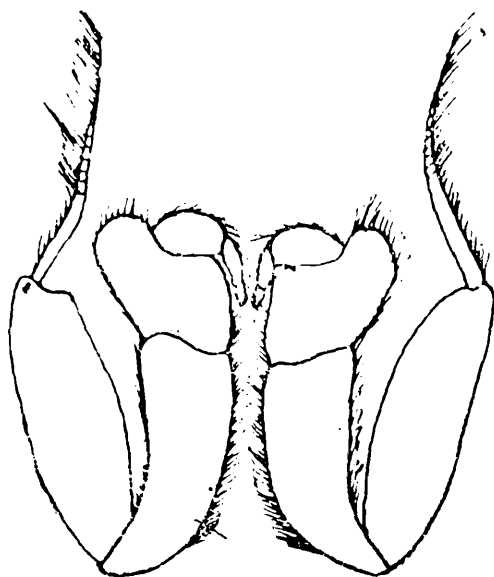
Last legs not dorsally placed ; a gap between third maxillipeds ; anterolateral side of carapace straight or arched ; front broad ; rarely true land crabs (Fig. 1).



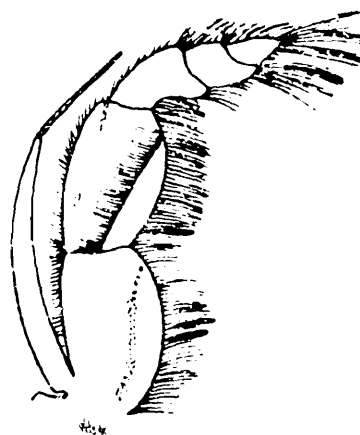
T. Fig. 1



T. Fig. 2



T. Fig. 3

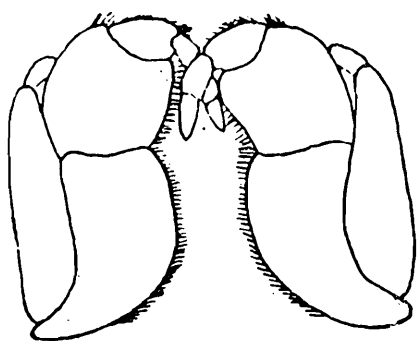


T. Fig. 4

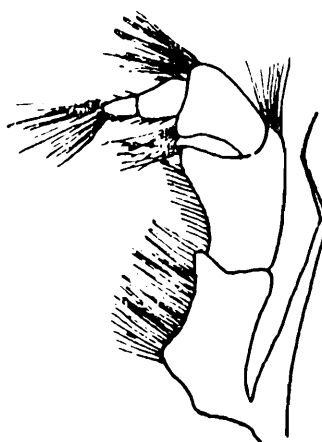
Figs. 1-4. 1. Broad front in grapsid crabs. 2. Gap between external maxillipeds in crabs of subfamily Grapsinae. 3. External maxillipeds which completely shut buccal cavern in crabs of subfamily Varuninae. 4. Oblique hairy crest on merus of external maxillipeds in crabs of subfamily Sesarminae.

Key to subfamilies of Grapsidae

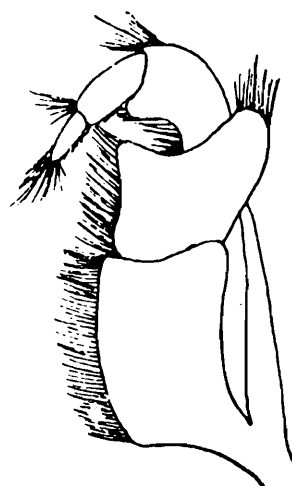
1. Front broad and deflexed ; flagellum of antenna very short ; external maxillipeds leaving rhomboidal gap between them (Fig. 2) ... *Grapsinae*
2. Front broad and not deflexed, sublaminar ; antennal flagellum lengthy ; external maxillipeds completely shut buccal cavern (Fig. 3) ... *Varuninae*
3. Front broad and strongly deflexed ; external maxillipeds slender ; oblique hairy crest on merus (Fig. 4) ... *Sesarminae*
4. Antennular fossets deeply divided into lobes ; infraorbital border curved ; external maxillipeds incompletely close buccal cavern (Fig. 5) ... *Plagusinae*



T. Fig. 5



T. Fig. 6



T. Fig. 7

Figs. 5-7. External maxillipeds which incompletely close buccal cavern in crabs of subfamily Plagusinae. 6. Merus of external maxillipeds longer than broad in crabs of genus *Grapsus*. 7. Merus of external maxillipeds broader than long in crabs of genus *Metapograpsus*.

Key to genera of Grapsinae

1. Front less than half of greatest breadth of carapace ; merus of external maxillipeds longer than broad ; dactylus of cheliped spoon shaped at tip (Fig. 6) ... *Grapsus*
2. Front more than half of greatest breadth of carapace ; merus of external maxillipeds broader than long ; antenna completely excluded from orbit (Fig. 7) ... *Metopograpsus*

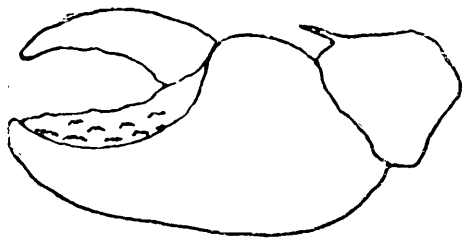
Genus *Grapsus* Lamarck

1801. *Grapsus* Lamarck, *Syst. Anim. Sons. Verte.*, 150.
 1900. *Grapsus* Alcock, *J. Asiatic Soc. Bengal*, 69 : 390.
 1918. *Grapsus* Tesch, *Siboga Expedn. Monogr.*, 39C : 71.
 1965. *Grapsus* Crosnier, *Fauna de Madagascar*, 18 : 10.

This genus is represented by two species in Parangipettai waters.

Key to species of Grapsus

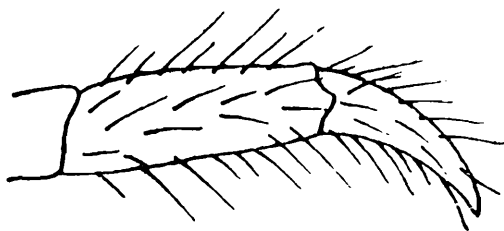
1. Front less deflexed and less high ; epistome short ; spine at inner angle of wrist of cheliped nearly straight (Fig. 8) ... *G. strigosus*
2. Front strongly deflexed and very high ; epistome very long ; spine at inner angle of wrist of cheliped curved (Fig. 9) ... *G. tenuicrustatus*



T. Fig. 8



T. Fig. 9



T. Fig. 10

Figs. 8-10. 8. Straight spine at inner angle of wrist of cheliped in *Grapsus strigosus*. 9. Curved spine at inner angle of wrist of cheliped in *Grapsus tenuicrustatus*. 10. Distinctly shorter dactylus (than propodus) and trilobed last segment of abdomen in *Metopograpsus maculatus*.

***Grapsus strigosus* Herbst**

1803. *Grapsus strigosus* Herbst, *Krabben*, III : 55.
 1893. *Grapsus strigosus* Henderson, *Trans. Linn., Soc. London Zool.*, **20** : 390.
 1900. *Grapsus strigosus* Alcock, *J. Asiatic Soc. Bengal*, **69** : 393.
 1950. *Grapsus strigosus* Tweedie, *Bull. Raffles Mus. Singapore*, **21** : 94.

Material : 10 males and 20 females ranging from 30 mm to 34 mm in carapace width were collected from Veller estuary.

Colour : Carapace green, mesogastric and hepatic regions light green, cardiac and other intestinal regions brownish and epibranchial region with scattered white patches ; dark green bands on pereopods and chelipeds light green.

Habitat : These are the inhabitants of rocky shore, constricted rocks, boulders and broken building material like iron bar. In Vellar estuary it is collected from underneath stones, pillars of railway bridge, jetty and from oyster beds.

Distribution : This species is widely distributed in the Indo-Pacific region from the East coast of Africa, Madagascar, Red sea, Arabian sea through Japan and Australia to Hawaii.

In and around India, the occurrence of this species has been reported from Andaman Nicobars, Mergui, Sri Lanka, East and West coasts of India, Sind and Baluchistan.

Remarks : This species is smaller than *G. tenuicrustatus* and is always found along with the latter. The presence of the straight spine at the inner angle of carpus of cheliped is very much helpful in distinguishing this species from *G. tenuicrustatus*.

Grapsus tenuicrustatus (Herbst)

- 1783. *Cancer tenuicrustatus* Herbst, *Krabben*, I : 113.
- 1840. *Grapsus hirtus* Randal, *Acad. Nat. Sci. Philadelphia Journ.*, 8 : 124.
- 1906. *Grapsus grapsus tenuicrustatus* Rathbun, *Bull. U. S. Fish. Comm.*, 23 : 838.
- 1918. *Grapsus maculatus gracilipes* Tesch, *Siboga Expedn. Monogr.*, 39 C : 71.
- 1922. *Grapsus grapsus* Balss, *Arch. f. Naturg. Bd.*, III, 88 : 147.
- 1965. *Grapsus tenuicrustatus* Crosnier, *Fauna de Madagascar*, 16 : 10.
- 1976. *Grapsus tenuicrustatus* Sakai, *Crabs of Japan and Adjacent Seas* : 629.

Material : 5 males and 20 females were collected from Vellar estuary.

Colour : Carapace velvet green with regularly arranged white patches, concentrated more on epibranchial region along striae ; dactylus of pereopods light brown and merus with irregularly scattered white patches which is absent in chela and palm of which appears violet in colour.

Habitat : This species occurs in the constricted rocks, stones and boulders of railway bridge and jetty at Parangipettai and in the oyster bed also.

Distribution : All tropical and subtropical seas.

Remarks : This fairly large sized crab runs faster when approached. It has already been recorded from the rocky habitat. Now it is found to inhabit the oyster bed also.

Genus **Metopograpsus** H. Milne Edwards

1853. *Metopograpsus* H. Milne Edwards, *Ann. Sc. Nat.*, 3 : 164.
 1918. *Metopograpsus* Tesch, *Siboga Expedn. Monogr.*, 39C : 79.
 1939. *Metopograpsus* Sakai, *Yokendo Ltd. Tokyo*, 646, 653.
 1956. *Metopograpsus* Crosnier, *Fauna de Madagascar*, 21.

This genus is represented by two species in Parangipettai coast.

Key to species of Metopograpsus

1. Walking legs larger, dactylus distinctly shorter than propodus ; lateral margin of carapace less convergent posteriorly ; last segment of abdomen trilobed (Fig. 10)
 ... *M. maculatus*
2. Walking legs shorter, dactylus nearly as long as propodus ; lateral margin markedly convergent posteriorly ; last segment of male abdomen triangular (Fig. 11)
 ... *M. messor*

Metopograpsus maculatus H. Milne Edwards

1853. *Metopograpsis maculatus* H. Milne Edwards, *Ann. Sci. Nat. Zool.*, (3) XX : 165.
 1887. *Metopograpsus maculatus* De Man, *Journ. Linn. Soc. Zool.*, 22 : 145.
 1900. *Metopograpsus maculatus* Alcock, *J. Asiatic Soc. Bengal*, 69 : 398.
 1918. *Metopograpsus maculatus* Tesch, *Siboga Expedn. Monogr.*, 39C : 80.

Material : 10 males measuring carapace width of 21 mm to 26 mm were collected from Pitchavaram mangroves.

Colour : Carapace dark green, few scattered light green patches on pereopods, dactylus of chelate leg violet.

Habitat : It is found in the muddy substrates of the intertidal region in Pitchavaram mangroves.

Distribution : Along the coasts of India, Ceylon, Mergui and East Indies. It has been recorded from Bombay coast by Alcock (1900).

Metopograpsus messor (Forsk.)

1775. *Cancer messor* Forskal, *Descrip. Anim. in itin Orient.*, : 88.
 1887. *Metopograpsus messor* DeMan, *Journ. Linn. Soc. London Zool.*, 22 : 144.
 1900. *Metopograpsus messor* Alcock, *J. Asiatic Soc. Bengal*, 69 : 397.
 1918. *Metopograpsus messor* Tesch, *Siboga Expedn. Monogr.*, 39C : 79.

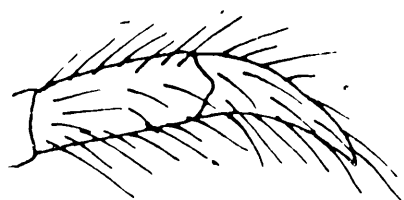
Material : 50 specimens of both males and females were collected from Vellar estuary and Pitchavaram mangroves.

Colour : Carapace dark green with scattered white patches on epibranchial and cardiac regions ; pereopods striped with light and dark green bands and dactylus of chela appears bright violet.

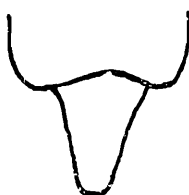
Habitat : Abundantly found in rocks and exposed oyster beds in subtidal region and also found in muddy substrata.

Distribution : Ranging from Red sea to Australia.

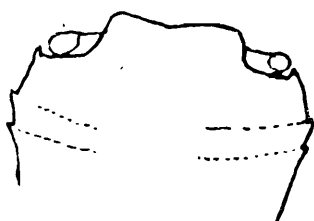
Remarks : This species is easily distinguishable from *M. maculatus* by the colour pattern and by the triangular shaped last segment of abdomen of male.



T. Fig. 11



T. Fig. 12



T. Fig. 13



T. Fig. 14

Figs. 11-14. 11. Equal sized dactylus and propodus and triangular shaped last segment of male abdomen in *Metopograpsus messor*. 12. Toothed lateral border and very flat carapace in crabs of genus *Ptychognathus*. 13. Subcircular carapace with flattish teeth on anterolateral border separated by very narrow notch in crabs of genus *Pseudograpsus*. 14. 'S' shaped upper orbital margin in carapace of *Pseudograpsus altimanus*.

Key to genera of Varuninae

1. Exognath of external maxillipeds broader than or nearly as broad as ischium ; carapace very flat lateral border toothed, no posterolateral facet defined (Fig. 12) ... *Ptychognathus*
2. Exognath of external maxillipeds narrower than ischium, external maxilliped do not close buccal cavern completely, merus of external maxillipeds shorter than ischium ; carapace subcircular, teeth on anterolateral border flattish and separated by very narrow notch (Fig. 13) ... *Pseudograpsus*

Genus *Ptychognathus* Stimpson

1858. *Ptychognathus* Stimpson, *Proc. Acad. Nat. Sci. Philadelphia*, **10** : 104.
 1900. *Ptychognathus* Alcock, *J. Asiatic Soc. Bengal*, **69** : 402.
 1918. *Ptychognathus*, Tesch, *Siboga Expedn. Monogr.*, **39C** : 85.
 1965. *Ptychognathus* Crosnier, *Fauna de Madagascar*, **18** : 37.

The genus is represented by a single species in Parangipettai waters.

Key to species of *Ptychognathus*

1. Carapace finely punctate, two pairs of indistinct transverse depressions on carapace, upper orbital margin 'S' shaped (Fig. 14) ... *P. altimanus*

***Ptychognathus altimanus* (Rathbun)**

1914. *Varuna altimana* Rathbun, *Proc. U. S. Nat. Mus.*, **47** : 70.
 1918. *Ptychognathus altimanus* Tesch, *Siboga Expedn. Monogr.*, **39C** : 88.

Material : 5 males and 7 females were collected from Vellar estuary and Pitchavaram mangroves.

Colour : Carapace brown, cardiac region less brighter.

Habitat : Inhabits muddy substrata along intertidal region.

Distribution : Indo-Pacific.

Remarks : From 'S' shaped orbital margin the species can be easily identified.

Genus *Pseudograpsus* H. Milne Edwards

1837. *Pseudograpsus* H. Milne Edwards, *Hist. Nat. Crust.*, **I** (2) : 81.
 1918. *Pseudograpsus* Tesch, *Siboga Expedn. Monogr.*, **39C** : 97.
 1965. *Pseudograpsus* Crosnier, *Fauna de Madagascar*, **18** : 39.

This genus is represented by a single species.

Key to species of *Pseudograpsus*

1. Legs hairy, not compressed, a fleshy lobe at dactylus of cheliped ... *P. intermedius*

***Pseudograpsus intermedius* Chhapgar**

1957. *Pseudograpsus intermedius* Chhapgar, *Marine Crabs of Bombay State* : 57.

Material ; 15 males and 10 females were collected from Pitchavaram mangroves.

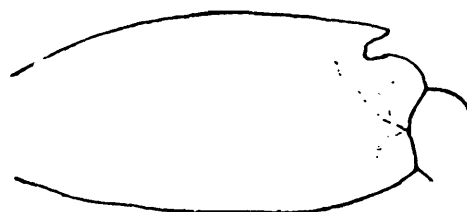
Colour : Chestnut.

Habitat : Found under the stones in muddy substrates.

Distribution : Indo-Pacific. It has been reported from Bombay coast by Chhapgar (1957).



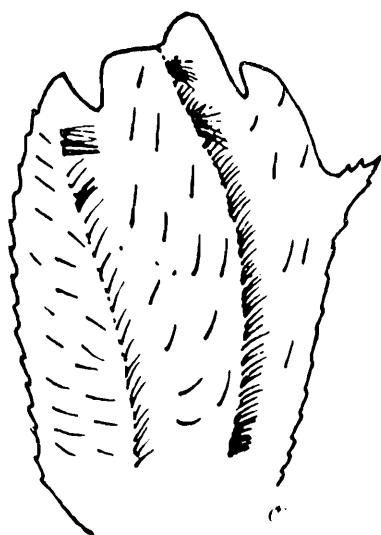
T. Fig. 15



T. Fig. 16



T. Fig. 17



T. Fig. 18



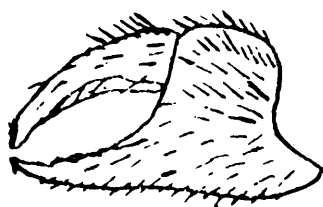
T. Fig. 19

Figs. 15-19. 15. Merus of pereopod 4-5, in crabs of genus *Nanosesarma* with dents. 16. Merus of pereopod 4-5, in crabs of genus *Neoepisesarma* without dents. 17. Anterior frontal margin with strong median concavity in crabs of genus *Neoepisesarma*. 18. Anterior border of merus of cheliped with subdistal triangular process distally denticulated in crabs of genus *Neoepisesarma*. 19. Carapace with no anterolateral tooth on carapace in crabs of genus *Parasesarma*.

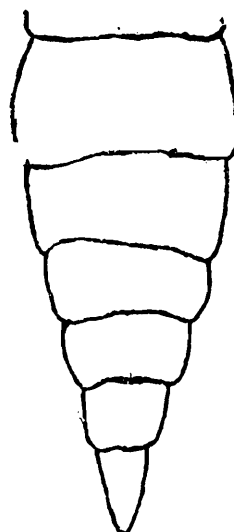
Remarks : The fleshy lobe at the dactylus of cheliped is helpful in the easy identification of this species.

Key to genera of Sesarminae

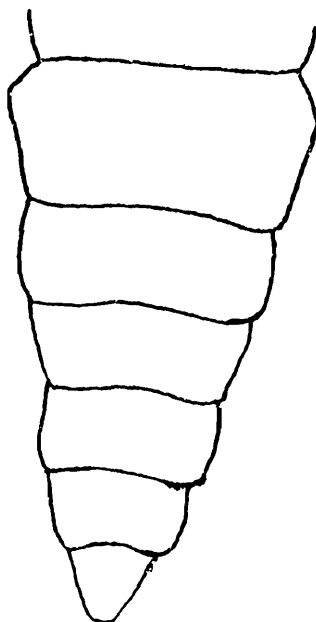
1. Antennal peduncle not excluded from orbit ; posterolateral border of merus of pereopod with 4-5 dents (Fig. 15) ... *Nanosesarma*



T. Fig. 20



T. Fig. 21



T. Fig. 22

Figs. 20-22. 20. Outerside of palm of cheliped entirely covered with soft hair in crabs of subgenus *Nanosesarma* (*Nanosesarma*). 21. Remarkably elongated male abdomen in crabs of subgenus *Nanosesarma* (*Nanosesarma*). 22. Not so remarkably elongated male abdomen in crabs of subgenus *Nanosesarma* (*Beanium*).

2. Antennal peduncle not excluded from orbit ; posterolateral border of merus of pereopods 4-5, without dents (Fig. 16) ; carapace with one or two antero-lateral teeth, anterior frontal margin with strong median concavity (Fig. 17) ;

upper surface of palm of cheliped with only one of pectinated crest, anterior border of merus of cheliped with subdistal trinangular process distally denticulated (Fig. 18) ... *Neopisesarma*

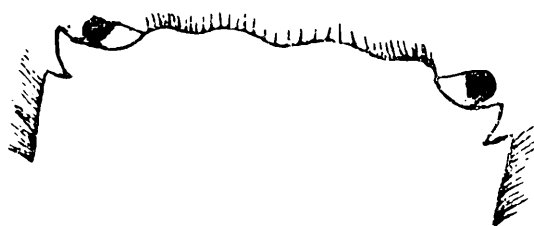
3. Antennal peduncle not excluded from orbit ; posterodistal border of pereopod without denticulation ; upper edge of palm of cheliped with 2-3 pectinated crest (Fig. 19) ; no anterolateral tooth on carapace ... *Parasesarma*

Genus *Nanosesarma* Tweedie

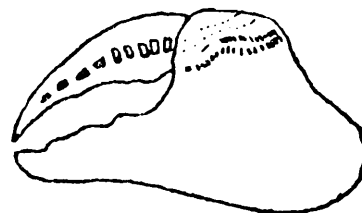
1950. *Nanosesarma* Tweedie, *Bull. Raffles. Mus. Singapore*, 13 : 310.

1965. *Nanosesarma* Crosnier, *Fauna de Madagascar*, 18 : 70.

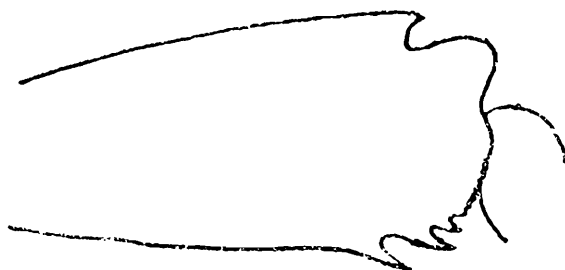
1970. *Nanosesarma* Serene and Soh, *Treubia*, 27 (4) : 393.



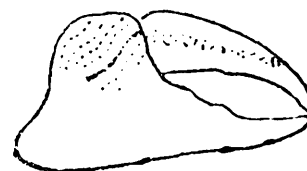
T. Fig. 23



T. Fig. 24



T. Fig. 25



T. Fig. 26

Figs. 23-26. 23. Clearly marked anterolateral teeth on carapace of *Nanosesarma* (*Nanosesarma*) *minutum*. 24. Upper edge of palm of cheliped with 2 oblique pectinated crest in *Nanosesarma* (*Beanium*) *batavicum*. 25. Three acute spines on posterodistal border of pereopod 4 in *Nanosesarma* (*Beanium*) *batavicum*. 26. Upper edge of palm of cheliped with numerous striae in *Nanosesarma* (*Beanium*) *andersoni*.

Key to subgenera of *Nanosesarma*

1. Outerside of palm of cheliped entirely covered with soft hair concealing lines of granules (Fig. 20), merus of pereopod with short denticulation ; male abdomen remarkably elongated (Fig. 21) ... *N.* (*Nanosesarma*)

2. Outer surface of palm of cheliped smooth or with limited patch of hair, merus of pereopod 4 with 2-4 acute spines posterodistally ; male abdomen not remarkably elongated (Fig. 22) ... *N. (Beanium)*

The subgenus *Nanosesarma* is represented by a single species and subgenus *Beanium* by two species in Parangipettai waters.

Key to species of Nanosesarma

1. Upper edge of palm of cheliped without pectinated crest ; anterolateral teeth on carapace clearly marked (Fig. 23) ... *Nanosesarma (Nanosesarma) minutum*
2. Upper edge of palm of cheliped with 2 oblique (Fig. 24) pectinated crest, three acute spines (one long and 2 short) on posterodistal border of pereopod 4 (Fig. 25) ... *Nanosesarma (Beanium) batavicum*
3. Upper edge of palm of cheliped with numerous striae (Fig. 26), one of which forms pectinated crest, four strong spines on posterodistal border of merus of pereopod 4 (Fig. 27) ... *Nanosesarma (Beanium) andersoni*

Nanosesarma (Nanosesarma) minutum (De Man)

1887. *Sesarma minutum* De Man, *Zool. Jahrb. Syst.*, II : 657.
 1917. *Sesarma (Sesarma) minuta* Tesch, *Zool. Meded. Leiden*, iii : 127.
 1935. *Sesarma (Sesarma) gordonii* Shen, *Chinese Journ. Zool.*, 1 : 27.
 1950. *Nanosesarma gordonii* Tweedie, *Bull. Raffles. Mus. Singapore*, 13 : 311.
 1957. *Sesarma (Sesarma) minuta* Chhappgar, *Marine Crabs of Bombay State* : 60.
 1965. *Nanosesarma gordonii* Crosnier, *Fauna de Madagascar*, 18 : 72.
 1970. *Nanosesarma (Nanosesarma) minutum* Serene and Soh, *Treubia*, 27 (4) : 404.

Material : 8 males and 15 females were collected from Pitchavaram mangroves.

Colour : Carapace lemon yellow, cardiac region less brighter ; pereopod, with yellow and light green bands, chela bright yellow.

Habitat : Occurs in the muddy substrata along intertidal area and also in loosely packed oyster shells in the subtidal area.

Distribution : Indian coasts, Sagami Bay and Inland Seas of Japan.

Nanosesarma (Beanium) batavicum (Moriera)

1970. *Nanosesarma (Beanium) batavicum* Serene and Soh, *Treubia*, 27 (4) : 394.

Material : 100 males and 100 females were collected from Pitchavaram mangroves and Vellar estuary.

Colour : Carapace light green in general, mesogastric and cardiac regions bright coloured ; pereopods with less pronounced stripes and dactylus of cheliped with light brown colour.

Habitat : Inhabits the oyster bed in the intertidal region of Vellar estuary and Pitchavaram mangroves.

Distribution : Widely distributed in Indo-Pacific region.

Remarks : This small grapsid crab dominates the crab fauna of oyster bed community. More number of adult specimens were collected during summer whereas during monsoon season, the juveniles were more.

Nanosesarma (Beanium) andersoni (De Man)

1887. *Sesarma andersoni* De Man, *Zool. Jahrb. Syst.*, II : 657.

1900. *Sesarma andersoni* Alcock, *J. Asiatic Soc. Bengal*, 69 (3) pt. 11 : 418.

1970. *Nanosesarma (Beanium) andersoni* Serene and Soh, *Treubia*, 27 (4) : 394.

Material : 4 males and 13 females were collected from Pitchavaram mangroves.

Colour : Carapace dark green with scattered white patches.

Habitat : Intertidal muddy substrata near railway bridge and also found in Pitchavaram mangroves.

Distribution : Indo-Pacific.

Remarks : Serene and Soh (1970) considered the presence of 2-3 acute spinules on the posterodistal border of the merus of pereopod 4 as subgeneric character of *Beanium*. Presently *N. (B.) andersoni* shows 4 strong spinules on posterodistal border of merus of pereopod 4, when reexamined. So the taxonomy of *N. (B.) andersoni* needs further detailed study.

Genus Neopisesarma Serene and Soh

1970. *Neopisesarma* Serene and Soh, *Treubia*, 27 (4) : 389, 395.

1976. *Neopisesarma* Sakai, *Crabs of Japan and Adjacent Seas*, 661.

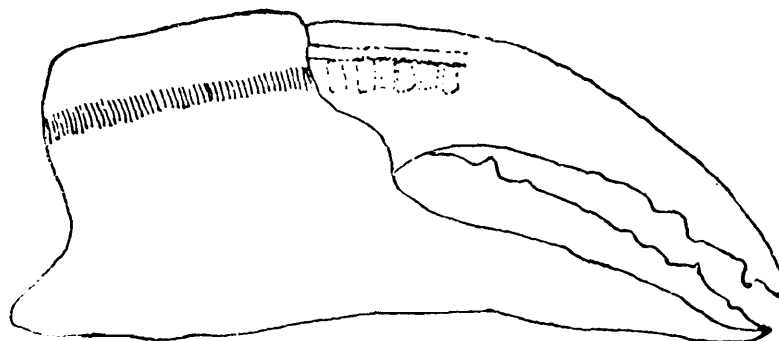
Key to subgenera and species of Neopisesarma

1. On upper surface of palm of cheliped low pectinated crest continued from distal end to proximal end, numerous transverse long swollen dactylar tubercles closely arranged in a continuous rim (Fig. 28) ... *Neopisesarma*
(*Neopisesarma*)
 - (i) Carapace quadrangular ; above transverse dactylar tubercles, a sulcus runs about 1/3 of total length of tubercles, vertical granular crest on inner palm salient (Fig. 29) ... *N. (Neopisesarma) mederi*

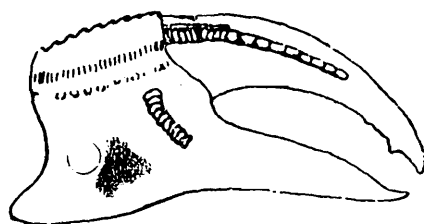
2. On upper surface of palm of cheliped, high pectinated crest limited to median part, proximally continued by smooth rim, distally continued by lines of granules ... *V. Neopisesarma (Muradium)*



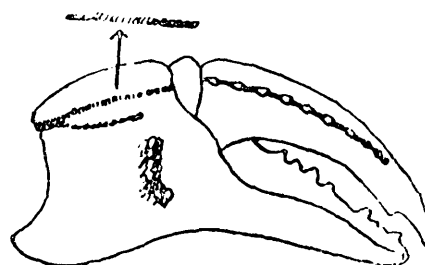
T. Fig. 27



T. Fig. 28



T. Fig. 29



T. Fig. 30

Figs. 27-30. 27. Four strong spines on posterodistal border of merus of fourth pereopod in *Nanosesarma (Beanium) andersoni*. 28. Pectinated crest on upper surface of palm in crabs of subgenus *Neopisesarma (Neopisesarma)*. 29. Salient vertical granular crest on inner palm of *Neopisesarma (Neopisesarma) mederi*. 30. Strongly salient vertical granular crest on inner palm of cheliped in *Neopisesarma (Muradium) tetragonum*.

- (i) Longitudinal dactylar tubercles widely separated from one another, a clear sulcus running between them, vertical granular crest on inner palm of cheliped strongly salient (Fig. 30) ... *(Muradium) tetragonum*
3. On upper surface of palm of cheliped, pectinated crest salient, only proximally replaced by smooth rim, vertical granular crest on inner palm salient ... *Neopisesarma (Salatium)*
- (i) Pectinated crest on upper palm distally reach margin, dactylar tubercles well separated from one another without transverse sulcus above (Fig. 31) ... *N. (Selatium) brockii*

Neoepisesarma (Neoepisesarma) mederi (H. Milne Edwards)

1853. *Sesarma mederi* H. Milne Edwards, *Ann. Sci. Nat. Zool.*, 20 (3) : 185.
 1880. *Sesarma teaniolatum* De Man, *Zool. Jahrb. Syst.*, II : 647.
 1900. *Sesarma teaniolatum* Alcock, *J. Asiatic Soc. Bengal*, 69 (3) pt. II : 419.
 1970. *Neoepisesarma (Neoepisesarma) mederi* Serene and Soh, *Treubia*, 27 (4) : 389, 396, 405.

Material : 3 males and 3 females were collected from Pitchavaram mangroves.

Colour : Carapace dark green, mesogastric region less brighter, pereopods less violet, dactylus of cheliped bright violet.

Habitat : Inhabits burrows as deep as one meter in the muddy substratum along intertidal area of Pitchavaram mangroves.

Distribution : Indo-West Pacific.

Remarks : This is recorded for the first time in Parangipettai coast. Altogether 3 males and 3 females were collected from the same spot during the study period. It has been observed that this species occurs in limited numbers and restricted to a particular habitat where another species of this genus (*tetragonum*) is dominant.

Neoepisesarma (Muradium) tetragonum (Fabricius)

1798. *Cancer tetragonum* Fabricius, *Ent. Syst. Suppl.*, 341.
 1799. *Cancer fascicularis* Herbst, *Krabben*, III : 49.
 1887. *Sesarma tetragona* De Man, *Zool. Jahrb. Syst.*, II : 646.
 1893. *Sesarma tetragona* Henderson, *Trans. Linn. Soc. Zool.*, 2 : 392.
 1970. *Neoepisesarma (Muradium) tetragonum* Serene and Soh, *Treubia*, 27 (4) : 397, 405.

Material : 100 males and 100 females were collected from burrows found in the muddy substrata of Pitchavaram mangroves and Vellar estuary.

Colour : Carapace dark brown, epibranchial region less brighter, pereopods purple coloured, chelipeds dark red and dactylus light red.

Habitat : Inhabits burrows as deep as 1 meter in muddy and bushy areas of Pitchavaram mangroves along intertidal region.

Distribution : Widely distributed in Indo-West Pacific region.

Remarks : In the present study, the generic and subgeneric characters reveal that there are differences in the pectinated crest.

Neoepisesarma (Selatium) brockii (De Man)

1887. *Sesarma brockii* De Man, *Zool. Jahrb. Syst.*, 9 : 651.
 1900. *Sesarma brockii* Alcock, *Lit. Cit.* : 419.
 1970. *Neoepisesarma (Selatium) brockii* Serene and Soh, *Treubia*, 27 (4) : 405.

Material : 5 males and 11 females were collected from Pitchavaram mangroves.

Colour : Carapace brownish, epibranchial and mesogastric less brighter, dactylus or chela violet.

Habitat : Like *N. (M.) tatragonum* and *N. (N.) mederi* this species occurs in burrows as deep as one meter along the intertidal area of Pitchavaram mangroves.

Distribution : Indo-Pacific.

Remarks : Alcock (1900) recorded this species as *Sesarma brockii*. Serene and Soh (1970) erected a new genus and subgenus and included this species.

Genus *Parasesarma* (De Man)

- 1895. *Sesarma* (*Parasesarma*) De Man, *Zool. Jahrb. Syst.*, **9** : 181.
- 1900. *Sesarma* Alcock, *Lit. Cit.* : 413.
- 1917. *Sesarma* (*Parasesarma*) Tesch, *Zool. Meded. Leiden*, **iii** : 187.
- 1950. *Sesarma* (*Parasesarma*) Barnard, *Ann. South Afric. Mus.*, **38** : 127.
- 1965. *Sesarma* (*Parasesarma*) Crosnier, *Fauna de Madagascar*, **18** : 65.
- 1970. *Parasesarma* Serene and Soh, *Treubia*, **27** (4) : 387, 392.

Key to species of *Parasesarma*

1. Outer transverse dactylar tubercles sharp, not much loosely packed, a clear sulcus runs between two rows of tubercles extended upto 2/3 of total length of dactylus, vertical granular crest on inner palm of cheliped clear (Fig. 32)
... *P. plicatum*

Parasesarma plicatum (Latreille)

- 1806. *Ocypoda plicata* Latreille, *Hist. Nat. Crust., & C.*, **6** : 47.
- 1900. *Sesarma quadrata* Alcock, *Lit. Cit.* : 413.
- 1917. *Sesarma* (*Parasesarma*) *plicata* Tesch, *Zool. Meded. Leiden*, **iii** : 187.
- 1950. *Sesarma* (*Parasesarma*) *plicata* Barnard, *Ann. South Afric. Mus.*, **38** : 127.
- 1965. *Sesarma* (*Parasesarma*) *plicatum* Crosnier, *Fauna de Madagascar*, **18** : 65.
- 1976. *Sesarma* (*Parasesarma*) *plicatum* Sakai, *Crabs of Japan and Adjacent Seas* : 657.
- 1978. *Parasesarma plicatum* Soh, *Vem. H. K. Nat. Hist. Soc.*, **13** : 11.

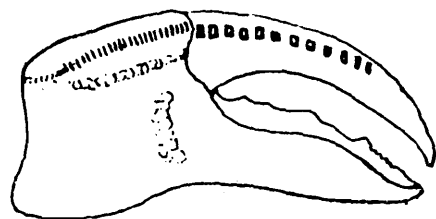
Material : 100 males and 100 females were collected from the Pitchavaram mangroves and the Vellar estuary.

Colour : Dark brown, dactylus of cheliped in striking violet.

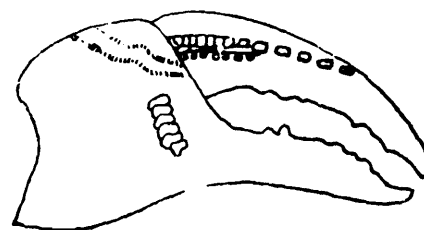
Habitat : Inhabits the muddy substratum in lower reaches of tidal creek and roots of mangrove plants.

Distribution : Widely distributed in Indo-Pacific region.

Remarks : This species was previously recorded as *Sesarma quadrata* by Balasubramanian (1962) from Parangipettai coast. Serene and Soh (1970) included this species in *Parasesarma* based on the presence of pectinated crest on the upper surface of palm of cheliped.



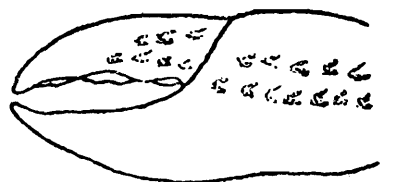
T. Fig. 31



T. Fig. 32



T. Fig. 33



T. Fig. 35



T. Fig. 34

- Figs. 31-35. 31. Well separated dactylar tubercles in *Neopisesarma (Selatium) brockii*. 32. Clean vertical granular crest on inner palm of cheliped in *Parasesarma plicatum*. 33. Merus of pereopods with one subterminal tooth on upper margin in *Plagusia depressa tuberculata*. Fig. 34. Carapace with squamiform tubercles in *Plagusia depressa tuberculata*. 35. Outer palm of cheliped longitudinally costate in *Plagusia depressa tuberculata*.

Key to genera of Plagusinae

1. Carapace thick ; merus of external maxillipeds as broad as ischium ... *Plagusia*

Genus *Plagusia* Latreille

1806. *Plagusia* Latreille, *Gen. Crust.*, 1 : 23.
1900. *Plagusia* Alcock, *Lit. Cit.* : 436.
1965. *Plagusia* Crosnier, *Fauna de Madagascar*, 18 : 80.

Key to species of *Plagusia*

1. Merus of pereopods (Fig. 33) with one subterminal tooth on upper margin ; carapace with squamiform tubercles (Fig. 34) ; outer palm of cheliped longitudinally costate (Fig. 35) ... *P. depressa tuberculata*

2. Merus of pereopods with a series of teeth on upper (Fig. 36) margin ; carapace devoid of tubercles ; outer palm of cheliped with longitudinal grooves deeply impressed (Fig. 37) ... *P. dentipes*

***Plagusia depressa tuberculata* (Lamarck)**

1818. *Plagusia tuberculata* Lamarck, *Hist. Nat. Anim. Sans. Vert.*, 5 : 247.
 1858. *Plagusia orientalis* Stimpson, *Proc. Acad. Nat. Sci. Philadelphia*, 10 : 103.
 1900. *Plagusia depressa squamosa* Alcock, *Lit. Cit.* : 437.
 1918. *Plagusia depressa tuberculata* Tesch, *Siboga Exp. Monogr.*, 39C : 129.
 1965. *Plagusia depressa tuberculata* Crosnier, *Fauna de Madagascar*, 18 : 80.

Material : 9 males and 6 females were collected from the tidal zone of Vellar estuary.

Colour : In general, carapace brownish, cardiac region reddish, merus of pereopods with red markings transversely in the middle on the outer surface dactylus of pereopods light red.

Habitat : inhabits rocks, constricted rocks and drift wood.

Distribution : Indo-Pacific, extending upto west coast of America.

***Plagusia dentipes* (De Haan)**

1835. *Grapsus plagusia dentipes* De Haan, *Ph. F. Von Seibold's Fauna Japonica Crust.*, 58.
 1918. *Plagusia dentipes* Tesch, *Siboga Expedn. Monogr.*, 39C : 129.
 1976. *Plagusia dentipes* Sakai, *Crabs of Japan and Adjacent Seas*, : 675.

Material : 10 males were collected from the tidal zone of the Vellar estuary.

Colour : Carapace reddish brown, few scattered red spots on epibranchial region, anterolateral teeth on carapace dark red, very light brown band like colouration in merus of pereopods.

Habitat : Inhabits rocky beaches, floating timbers.

Distribution : Indo-Pacific and Japan.

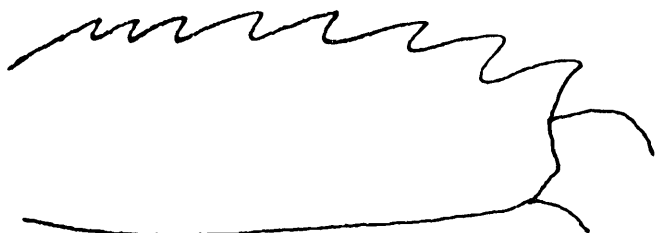
Key to Xanthidae

Legs not adapted for swimming ; carapace anteriorly broadened, branchial region not swollen ; no inner lobe on endopodite of first maxilliped.

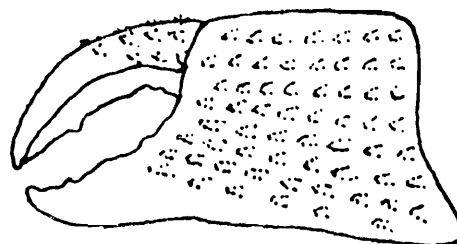
Key to subfamilies of Xanthidae

Carapace usually much broader than long, transversely oval, sometimes hexagonal, front narrow, one third to one fifth of greatest breadth of carapace ... *Xanthinae*

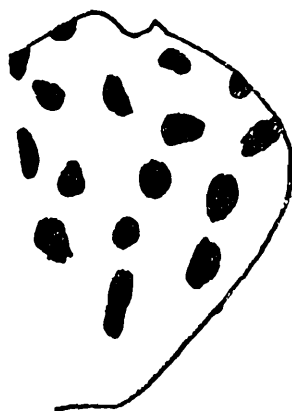
Carapace moderately broad, front about a third of greatest breadth of carapace, anterolateral borders of carapace not longer than posterolaterals; basal antennal joint does not or just touches front ... *Pilumninae*



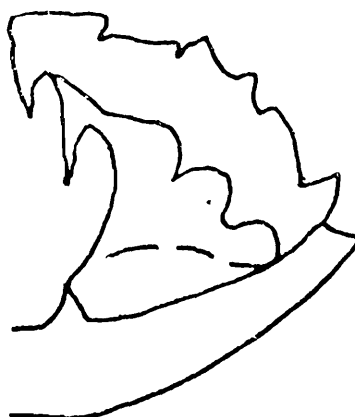
T. Fig. 36



T. Fig. 37



T. Fig. 38



T. Fig. 39

Figs. 36-39. 36. Merus of pereopods with a series of teeth on upper margin in *Plagusia dentipes*. 37. Outer palm of cheliped with longitudinal grooves deeply impressed in *Plagusia dentipes*. 38. Reddish spots on carapace of *Liagore rubromaculatus*. 39. Anterolateral border in *Leptodius crassimanus* cut into 5 teeth.

Key to genera and species of Xanthinae

1. Carapace perfectly smooth, no trace of regions, anterolateral border entire ... *Liagore*

Front faintly bilobed; little pimple like thickenings (tubercles) on outer angle of orbit; borders of merus hairy, upper borders with a denticle, dactyli of leg elongately plumed; reddish spots on carapace (Fig. 38) as well as on legs ... *L. rubromaculatus*

Genus **Liagore** De Haan

1835. *Liagore* De Haan, *Ph. F. Von Siebold's Fauna Japonica, Crust.*, 1 : 19.

1851. *Liagore* Dana, *Amer. J. Sci. & Arts.*, 12 (2) : 121.

1898. *Liagore* Alcock, *Lit. Cit.* : 93.

Liagore rubromaculatus (De Haan)

1835. *Cancer (Liagore) rubromaculatus* De Haan, *Ph. F. Von Siebold's Fauna Japonica, Crust.*, 1 : 49.

1898. *Liagore rubromaculatus* Alcock, *Lit. Cit.*, 67 : 93.

1976. *Liagore rubromaculatus* Sakai, *Crabs of Japan and Adjacent Seas*, 389.

Material : 8 males and 10 females were collected from the trawl catches of local inshore waters.

Colour : Yellowish with numerous scattered large red spots on carapace and pereopods.

Habitat : Inhabits the bottom or rocks and stones.

Distribution : Indian coasts, Irrawaddy delta, Hong Kong and Japan.

2. Anterolateral borders not prolonged beyond orbit, cut into 4 or more teeth ;
dactylus of cheliped blunt hollowed at tip ... *Leptodius*

Front narrow with edges of its lobes deeply concave, appears quadridentatus,
anterolateral border cut into 5 teeth (Fig. 39) ... *L. crassimanus*

Genus **Leptodius** A. Milne Edwards

1863. *Leptodius* A. Milne Edwards, *Ann. Sci. Nat. Zool.*, 20 : 284.

1898. *Xantho (Leptodius)* Alcock, *Lit. Cit.* : 117.

1968. *Leptodius* Guinot, *Cahiers du Pacifique*, 15 : 1091.

Leptodius crassimanus Milne Edwards

1882. *Leptodius crassimanus* Haswell, *Catalogue Austr. Crust.*, 61.

1898. *Xantho (Leptodius) crassimanus* Alcock, *Lit. Cit.* : 120.

1957. *Leptodius crassimanus* Chhapgar, *Marine Crabs of Bombay State* : 30.

Material : 10 males and 6 females were collected and examined in the present study.

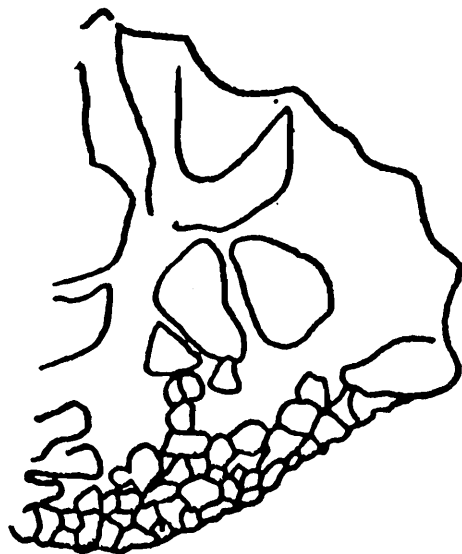
Colour : Carapace grey ; dactylus of cheliped black with whitish tip.

Habitat : Inhabits rocky beaches and is found under stones and crevices.

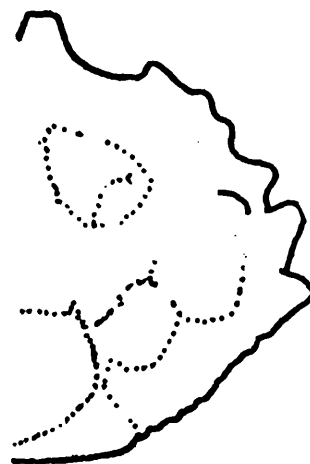
Distribution : Bombay coast, Andamans, Karachi and Australia.

3. Anterolateral borders of carapace lobed, first two indistinct, carapace regions and subregions well defined (Fig. 40) ... *Demania*

Dactylus of cheliped sharp and incurved, surface of cheliped entire with mosaic pattern ... *D. buccalipes*



T. Fig. 40



T. Fig. 41



T. Fig. 42



T. Fig. 43

Figs. 40-43. 40. Lobed anterolateral border and well defined regions and subregions in crabs of genus *Demania*. 41. Round and smooth tubercles in carapace of *Halimede ochtodes*. 42. Pentagonal carapace in *Galene bispinosa*. 43. Anterolateral border armed with 4 teeth behind the external orbital angle in crabs of genus *Heteropanope*.

Genus Demania Laurie

1906. *Demania* Laurie, *Ceylon Pearl oyster Fish. Report* London, 5 : 396.
 1969. *Demania* Serene, *J. Mar. Biol. Ass. India*, 11 (1) : 1.
 1971. *Demania* Guinot, *Bull. Mus. Hist. Nat.*, (2) : 1074.
 1986. *Demania* Deb. *Rec. Zool. Surv. India*, 83 (3 & 4) : 127.

***Demania buccalipes* (Alcock)**

1898. *Xantho* (*Lophoxanthus*) *scaberrimus buccalipes* Alcock, *J. Asiatic Soc. Bengal*, 67 : 117.
 1938. *Xantho reynaudii buccalipes* Balss, *Bull. Raffles Mus.*, 14 : 51.
 1957. *Xantho* (*Lophoxanthus*) *scaberrimus buccalipes* Ohhappgar, *Marine Crabs of Bombay State* : 29.
 1971. *Demania scaberrima buccalipes* Guinot, *Bull. Mus. Hist. Nat.*, 42 (5) : 1074.
 1976. *Demania buccalipes* Sakai, *Crabs of Japan and Adjacent Seas*, 421.
 1986. *Demania buccalipes* Deb, *Rec. Zool. Surv. India*, 83 (3 & 4) : 132.

Material : 20 males were collected from the trawl catches of local inshore waters.

Colour : Carapace dull red, pereopods bright red and dactylus of cheliped yellowish.

Habitat : Inhabits the bottom of rocks, stones and broken shells.

Distribution : Bombay, Sri Lanka, Malacca Strait and Japan.

4. Front square cut and narrow, two lobes not strongly convex dorsally, carapace rugose and granular, ... *Halimede*
 Tubercles of carapace and chelipeds ill isolated and their surface round and smooth ; anterolateral tooth abtusely angular (Fig. 41). ... *H. ochtodes*

Genus Halimede De Haan

1835. *Halimede* De Haan, *Crustacea* in : *de SIEBOLD'S Fauna Japonica*, 35.
 1852. *Halimede* Dana, *Crustacea United States Exploring Exped.*, 13 : 149.
 1898. *Halimede* Alcock, *Lit. Cit.* : 135.
 1976. *Halimede* Sakai, *Crabs of Japan and Adjacent Seas*, 386.

***Halimede ochtodes* (Herbst)**

1783. *Cancer ochtodes* Herbst, *Krabben*, I : 158.
 1898. *Polycremnus ochtodes* Alcock, *Lit. Cit.* : 135.
 1906. *Halimede hendersoni* Nobili, *Anni. Sci. Nat. Ser. 9, Zool. Paris*, 4 : 123.
 1910. *Halimede ochtodes* Rathbun, *The Danish Exped.*, 4 : 853.
 1945. *Halimede ochtodes* Stephensen, *Danish Sci. Invest. in Irran, Copenhagen*, 4 : 158.
 1976. *Halimede ochtodes* Sakai, *Crabs of Japan and Adjacent Seas*, 387.

Material : 7 males and 4 females were collected from the trawl catches of local inshore waters.

Colour : Cream coloured.

Habitat : Inhabits muddy or sandy habitats in the inshore waters.

Distribution : Madras coast, Penang, Singapore, Gulf of Thailand, Hong Kong, Sagami Bay.

5. Carapace granular marginally, regions vaguely defined ; basal antennal joint not reaching front, anterolateral border with lobes or teeth ... *Galene*

Carapace pentagonal (Fig. 42), surface lumpy and scabrus near borders, pterygostomian region almost hairy, anterolateral border indistinctly four lobed, posterolateral border longer than anterolateral border ; inner and outer surfaces of palm and wrist spiniform ... *G. bispinosa*

Genus *Galene* De Haan

1883. *Galene* De Haan, *Ph. F. Von Siebold's Fauna Japonica Crust.* 19.

1886. *Galene* Miers, *Report H. M. S. "Challenger"*, London, 17 : 118.

1898. *Galene* Alcock, *Lit. Cit.* : 136.

Galene bispinosa (Herbst)

1783. *Cancer bispinosa* Herbst, *Krabben I. II* : 144.

1835. *Cancer (Galene) bispinosa* De Haan, *Ph. F. Von Siebold's Fauna Japonica Crust.*, 49 : 21.

1971. *Galene bispinosa* Guinot, *Bull. Mus. Dist. Nat.*, 42 (5) : 1070.

Material : 50 males and 50 females were collected from the trawl catches of local inshore waters.

Colour : Carapace grey, frontal and protogastric region brighter, dactylus of pereopods less violet, inner and outer palm light grey.

Habitat : Inhabits the bottom of sandy mud at about 3 to 50 meters deep.

Distribution : Indian coast, Singapore, coasts of South China, Formosa, Hong Kong, Queensland.

Remarks : In Parangipettai region this species is being eaten by coastal inhabitants. This species dominates the catches during summer months. The systematic position of *bispinosa* is still uncertain. Though the adults have all the morphological characteristics of the subfamily Xanthinae, the larvae (Mohan, 1984) showed close similarities to pilumnids in their antennal morphology (Hyman, 1925) and armature of abdominal segments (Sandifer, 1974). As revealed by larval characteristics this species should be removed from Xanthinae and included into the subfamily Pilumninae.

Key to species of Pilumninae

Carapace transversely oval, markedly convex and glabrous, broader, frontal lobe straight and truncate, anterolateral border armed with 4 teeth behind external orbital angle (Fig. 43). ... *Heteropanope*

Dorsal surface of carapace convex in both directions, transverse ridges beaded with depressed granules ; carpus and propodus of cheliped studded with pearly granules ... *H. indica*

Genus *Heteropanope* Stimpson

1858. *Heteropanope* Stimpson, *Proc. Acad. Nat. Sci. Philadelphia*, **10** (4) : 35.

1898. *Heteropanope* Alcock, *Lit. Cit.* : 207.

1933. *Heteropanope* Balss, *Capite Zoologica deel 4, ofl.* **35**, 31.

1939. *Heteropanope* Sakai, *Yokendo Ltd., Tokyo*, 512, 545.

***Heteropanope indica* de Man**

1887. *Heteropanope indica* De Man, *Journ. Linn. Soc. Zool.*, **22** : 53.

1898. *Heteropanope indica* Alcock, *Lit. Cit.*, **67** (2).

Material : 20 males and 30 females were collected from Pitchavaram mangroves and Vellar estuary.

Colour : Carapace dark green, dactylus of cheliped black.

Habitat : Inhabits the loosely packed oysters, present along the subtidal region of Pitchavaram mangroves and Vellar estuary.

Distribution : Indo-Pacific.

Remarks : The maximum size of the species recorded in the present study is 24 mm in carapace width. This species is restricted to the oyster bed community. The antennal morphology of the larvae of this species suggests erection of a third group of Xanthid larvae in addition to the already existing 2 groups of Hyman (1925).

SUMMARY

Collection and identification of crabs belonging to the families Grapsidae and Xanthidae revealed the occurrence of 15 species of grapsids under 8 genera and 6 species of xanthids belonging to 6 genera. A figurative key for their identification has been prepared and presented, along with notes on their distribution. A check list is also provided.

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RECORDS OF *MEGAEROPS NIPHANAE* YENBUTRA & FELTEN, 1983
(MAMMALIA : CHIROPTERA : PTEROPODIDAE), *HIPPOSIDEROS*
LANKADIVA KELAART, 1850 AND *HIPPOSIDEROS ARMIGER*
ARMIGER (HODGSON, 1835) (CHIROPTERA
RHINOLOPHIDAE) FROM MANIPUR,
INDIA, WITH TAXONOMIC NOTES

AJOY KUMAR MANDAL

A. K. PODDAR

T. P. BHATTACHARYYA

Zoological Survey of India

'M' Block, New Alipore

Calcutta 700 053

Faunistic surveys were conducted in Manipur, specially for mammals, during March and November-December, 1992, by the Zoological Survey of India. The collection thus obtained contains several species of bats, of which, three, namely, *Megaerops niphanae* Yenbutra & Felten, *Hipposideros lankadiva* Kelaart and *Hipposideros armiger armiger* (Hodgson) were found to be unrecorded from that state (Blanford 1891, Roonwal 1950, Ellerman and Morrisson-Scoot 1966, Agrawal *et al.* 1992). Hence, they are reported hereunder. In addition, taxonomic remarks and distribution of these bats have been given.

External measurements have been taken in the field and the skull-measurements in the laboratory. All measurements are in millimeters and have been taken after Khajuria (1953), except cranial rostrum and the rostral height at front of c^1 which have been taken after Sinha (1969) and Yenbutra & Felten (1983), respectively.

SYSTEMATIC ACCOUNT

Order : CHIROPTERA

Family : PTEROPODIDAE

***Megaerops niphanae* Yenbutra & Felten, 1983 Niphan's Fruit Bat**

1983. *Megaerops niphanae* Yenbutra & Felten, *Senckenberg. biol.*, 64 : 2 (Sakaerat Environmental Research Station (14°30' N—101°56' E), Amphoe Pak Thong Chai, Prov. Nakhon Ratchasima, Thailand).

Material examined : Manipur : Tamenglong district 1 ♂, Tamenglong (c 1280 m), coll. Ajoy K. Mandal, 22 Nov 1992 (in spirit, skull extracted), Zoological Survey of India Registration Number (ZSI Reg. No.) 23904. Imphal district : 1 ♀, Uchathol (c 175 m), coll. Ajoy K. Mandal, 28 Nov 1992 (in spirit, skull extracted), ZSI Reg. No. 23905.

Measurements : External : 1 ♂, 1 ♀ : length of forearm 59.4, 59.0 ; length of ear 19.2, 17.5 ; length of tibia 23.0, 22.7 ; length of foot and claw 14.0, 14.0. Cranial : 1 ♂, 1 ♀ : greatest length 28.0, 26.3 ; cranial rostrum 6.3, 6.3 ; length of maxillary tooth-row 8.6, 8.3 ; canine width 5.7, 5.3 ; least interorbital width 5.0, 5.0 ; cranial width 12.4, 12.0 ; zygomatic width 17.8, 17.6 ; molar width 8.3, 7.9 ; mandibular length 20.0, 19.0 ; rostral height at front of c¹ 4.4, 4.4.

Distribution : *Megaerops niphanae* was described from northern Thailand (Yenbutra & Felten 1983). The occurrence of this species in Vietnam and Pashok (Darjiling district, West Bengal), India, was confirmed by Koopman (1989). The present specimens therefore, constitute the first record of *Megaerops niphanae* from Manipur, and extend its distributional range further south-eastwards in India.

Remarks : Wroughton (1916) reported a specimen from Pashok, as *Cynopterus sphinx* which was subsequently identified by Hill (1983) as *Megaerops ecaudatus* (Temminck), with some hesitation. Hill (1983) also treated specimens from northern Thailand and Vietnam in the same manner. Koopman (1989) confirmed the specimen from Pashok as *Megaerops niphanae*. He also mentioned a specimen from Vietnam (present in the American Museum of Natural History) as *M. niphanae*. Incidentally, *M. niphanae* is the largest among the four species known thus far of the Indo-Malayan genus *Megaerops*.

Both the specimens were collected at night with the help of nylon mist nets, and were found to be entangled in the uppermost tier of the nets at a height of about 4.5 m above the ground. The habitat at Temenglong was undulating hilly terrain with bushes and a banana plantation. Two nets were set up in a V-shaped manner alongside the banana plantation. A large number of *Cynopterus* sp. were also caught in these nets. In Uchathol, nets were set up on the hill-slope with *Lantana* bushes around. Besides *Megaerops niphanae*, individuals of *Cynopterus* sp. and *Pipistrellus* sp. were also caught in the nets. *M. niphanae* was found to be less noisy than *Cynopterus sphinx* and when disturbed, emitted a call somewhat reminiscent of the call of that species, but with less harshness.

Family : RHINOLOPHIDAE

Subfamily : HIPPOSIDERINAE

Hipposideros lankadiva Kelaart, 1850

Sri Lanka Gigantic Leaf-nosed Bat,

Kelaart's Leaf-nosed Bat

1850. *Hipposideros lankadiva* Kelaart. *J. Ceylon Branch R. Asiat. Soc.*, 2 : 216 (Kandy, Ceylon = Sri Lanka).

Material examined : Manipur : Imphal district : 1 ♀, Jiribam (c 175 m), coll. A. K. Poddar, 19 Mar 1992 (in spirit, skull extracted), ZSI Reg. No. 23902.

Measurements : External : 1 ♀ : length of forearm 86.5 ; length of ear 24.0 ; length of tibia 36.0 ; length of foot and claw 15.0. Cranial : 1 ♀ ; greatest length 32.5 ; condylocanine length 27.9 ; length of maxillary tooth-row 11.7 ; canine width 8.0 ; least interorbital width 3.4 ; cranial width 13.7 ; zygomatic width 19.3 ; molar width 12.8 ; mandibular length 23.0.

Distribution : *Hipposideros lankadiva* is known from Sri Lanka and India (Karnataka, Maharashtra, Madhya Pradesh, Orissa, West Bengal and Meghalaya) (Agrawal *et al.* 1992). Hence, the present specimen constitutes the first authentic record of the species from Manipur, and also extends its distributional range eastwards.

Remarks : Ellerman & Morrison-Scott (1966) recognised three subspecies of *Hipposideros lankadiva* from the Indian mainland, viz., *H. l. indus*, *H. l. mixtus* and *H. l. unitus*. Brosset (1962) did not consider the variation in colour in the present species as zoogeographically related and he considered this species as monotypic. Hill (1963) has maintained all the mainland subspecies of *lankadiva*. Under the circumstances, further study of fresh material from the entire range of distribution of the species is very much necessary to reach to a definite conclusion.

The specimen was collected with the help of mist nets placed on hill-top with rubber plantations. It was found entangled in the net, at about midnight, 3 m above the ground level along with specimens belonging to the genera *Cynopterus* and *Pipistrellus*.

***Hipposideros armiger armiger* (Hodgson, 1835)**

Great Himalayan Leaf-nosed Bat

1835. *Rhinolophus armiger* Hodgson, *J. Asiat. Soc. Beng.*, 4 : 699 (Nepal).

Material examined : Manipur : Tamenglong district : 1 ♀, Tharon Cave (30 Km North of Tamenglong, c 1,280 m. coll. Ajoy K. Mandal, 23 Nov 1992 (in spirit, skull extracted but damaged), ZSI Reg. No. 23903.

Measurements : External : 1 ♀ : length of forearm 89.1 ; length of ear 26.0 ; length of tibia 37.6 ; length of foot and claw 16.5.

Distribution : *Hipposideros armiger armiger* is known from Nepal ; India (Uttar Pradesh, Sikkim, West Bengal, Assam, Meghalaya) ; Burma ; southeastern China ; Hong Kong ; Vietnam ; Thailand ; Malay Peninsula and nearby islands (Agrawal *et al.* 1992). Hence, the present specimen constitutes the first record of the species from Manipur and extends its distributional range southeastwards, in India.

Remarks : Ellerman & Morrison-Scott (1966) recognised six subspecies of *Hipposideros armiger*, of which, Hill (1963) has synonymised *swinhoii* Peters and *debilis* Andersen with the nominate subspecies.

This specimen was collected from Tharon Cave (a limestone cave, 30 Km North of Tamenglong), where a colony of this species exists. The bat was collected by striking with a stick when it was flying. Two albino specimens of this from were also noticed which could not be collected. No other species of bats could be located in the cave.

SUMMARY

Megaerops niphanae, *Hipposideros lankadiva* and *Hipposideros armiger armiger* have been recorded for the first time from Manipur, India. Their locality, measurements, distribution and taxonomic remarks have been appended.

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SPIDERS AS LARVAL FOOD OF *SCELIPHRON VIOLACEUM*
(DAHLB.) (HYMENOPTERA : SPHECIDAE)

D. B. BASTAWADE

Arunachal Pradesh Field Station,

Itanagar-791 111 (Ar. Pr.)

Zoological Survey of India

INTRODUCTION

The Sphecid wasps are known to prepare mud cell, in and around the human habitations. They construct the mud cells in the corners of houses, on walls and logs, underneath of furnitures (Jaykar and Spurway 1964) and in pin-holes of electrical fittings (Joshi, 1984 and personal observations). The wasps, as mud potters, are known to be adapted for collecting and transporting small balls of soft mud for daubing their nests (Hingston, 1926, 1927, Jaykar and Spurway, 1960, 1968, and Joseph and Raphael, 1991).

The mud potters are known to collect insects, both adults and larvae, spiders, and after narcotising, they are deposited in the cell, the breeding nest, in the form of ready food for the development of their larvae upto pupation. The above has been reported in the species of genera *Sceliphron*, *Chalybion*, *Tryperylon*, *Trypargilum* and *Pison*. This habit of them is known since 1898. The taxonomic studies on spider collections made by the mud potters have been initiated in recent years (Callan, 1987 ; Durris, 1969, 1970, Laing 1988 ; Obin 1981). Landes and his associates (Landes et al. 1988) report the seasonal and latitudinal variations in the spider prey of *Chalybion californicus* (Saussure) (Sphecidae) from four localities in Maryland, U. S. A. Similar studies have been made by Jocque (1988) on *Sceliphron spirifex* (Linn.) from Central Africa.

There is no work on the above aspects on any species of Indian doubbers except *S. madraspatanum* (Fabr.) made by Jaykar and Spurway, (1960 & 1968), and on *S. violaceum* (Dahlo.). The collection of spiders, as larval food has been accounted in their work but however, they have not dealt with the taxonomy of spider species and also have not mentioned regarding the preference to the spider species as larval food. In this communication efforts have been made to analyse both the above referred aspects.

METHODS

Two study areas, one at Shivajinagar, Pune 5 and another in the University campus, Pune 7 were selected. The nesting sites of *S. violaceum* (Dahlb.) were located in the study areas. The wasps were allowed to cap the breeding nests. These nests were uncapped gently with the help of forceps. The deposited prey (spiders) was gently taken out with the help of camel hair brush and collected in the specimen tubes containing 70% alcohol. Nest wise data was prepared and identification of the spiders was done using fauna of India : Araneidae (1982).

OBSERVATIONS AND DISCUSSION

The Spiders collected and stored by the daubber wasps. *S. violaceum* at study area I belonged to the families Araneidae (96%), Theridiidae (2.6%), and Hersiliidae and Uloboridae (0.7%) each. Whereas in the study area II the spiders collected by the wasp belonged to only one family, Salticidae. It was observed that the wasp generally collects 9-13 spiders per cell, may be depending on the size of the spiders collected for the respective cell. Table no. I presents species wise preference of spiders at locality I. The species *Neoscona muketjei* Tikader was preferred in large numbers (30%). It is followed by *Leucauge decorata* (Black Wall) (11%), *Larina chloris* (Savigny & Audin) 9% ; *Meta* sp. 8%, *Araneus mitifica* (Simon) and *Cyclosa hexatuberculata* Tikader & Bal. 6% each, *Araneus bituberculatus* (Walk) 4%. It was interesting to note that at both the localities the prey mainly included the female spiders (83%).

From the above observations it is clear that *S. violaceum* have different larval food preference, which appears to be dependent on the locality. At locality I they prefer Araneid spiders in large numbers (percentage) and Salticids are preferred at locality II. Interestingly the above two spider families differ considerably in their habits and habitats. The spiders belonging to Araneid group are the true orb weavers. They occur on the webs while feeding, whereas the Salticids are either ground or tree trunk dwellers and non-orb-weavers. They prefer to hunt their prey through direct attacks.

At locality I, there is an abundance and diversity of Araneid spiders which it appears, gives a choice for the wasp to select and prefer different species as their larval food. Such a situation does not exist at locality II which has only one species of Salticid. Twenty one species of Araneids at locality I are found to be collected by the wasp as larval food. Amongst these *Neoscona muketjei* Tikader are most commonly caught (30%) *Leucauge decorata* (Black Wall) (11%) and *Larina chloris* (Sav. and Audin) (9%) form the next choice. Thus, it indicates that the Araneid spiders constitute a dominant community at locality I. At the II locality, such a choice and preference is not possible, because it is having the dominance of only one species of Salticids.

Another interesting observation made in this regards relates to the preference by the wasp for female spiders at both the localities (83%). This further indicates an

TABLE I. Showing the food preference for the wasp *S. violeceum* (Dahlb.) in two study areas.

Spider Families	Name of spider species	Locality (Study areas)	Nest Nos. 1 to 13	Particulars of prey Female Male		Species in %	Family in % (Appr.)
1	2	3	4	5	6	7	8
Araneidae.	1. <i>Neoscona mukerjei</i> Tikader		1 to 10	36 ♀ ♀	2 ♂ ♂	30.3%	
	2. <i>N. rumfi</i> (Thorell).		6	1 ♀		0.7%	
	3. <i>N. elliptica</i> & Bal.		10	2 ♀ ♀		1.5%	
	4. <i>N. sinhagadensis</i> (Tikader)		4, 7 & 8	4 ♀ ♀	1 ♂	3.9%	
	5. <i>N. theis</i> (Wrlckenaer)		5, 8 & 9	7 ♀ ♀	1 ♂	6.3%	
	6. <i>N. laglaizei</i> (Simon)		2, 3 & 9	3 ♀ ♀	1 ♂	3.2%	96%
	7. <i>Neoscona</i> sp.	I	9	3 ♀ ♀		2.3%	
	8. <i>Lecaue decora</i> (Blackwall)		1, 2, 3, 5, 6, 7, 8 & 11	13 ♀ ♀	1 ♂	11%	
	9. <i>Lecaue</i> sp.		1	1 ♀		0.7%	
	10. <i>Larina chloris</i> (Sav. & Audin)		7, 8, 10, & 11	10 ♀ ♀	1 ♂	8.7%	
	11. <i>Araneus mitifica</i> (Simon)		1, 2, 4, 5, 6 & 11	3 ♀ ♀	4 ♂ ♂	6.3%	
	12. <i>A. bituberculatus</i> (Walk)		11	5 ♀ ♀		3.9%	
	13. <i>Cyclosa hexatuberculata</i> Tikadar & Bal.		1, 2, 6, 10 & 11	7 ♀ ♀		6.3%	
	14. <i>C. confraga</i> (Thorall)		4 & 5	2 ♀ ♀		1.5%	
	15. <i>C. mulmeinensis</i> (Thorall)		5	2 ♀ ♀		1.5%	
	16. <i>C. spirifera</i> Simon		8	1 ♀		0.7%	
	17. <i>Cyclosa</i> sp.		5	2 ♀ ♀		1.5%	
	18. <i>Meta</i> sp.		4 & 11		1 ♂ 9 Immature	7.9%	

TABLE I. (Continued)

1	2	3	4	5	6	7	8
	19. <i>Cyrtophora citricola</i> (Forsk.)	I	1, 5 & 6	3 ♀ ♀		3.0%	
	20. <i>Argeope aemula</i> (Walk.)		6	2 ♀ ♀		1.5%	
	21. <i>Poltya</i> sp.		2	1 ♀		0.7%	
Hersiliidae.	22. <i>Muricia indica</i> Simon		3	1 ♀		—	0.7%
Uloboridae.	23. <i>Uloborus</i> sp.		2	1 ♀		—	0.7%
Theridiidae.	24. <i>Theridion</i> sp.		3	3 ♀ ♀		—	2.6%
Salticidae.	25. <i>Salticus</i> sp.	II	12 & 13	13 ♀ ♀		—	100%

abundance of female spiders in population at both the locations. Apart from it, it may also be concluded that the wasps have developed the ability to locate and hunt the female spiders, since the female spiders provide more nourishment to the developing larvae of the wasp because they are larger in size. This would also result in minimum hunts to catch the spiders. Since the natural status of the ratio of female to the male in a population was not yet established in case of any spider species from India, it would be imperfect to mention about it but now it is known that the natural spider population always has more number of females than males for any species of spiders.

Jocque (1988) has indicated that the prey of *Sceliphron spirifex* (Linn.) belong to 8 spider families. 56% spiders belong to Araneidae, and 31% to Salticidae. The other families like Clubionidae, Theridiidae, Hersiliidae, Tetragnathidae represent less than 10%, while (1962) reports on the presence of Lycosidae and Zodariidae in the nests of some species of *Sceliphron* in Sierra Leon.

The above studies, thus indicate that the above cited two species of *Sceliphron* have an impact on the population of certain spider species, since a large prey per cell per nest is required. Further, the wasp *S. violaceum* mainly predate on female spiders and this would have a direct impact on the spider population, because before breeding activities are completed the female individuals are preyed upon, further, the two Indian species, *S. madraspatanum* and *S. violaceum* might have a competition for prey, and to confirm this further efforts are needed and the same are in progress.

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BIOMONITORING OF INLAND WATER : PHYSICAL, CHEMICAL AND
BIOLOGICAL PARAMETERS OF RIVER MUSI AT HYDERABAD
ANDHRA PRADESH, INDIA.

RAMAKRISHNA*

*Freshwater Biological Station
Zoological Survey of India
Ashoknagar, Hyderabad.*

INTRODUCTION

The close dependence of man on water for life accounts for the association which has existed between him and several rivers over centuries. In the process of dependency, of using surface water for development, man has interfered so much, streams, rivers and lakes that are now, can be hardly called natural. Water was being withdrawn excessively and faunal associations and population balances have been grossly affected by disturbances, where the water flow is checked by barrier, ecological systems have been drastically changed down stream and water quality is affected by dissolved and suspended matter. Furthermore, surface water is often used for the disposal of human waste, and industrial effluents; the organic and inorganic material thus introduced into them in this way affected the delicately balanced ecosystem.

The effect of these modifications in tropical water is not understood properly. Only limited studies have been carried out by Venkateswarulu (1976, 1981, 1986) on river Musi on the interrelationship of algal distribution. The present study was undertaken to understand the distribution of faunal components in clean and polluted zones of the river Musi for a period of two years.

RIVER MUSI

The river Krishna rises near Mahabaleshwar at 1360 m above msl and flows towards east (1400 km) to join Bay of Bengal (Figure 1). River Musi, a tributary of Krishna originates from Anantagiri hills of nearby Medak district of Andhra Pradesh. It traverses nearly 240 km and joins Krishna at Wazirabad, 40 km below Nagarjuna sagar reservoir. In the entire basin, a semi arid condition prevails and as a result, most part of the year the flow is very less. In addition, to augment the drinking water facility to the city of Hyderabad, and also to check flash floods, two reservoirs have been constructed along its course *viz.* Himayat sagar and Osman sagar in the peripheral

*Present Address : Marine Aquarium cum Research Centre, Digha-721428.

area of the city. The flow of the river is therefore, controlled by the sluice gates of these two reservoirs.

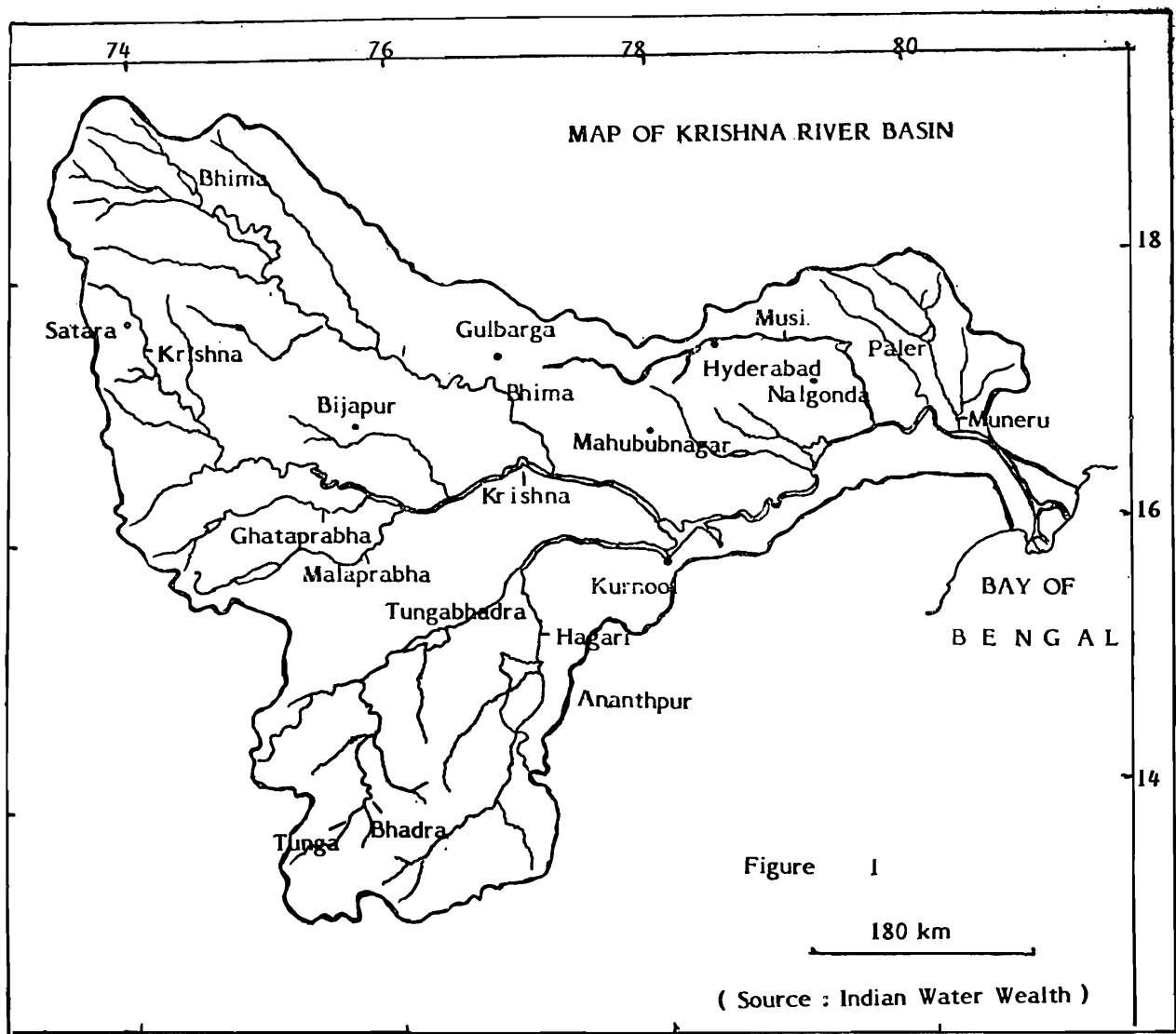


Fig. 1. Course of River Musi in the Krishna River Basin.

The river along its course in the city flows over rocky bed and receives waste water at various points. The major source of waste water entering the river are 1. the return canal from highly polluted lake, Husain sagar passing through the middle of the city, 2. seepages from Burning ghat, sewage treatment plant, washing ghat, slaughter house, hutments on the river bed etc. and 3. effluents from automobile industry and dumping wastes from various sources along its bank ; all resulted in the deterioration of the water quality.

SAMPLING STATIONS

Sampling stations were marked for periodic collection and analysis as in figure—
2. Sampling station—1 represents the area in the upper tributary receiving seepages

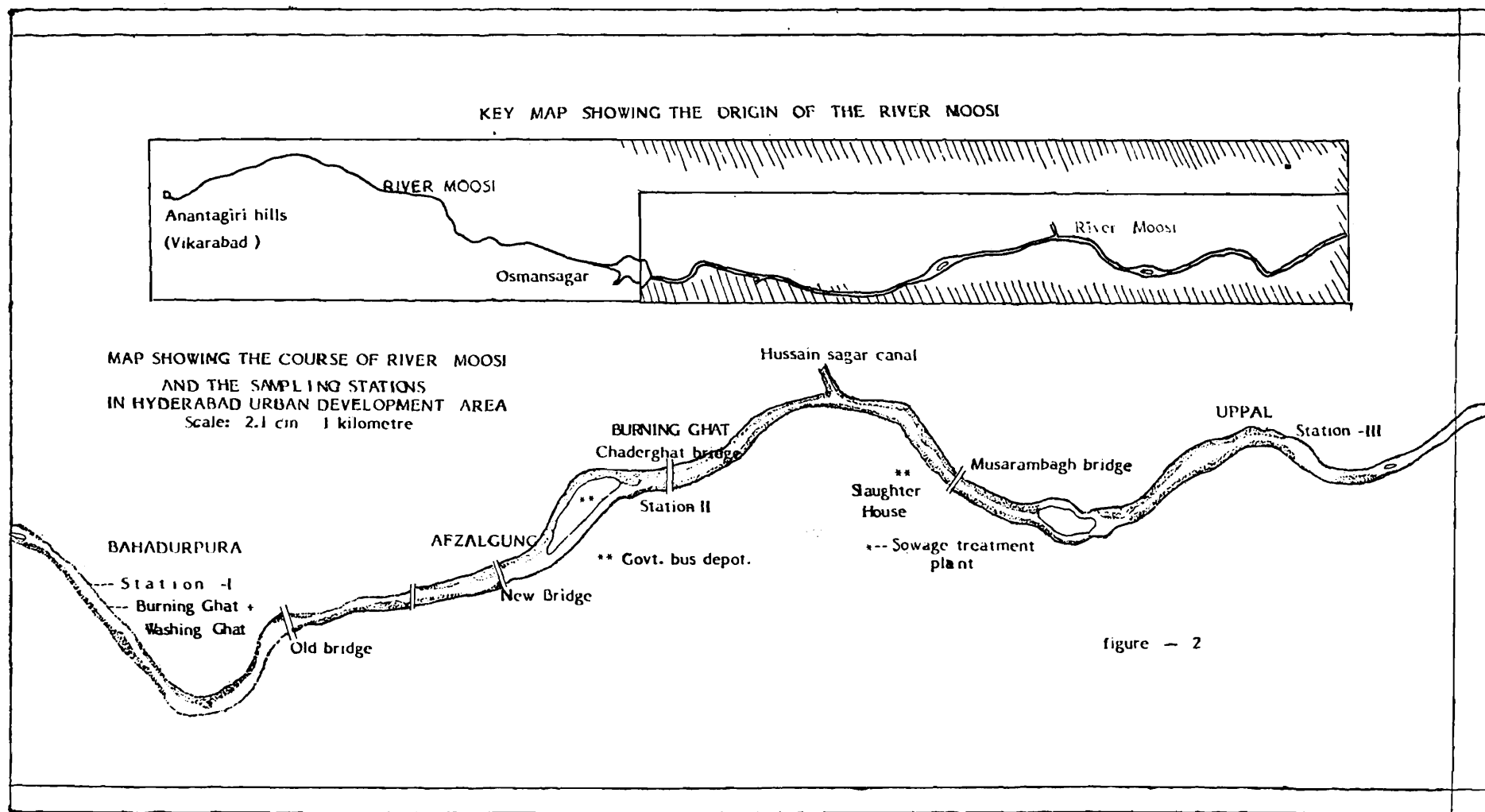


Fig. 2. Origin, course and sampling stations of River Musi.

from Mir Alam tank passing through zoo garden with substrate predominantly of boulders and black soil. Sampling station—2 located in the middle of the city devoid of any boulders but with grass cultivation along its bank. Sampling station—3 is located on a less densely populated area, outside the city limits receiving run-off from slaughter house, sewage treatment plant, grass land, industrial and domestic wastes. A rich growth of *Eicchornia crassipes* was found as free floating plant. Moderate flow was noticed in this sampling station—4 was located at about 150 km. from the city limits, almost near its confluence with river Krishna at Dameracherla, wherein, the gauging station is maintained by the Central Water Commission.

MATERIAL AND METHODS

Water samples collected periodically from different sampling stations of the river are brought to the laboratory for detailed analysis for a period of two years (May 1985-

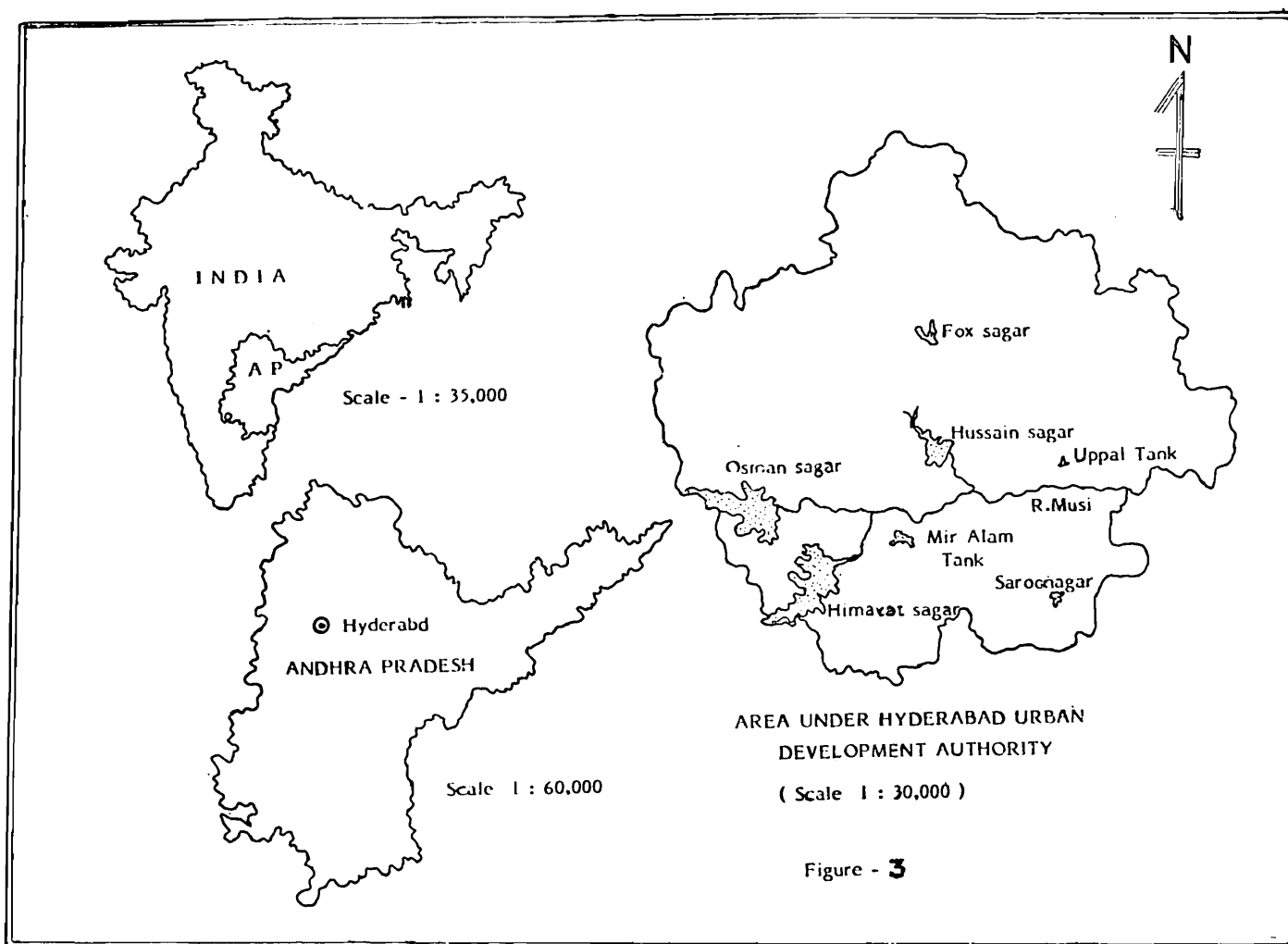


Fig. 3. Location of River Musi under Hyderabad Urban Development Authority with other reservoirs.

April 1987). Parameters such as temperature, humidity, pH, transparency of water was measured in the field. Specific conductance, dissolved oxygen, carbondioxide,

Bio-chemical oxygen demand (BOD), total hardness, carbonates, bicarbonates, chlorides, sodium, potassium, nutrients such as Nitrate-nitrogen, phosphates, sulphates are analysed in the laboratory as recommended by *Standard Methods*, (A P H A), 1985, and the results are expressed in mg/l, unless otherwise mentioned.

PHYSICAL FACTORS

a. Temperature : Hyderabad city located in the semi arid region of Andhra Pradesh, exhibits tropical climate with maximum day temperature rising to 42-45 degree Celcius during summer and minimum winter night temperature falls to 12-15 degree Celcius, the mean annual diurnal range exceeding 20-25 degree Celcius. Water temperature followed a characteristic seasonal cycle at all stations, the maximum generally in the month of April and minimum in the month of January. Gradual decrease in the surface water temperature has been noticed from October onwards upto January and at no time of the year, the temperature fell below 23 degree Celcius.

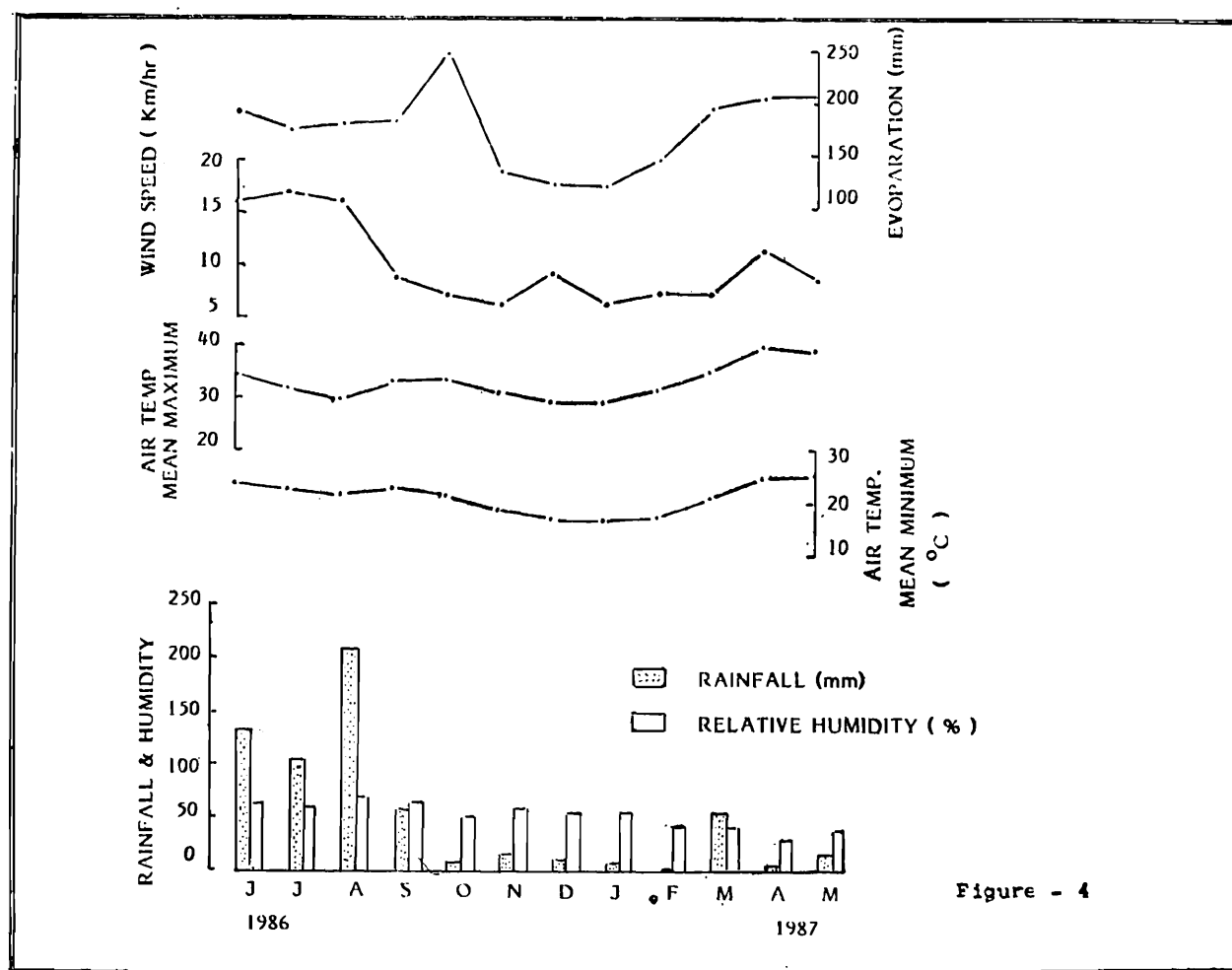


Figure - 4

Fig. 4. Temperature, Evaporation, Rainfall and Humidity records at Hyderabad for 1986-87.

b. Sunshine Hours : Hyderabad is located in the southern peninsular part at about 510 m above msl and receives maximum light. From the study of solar radiation reaching the earth (Zafar, 1964), during January it is a 3gm/cal/cm/min, from February

onwards, a slight decline is seen and balanced during July. Thus at no time of the year, the region loses radiation in excess of what is gained from Sun. If biological function is taken as a function of radiation gain, Hyderabad city could be regarded as continuously productive all through the year.

c. Rainfall : Hyderabad city is situated at a distance of about 265 km from eastern sea coast and as a result, the marine climate generally becomes peninsular, the air becomes drier and amount of rainfall decreases. Long term averages of rainfall in the district varies from 672-800 mm/year of which 78% is received from South-West monsoon, with an average of 48 rainy days/year. The monsoon reaches its peak during August-September and gradually decreases from October onwards.

d. Evaporation : The rate of evaporation dependent on both temperature and humidity as well as wind stress on the water surface. It has been estimated that the present rate of evaporation at Hyderabad is 2172 mm/year, which gives a daily average of 6 mm.

CHEMICAL CHARACTERISTICS

a. Dissolved Oxygen : Dissolved oxygen is a valuable tracer for water and sensitive indicator for biological and chemical processes occurring in it. The value of oxygen was comparatively low indicating anaerobic condition. In most part of the year, the dissolved oxygen never exceeded 3.3 mg/l. Post monsoon months of September-December 1985 exhibited no oxygen, while during 1986, it was in traces at all three sampling stations as in table—1 and 2.

TABLE 1. Values of Dissolved oxygen at 3 sampling stations for 1985-86.

Station	May	June	July	Aug.	Sept.	Octo.	Nov.	Dec.	Jan.	Feb.	March	April
I	Nil	1.0	0.5	Nil	Nil	Nil	Nil	Nil	3.2	3.0	2.2	0.9
II	0.5	0.5	0.6	Nil	Nil	Nil	Nil	Nil	0.8	Nil	Nil	Nil
III	2.1	0.6	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.2	Nil	Nil

TABLE 2. Values of Dissolved oxygen at 3 sampling stations for 1986-87.

Station	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April
I	Nil	Nil	Nil	0.9	Nil	0.4	0.6	1.2	1.7	Nil	Nil	1.0
II	Nil	1.2	0.8	0.6	Nil	Nil	Nil	0.6	Nil	0.4	Nil	0.8
III	Nil	1.2	0.8	1.9	Nil	0.9	Nil	Nil	0.2	Nil	0.4	Nil

(Values are in mg/l)

According to present data, all sampling stations receive waste water leading to high organic matter and low oxygen values. The reason for such a condition is the application of synthetic detergents throughout the drainage basin and these detergents are resistant to secondary sewage treatment and frequently produces a layer of surface foam, as observed at all stations, when the effluents are discharged in to the river. This foam restricts re-oxygenation and causes anaerobic condition to rise.

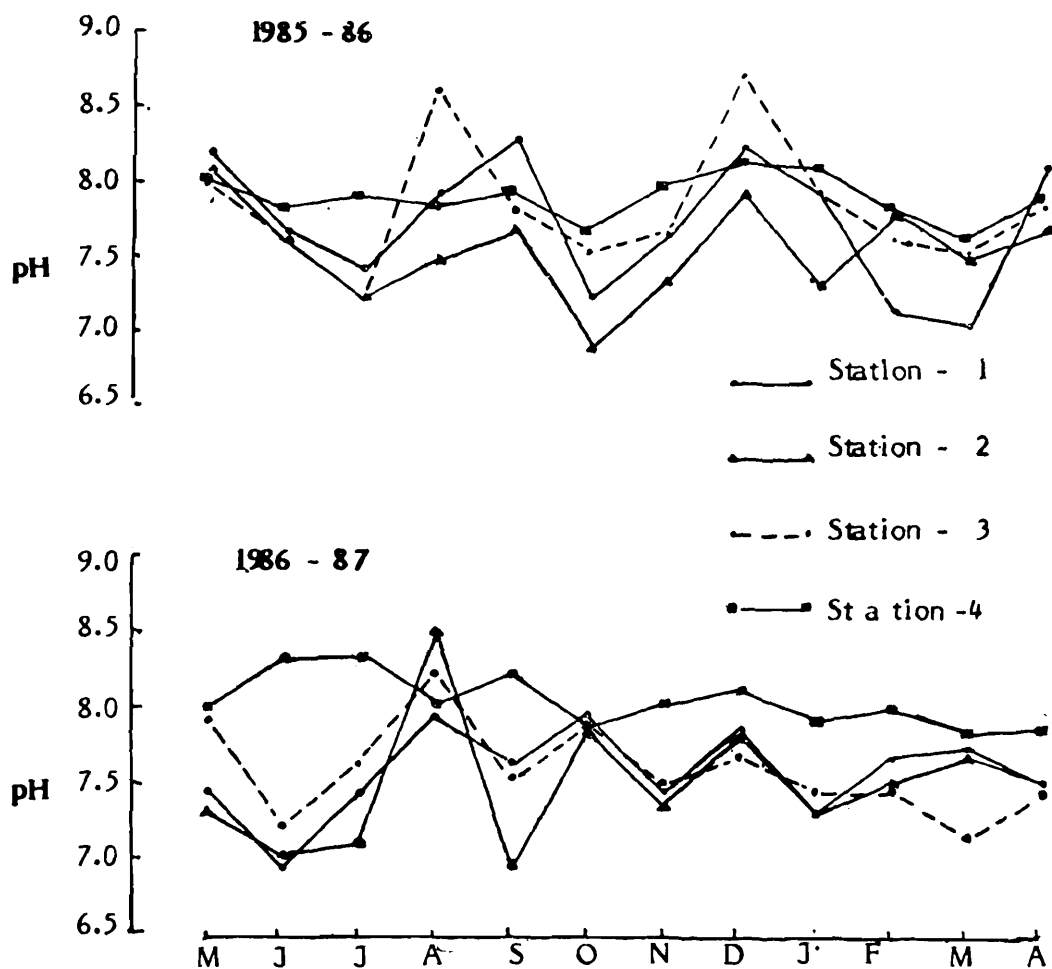


Figure - 5

Fig. 5. Monthly variation of pH in River Musi for different sampling stations.

Running water contain typically high concentration of dissolved oxygen tending towards saturation, however, larger organic discharges perhaps adding to upstream

pollution already present, causes great ecological changes (Dix 1981), resulting in a large oxygen deficit in the down stream. According to Hawkes (1981), the presence of surface active material in the sewage effluent suppresses the rate of reaeration of the receiving stream and thereby delays self purification, and this effect is greater in sluggish rivers. According to Butcher and Blum (1957), the low values of dissolved oxygen is

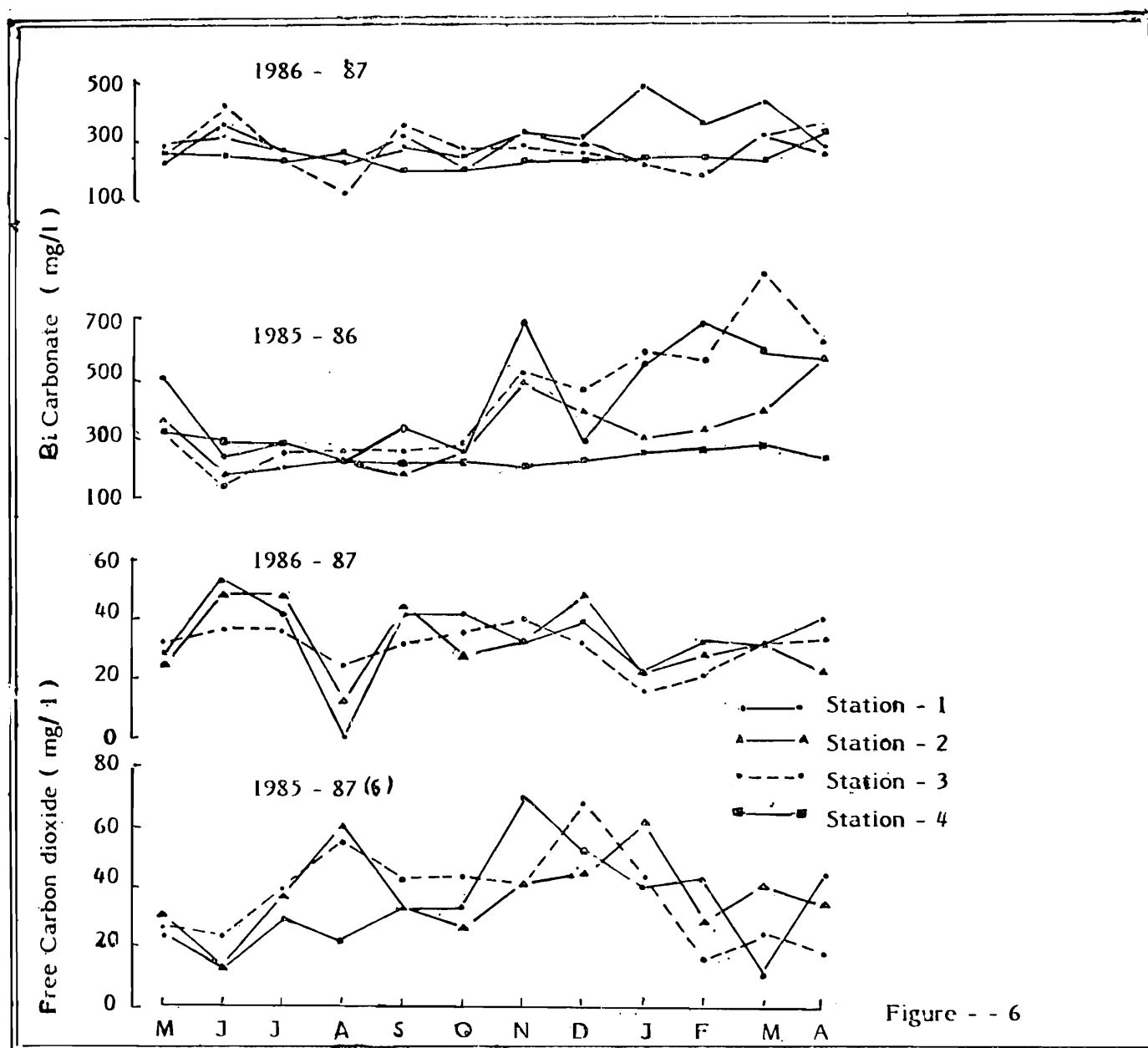


Fig. 6. Monthly variation of Free Carbon Dioxide and Bicarbonate in River Musi.

generally associated with high organic matter and due to the active aerobic bacteria, dissolved oxygen content is known to fall down below the sewage outfalls.

Unlike lake ecosystems, river water quality cannot be characterised by the concentration of nutrients only (Wong et. al. 1979), however, dissolved oxygen content which plays a vital role in supporting aquatic life in running water is susceptible to

slight environmental changes. A similar condition is already noticed (Hynes 1966), that high organic pollution also lead to local depletion, frequently eliminating certain elements from the fauna. In the present case also, the occurrence of faunal components are restricted to organisms capable of living anaerobic condition, such as Chironomids, musquito larvae, a few hemipterans such as *Diplonychus* and *Laccotrephes* species.

b. *Carbonate and Bicarbonate* : Carbontes are absent in water and the total alkalinity available was in the form of bicarbonate, the values of it varied between 150-900 mg/l as in figure 6. According to Rutner (1957), accumulation of large quantity of bicarbonate during summer may be due to the liberation of carbon dioxide in the process of decomposition of bottom sediments which resulted in the conversion of insoluble carbonate into soluble bicarbonate. Present investigation is in confirmity with the work of Rao and Govind (1964), that the water having carbonates was devoid of carbon dioxide and vice versa. The absence of carbonates was mainly related to the absence of macrophytes, phytoplankton and decomposition of organic matter.

c. *Carbon dioxide* : Carbon dioxide is present at all stations throughout the year, the maximum was 68.91 mg/l and the minimum was 9.98 mg/l (Figure 6). The presence of large quantity of carbon dioxide at every sampling station is the effect of microbial activity of converting organic waste into water and carbon dioxide because the respiratory activity is nearly absent due to absence of biota. From the earlier work of Venkateswarulu (1968), carbon dioxide values appear to be negligible and are found only in the lower stretches of the river, which was mainly due to the presence of phytoplankton. However, in recent years, anthropogenic activity has added considerable material resulting in the change of water condition.

d. *pH* : pH of the water vary widely between different rivers and streams and influenced by carbonate-bicarbonate alkalinity and the concentration of carbon dioxide (Talling 1976). In the present case, the pH of the water was found to be in the alkaline range and the values are in figure 5. The pattern of fluctuation was almost irregular at all three sampling stations for a major part of the year and comparatively lower values were obtained during summer months except at sampling station—1 during 1986 April. The decline in pH during summer months is normally due to the surplus amount of carbon dioxide in water. A similar inverse relationship between pH and free carbon dioxide has been reported earlier by Rao and Govind (1964) and Zafar (1964).

TABLE 3. River Musi—pH changes at different sampling stations

<i>Sampling stations</i>	<i>1985-86</i>	<i>1986-87</i>
Station—1	7.48 (6.9-7.9)	7.52 (7.0-8.2)
Station—2	7.74 (6.9-8.5)	7.42 (6.8-8.0)
Station—3	7.81 (7.1-8.2)	7.55 (7.2-8.7)
Station—4	8.02 (7.6-8.4)	7.95 (7.8-8.3)

(Values are in mg/l)

e. *Chloride* : Chloride content of the river varied from 90-590 mg/l indicating a significant portion of human and animal refuse entering into the river, causing high degree of pollution. From the study, that the up stream and mid stream indicated a high degree of variation, and the down stream showed a normal curve except for the month of October 1985 at all sampling stations. The high degree of chloride at all places was due to the anthropogenic activity and absence of seasonal variation was due to the absence of river flow, except for station 3 and 4 which showed a near uniform value due to moderate flow.

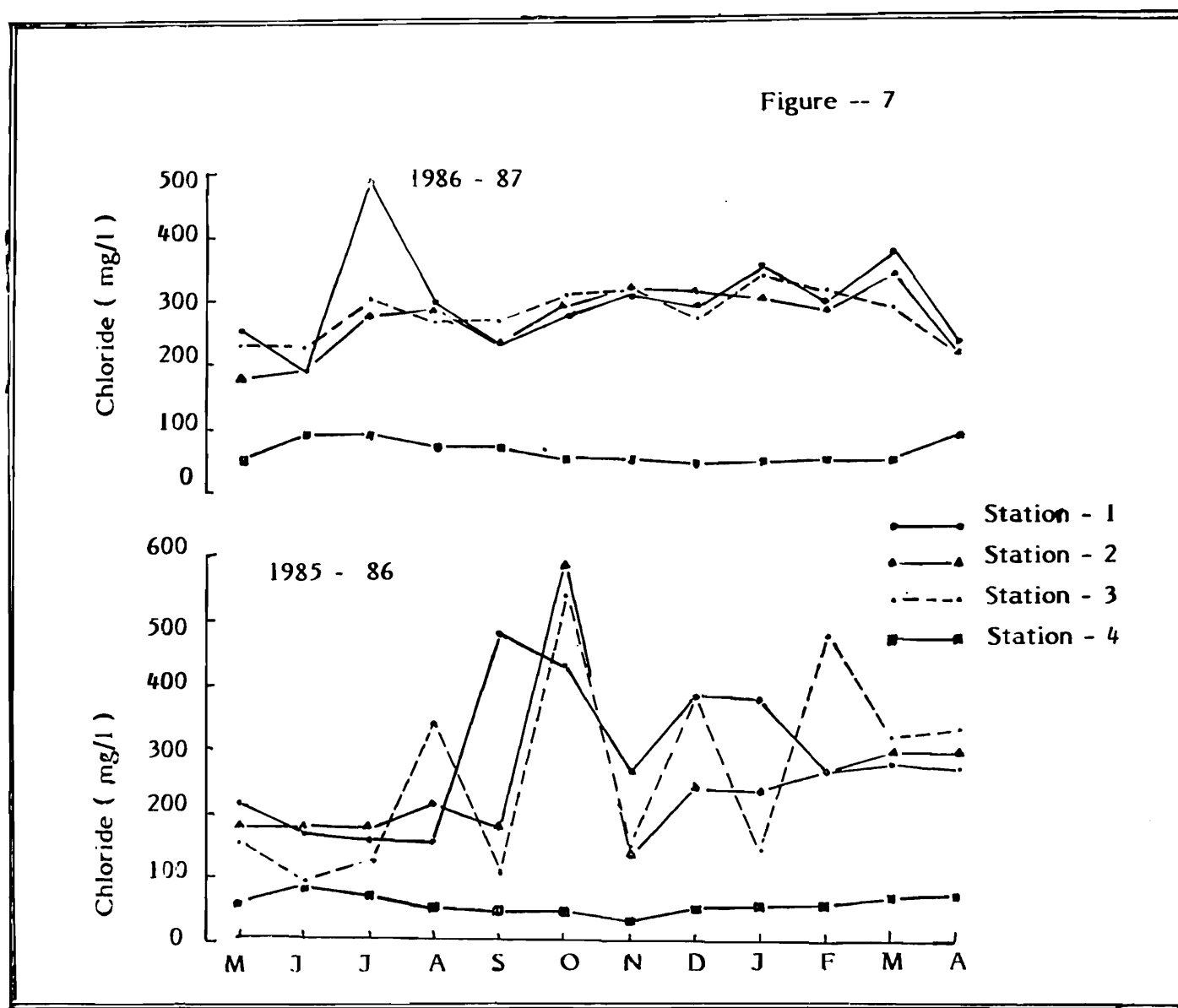


Fig. 7. Chloride concentration for different sampling stations of River Musi.

Klein (1957) found a direct correlation between chloride content and pollution level and therefore, higher value of chloride in the river showed high degree of pollution. According to Munawar (1970) higher value of chloride is an index of pollution of animal origin. Several investigators such as Blum (1957), Hawkes (1957), Venkateswarulu

(1986), Somashekar (1988) have reported sharp increase in chloride content at sewage polluted stretches of the river.

f. Specific conductance and Total Dissolved solids : Conductivity which measures the total ionic composition of water and therefore, its overall chemical richness is vital as it indicates the biogenic potential of any body of water. In the present observation, anthropogenic influences by way of effluents and sewage released into the river appears to be more responsible and values always exceeded 1000 mmho/cm at all sampling stations. The electrical conductivity of any water is roughly proportional to the concentration of dissolved major elements and the conductivity is often employed as it correlates closely with the dissolved solids. On the basis of this, the values of dissolved solids so calculated exceeded 700 mg/l on an average and showed a positive increase from the month of December.

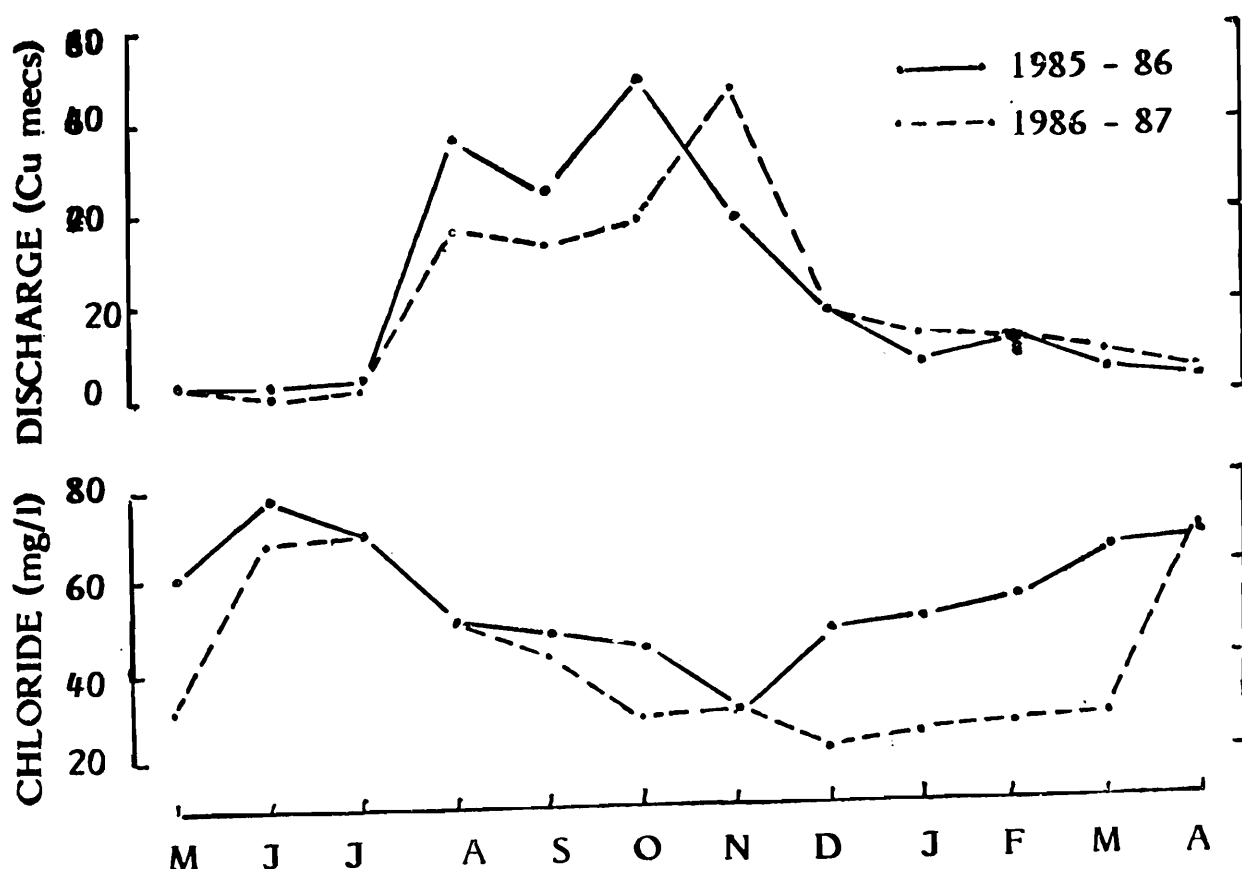


Fig. 8. Rate of discharge of water from River Musi to River Krishna at the confluence point and its relation with chloride.

The inert organic and inorganic material released into the river from various sources adds significant contribution to the specific conductance and dissolved solids. This is clearly visible from the black colour of the water. According to Claussen (1973) such suspended solids interfere with the self purification of water by diminishing light penetration and hence the photosynthetic activity and damage fisheries by silting over

food organisms. Probably due to this, planktonic and benthic populations have been highly destroyed in the river. Absence of many freshwater fauna in the river Musi can therefore, be attributed to the high specific conductance as normally inland water having a range of 150-500 mm ho/cm support a good fish fauna (Ellis 1937).

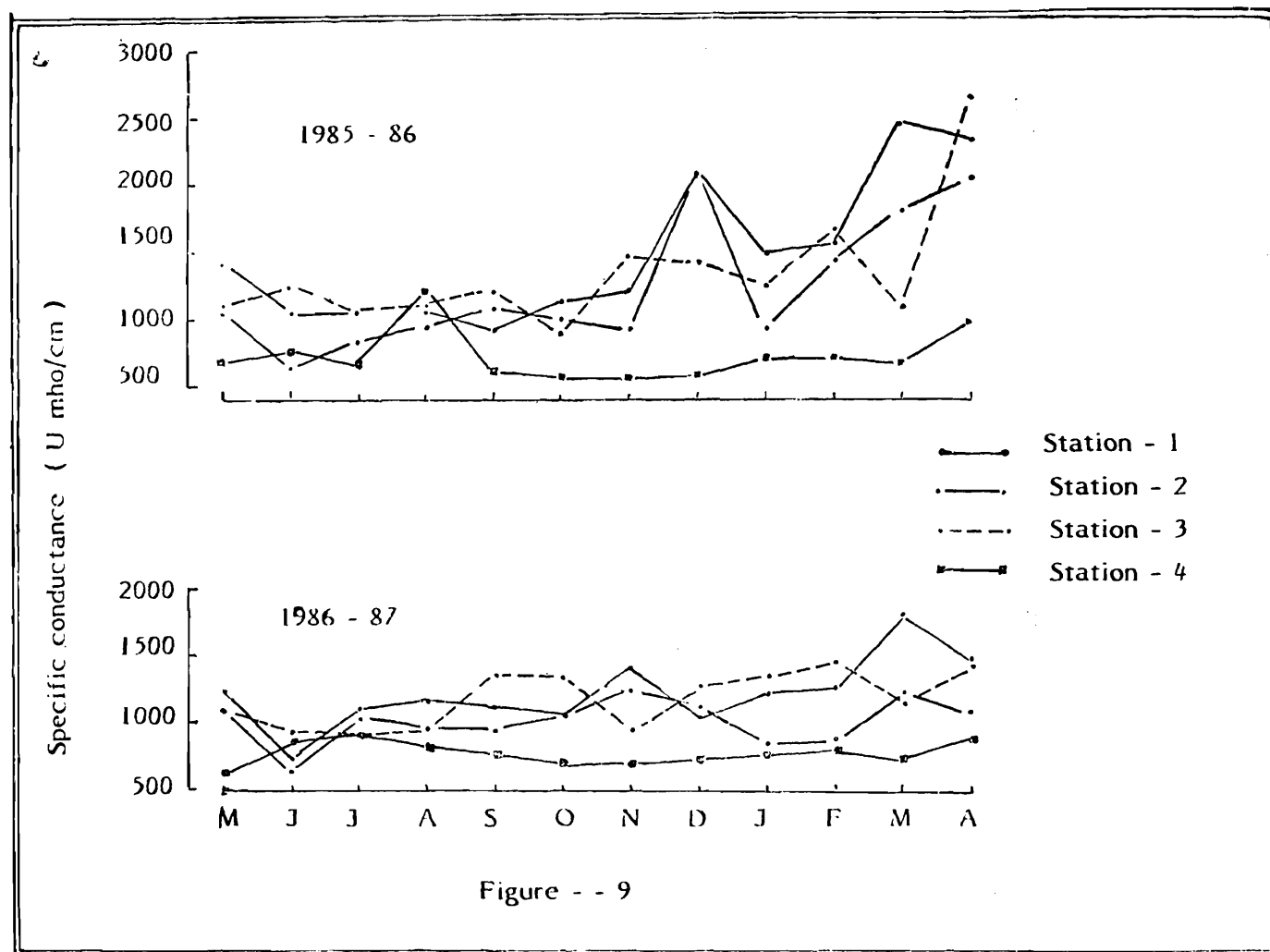


Fig. 9. Specific conductance of water at different sampling stations.

g. Sodium Absorption Ratio (SAR) : Importance of sodium absorption ratio is well understood, as it provides an indicator of effect of sodium in the soil. This (SAR) is evaluated in terms of Sodium Absorption which is defined as :

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

On the basis of the salinity diagram, the water in the polluted zone of the river Musi falls under $C_3 S_1$ with medium to high conductivity and low S A R. Similar condition was noticed even in the down stream near the confluence with the river Krishna at about 150 km. down stream, indicating it quality (Less suitability) for irrigation. Generally $C_1 S_1$ or $C_3 S_2$ are are considered excellent for use in irrigation.

h. Biochemical Oxygen Demand (B O D) : B O D values of the river varied from 54-109 mg/1 and range of variation at different sampling stations showed that highest value was 96, 102 and 109 mg/1 respectively in stations 1, 2 and 3. A steady increase in the values were observed at all sampling stations from the post monsoon months of September and highest during summer months. Absence of seasonal variation and comparatively higher values in the river during all seasons of the year is indicative of high organic pollution due to discharge of waste water from various points. A similar condition exists in the river Cauvery (Somashekar 1988) and in the river Ganges at Kanpur (Mahajan, 1938) resulting in the degradation of water quality.

i. Nutrients : Concentration of nutrients *viz.* Nitrogen and phosphorous are important in standing water and running water as they are directly related to the biological productivity. Nitrogen is one the important nutrient for plants, however excess of this element in water results in eutrophication. Phosphorous, an another nutrient, limits the growth of phytoplankton. The source of nitrate in the river Musi, is from the run-off received at several points and not geologically as the water passes through laterite soil and granite rocks, which are poorer in nitrate content. This is in conformity with the work of Whitton (1972), that the rivers draining primarily agricultural area, land drainage is the major source of nitrogen and chloride where as the industrialised and urbanised catchments, the major portion of these ions are derived from effluents. The nitrate fluctuated in a narrow range but showed a similar trend at all sampling stations except down stream of the river (sampling station—4) and summer months showed maximum level in water and minimum during rainy season indicating the effect of temperature and dilution respectively. Loss of nitrate by denitrification is the reason for their low values. However, according to Ganapati (1943) and Zafar (1964) deficiency of oxygen or the absence of proper organisms are being the prime factors responsible for the incomplete oxidation of the free ammonia accounting for the low nitrate values.

Values of phosphate obtained in the river water are on the higher side as in the table and this is due the sewage contamination and application of synthetic detergents containing Glycero-polyphosphate. According to Chakraborty et. al. (1959), Pahwa and Mehrotra (1966), many Indian rivers exhibited lower concentration of phosphate than nitrogen, therefore, the present trend of increased amount of phosphate is due to the application of detergents and biodegradation of these compounds is comparatively less, as evidenced in the present case at Sampling station-4, which is about 150 km. from others points (0.65-1.45 mg/1).

j. Sulphate : Sulphur is an essential element to all life and enters the biomass as sulphate. Sulphate deficiency can inhibit algal population directly by hindering chlorophyll synthesis (Cole, 1979), The Concentration of sulphate in the river water was low in area with less flow and anaerobic condition. This was mainly because of

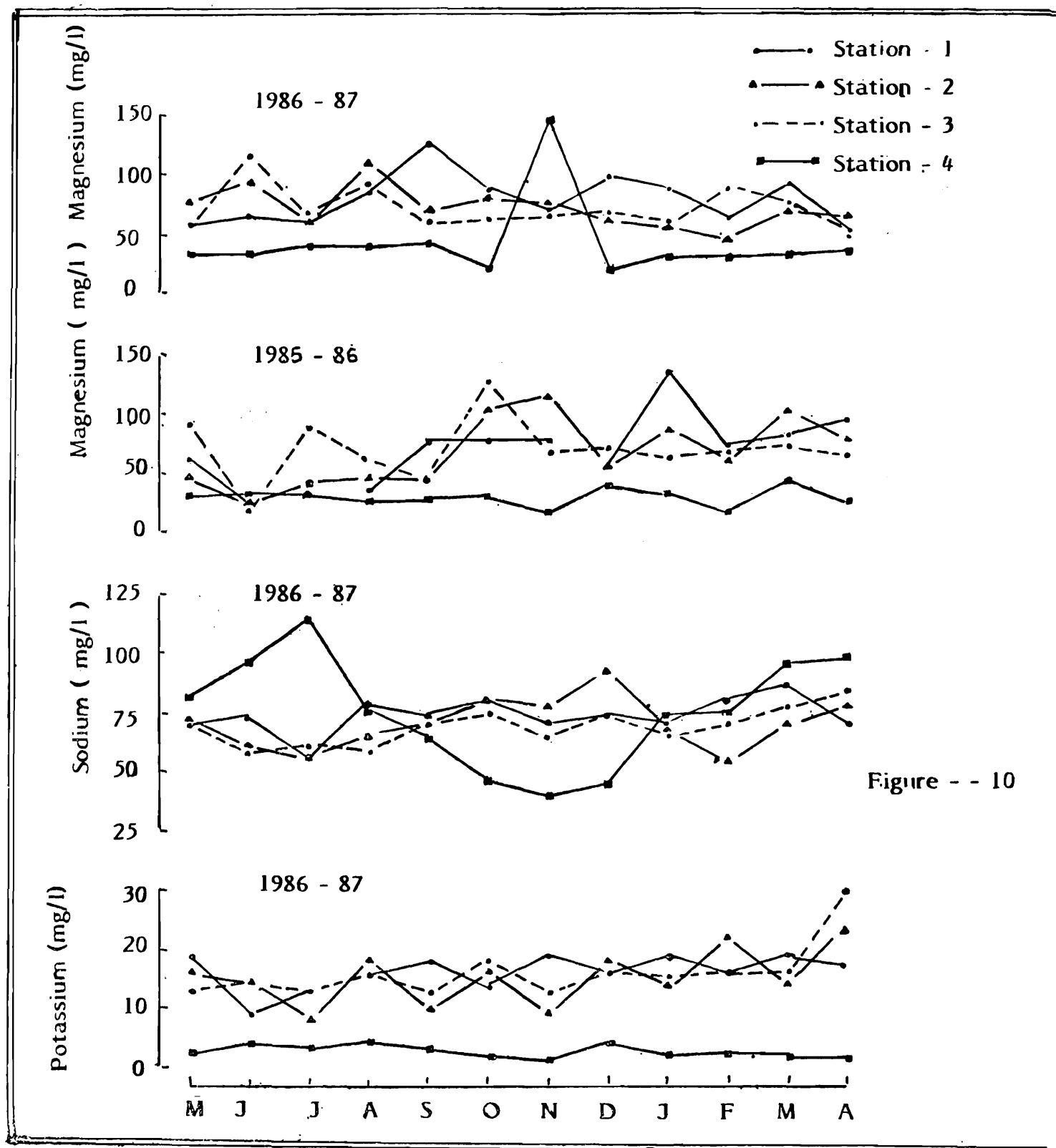


Figure - - 10

Fig. 10. Variation in monthly concentration of Sodium, Potassium and Magnesium.

the reduction of sulphates as hydrogen sulphide. According to Poste Gate (1954), many bacteria reduces sulphate to sulphide under anaerobic condition thus releasing abnoxious hydrogen sulphide and blackening mud and sand, as this gas combines with iron forming ferrous sulphide, the bacteria causing such a reaction are *Desulpho desulphuricans*. This condition appears to be same in the river Musi, with sulphate concentration varying from 2.65-6.2 mg/l in the polluted zone and above 60 mg/l in the down stream. The source of sulphate is mainly from the run-off of the catchment area and hence concentration increases with the increase of discharge or river flow.

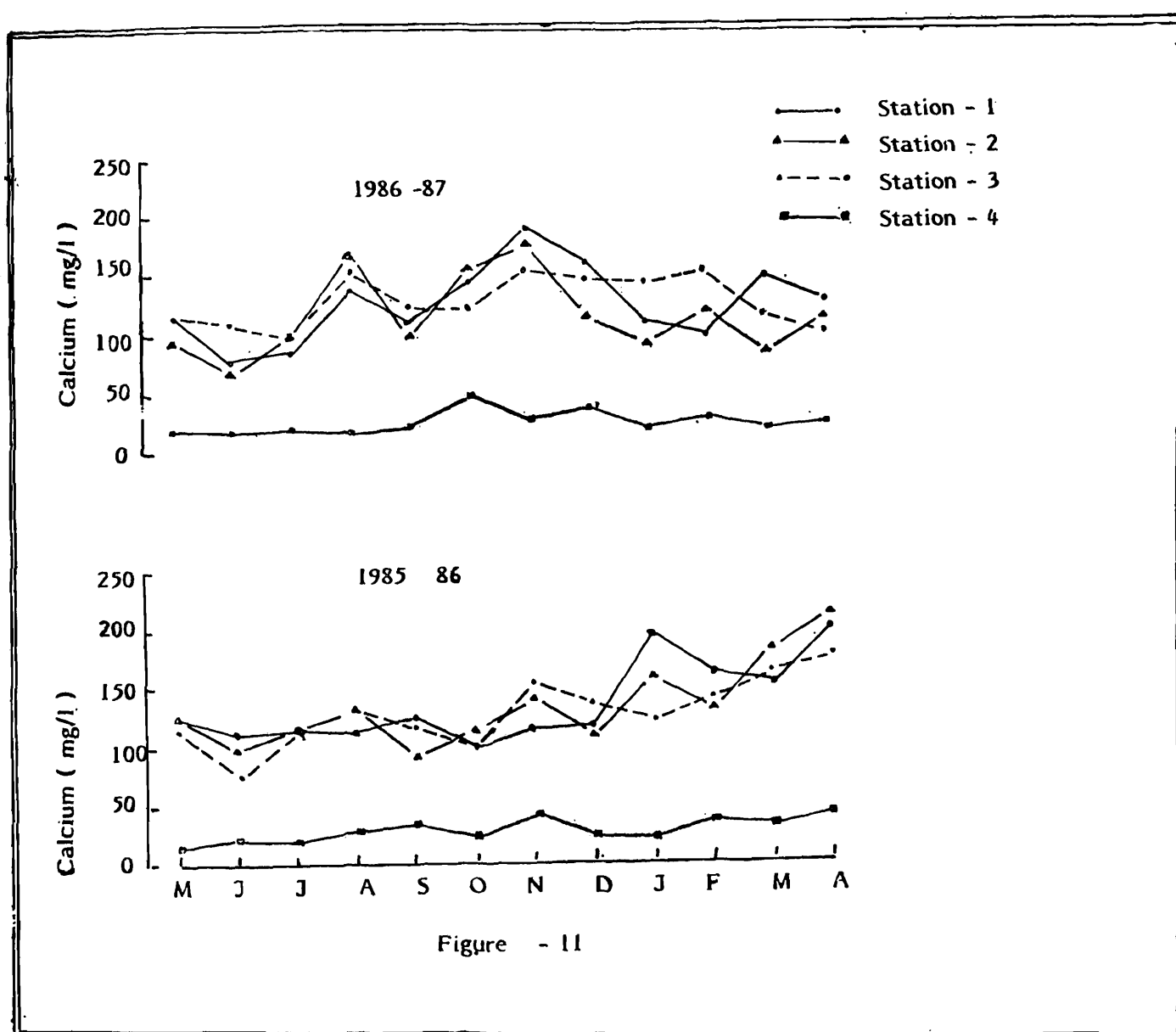


Fig. 11. Concentration of Calcium in River Musi.

k. Ionic composition : Calcium and magnesium are two important cat ions imparting hardness to the water, in comparison to monovalant sodium and potassium. These ions are normally leached from different types of rocks. In temperate climate,

as in river Wye, the major ions such as of calcium, magnesium, sodium, potassium and bicarbonate are generally lowest during winter and highest during summer (Whitton, 1972). However, in tropics, the ionic composition found to vary according to the river flow or alteration in the catchment area.

Based on the averages, the ionic composition of the river Musi was found to be $\text{Ca}^{++} > \text{Mg}^{++} > \text{Na}^+ > \text{K}^+$ in the polluted zone and $\text{Na}^+ > \text{Mg}^{++} > \text{Ca}^{++} > \text{K}^+$ in the unpolluted zone, among anions $\text{HCO}_3^- > \text{Cl}^- > \text{SO}_4^{--}$ at all sampling stations. The ionic composition of river Musi, even differed from that of river Cauvery in the South and Jhelum in the North ($\text{Ca}^{++} > \text{Na}^+ > \text{Mg}^{++} > \text{K}^+$) in the polluted and unpolluted zones.

TABLE 4. Seasonal variation of Nitrate and Phosphate at different sampling stations of the river Musi for the Year 1986-87.

Sampling stations	June-Sept. 1986		Oct.-Jan. 1986-87		Feb.-May 1987		Average Yearly	
—	Nitrate	Phosphate	Nitrate	Phosphate	Nitrate	Phosphate	Nitrate	Phosphate
Station-1	0.052	0.186	0.237	0.490	0.168	0.465	0.131	0.363
Station-2	0.079	0.195	0.207	0.475	0.339	0.530	0.180	0.413
Station-3	0.088	0.209	0.770	0.522	0.269	0.423	0.176	0.386
Station-4	0.002	1.450	0.040	0.650	0.056	1.260	0.04	1.15

TABLE 5. Seasonal variation of sulphate in river Musi at different sampling stations for the Year 1986-87.

Sampling Stations	Oct.-Jan. 1985-86	Feb.-May 1986	June-Sept. 1986	Oct.-Jan 1986-87	Feb.-May 1987
Station-1	6.20	3.16	4.12	6.00	5.30
Station-2	3.50	4.59	3.50	3.50	2.35
Station-3	3.65	6.12	2.60	2.85	2.65
Station-4	22.00	51.00	100.00	40.50	39.00

(Values are in Mg/l)

IMPACT OF ANTHRAPOGENIC ACTIVITY ON THE RIVER MUSI

Rivers differs from that of lacustrine environment by having unidirectional, continuous motion over an area extended often with rocky stretches and variable soil composition. In the process, acquire mineral components, solids and solutions from a wide range of their basin (Rzoska 1978) and thus creates a different condition for

life. Impact of man has so profound effect on the nature of rivers, streams and tributaries, especially in recent years, it is extremely difficult to find any river or stream which has not altered for his benefit. This has been ably achieved by the way of construction of dams and reservoirs. In tropical countries, these problems are further aggravated by the unseasonal rains, unprecedented extreme climatic conditions such as high temperature, low humidity and high rate of evaporation.

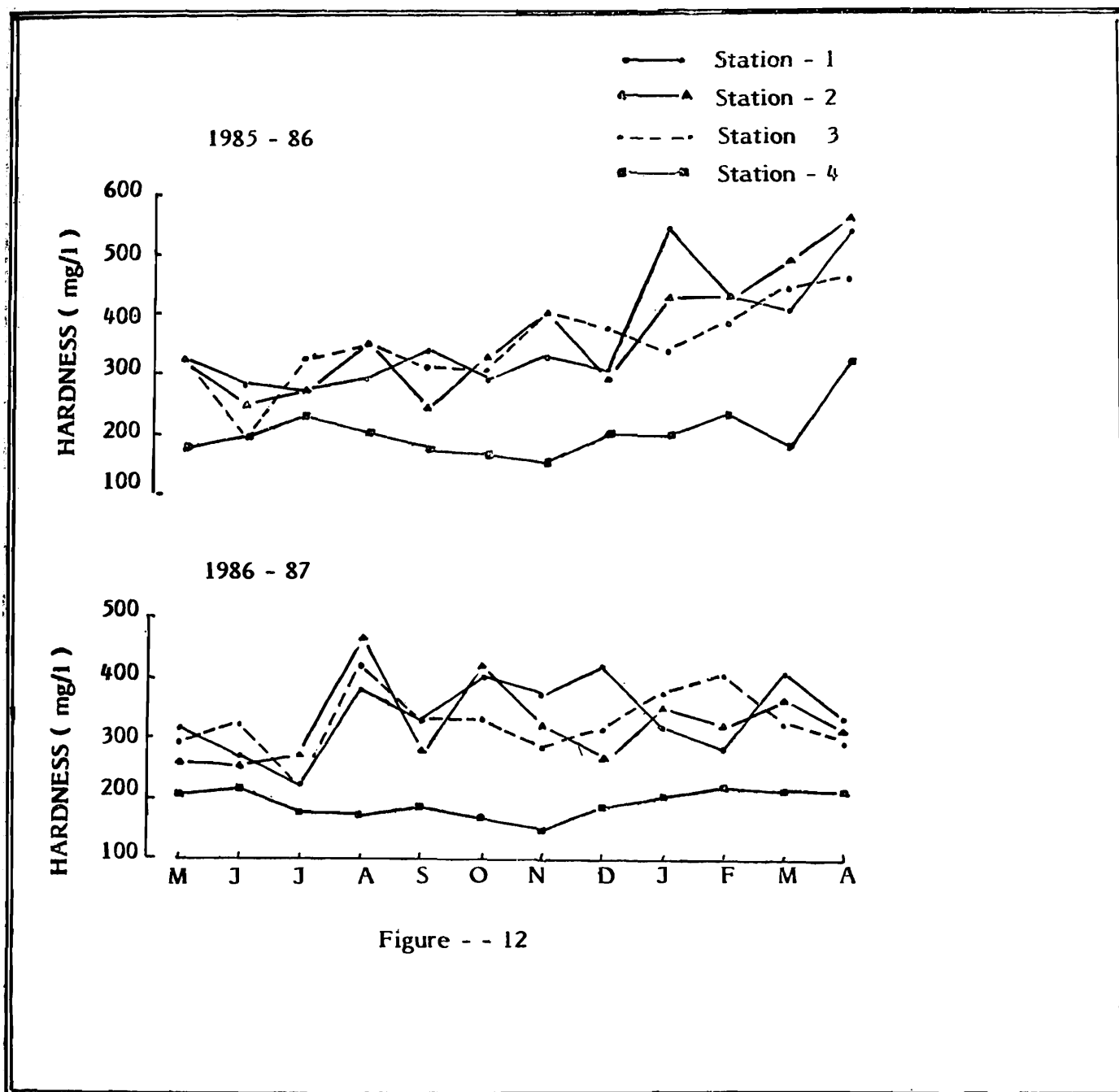


Figure - - 12

Fig. 12. Seasonal variation of hardness of water samples of River Musi.

Impact of human settlement, degradation of water quality and excessive exploitation resulted in the imbalance of freshwater ecosystem. The initial effect of

this on a stream or river is to degrade the physical quality of water, as the deterioration is more pronounced, a shift to chemical degradation is biologically induced in terms of number and variety of organisms. The initial effect of anthropogenic activity on river Musi is felt by way of deterioration of water quality, alteration in the habitat structure and elimination of large groups of vertebrates and invertebrates.

The exact reason for the elimination of such a diverse group is not known, however, it can be assumed that fishes are usually eliminated for long stretches by severe organic pollution particularly ammonia, sulphide and cyanide, apart from low oxygen tension as in the present case. Low oxygen tension enhances the toxicity of most poisons, and high degree of suspended solids in the river have serious effect on the spawning sites of many fishes. According to Ellis (1937), the specific conductivity of inland water of supporting good fish fauna lies between 150-500m mho/cm where as in the present case exceeds 1000m mho/cm in the polluted zone and exceeds 700m mho/cm in the down stream.

Impact on phyto-zooplankton :

Pollution of organic matter is very complex, as it involves not only deoxygenation of the water, but also addition of suspended solids. Organic wastes such as saw dust, wood fibre, fibrous textile waste, which are capable of slow bacterial breakdown produces deoxygenation and sewage fungus. Suspended solids tend to eliminate algae and plants and they alter the fauna by blanketing over stream bed (Hynes 1966). This is evident from the work of Venkateswarulu (1968, 1974, 1986), a shift in the algal population in the river Musi is noticed especially in the polluted zone (Bacillariophyceae > Cyanophyceae > Euglenophyceae > Chlorophyceae during 1961-63 and Chlorophyceae > Bacillariophyceae > Cyanophyceae > Euglenophyceae in 1973-74).

The plankton of the river has completely altered during the recent years with gradual deterioration in the water quality as evidenced in the earlier chapters with very few species of phytoplankton, especially belonging to cyanophyceae, euglenophyceae, abundant sewage fungus and bacterial flora (Bacterial counts ranged from 23×10^3 to 10^4 /ml with an average of 10×10^2 /ml). Similarly zooplankton analysis showed a very limited abundance (2-22/100 ml). Zooplankton community showed the presence of pollution tolerant copepods and cladocerans and on rare occasions with rotifera. The cladocera recorded belongs to *Diaphanosoma*, *Ceriodaphnia cornuta*, *Moina micrura*; copepoda belonging to *Mesocyclops* and *Diaptomus* and rotifera having *Keratella* and *Brachionus* species. Among protozoans the river water exhibited several colonial members such as *Carchesium*, *Vorticella*, and *Stentor* and ciliates like *Paramoecium*, *Euplotes*, *Stylonychia*, *Colpodium* and *Lynotus* species.

Impact on invertebrates :

Usually according to Hynes 1966, in the polluted zone of the stream or river, the tolerant species are replaced by abundant "Pollution fauna" consisting of largely

sludge worms (Tubificidae), blood worms (Chironomidae) and water louse (*Ascellus* species). In the present case, larval groups of several invertebrates such as Chironomidae and Diptera (Mosquitoes) were found in abundant number. Only on few occasions, Odonate and Mayfly larvae were observed in the unpolluted puddles found on the bank of the river, belongs to *Pantala*, *Crocothemis*, *Diplocodes* and *Trithemus* species. Hemiptera such as *Diplonychus*, *Laccotrephes* (*Nepa*) and *Microvelia* were found in abundant number among the macrophytic vegetation of *Eicchornia crassipes*.

Another striking feature of the river is the total absence of molluscan members in the polluted zone, where as several species of *Lamellidens*, *Parreysia*, *Lymnaea*, *Bellamia*, *Indoplanorbis* are abundant in the upper stretches of the river especially in the impounded area. Invertebrates characterstic of fast flowing water such as gerridae, simuliidae, macro-invertebrates such as crustacean were totally absent in the polluted zone. Macroenthic invertebrates were also absent due to suspended, dissolved solids and microbial activity with deoxygenation.

Absence of many insect species was mainly due to the presence of surface active material in the sewage effluent, which suppresses the rate of reaeration of the receiving stream and thereby delays self purification (Dix, 1981). The effect is greater in sluggish rivers, especially in the present case. Further more, many aquatic insects are associated at some stage in their life cycle with air water interface, the affect of surface active agents on the surface tension might be expected to affect such insects. Also, the presence of foam on surface water due to high levels of phosphates would affect the emergence of egg laying activity of many insects.

Impact of pollution on the river Musi.

The capacity of the river to cope up with the pollution load, depends on oxygen balance, resulting from the compition between the demands imposed by the oxidisable material and the existing oxygen resources and capacity of reaeration (Anandavalli & Krishna swamy (1988). A high degree of self purification capacity appears to be feature of tropical ecosystem. The self purification powers of the rivers of Northern India especially Ganges are high on account of shallow depth, turbulent flow, prolific biological activity and the deposition of organic matter on the river beds, but converse appears to be true in South Indian rivers. This is true due to dry and lean seasons, the chemistry of the water vary enormously resulting in the variation of seasonal abundance and diversity of fauna.

Suspended solids and sediments, falling on the eroding substrata fillup the interstices between stones, thus depriving the cryptic animals of their hiding place. Slow flow also coat these suspended material over the stones and so render ineffective to various holdfast mechanisms of stone fauna (Hynes 1966). It is found, that all or most fauna disappears and are replaced by burrowing or tube dwelling animals, such as worms and chironomid larvae. Suspended and dissolved solids also interfere in the

self purification of water by diminishing light penetration and reducing the photo-synthetic activity. The concentration of organic matter, free ammonia and phosphates released by the decomposition of particulate organic matter with high microbial demand for dissolved oxygen has increased the concentration of toxic substances in the river Musi. The river Musi being a small tributary with a limited capacity of dilution to the pollutants, it is not surprising that it exhibits severe reaction to effluents entering in it.

TABLE 6. Water quality standards specified by Bureau of Indian Standards (Tolerance limits) in comparison to water quality parameters of river Musi in polluted and unpolluted zone.

Parameters	Unstream 1	Polluted zone	Down stream	A	B	C	D	E
1. pH	7.6-8.3	6.90-8.5	7.80-8.3	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.0-8.0
2. Dissolved oxygen	7.3	Traces	—	6.0	5.0	4.0	4.0	—
3. Biochemical Oxygen Demand	2-4	76.0	—	2	3	3	—	—
4. Total Coliform	—	10×10^4	—	50	500	5000	—	—
5. Odour	Nil	Sulphide	Nil	Unobjectinable				
6. Taste	Tasteless	Irritating	—	Tasteless				
7. Sp. Conductivity	258	1125	711	—	—	—	1000	2 2 5 0
8. Total Hardness (as Ca Co)	136	329	201	300	—	—	—	—
9. Calcium hardness	77	242	56	209	—	—	—	—
10. Magnesium hardness	59	140	60	100	—	—	—	—
11. Iron	—	—	6.01	0.3	—	1.5	—	—
12. Chlorides	32	279	55.0	250	—	600	—	6 0 0
13. Sulphate	Trace	3.8	40.0	400	—	400	—	1 0 0 0
14. Nitrate-Nitrogen	Nil-2.2	0.15	6.04	20	—	50	—	—
15. Free Carbon dioxide	Nil	32	6.0	—	—	—	6.0	—
17. Total Dissolved Solids	160	720	440	500	—	1500	—	2 1 0 0
18. Sodium Absorption Ratio	—	—	2.15	—	—	—	—	2.6

(Note : Values are in mg/l except Ss. Conductance—Umhos/cm)

Unstream—1—Impounded area of the river such as Osman sagar. Polluted Zone—Sampling spots in the city limits ; Down Stream—At the confluence with River Krishna at Damercherla ; A—Drinking water sources without conventional treatment but after disinfection ; B—Outdoor bathing ; C—Drinking water sources with conventional treatment followed by disinfection ; D—Fish culture and wild life propagations ; E—Irrigation, Industrial cooling and controlled waste disposal.

TABLE 7. River Musi—Seasonal variation in Chemical characteristics for the year 1985-86 for different sampling stations.

Parameters	June—September 1985				June—September 1986			
	1	2	3	4	1	2	3	4
pH	7.70	7.40	7.80	8.20	7.45	7.38	7.62	7.90
Sp. Conductance	1025	980	1140	796	915	1000	1080	844
Total Diss. Solids	645	633	615	478	557	640	684	634
Bicarbonate	200	172	244	261	283	279	275	232
Chloride	244	172	184	61	300	234	261	78
Calcium	114	107	110	25	102	109	114	22
Magnesium	40	37	49	31	108	111	80	39
Sodium	—	—	—	74	69	63	62	90
Potassium	—	—	—	4.4	14.0	12.5	14.0	3.7
Sulphate	—	—	—	40	4.12	3.5	2.6	100.0
Hardness	296	284	296	200	300	320	320	190
BOD	—	—	—	—	62	60	64	—
Ionic composition :								
Station 1 to 3 : $\text{Ca}^{++} > \text{Mg}^{++}$ and $\text{HCO}_3^{--} > \text{Cl}^-$				Station 1 to 3 : $\text{Ca}^{++} > \text{Mg}^{++} > \text{Na}^+ > \text{K}^+$ and $\text{HCO}_3^- > \text{Cl}^- > \text{SO}_4^-$				
Station 4. $\text{Na}^+ > \text{Mg}^{++} > \text{Ca}^{++} > \text{K}^+$ and $\text{HCO}_3^{--} > \text{Cl}^- > \text{SO}_4^- > \text{CO}_3^-$				Station 4. $\text{Na}^+ > \text{Mg}^{++} > \text{Ca}^{++} > \text{K}^+$ and $\text{HCO}_3^{--} > \text{SO}_4^- > \text{Cl}^-$				

TABLE 8. River Musi—Seasonal variation in chemical characteristics for the year 1985-86 for different sampling stations.

Parameters	October 1985 to January 1986				October 1986 to January 1987			
	1	2	3	4	1	2	3	4
pH	7.72	7.42	7.92	8.00	7.58	7.45	7.60	8.15
Sp. Conductivity	1250	940	1250	585	1186	1044	1222	700
Total Diss. Solids	800	595	940	331	758	667	780	440
Bicarbonate	437	358	461	226	240	280	260	247
Chloride	363	243	380	44	306	306	291	45
Sulphur	6.2	3.5	3.65	22	6.00	3.5	2.85	40.5
Calcium	140	140	127	28	151	133	142	34
Magnesium	86	88	82	30	85	68	62	54
Sodium	—	—	—	50	73	78	69	47
Potassium	—	—	—	2.00	17.00	14.50	15.10	2.50
Hardness	382	388	354	178	377	337	326	176
B O D	—	—	—	—	79	82	84	—
Ionic Composition :								
Station No. 1 to 3 : $\text{Ca}^{++} > \text{Mg}^{++}$ and $\text{HCO}_3^{--} > \text{Cl}^- > \text{SO}_4^-$				Station No. 1 to 3 : $\text{Ca}^{++} > \text{Na}^+ > \text{Mg}^{++} > \text{K}^+$ and $\text{HCO}_3^- > \text{Cl}^- > \text{SO}_4^-$				
Station No. 4 : $\text{Na}^+ > \text{Mg}^{++} > \text{Ca}^{++} > \text{K}^+$ and $\text{HCO}_3^{--} > \text{Cl}^- > \text{SO}_4^-$				Station No. 4 : $\text{Mg}^{++} > \text{Na}^+ > \text{Ca}^{++} > \text{K}^+$ and $\text{HCO}_3^- > \text{Cl}^- > \text{SO}_4^-$				

TABLE 9. River Musi-Seasonal variation in chemical characteristics for the year 1986-87 for different sampling stations.

Parameters	February 1986 to May 1986				February 1987 to May 1987			
	1	2	3	4	1	2	3	4
pH	7.40	7.50	7.70	7.90	7.55	7.50	7.30	7.80
Sp. Conductivity	1890	1590	1620	733	1485	1024	1335	718
Total Diss. Solids	1210	1062	1035	493	950	676	840	490
Bicarbonate	530	391	563	260	360	261	290	277
Chloride	265	323	275	60	298	280	275	53
Sulphate	3.16	4.59	6.12	51	5.3	2.35	2.65	39
Calcium	156	153	146	39	124	103	117	22
Magnesium	72	78	59	30	64	58	70	41
Sodium	69	72	68	85	78	66	76	85
Potassium	19	16.1	12.8	2.25	17.0	19.5	19.0	2.3
Hardness	419	432	390	235	342	333	342	205
B O D	92	90	86	—	85	87	87	—
Ionic Composition								
Station 1 to 3 : $\text{Ca}^{++} > \text{Mg}^{++} > \text{Na}^{+} > \text{K}^{+}$ and $\text{HCO}_3^{--} > \text{Cl}^{-} > \text{SO}_4^{-}$				Station 1 to 3 : $\text{Ca}^{++} > \text{Na}^{+} > \text{Mg}^{++} > \text{K}^{+}$ and $\text{HCO}_3^{--} > \text{Cl}^{-} > \text{SO}_4^{-}$				
Station No. 4 : $\text{Na}^{+} > \text{Ca}^{++} > \text{Mg}^{++} > \text{K}^{+}$ and $\text{HCO}_3^{--} > \text{Cl}^{-} > \text{SO}_4^{-}$				Station No. 4 : $\text{Na}^{+} > \text{Mg}^{++} > \text{Ca}^{++} > \text{K}^{+}$ and $\text{HCO}_3^{--} > \text{Cl}^{-} > \text{SO}_4^{-}$				

TABLE 10. Yearly averages of chemical characteristics from the polluted zones of the River Musi during various year.

Parameters	1961-63	1973-74	1981-82	1985-86	1986-87
pH	7.95	7.29	7.4	7.70	7.50
Carbonate	2.88	Nil	Nil	Nil	Nil
Bicarbonate	331.15	—	447.45	395	287
Chloride	40.75	146.44	108.0	265	279
Dissolved Oxygen	3.09	0.6	Nil	0.5	0.40
Calcium	—	—	45.18	131	121
Magnesium	—	—	27.18	66	69
Sodium	—	—	27.18	—	15.6
Potassium	—	—	23.75	—	15.6
Nitrate-Nitrogen	0.39	0.13	0.7	—	0.165
Phosphate	0.855	0.32	11.5	—	3.86
Silicate	16.75	8.7	15.6	—	13.6
B O D	—	—	—	—	76

(Source : 1961-62, 1973-74 & 1981-82, V. Venkateswarulu & 1985-87, Ramakrishna)

TABLE 11. River Musi—Chemical characteristics of the River in the polluted Zones of the City and Down stream (Near the confluence with the River Krishna at Dameracherla).

	1985-86		1986-87	
	In city limits	Down stream	In city limits	Down stream
pH	7.70	8.02	7.50	7.95
Carbonate	3.50	7.33	Nil	Nil
Bicarbonate	395	253	288	240
Chloride	265	55.3	279	60.1
Sulphate	—	40.3	3.9	57.3
Dissolved Oxygen	0.5	—	0.4	—
BOD	—	—	76	—
Calcium	131	28.08	121	26
Magnesium	66	30.0	73	41.3
Sodium	—	71.25	69	72
Potassium	—	2.90	15.6	2.78
Nitrate	—	0.04	0.165	0.26
Phosphate	—	1.15	3.86	0.888
Silicate	—	—	13.6	32.83
Hardness	360	201	329	192.08
Conductivity	1345	711	1127	762.8
Total Diss. Solids	858	440	721	512.9
Sodium Absorption Ratio	—	C ₂ S ₁	C ₃ S ₁	C ₃ S ₁
Ionic composition :				
Cation	Ca ⁺⁺ > Mg ⁺⁺	Na ⁺ > Mg ⁺⁺ > Ca ⁺⁺ > K ⁺	Ca ⁺⁺ > Mg ⁺⁺ > Na ⁺⁺ > K ⁺	Na ⁺ > Mg ⁺⁺ > Ca ⁺⁺ > K ⁺
Anion	HCO ₃ ⁻⁻ > Cl ⁻ > CO ₃ ⁻⁻	HCO ₃ ⁻⁻ > Cl ⁻ > SO ₄ ⁻	HCO ₃ ⁻⁻ > Cl ⁻ SO ₄ ⁻	HCO ₃ ⁻⁻ > Cl ⁻ > SO ₄ ⁻

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ECOLOGICAL STUDIES ON THE RIVER COOUM WITH SPECIAL REFERENCE TO POLLUTION

M. MARY BAI

*Southern Regional Station, Zoological Survey of India,
Ma ras-28.*

INTRODUCTION

The indiscriminate loading of the rivers with the large amounts of effluents from wide and varied sources like sewage, industries and agricultural fields lead to the pollution of the rivers. River Cooum plays an important role in the cleanliness of Madras City. It derives its name from village Cooum whose surplus lake water flows into this river. It starts near Sattarai village in Tiruvallur Taluk and flows through 65 kms. before it joins the sea. It enters the city near Aminjikarai, runs for about 18 km. through the city and empties its waters into Bay of Bengal. During November and December the river is mainly tidal. The ebb and flow of the tide flush the river to some extent. When the monsoon is over, water movement is affected due to the formation of a sand-bar at the river mouth region preventing the continuity of the river with the sea. Consequently, the river is not flushed and acute sewage problem is caused. Urban growth on either side of the river, without adequate storm and sanitary sewers, spread over several decades has brought about an adverse impact on the river ecosystem. Sornavel (1978) reported that about 400 million litres per day of sewage was discharged in different zones of Cooum river. This heavy load of sewage prevents the river from self purification and regeneration.

There have been extensive studies on the limnology of River Cooum. (Panikkar and Aiyar, 1937 ; Govindan Potti, 1958 ; Abraham, 1962 ; Narayanan, 1980 ; Joseph et al, 1989). The earlier workers have studied about 18 km. stretch of the River Cooum within the vicinity of Madras. But in the present study the entire stretch of River Cooum was studied for physico-chemical and biological characteristics of polluted and unpolluted regions. In the present study an attempt has been made not only to study the extent of pollution caused by sewage and other pollutants but also to monitor the sewage pollution by indicator species. These indicator species can be used for further monitoring of the freshwater bodies.

Study area, Materials and Methods :

The following six stations given in Fig. I and Table I and Plate I and II were selected along the River Cooum to study the changes in the physio-chemical and biological features.

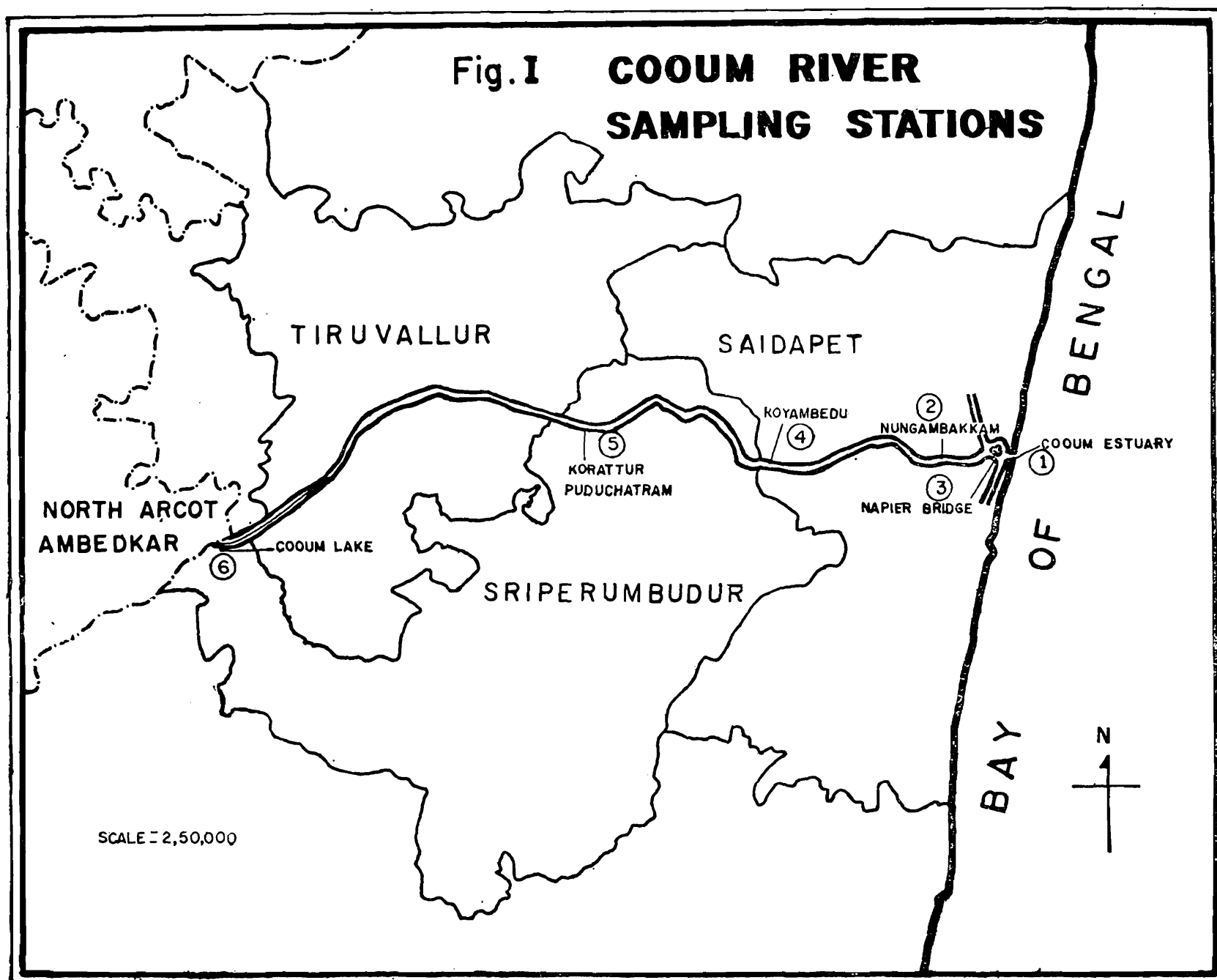


Table I Sampling Stations

Station	Name	Location	Distance in kms. from sea	Depth Range (in Metres)	
				Maximum	Minimum
1.	Cooum Estuary	Bay of Bengal	0.0	3.00	·6
2.	Napier Bridge	On Kamaraj Salai near University	0.5	3.8	2.0
3.	Nungambakkam	Opposite to Malaria Research Institute	10	3.6	1.3
4.	Koyambedu	Bridge over Cooum	16	3.5	0.8
5.	Korattur Puduchattram	Near Korottur Puduchattram village	45	3.2	1.2
6.	Cooum	Cooum Village	65	6	1.0

Water samples taken at monthly interval from a central area of the estuary and from all the six stations of the river were used for physiochemical and biological analysis. The water samples were collected using a Friedinger type water sampler (Narayanan 1980).

Water sampler was lowered to a specified depth and the sample was collected. The sampler was then lifed up and the air and water temperature were noted immediately. Samples collected at each station were transferred individually to one litre capacity polyethylene bottles and were transported immediately to the laboratory. PH was determined in the field using BDH wide and narrow range PH papers. PH measurements were also made in the laboratory using an electrical PH meter-HACH DREL 5 spectrophotometer. The depth was measured using a line marked in meters. Dissolved oxygen, free carbondioxide, Alkalinity and Acidity were determined using HACH DREL Digital titrator in the field itself. The other parameters like Biological Oxygen Demand (B. O. D.) Chemical Oxygen Demand (C. O. D.), Salinity, Nitrogen Compounds (Nitrite (NO_2), Nitrate NO_3), Ammonia (NH_4), Colour, suspended solids, phosphate, sulphate, chloride and silica were determined in the laboratory using HACH DREL Spectrophotometer following the methods in water analysis Handbook (HACH 1983). Months from September to January were taken as the rainy season and February to August as the summer season based on rainfall data.

Plankton samples were collected using a standard plankton net (no. 35 H. D.). At each station standard horizontal hauls were made for a specific period of 3 minutes.

Samples were preserved in 5% formaldehyde solution and the organisms were identified, sorted and counted using Hydrobios plankton microscope. Most of the Micro and Macro fauna were identified to generic level and when possible to species level. (Davis 1955 and Welch 1952).

RESULTS AND DISCUSSION

Depth of the river :—Data relating to depth measurements during the period of 1988-1990 were given in Table I. The river is shallow during summer and with the onset of the North-East monsoon during November and December, the depth of the river increases.

TEMPERATURE

Water temperature following the atmosphere temperature was maximum in the summer months and minimum in the rainy months (Tables II and III). The water temperature range in the polluted stations (I to III) was higher (23.4°C to 32.6°C) than unpolluted stations (22.0°C - 24.0°C). Similarly, the summer months had the highest temperature range (28.8°C - 32.6°C) in polluted stations, in contrast to the unpolluted stations (27.8°C - 30.8°C). The water temperature during other months in the two sets of stations also behaved the same way. The higher temperature recorded at the polluted stations may be due to the discharge of hot effluents from the factories (Manimegalai *et al* 1986) and longer term of bright sunshine and lack of rainfall. The minimum values recorded in the rainy months may be due to rainfall (Sreenivason 1977).

COLOUR

By filtering and centrifuging out the suspended materials, the true colour could be determined. The colour of Cooum river is expressed in units of apparent colour following the method in HACH (1983). Observations on the colour variations are recorded in Table II and III. It is seen from the table that the colour of the water varied mostly in accordance with season. During the summer season, the apparent colour of the polluted stations was high (170-680 units) and of the unpolluted stations low (160-420 units). But the apparent colour of the polluted stations during the rainy season was comparatively lower than that of summer. The apparent colour may be due to the presence of algae, rotifers, dissolved substrates or bacteria (Narayanan 1980).

pH

It is seen from the Tables II and III that during the course of study the pH of the polluted stations was alkaline (8-9.5) except for rainy season when it was slightly

Table II. Physico-chemical parameters (mg/l) in the river coom at polluted stations during 1988-1990 (Mean values have been shown along with range in brackets).

	Station I						Station II						Station III					
	1988		1989		1990		1988		1989		1990		1988		1989		1990	
	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy
Air temp°C	28.8 (28.4-31.0)	25.0 (23.4-28.4)	28.8 (23.8-31.6)	25.68 (23.4-28.5)	30.1 (26.8-31.1)	26.5 (23.6-28.5)	29.9 (28.4-31.8)	26.4 (24.6-28.6)	28.8 (24.0-32.0)	25.9 (23.8-29)	28.8 (26.8-31.2)	26.6 (23.8-28.6)	30.6 (28.6-32.6)	28.4 (25.0-29)	28.9 (21.6-32.6)	26.0 (23.6-29.2)	29.0 (27.0-30.3)	26.7 (24.4-28.9)
Water temp°C	29.6 (28.6-31.8)	26.2 (23.6-28.4)	28.6 (24-32)	26.4 (23.6-29.0)	27.5 (25.2-31.2)	22.1 (23.8-23.6)	30.6 (29.0-32.9)	27.1 (24.8-28.8)	28.6 (24.2-29.8)	26.0 (24.0-29.0)	29.0 (25.4-31.4)	22.7 (24.0-28.6)	31.2 (29.4-32.9)	27.5 (25.2-29.3)	29.3 (21.9-32.8)	26.4 (24.0-29.4)	29.0 (27.0-31.4)	26.9 (24.4-28.9)
Colour (in units)	200 (170-240)	180 (160-220)	220 (160-250)	190 (180-240)	230 (190-260)	200 (160-220)	610 (540-680)	300 (215-340)	600 (515-635)	250 (220-270)	630 (600-660)	310 (300-320)	580 (560-590)	290 (285-310)	600 (580-650)	320 (310-335)	650 (610-680)	480 (470-490)
pH	8.3 (7.4-9)	7 (6.6-7.5)	8.6 (8.1-9.1)	7.2 (6-7.5)	8.8 (8.4-9.2)	7.5 (6.5-7.5)	8.7 (8-9.2)	7.2 (7-7.5)	8.9 (8.6-9.3)	7.3 (7-7.5)	8.9 (8.6-9.4)	6.8 (6.2-7.2)	9.1 (8.8-9.4)	7.1 (6.8-7.5)	9.1 (8.9-9.5)	7.4 (7-7.5)	9.1 (8.8-9.4)	7.0 (6.4-7.5)
Salinity	33.4 (23.6-43.5)	13.4 (8.4-20.1)	25 (12.4-44.6)	13.9 (8.4-15.8)	24.9 (14.6-43.8)	11.2 (8.6-17.4)	29.1 (22.1-38.1)	12.5 (7.4-18.2)	20.7 (9.6-40.1)	9.78 (8.1-14.4)	21.3 (12.4-40.3)	8.2 (5.6-14.2)	17.15 (9.6-18.6)	7.54 (6.4-8.6)	15.6 (8.4-31.2)	7.84 (6.2-10.1)	16.7 (8.6-28.6)	7.38 (5.6-10.2)
Total Suspended Solid	208 (192-212)	83 (72-80)	236 (212-241)	88 (78-96)	245 (192-263)	95 (85-118)	470 (90-490)	62 (56-87)	468 (382-483)	112 (94-126)	475 (321-486)	120 (92-136)	430 (385-468)	106 (94-128)	465 (323-487)	98 (82-108)	525 (386-570)	125 (110-155)
Free Carbondi-oxide	84.5 (72-101)	69.4 (43-93)	93.8 (79-108)	63.4 (40-90)	94 (63-112)	66 (40-90)	125 (101-138)	77 (58-94)	123 (101-146)	82 (65-98)	121.7 (98-152)	79.8 (50-97)	133 (121-141)	82 (58-94)	117 (84-138)	82.2 (72-91)	121 (88-142)	86.2 (74-97)
Dissolved oxygen	4.1 (3-7)	6.2 (5.2-7.8)	4.3 (3.1-6.8)	6.4 (4.1-8.4)	3.6 (2.5-7.6)	5.6 (2.7-9.8)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
B. O. D.	26 (25-27)	27 (25-29)	28 (25-29)	27 (26-29)	25 (24-26)	20 (25-27)	64 (60-66)	64 (61-69)	65 (62-67)	65 (61-67)	66 (62-68)	65 (63-68)	26 (26-27)	25 (24-26)	26 (26-28)	25 (25-27)	25 (24-26)	26 (26-27)

Table II. (Continued)

	Station I						Station II						Station III					
	1988		1989		1990		1988		1989		1990		1988		1989		1990	
	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy
C. O. D.	236 (232- 241)	236 (230- 241)	234 (230- 239)	235 (228- 242)	234 (229- 240)	235 (230- 244)	476 (465- 485)	474 (460- 483)	468 (461- 485)	455 (453- 487)	473 (461- 483)	470 (451- 483)	239 (212- 253)	249 (243- 255)	244 (213- 254)	250 (245- 258)	251 (245- 259)	244 (214- 255)
Acidity	227.5 (201- 241)	62.8 (54- 74)	188.8 (68- 246)	61.2 (59- 73)	62.6 (54- 76)	178.2 (69- 249)	305.5 (260- 328)	160.2 (128- 201)	275.5 (137- 331)	163 (130- 213)	516 (128- 330)	160.4 (131- 211)	264.5 (118- 328)	172.6 (124- 198)	242.4 (114- 308)	181.4 (164- 208)	227.5 (115- 342)	166 (103- 201)
Alkalinity	566 (510- 612)	101.4 (94- 108)	416.7 (139- 631)	119.4 (107- 129)	512.5 (141- 624)	119.2 (112- 131)	305.5 (260- 328)	160.2 (128- 201)	275.5 (137- 331)	163 (130- 231)	258 (216- 330)	160.4 (131- 211)	264.5 (118- 328)	172.6 (124- 198)	710.4 (340- 742)	465.6 (406- 586)	571.2 (342- 746)	444.2 (386- 541)
Nitrite	0.02 (.01- .03)	0.015 (.01- .03)	0.03 (.01- .04)	0.018 (.01- .02)	0.025 (.01- .03)	0.018 (.01- .02)	0.03 (0.01 .04)	0.025 (.01- .03)	0.035 (.01- .04)	0.023 (.01- .03)	0.04 (.01- .05)	0.026 (.01- .03)	0.04 (.03- .06)	0.025 (.01- .03)	0.042 (.02- .05)	0.03 (.01- .04)	.04 (.015- .06)	.03 (.01- .05)
Nitrate	4.5 (4.3- 4.9)	3.6 (2.1- 3.8)	4.7 (2.7- 4.9)	3.8 (2.0- 4.4)	4.8 (3.9- 5.9)	3.4 (2.8- 3.6)	5.6 (4.2- 6.2)	5.1 (4.3- 5.4)	5.7 (4.1- 5.9)	5.0 (3.8- 5.9)	5.8 (4.2- 6.4)	5.1 (3.8- 5.6)	6.8 (5.2- 7.4)	5.2 (4.3- 5.8)	6.9 (6.1- 7.4)	5.7 (4.3- 5.9)	6.8 (5.4- 7.6)	5.2 (4.3- 5.8)
Ammonia	2.8 (1.4- 3.9)	1.9 (1.1- 2.3)	2.9 (1.7- 3.8)	2.0 (1.2- 2.4)	3.1 (2.5- 3.8)	2.6 (1.8- 3.2)	3.4 (2.4- 4.8)	3.2 (2.4- 4.6)	3.6 (2.8- 4.6)	2.8 (1.6- 3.6)	3.8 (3-4.2)	2.7 (2.0- 3.3)	4.3 (3.2- 5.2)	3.8 (2.1- 4.2)	4.4 (2.6- 4.6)	3.8 (2.6- 4.2)	4.5 (3.2- 4.8)	3.7 (2.1- 3.9)
Phosphate	2.6 (1.4- 3.2)	2.4 (1.8- 2.8)	3.2 (1.8- 3.3)	2.8 (1.3- 2.6)	3.8 (2.0- 4.6)	2.9 (2.2- 3.8)	5.6 (4.3- 5.8)	4.7 (2.9- 4.8)	5.85 (3.9- 6.1)	3.2 (2.3- 4.6)	6.4 (4.3- 7.9)	5.3 (4.6- 5.4)	6.8 (4.9- 7.9)	3.2 (2.8- 8.4)	7.3 (5.2- 7.6)	5.3 (4.3- 5.6)	7.5 (5.6- 8.1)	5.8 (4.5- 6.4)
Sulphate	85 (76- 119)	54 (42- 68)	200 (106- 218)	65 (52- 85)	185 (92- 218)	72 (65- 110)	172 (95- 186)	60 (51- 78)	215 (82- 240)	160 (85- 85)	240 (162- 269)	89 (68- 124)	162 (115- 218)	85 (58- 95)	188 (96- 221)	58 (41-79)	240 (108- 264)	105 (76- 128)
Chloride	1800 (1640- 1920)	860 (800- 980)	1920 (1760- 1980)	890 (640- 920)	2320 (1830- 2440)	940 (826- 984)	1210 (1140- 1380)	810 (740- 880)	1230 (1030- 1310)	840 (720- 860)	1360 (1230- 1440)	860 (720- 893)	1105 (1080- 1210)	780 (640- 840)	1140 (1020- 1260)	810 (724- 960)	1260 (1140- 1380)	840 (760- 890)
Silica	2.8 (1.6- 3.4)	6 (4.2- 6.8)	2.9 (1.8- 3.1)	7.2 (6.4- 7.8)	4.1 (3.0- 4.4)	8.1 (6.1- 8.6)	2.2 (1.6- 3.2)	4.9 (3.0- 5.8)	2.8 (1.7- 3.4)	6.7 (6.1- 6.8)	3.3 (3.0- 4.8)	7.6 (5.0- 8.1)	2.1 (1.6- 3.0)	4.3 (3.0- 5.9)	2.2 (1.8- 2.6)	6.4 (6.0- 6.7)	3.1 (2.8- 3.6)	7.2 (5.0- 7.8)

Table III. Physico-chemical parameters (mg/l) in the river cooum at unpolluted stations during 1988-1990 (Mean values have been shown along with range in brackets).

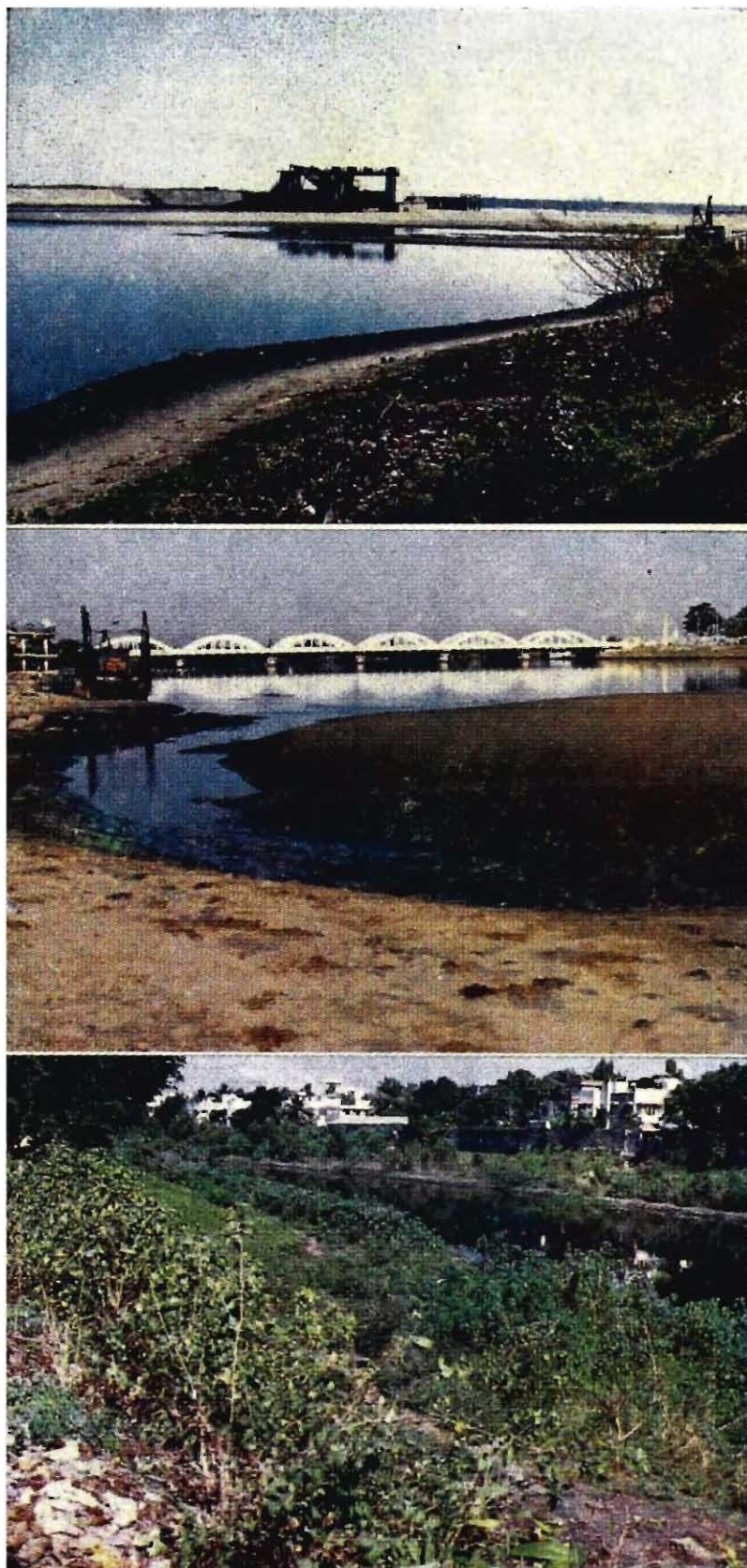
	Station IV						Station V						Station VI					
	1988		1989		1990		1988		1989		1990		1988		1989		1990	
	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy
Air temp°C	28.8 (26.6-30.2)	25.6 (23.0-27.6)	27.8 (22.6-30.8)	25.28 (22.6-28.4)	28.35 (25.2-30.8)	26.32 (22.4-28.5)	28.2 (26.4-30.4)	25.8 (23.2-27.8)	27.8 (22.8-30.6)	19.7 (12.6-27.8)	27.9 (25.0-30.6)	20.4 (22.0-28.0)	28.1 (26.3-30.6)	25.4 (23.0-27.6)	28.2 (26.0-29.4)	20.64 (24.0-27.6)	27.9 (25.0-30.4)	26.12 (22.6-28.1)
Water temp°C	30.6 (29.0-33.6)	19.7 (25.1-28.4)	29.1 (23.8-32.6)	26.1 (23.8-29.2)	28.3 (26.4-30.8)	27.8 (22.4-26.3)	30.5 (29.0-33.0)	26.75 (25.1-28.4)	29.2 (34.1-32.4)	26.8 (22.6-27.8)	29.4 (25.6-31.4)	27.2 (25.6-31.4)	30.6 (29.2-33.2)	26.9 (25.2-28.6)	29.4 (24.2-33.6)	26.3 (24.2-29.0)	29.3 (25.5-31.5)	27.4 (24.2-29.6)
Colour (in units)	210 (160-260)	123 (107-136)	221 (143-248)	131 (122-156)	230 (136-265)	125 (108-138)	325 (240-356)	182 (156-210)	383 (278-395)	176 (162-186)	392 (310-420)	188 (165-214)	121 (96-138)	82 (73-96)	186 (112-198)	86 (73-94)	193 (121-241)	92 (81-118)
pH	6.8 (6.3-7.3)	6.3 (6.1-6.6)	7.1 (7.0-7.5)	6.3 (6.0-7.0)	7.3 (7.1-7.6)	6.9 (6.8-7.0)	6.8 (6.4-7.0)	6.2 (6.1-6.6)	6.7 (6.3-7.1)	6.5 (6.0-7.1)	7.0 (6.8-7.2)	6.9 (6.8-7.1)	6.2 (6.1-6.4)	6.1 (6.0-6.3)	6.1 (6.0-6.2)	6.0 (6.0-6.2)	6.4 (6.2-6.8)	6.1 (6.0-6.2)
Salinity	4.8 (3.6-7.4)	3.9 (3.2-7.6)	9.3 (4.0-9.8)	3.5 (2.8-6.8)	11.0 (6.4-12.6)	4.0 (2.2-7.1)	7.1 (5.6-8.9)	2.4 (0.17-4.0)	6.2 (4.0-9.8)	1.4 (0.16-3.6)	6.0 (4.0-9.8)	1.4 (0.16-3.6)	1.8 (0.69-2.8)	0.74 (0.18-1.9)	1.3 (0.8-2.1)	0.41 (0.13-0.68)	1.2 (0.9-1.8)	0.4 (0.2-0.8)
Total Suspended solids	48 (32-68)	23 (18-25)	54 (48-76)	25 (18-38)	51 (48-73)	28 (19-32)	69 (52-78)	34 (26-42)	65 (58-73)	30 (22-41)	71 (58-86)	29 (18-39)	65 (52-68)	33 (27-45)	68 (52-75)	35 (27-48)	72 (64-86)	31 (28-46)
Free Carbondi-oxide	55.4 (71-92)	37.25 (26-52)	75.1 (41-94)	40.4 (24-58)	78.8 (76-91)	41 (24-65)	47.7 (36-61)	26.5 (21-31)	52.3 (42-72)	31 (22-40)	51.1 (24-78)	22.2 (17-26)	26.6 (24-31)	18.5 (18-24)	32.1 (29-68)	17.0 (15-28)	30.5 (26-36)	17.2 (13-21)
Dissolved Oxygen	4.9 (4.5-5.8)	11.02 (9.1-12.6)	5.1 (3.8-8.4)	8.94 (6.2-14.2)	7.1 (4.1-13.1)	10.2 (5.1-16.4)	7.35 (6.1-8.3)	14.4 (10.4-17.2)	6.1 (4.1-10.1)	8.9 (5.6-15.8)	8.9 (6.5-17.0)	12.82 (7.8-18.2)	7.35 (6.1-8.3)	14.4 (10.4-17.2)	7.1 (5.6-10.8)	10.7 (6.9-17.4)	10.6 (7.6-18.3)	15.7 (8.2-19.8)
B. O. D.	12.6 (12-13)	13.25 (12-14)	12.4 (12-14)	13.6 (13-15)	12 (11-14)	13.8 (12-15)	10.2 (9-12)	10 (9-12)	10.4 (9-11)	9.8 (8-11)	11.1 (9-12)	10.6 (1-12)	8.2 (7-10)	7.7 (6-10)	8.7 (8-10)	8 (6-10)	6.8 (6-8)	8.4 (8-9)
C. O. D.	45.8 (41-52)	47.5 (42-51)	49 (45-52)	47 (42-52)	48.2 (44-52)	46.8 (40-51)	23 (21-26)	23.8 (21-25)	23.5 (22-26)	24 (21-25)	23.5 (21-26)	24 (22-26)	17.6 (14-21)	18 (17-20)	17.2 (13-23)	18.4 (16-21)	19.1 (14-22)	18 (15-26)

Table III. (Continued)

	Station IV						Station V						Station VI					
	1988		1989		1990		1988		1989		1990		1988		1989		1990	
	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy	Sum- mer	Rainy
Acidity	84.5 (84-89)	77.6 (70-85)	78.2 (58-86)	76.6 (71-84)	71.8 (61-88)	76.2 (64-81)	59.2 (78-72)	46.4 (47-69)	53.8 (24-71)	50.4 (47-51)	48.8 (26-68)	39.4 (28-55)	25.2 (20-28)	22.2 (18-28)	24.7 (18-44)	22 (18-45)	22.7 (16-36)	21.2 (18-25)
Alkalinity	202 (182-210)	190 (157-210)	191.5 (170-210)	172.2 (126-196)	186.4 (132-204)	159 (104-206)	148 (104-186)	114.4 (96-136)	150 (86-185)	123.8 (98-146)	179.7 (88-251)	110 (98-108)	65.5 (59-73)	50 (36-53)	70.1 (61-108)	47.8 (36-52)	73.5 (52-90)	52 (43-62)
Nitrite	.008 (.004-.01)	.004 (.002-.006)	.01 (.008-.027)	.008 (.005-.009)	.015 (.012-.018)	.009 (.006-.01)	.006 (.004-.008)	.002 (.001-.006)	.004 (.002-.005)	.003 (.001-.004)	.006 (.004-.007)	.002 (.001-.004)	.004 (.002-.006)	.002 (.001-.003)	.005 (.001-.006)	.002 (.001-.003)	.006 (.004-.007)	.002 (.001-.003)
Nitrate	3.6 (2.8-3.9)	2.8 (2.4-3.2)	3.65 (2.4-3.8)	2.6 (2.2-2.8)	3.5 (3.1-3.8)	2.4 (2.1-2.6)	3.3 (2.1-3.6)	2.0 (1.8-2.6)	3.5 (2.4-3.8)	2.2 (1.8-2.6)	4.3 (2.9-4.8)	2.4 (1.8-2.6)	3.4 (2.8-3.9)	2.6 (1.9-2.9)	3.6 (2.4-3.8)	2.3 (1.9-2.8)	3.8 (2.9-4.2)	2.6 (2.1-2.8)
Ammonia	1.2 (.08-1.4)	0.08 (.03-.09)	1.4 (1.1-1.6)	.5 (.2-.8)	1.2 (.8-1.4)	.3 (.1-.8)	1.6 (1.1-1.8)	.86 (.72-.9)	1.4 (1.1-1.6)	.6 (.3-.8)	1.3 (1.1-1.5)	.4 (.3-.7)	1.7 (1.1-1.9)	.8 (.6-.9)	1.2 (1.1-1.6)	.6 (.5-.9)	2.1 (1.8-2.4)	.5 (.3-.8)
Phosphate	0.003 (0.001-0.004)	0.001 (0.001-0.002)	0.002 (0.001-0.003)	0.0015 (0.001-0.002)	0.004 (0.003-0.005)	0.002 (0.001-0.003)	0.002 (0.001-0.004)	0.001 (0.001-0.02)	0.003 (0.001-0.004)	0.002 (0.001-0.002)	0.003 (0.002-0.004)	0.002 (0.001-0.003)	0.006 (0.002-0.007)	0.002 (0.001-0.003)	0.009 (0.002-0.009)	0.004 (0.003-0.005)	0.008 (0.003-0.009)	0.003 (0.002-0.004)
Sulphate	62 (53-65)	23 (15-27)	58 (42-61)	21 (19-27)	64 (52-68)	31 (28-37)	52 (48-56)	23 (21-27)	55 (48-56)	27 (22-31)	56 (42-64)	24 (18-28)	56 (48-51)	24 (21-36)	42 (32-56)	27 (22-31)	59 (41-52)	32 (22-46)
Chloride	88 (62-96)	43 (34-48)	96 (81-115)	51 (41-56)	112 (89-118)	64 (52-78)	62 (51-66)	34 (26-38)	76 (62-84)	38 (21-42)	92 (71-98)	42 (31-46)	28 (31-38)	16 (12-24)	32 (18-36)	19 (12-24)	34 (18-42)	18 (12-21)
Silica	2.6 (1.4-3.2)	5.9 (3.8-6.8)	2.8 (1.6-3.0)	6.9 (6.3-7.2)	3.8 (3-4.6)	7.8 (6-8.4)	3.3 (1-3.6)	7.5 (6-8.2)	3.8 (1.6-4.2)	8 (5-8.8)	4.4 (2.6-4.8)	9 (4-10.6)	3.1 (2.1-4.1)	7.2 (6-8.3)	3.2 (3.3-4.4)	7.6 (6.1-9)	4.3 (3.4-5.6)	8.6 (7.2-9.4)

MARY BAI

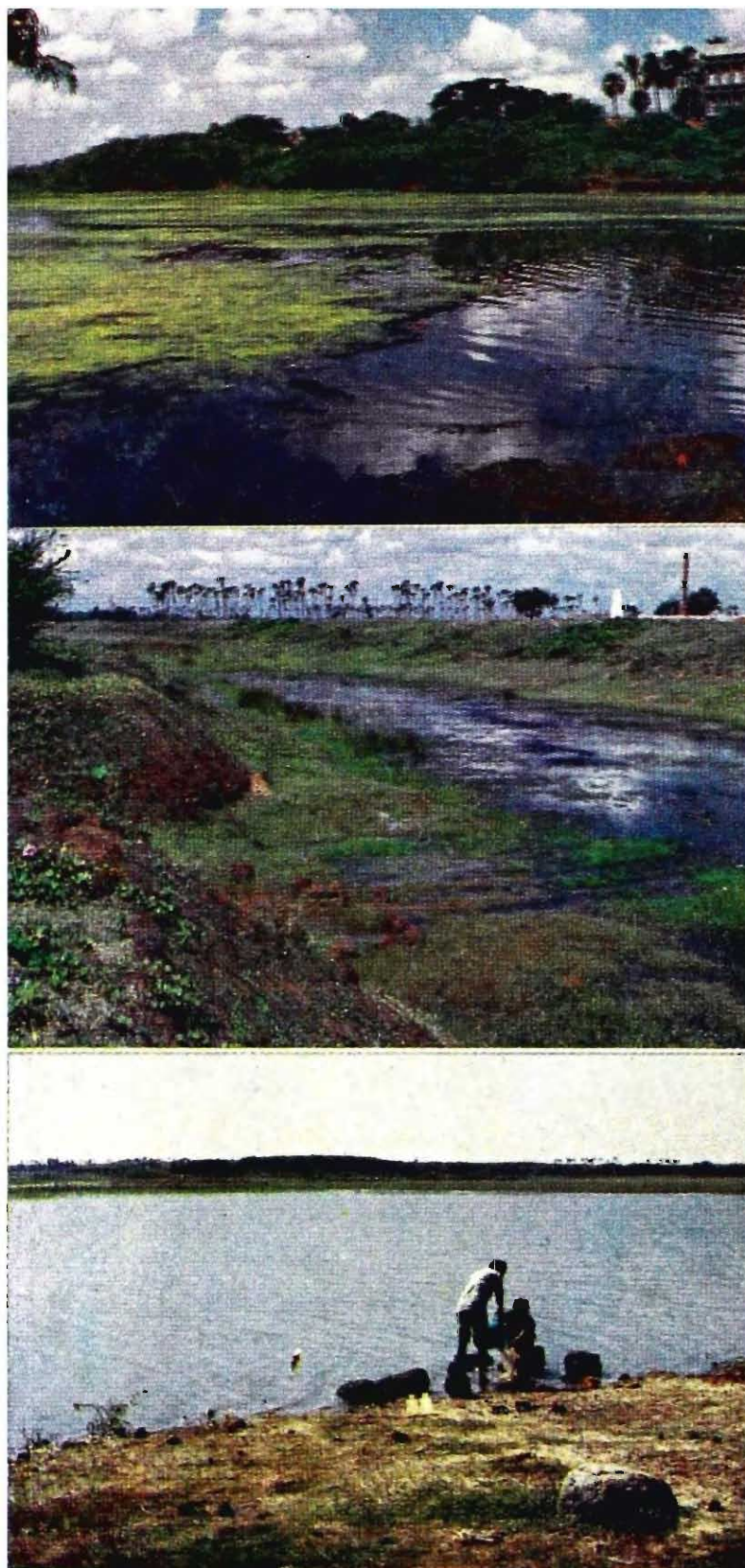
PLATE I



1. Cooum Estuary at Bay of Bengal.
2. Napier Bridge on Kamaraj Salai near Madras University.
3. Nugambakkam : Opposite to Malaria Research Institute.

MARY BAI

PLATE II



4. Koyambedu, near bridge over Cooum.
5. Koratur Puduchatram, near Koratur Puduchatram Village.
6. Cooum lake near Cooum Village.

acidic to neutral (6-7.5). In the unpolluted stations it was acidic or neutral through out the year. The same condition has been reported by Manimekalai *et al* (1986) in River Bhavani and Kulshrestha *et al* (1989) in the river Chambal, due to the discharge of effluents into these rivers. The low value in pH in the unpolluted stations may be due to the dilution by rain water, absence of effluents and high concentration of free Carbondioxide (Welch, 1952 ; Jhingran, 1982).

SALINITY

The salinity of the polluted stations varied from 8.4‰ to 44.6‰. The salinity of unpolluted stations varied from 0.13‰ to 12.6‰. It is seen from the data that there is a general uniformity in the pattern of salinity variation in all the six stations. The minimum range occurred in the rainy season and the maximum in the summer season. The pattern of seasonal variation appears to be repetitive year after year. The reduction in the salinity appears to be closely linked with the amount of rainfall (Table IV). The enrichment in salinity at Station I may be due to the incoming sea water during high tide (Narayanan 1980 and Joseph *et al* 1989).

TABLE IV. Rainfall (24 hrs. in mm. data collected from Meteorology Deptt.)

Month	1988	1989	1990
January	000.7	09.0	006.5
February	21.9	Nil	002.9
March	Nil	Nil	16.0
April	.006.1	Nil	Nil
May	29.6	003.0	408.5
June	27.4	128.5	20.3
July	32.5	191.5	096.7
August	291.7	56.0	085.7
September	220.7	148.9	195.0
October	77.2	179.9	573.5
November	477.9	492.3	309.3
December	110.8	196.1	191.9

TOTAL SUSPENDED SOLIDS

It is evident from Tables II and III that the total suspended solids in the polluted stations were much higher than that of unpolluted stations. The maximum values of

total suspended solids ranging between 90-570 mg/l were recorded during summer and the lowest values were observed during the rainy season. (70-150 mg/l); (Tables II & III in the polluted stations. This is in consonant to the findings of Somashekar (1985), Manimegalai *et al* (1986), Venkateswarlu (1986) and Shashikant and Rajkumar Rampal (1989).

FREE CARBONDIOXIDE

The free carbondioxide values have a direct relation to the dissolved oxygen. The free CO_2 was very high in the polluted stations having a range of 84.5-146 mg/l in summer and 40-98 mg/l in rainy season. In the unpolluted stations also the summer values of free CO_2 were high 26-94 while in the other season it ranged between 13-24 mg/l (Table III). Similar results were reported by Shashikant and Anil Raina (1989) and Kulshrestha *et al* (1989). The annual peak in the month of May is attributed to the increased decomposition of dead organic matter with the rise in temperature. The fall in free CO_2 in rainy season may be due to the reduced decomposition of dead organic matter at low temperature during this season and dilution of water.

DISSOLVED OXYGEN

Dissolved Oxygen influences the distribution and abundance of phytoplankton and zooplankton and is important in bringing about various biochemical changes in water. The distribution of the dissolved oxygen in River Cooum showed marked oscillations. The dissolved oxygen was greater in the unpolluted stations in comparison to the polluted (Tables II & III) ones. The minimum and maximum oxygen values in the Cooum estuary is in 1st station ranged from 2.5 (Feb. '90) to 9.8 mg/l (Oct. '90). In the polluted stations, second and third stations of the river was devoid of dissolved oxygen except in the months of N. E. monsoon. In the fourth station, the minimum was 3.6 (May'89) and maximum 16.4 mg/l (Oct. '90). In the fifth station, the D. O. ranged from 4.1 (May'89) to 18.2 mg/l Oct. '90). In the sixth station the D. G. ranged from 5.6 (May'89) to 19.8 mg/l (Oct. '90). Similar condition was recorded by Venkateswarlu 1986, Shashikant and Rajkumar Rampal 1989, Jebanesan *et al* 1989, and Kulshrestha *et al* 1989. The D. O. values were high during rainy season at all the stations since the colder water has a greater capacity for holding dissolved gases. (Hutchinson 1957). The absence and lower values of D. O. in the polluted station have been attributed to the heavy organic load at the polluted stations through the addition of raw sewage and other municipal wastes and due to the decomposition processes set in by micro organisms which utilize the oxygen in great quantity. (Narayanan 1980).

B. O. D. AND C. O. D.

The B. O. D. Values (Tables II and III) ranged from 24 to 68 at the polluted stations. There was a decreasing trend from IV station. The values ranged from 6

to 15 at the Vth and VIth stations. The C. O. D. ranged from 212 to 485 at the polluted stations and from 14-52 in the unpolluted stations. High B. O. D., C. O. D. and low content of dissolved oxygen (DO) are all indicators of pollution. The high content of B. O. D. C. O. D., and low content of DO in the downstream of River Cooum may be due to the heavy organic pollution. Similar conditions have been reported by Somashekar 1985. Venkateswarlu 1986, Manimegalai *et al* 1986 Jebanesan *et al* 1989. Shashikant and Anil Raina 1989, Kulshresthe *et al* 1989, Joseph *et al* 1989, Shashikant and Rajkumar Rampal 1989. It was also noticed that during summer months the B. O. D. and C. O. D. values were high which may be due to the presence of aerobic micro-organisms which easily degrade organic matter in the presence of oxygen (Shashikant *et al* 1989 and Naryanan 1980).

ACIDITY AND ALKALINITY

In the polluted stations, the acidity value range from 54 to 342 mg/l and in the unpolluted stations it ranged from 18 to 89 mg/l (Tables II and III). In the polluted stations, the total alkalinity value ranged from 94 to 746 mg/l and in the unpolluted stations from 36 to 210 mg/l. Both the values were high during summer i.e. May and low during the rainy season i.e. in November-December. The values of acidity and alkalinity were high at the first three stations indicating the pollution. (Kulshresthe *et al* 1989 ; Shashikant and Anil Raina 1989 and Patil *et al* 1984). Of these, two parameters, the total alkalinity seems to be high, indicating the alkaline nature of the effluent.

INORGANIC NITROGEN (NITRITE, NITRATE AND AMMONIA)

The chemical composition at the polluted stations in River Cooum, reveals that in the nitrogen complex, nittates were more like that of river Tungabhadra (Venkateswarlu 1986). The three forms of nitrogen indicated high level during summer season in the polluted station (nitrite .02-.042 mg/l, nitrate 4.5-6.9 mg/l, NH_4 2.8-4.5 mg/l) and during rainy season the values were low. Low values of nitrite—.004-.015 mg/l, Nitrate 3.3-4.3 mg/l, Ammonia 1.2-2.1 mg/l (all in summer) and lowest values of Nitrite .004-.009 mg/l, Nitrate 2.0-2.8 mg/l and Ammonia .08-.86 in rainy season were recorded in unpolluted stations. This find support from the studies Narayanan (1980). Shashikant and Anil Raina (1989). Very high amounts of nitrogen compounds are indicative of organic pollution due to sewage. The lack of rainfall was the reason for maximum concentration in summer and minimum value in rainy season. Increase in ammonia concentration results in the biochemical, physiological, histological and immunological changes in the vital organs of fish (Colt and Techobanoglous 1978 and Hillaby and Randal 1979).

PHOSPHATES

Phosphates are essential for the growth of algae but are usually present in low concentration in natural, unpolluted freshwaters. The phosphate in the unpolluted stations of the River Cooum ranged between 0.001 mg/l and 0.007 mg/l during rainy season with maximum values of 0.009 mg/l during summer months. In contrast, in the polluted stations, the Po_4 concentration was very high. The maximum values ranging between 5.6 to 8.1 mg/l were recorded in Station III during summer and the minimum being 1.3-2.3 mg/l during rainy season. (Willam *et al.* 1972, Shahshikant and Anil Raina 1989; Venkateswarlu 1986). This condition of higher amount of Po_4 in the polluted stations indicates a higher level of pollution in Cooum river, probably due to sewage contamination (Welch, 1952) or due to chemical compounds used in industries (Manimegalai *et al.*, 1986).

SULPHATE

In the present study, the sulphate content of the polluted stations ranged between 85-240 mg/l in summer and 54-160 mg/l in rainy season. In contrast, in the unpolluted stations the values ranged between 58-64 mg/l in summer and 21-32 mg/l in rainy season. Sulphate is involved in biodegradation and is converted to sulphide which may cause obnoxious odour in polluted stations in River Cooum. This is common in sewage contaminated streams (Welch 1952). Similar results were observed by Govindan and Sundaresan (1979) in Adyar river in Madras.

CHLORIDE

Chlorides are present in all potable water supplies and in sewage, usually as a metallic salt. The high amounts of chlorides are also indicators of large amounts of organic matter in the water. In the present study (Table III & IV), the same trend is noticed. Chloride was very high in polluted stations (780-2320 mg/l) compared to the unpolluted stations (16-112 mg/l) (Venkateswarlu, 1986, Manimegalai *et al.*, 1986 and Sahshikant and Rajkumar Rampal, 1989). The chloride content was minimum during rainy season and maximum during summer season (Sangu and Sharma 1985, Joseph *et al.* 1989). The increase in Chloride in the first station is attributed to sea water intrusion during high tide. The addition of allochthonous materials in the form of domestic sewage, human wastes and the effluents discharged from the industries located adjacent to the river finally leads to nutrient enrichment.

SILICA

Silica normally exists as an oxide (SiO_2 as in sand) or as a Silicate. It has no known toxic effect. Davis 1964 observed that Silica is less variable in natural waters

than the other dissolved constituents. In the present study, silica is estimated in SiO_2 . Variations in the silica values in all the six stations show that it is independent of the effluent discharge (Table II and III). The higher amount of silica at station V may be due to the sandy nature of the substratum with small pebbles and stones (Venkateswarlu 1986). The high value of silica during rainy season may be due to the floods during this season and weathering of rocks and mineralisation in the catchment area (Manimegalai *et al* 1986).

PLANKTON

Plankton not only indicate the level of pollution but provide insight in the composition of their substratum. Indicator organism concept is based on the presence of particular taxa indicative of the existence of certain environmental condition, whereas its absence is indicative of the absence of that condition (Warren 1971).

Phytoplankton : Three groups of algae were commonly represented in the river and percentages in unpolluted and polluted stations are shown in Tables V and VI (Fig. II).

In general in polluted stations Bacillariophyceae (diatoms) dominated followed by cyanophyceae and chlorophyceae. In unpolluted stations chlorophyceae dominated followed by Bacillariophyceae and Cyanophyceae like the river Moosi of Andhra Pradesh (Venkateswarlu *et al* 1986). Of all the stations, unpolluted stations (i.e. IV-VIth) supported the highest amount of algae. The species composition at the unpolluted and polluted sites of the River Cooum indicates a clear demarcation, certain species always occurring only in the uncontaminated waters whereas some species live in polluted waters. (Table V). Similar results have been reported by Venkateswarlu, 1986, Shashikant and Anil Raina (1989), Kulshrestha *et al* (1987), Ray *et al* (1979). This distinction can be attributed to the type of effluents entering the river. Seasonally, the highest standing crop of total phytoplankton was recorded in summer particularly April-May. Similar conditions have been reported by Gopinathan (1972). The highest population of phytoplankton groups during summer months can be correlated to the higher temperature (optimum for algal growth) and higher concentration of essential nutrients particularly phosphates, nitrates and nitrites during these months.

Zooplankton : The quality and quantity of zooplankton offers additional evidence for the poor quality of water. 14 species of zooplankton were identified from River Cooum (Table V). Among these, Vorticella, Rotifers and Moina were represented abundantly at the polluted stations and moderately at unpolluted stations whereas copepodes and ostracodes were abundant at unpolluted stations and rare in polluted stations (Narayanan 1980).

Rotifers as biological indicators of pollution have been recorded earlier. (Rao and Chandramohan 1977, Michael 1964 and 68, Sampath *et al* 1979 and Ramesh Konnur

et al 1986). *Brachionus calvciflorus* Pallus, *B. rubens* Ehr, *B. quadridenta*, *B. forficula*, *Filium longiseta* were found to be predominant in River Coom suggesting that these five species are more pollution tolerant than the other species. (Ramesh Konnur et al

xx
xx Bacillariophyceae

ooo
ooo Chlorophyceae == Cyanophyceae

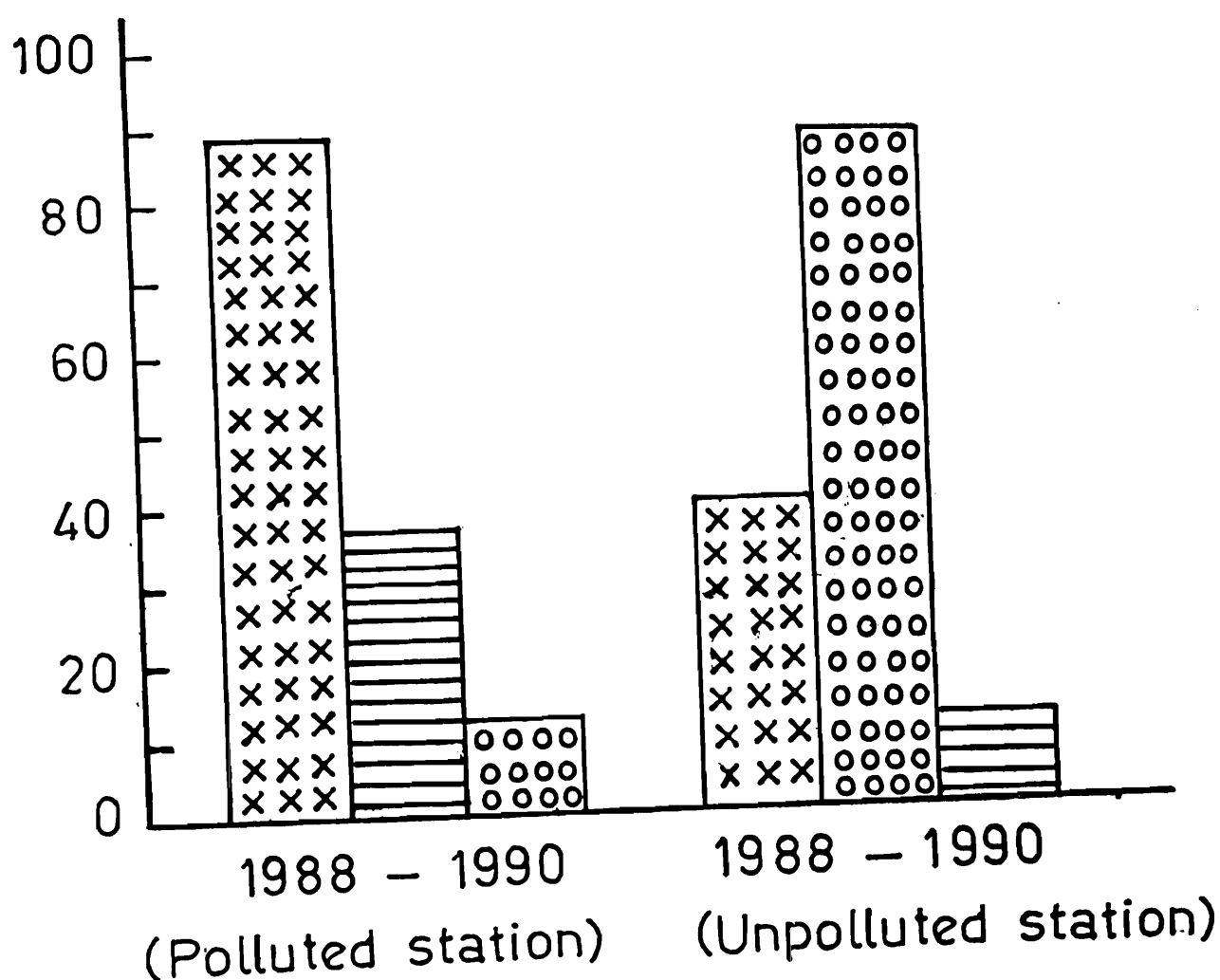


Fig.II Algal composition(%) in R. Coom at polluted and unpolluted stations.

1986). Presence of rotifers throughout the year and their abundance during April and May suggests the constancy in occurrence of pollution in the River Coom.

The macroinvertebrates are also valuable indicators of environmental quality in aquatic ecosystem because of their life cycle stages, their comparatively stable mode of

life and their convenient size and distinct characters which offers an easy sorting and identification of these organisms (Kulshrestha *et al* 1989 and Rao and Jain 1985). Larvae and pupae of dipterans are the second large group of macro-invertebrates in River Cooum.

Dipteran larvae correlate well with the physico-chemical data to suggest that these groups can be taken as the indices of pollution as in River Tawi at Jammu (Shashikant and Anil Raina 1989). The larvae and pupae of Diptera were abundant in stations I, II & III, the maximum in Station III. They were completely missing in stations IV to VI which indicates that these can also be used as a biological indicator. Chironomid larvae and mosquito larvae were also represented in the polluted stations (Kulshrestha *et al* 1989).

Aquatic Hemipterans population was more in IV to VI stations. *Diplonychus indicus*, *Anisops* sp., *Ranatra* sp., *Limnogonus fossarum fossarum*, *Lacatrephes* sp. were abundant in the unpolluted stations.

The semi aquatic insects such as *Gerrid* sp. and *Hydrometra*, *Micronecta punctata* were also present in the unpolluted stations. These insects were not at all found in the polluted stations indicating that they are all sensitive to organic pollution. The plausible reasons for their absence are intolerable conditions of the water and the non-availability of vegetation and food organisms. (Jebanesan *et. al.* 1989, Krishnamoorthy and Sarkar 1979).

Crustacea : Crustaceans like *Macrobrachium rosenbergi*, *Macrobrachium lamarrei*, *Macrobrachium javanicum* and *Scylla serrata* were found only in unpolluted station IV to VI. The polluted stations I to III were characterised by the absence of crustaceans.

Molluscs : There were many species of molluscs like *Planorbis exustus*, *Aniscus hypotoclos*, *Pila virens*, *Pila globosa* and *Vivipara balonsis* in the unpolluted stations while they are completely absent in the polluted stations (Krishnamoorthy and Sarkar 1979). Thus the total absence of macroinvertebrates in polluted stations where Dissolved Oxygen is completely depleted and sludge smells of H_2S is indicative of high degree of pollution. (Krishnamoorthy and Sarkar 1979).

Pisces : Fifteen species of fishes (Table V) were noticed in unpolluted stations (IV to VI). But the polluted stations were characterised by rare presence of *Magalops cyprinoides* (Broussonet), *Mugil cephalus* (Linnaeus), *Mugil macrolepis* (Smith) and *Therapon jarbua* (Forsk). The fishes appear generally to avoid the chlorine containing water. The polluted stations of River Cooum are devoid of large number of fishes due to the toxicity of chlorine. (Zillich 1972).

The amphibian like *Rana cyanophytis*, *Rana limnocharis* and reptile *Natrix* sp. were restricted only to unpolluted stations. The severely altered depressed macrofauna

in polluted stations indicated the numerous discharges invariably exceeded the waste assimilative capacity of the river, causing alarming deterioration in the water quality.

The higher values of all physicochemical parameters except DO and low representation of micro and macro fauna in the polluted stations and during summer months are in accordance with the earlier findings of Shashikant and Rajkumar Rampal (1989).

The analysis of physico-chemical and biotic factors of River Cooum confirm the high degree of industrial and sewage pollution, which needs care and treatment to sustain aquatic life. It is recommended that there should be regular monitoring of River Cooum to maintain the comprehensive picture of its characteristics as a basis for management of this river.

TABLE V. List of dominant phyto-zoo-plankton and Macrofauna in polluted stations of River Cooum.

CYANOPHYCEAE

Apanozomenon flosaquae

Microcystis elebans

Pleurocapsa sp.

Oscillatoria chalybea

Oscillatoria putrida

Oscillatoria formosa Bory

Phormidium ambigenum

Spirulina jenneri (Stizb) geitler

Anabaena constricta

Anabaena circinalis

Anthrospira sp.

Merismopedia blauca

Euglena acus

Euglena polymorpha

Spirulina gigantea

CHLOROPHYCEAE

Chlorella vulgaris

Closterium acerosum (Schrank) Ehr

Eudorina sp.

Oxystis sp.

Seenedesmus quadricauda (Turp) Brela

Schroederia

Ankistrodesmus

Cryptomonas ovata

Spriogya crassa Kutz

Staurostrum punctulatum Brel

Ulotrix zonata (Weber and Mohr) Kutz

Volvox globator

BASCILLARIOPHYCEAE

Amphora

Cyclotella menghiniana

Fragilaria halophila

Navicula pupula F. Capitata

Navicula pygmaea

Fitzschia acicularis var

Nitzschis palea (Kutz)

Asterionella japonica

Bacteriastrum

Biddulphia sinensis

Thalassionema

DIATOMS

Tabellaria fenestrata (Lyngb) Kutz

Navicula pupula capitata

Rhizosolenia

Carcinodiscus

Asterionella formosa Hass

ROTIFERS

Brachionus rubens Ehr

Brachionus calyciflorus Pallus

Brachionus quadridentatus

Brachionus forficula

Filum longiseta

Cladocera

Moina sp.

COPEPODA*Diaptomus* sp.*Mesocyclops* sp.*Nauplius**Platyhelminthes***Nematode worm***Crustacea**Balanus* sp.*Larval forms**Chironomous larva**Culex fatigans***Dipteran Larva, *Brachydeutera longipes* Hendel****Culecine pupa****Dipteran pupa****FISHES***Magolops cyprinoides* (Broussonel)*Mugil cephalus* (Linnaeus)*Mugil microlepis* (Smith)*Therapon jarbuva* (Forsk)

TABLE VI. List of dominant phyto-zoo-plankton and Macrofauna in unpolluted station of River Cooum.

CYANOPHYCEA*Coelosphaerium huetzingianum**Gleocapsa**Polycystis**Protococcus**Aphanocapsa pulchra* (Kutz) Raben*Spirulina**Euglena viridis* Ehr*Mougeotia indica* Randhawa**BACILLARIACEA***Navicula cryptocephala* Kutz

Synedra acua Kutz

Synedra ulna (Nitz) Ehr

Fragilaria capucina Desmaz

Gomphonema parvulum (Kutz) green

Gomphonema sphacrophorum (Ehr). f. *subscapitata*

Navicula pygmaca (Kutz) green

Navicula laterostrata Hust.

Nitzschia obtusa Wrn. Srn. Vi

Nitzsbhia palea (Kutz) wrn. srn.

CHLOROPHYCEAE

Closterium

Stauroneis parvula green

Tetraedron tumidulum

Hydrodictyon

Actinastrum sp.

Ankistrodermus falcatus (corda) Ralfs.

Chlamydomonas sp.

Chlorococcum humicola (Naeg) Raben

Crucigenia quadradata

Crucigenia tetrapedia

Eudorina elegans Ehr

Eudorina indica Iyengar

Oxystis ecballocystiformis Iyengar

Pandorina morum Mull Bory

Pediastrum duplex

Scenedesmus bernardii G. M. Smith

Scenedesmus dimorphus (Turp) Kutz

Oxystis crassa Wittrock

Staurostrum iotantum

ZOOPLANKTON

Rotifers

Brachionus calyciflorus

Brachionus quadridentata

Asplanchna sp.

Filinia sp.

Cladocera

Moina

Ostracod

Cypris

Copepoda

Euealanus elongatus (Dana)

Undinull vulgaris Var. Sewell

Lucifer sp.

Mesocyclops sp.

MACROFAUNA

Mollusca

Anisus (Diplodiscus) *Hyptocylos* (Bensen)

Pilaglobosa (Swainson)

Pilavirens (Lamarck)

Planorbis exustus (Deshayes)

Vivipara sengalensis

CRUSTACEA

Macrobrachium javanicum (Heller)

Macrobrachium lamarrei (H. Mibre Edwards)

Macrobrachium rosenbergi (de Man)

INSECTA

Anisops nivea Fieber

Hydrometra sp.

Micromecta punctata (Fieb)

Nepa sp.

Gerrid sp.

Ranatra sp.

Laccotrephes sp.

Sphacrodema annulatum Fabr.

Diplonychus indicus

Limnogonus fossarum fossarum

FISHES

Amblypharyngodon mola Hamilton

Channa punctatus (Bloch)

Colisa fasciata (Schneider)

Esomus dandricus (Hamilton)

Etroplus maculatus (Bloch)

Glossogobius giuris (Hamilton)

Leiognathus aculeatus (L)

Macrognathus aculeatus (Bloch)

Muraena sp.

Mystus vittatus (Bloch)

Oxygaster bacaila Hamilton

Puntius amphibia (Valenciennes)

Puntius sophor (Hamilton)

Rasbora daniconius (Hamilton)

Tilapia mossambica (Peters)

AMPHIBIA

Rana hexadactyla

Rana sylvatica Schneider

Rana limnocharis Boie

REPTILES

Natrix sp.

SUMMARY

Ecological investigations in the river Cooum have been made for three years (1988-90). Physical, Chemical and Biological Parameters were analysed at both unpolluted and polluted stations in the river for summer and rainy season. The results suggest that a group of phytozooplankton and Macrobenthos can prove very successful indicators of pollution and can be very useful in monitoring sewage pollution in inland waters.

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AVIFAUNA OF KALAKAD WILDLIFE SANCTUARY,
TAMIL NADU, INDIA

M. VASANTH

*Freshwater Biological Station, Zoological Survey of India,
Hyderabad**

INTRODUCTION

On the basis of a decision taken by the Tamil Nadu Wildlife Advisory Board, the Zoological Survey of India was requested by the Chief Wildlife Warden, Tamil Nadu Forest Department, Tirunelveli, to prepare a checklist of the lower invertebrates of Kalakad Sanctuary. This work was taken up in 1984 as part of the approved Annual Programme of Work of Southern Regional Station, Zoological Survey of India, Madras, with Dr. R. S. Pillai, the then Officer-in-Charge of the station as the Chief Coordinator. But it was decided to include inventorisation of birds as well as part of the programme.

Between August, 1984 and April, 1987 a party led by the present author conducted a total of eight survey tours to various parts of Kalakad Sanctuary. Dr. Pillai accompanied the party on all but one of its trips.

The present paper is the fruit of field studies made by the present author on the rich avifauna of the sanctuary. The list includes birds observed by him, and also those which he was unable to observe, but which find mention in the Management Plan of the sanctuary by Sri S. Ramanathan. The present list is by no means complete. Nevertheless, it indicates the richness of the bird fauna of Kalakad Sanctuary.

KALAKAD SANCTUARY

Location and Area :

Kalakad Sanctuary is located in the Nanguneri Taluk of the southwestern part of Tirunelveli District of Tamil Nadu, between 8°25' and 8°35' N latitudes, and 77°25' and 77°35' E longitudes. The sanctuary comprises the whole of the Kalakad Reserve Forest.

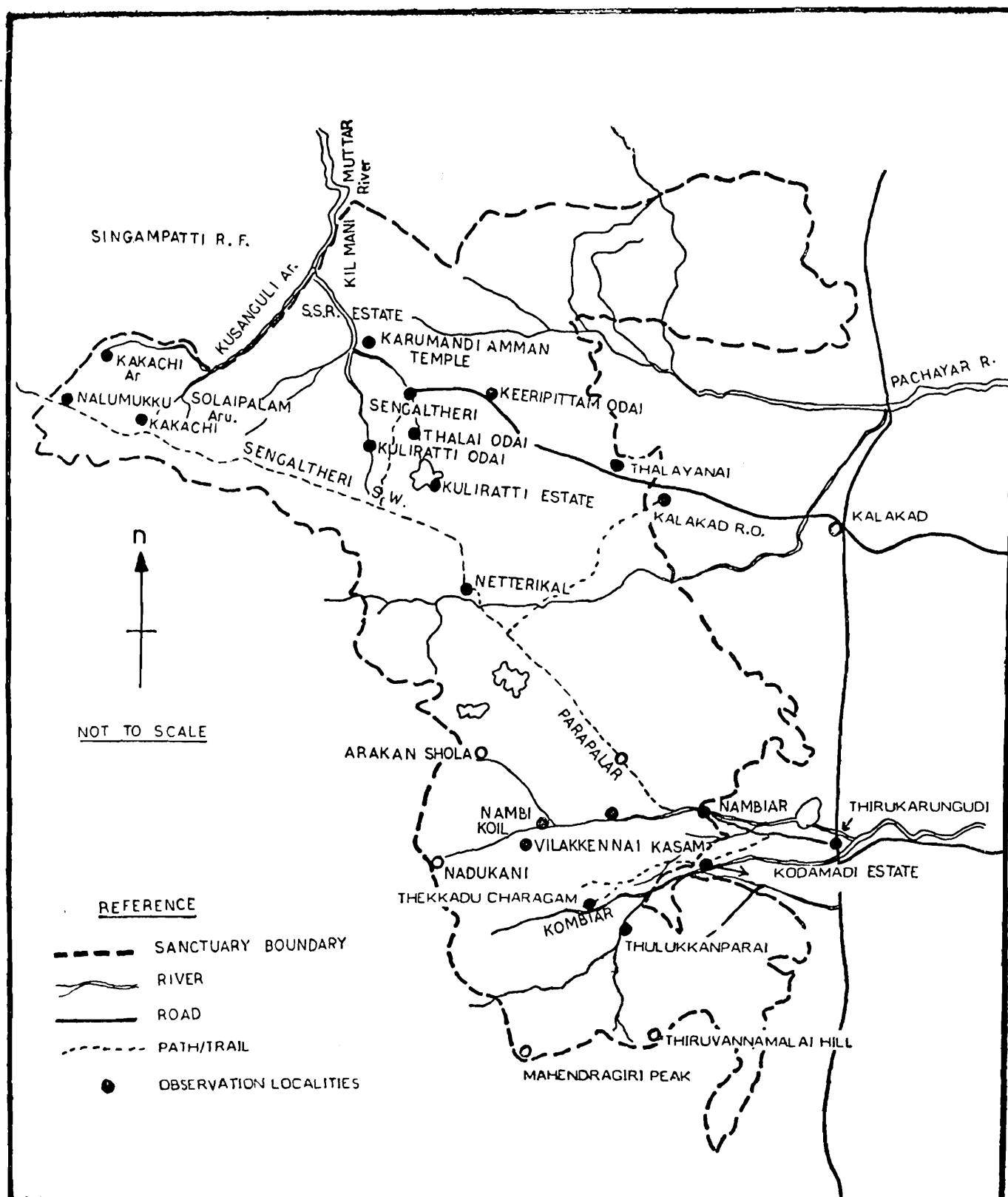
Covering an area of 22375.85 hectares, the sanctuary is easily approachable by road from Tirunelveli, about 45 Km. away. The nearest railway station is Cheranmadevi, 20 Km. away from Kalakad, a small town situated 4 Km. from the eastern boundary of the sanctuary. The nearest airport is Thiruvananthapuram (Trivandrum) Kerala, 140 Km. away.

* *Current address :* 232 Gerry Road, Brookline, MA 02167 USA

STUDY AREA-Physiography :

The sanctuary is characterised by rugged, undulating, mountainous and inaccessible terrain. Only in its periphery, viz., in the Kalakad beat, is the terrain plain. However,

MAP OF KALAKAD WILDLIFE SANCTUARY



its extent is negligible, not extending to more than a square kilometer. The hills are not accessible to any kind of vehicle, except the Sengaltheri hills, which are accessible only by jeep.

Therkkuveeravanallur Reserve Forest forms the northern boundary of the sanctuary, while the mighty Mahendragiri peak and Reserve Forest form its southern boundary. To the eastern side lie vast stretches of private uncultivated lands. On the west, the sanctuary is contiguous with the Mundanthurai Tiger Reserve.

The lowest altitude within the sanctuary is about 100m along the eastern boundary. The highest peak—Kalakad Peak (1775m)—is on the southern boundary, in Veerapuli Reserve Forest. Other noteworthy peaks are Kuliratti (1396m), Thiruvannamalai (1387m), Netterikal (1350m), Kakachi (1233m) and Panchanthangi mottai (1192m).

A few perennial rivers and streams, and several seasonal ones, traverse the sanctuary.

The rivers Kodumudiar, Nambiar, Netterikal and Pachayar flow eastwards across the sanctuary. The Keelamanimuthar, with its tributaries, the Kulirattiar and Kusanguliar, drain the western aspect of the sanctuary. These perennial rivers form the major sources of water for animals all through the year. Besides these, three artificial water holes have been dug within the sanctuary. There are, at present, no reservoirs, natural pools and tanks within the sanctuary.

There are three roads within the sanctuary : 1. Manimuthar—Upper Kodayar road, an all-weather road ; 2. Kalakad—Sengaltheri road, which is *pucca* most of the way ; and 3. Thirukarungudi—Nambikoil road, which needs further improvement.

Besides these, there is a bridle path—the Thirukarugudi—Netterikal—Sengaltheri—Kalachi bridle path—dividing the sanctuary into two almost equal halves, starting from the eastern boundary of the sanctuary and ending at the western one.

The sanctuary is divided into the following zones : 1. Wilderness zone ; 2. Buffer zone ; and 3. Tourism zone.

The *wilderness zone*—the core area of the sanctuary—is formed by the upper reaches, containing tropical wet evergreen forests. Forestry operations are prohibited in this zone. Only research studies are permitted to be undertaken in it. The forests surrounding the Panchanthangi peak also come under this zone as they contain populations of Nilgiri Tahr.

The *buffer zone* consists of the belt of evergreen forests devoid of the association of *Durio*, *Palaquium* and *Syzygium*, and the rest of the sanctuary not included in the tourism zone. Wildlife-oriented forestry operations are planned in this zone.

The *tourism zone*, where paths and trails will be cleared periodically, and where watch-towers and tree-top cabins will be built at suitable places, will be a zone where tourists can observe and learn about wildlife, without undue disturbance to the environment. Protection of wildlife is of primary concern in the management of the sanctuary. Promotion of tourism is only secondary.

The geological formations are, for the most part, of archaen age, represented by gneisses and granites. The granitoid gneiss is a pale grey rock banded with quartz and felspar, and contains narrow veins of black mica, and is intercalated with numerous small, pale red and pink garnets.

The following types of soil are met with in the sanctuary : 1. In the outer slope of the sanctuary, which is subjected to heavy wash on the surface due to sparse plant growth, the soil consists of reddish-yellow ferruginous sandy loam of very little depth, always intermingled with numerous boulders ; 2. in the upper reaches of the sanctuary, where the moist evergreen forests are met with, the soil is mostly loamy, assuming sandy or clayey character, depending on the accumulation of wash on the surface. In the valleys and low-lying areas the soil is fairly deep.

Climate :

The outer fringe of the hills is generally hot and dry upto an elevation of about 500m. The minimum and maximum annual temperatures in the plains are in the neighbourhood of 24°C and 43°C. The hills are cooler and drier in summer.

Kalakad Sancturay gets the benefit of both the southwest and northeast monsoons. The former begins in June and continues till the end of August, while the latter brings rain from October to December. The sanctuary receives the bulk of the rainfall from the northeast monsoon.

Two prevailing winds are noticed in the sanctuary, one usually accompanying the southwest monsoon, and the other accompanying the northeast monsoon. While the latter are seldom of high velocity, the former blowing from the western aspect, are strong. These winds have little impact on the eastern slopes.

Although thick mist is generally seen in the upper reaches of the hills during the winter and monsoon months, frost is not encountered anywhere in the sanctuary.

Vegetation :

Tropical wet evergreen forests cover the upper reaches of the Kalakad Reserve Forest from an elevation of 600m upto 1500m and extending nearly to the crest of the mountains. The wind-swept ridges exhibit poor growth. Tropical dry deciduous forests occur along the foot of the hills in Kalakad Reserve Forest. In the low

undulating hills in Vallioor and Parivarisurian beats carniatic imbrella thorn forests occur.

MATERIAL AND METHOD

Field observations were made with the aid of field binoculars of the power 8×21 , field 7° . Notes were taken down on locality of sighting, habitat in which sighted, whether adult or juvenile, male or female (where the sexes are distinguishable), solitary, in a pair or gregarious. Notes on behavioural aspects were also jotted down, as well as associations with other birds, if any. Nesting details, where observed, were recorded.

ANIFAUNA

Kalakad Sanctuary offers a very wide range of habitats for a variety of birds. Consequently, the bird fauna is quite rich. Additionally, the inaccessible, undisturbed and protected nature of some areas of the sanctuary has resulted in the preservation of many species of birds. The thorn forests at the base of the hills, the tropical dry deciduous and tropical wet evergreen forests harbour several different species. Some, like the Jerdon's Imperial Pigeon (*Ducula badia* (Raffles)), the Drongo-cuckoo (*Surniculus lugubris* (Horsfield)), the Indian Great Black Woodpecker (*Dryocopus javensis* (Horsfield)), the Whitebellied Tree Pie (*Dendrocitta leucogastra* (Gould)), the Fairy Bluebird (*Irena puella* (Latham)), the Malabar Whistling Thrush (*Myiophonus horsfieldii* (Vigors)) and the Nilgiri Verditer Flycatcher (*Muscicapa albicaudata* Jerdon) were found to be highly restricted to the evergreen biotope. Others, including the Spotted Dove (*Streptopelia chinensis* (Scopoli)), the Little Brown Dove (*S. senegalensis* (Gmelin)), the Whiteheaded Babbler (*Turdoides affinis* (Jerdon)), the Indian Robin (*Saxicoloides fulicata* (Linn.)), the Small Green Bee-eater (*Merops orientalis* Latham) and the Indian Roller (*Coracias benghalensis* (Linn.)) frequented scrub, thorn and light forest, and even fallow land, at lower elevations. Two species, viz., the Paradise Flycatcher (*Terpsiphone paradisi* Linn.) and the Black Drongo (*Dicrurus adsimilis* (Bechstein)) were sighted in all kinds of forest upto about 900m. Six species each of Bulbul and Flycatcher were sighted during the present study. About 94% of the birds observed are resident birds.

SYSTEMATIC LIST

Order : PELECANIFORMES

Family : PHALACROCORACIDAE

1. *Phalacrocorax niger* (Vieillot)

Little Cormorant

Dates of sighting : 8 & 9.1.1987

Flocks of these birds (one flock comprising at least 40 individuals) were seen

on wet grassy patches forming little islands near the edge of the tank at Periakulam on the road to Nambikoil from Thirukarungudi.

Order : CICONIFORMES

Family : ARDEIDAE

2. **Arodeola grayii** (Sykes)

Paddy Bird or Pond Heron

Dates of sighting : 22.8.1986 ; 8.1.1987

This bird was sighted in the paddy fields just outside the sanctuary boundary.

3. **Bubulcus ibis** (Linnaeus)

Cattle Egret

Dates of sighting : 8, 9 & 10.1.1987

Two or three of these egrets were seen attending on grazing cattle on the way to Karungal Kasam from Chidambarapuram village ; a few at Periakulam tank, with no cattle nearby.

4. **Egretta garzetta** (Linnaeus)

Little Egret

Dates of sighting : 15.2.1986 ; 8, 9 & 10.1.1987

The commonest of the egrets seen, the Little Egret was found in fair numbers at Periakulam tank and near Chidambarapuram village. A single bird was found near the Thalayanai dormitory, on a boulder in a stream that had only slow water movement.

Family : THRESKIORNITHIDAE

5. **Threskiornis melanocephala** (Latham)

White Ibis

Date of sighting : 9.1.1987

One bird was sighted at the Periakulam tank. This ibis is supposed to be of gregarious habits, so it was unusual to find a solitary bird.

6. **Platalea leucorodia** Linnaeus

Spoonbill

Date of sighting : 9.1.1987

This bird was recorded at the Periakulam tank along with the previous species. As a matter of fact, the two birds were sighted close to each other. The spoonbill is also known to be gregarious, but the present record is of one individual only.

Order : FALCONIFORMES

Family : ACCIPITRIDAE

7. **Milvus migrans** (Boddaert)

Pariah kite

A common kite sighted frequently only in the vicinity of human habitation at the base of the hills.

8. **Haliastur indus** (Boddaert)

Brahminy Kite

A kite that was more commonly seen than the previous species and which was not restricted to the vicinity of human habitation. This species was sighted flying over the forest on the way to Nambikoil at Sengaltheri, Vallioor R. F. and Manjolai. At Sengaltheri, these kites were seen soaring overhead on two cloudy afternoons in late April, 1987. One day only a solitary bird was sighted, while on the subsequent afternoon five birds were seen together. Every now and then a shrill squeal was heard from the birds on the wing.

9. **Accipiter badius** (Gmelin)

Shikra

Dates of sighting : 9.2.1986 ; 22.8.1986 ; 14.1.1987

Sighted in the open dry deciduous forest. In January, 1987 one bird was seen to pick and eat winged termites emerging from the ground in the Vallioor R.F. Range Office complex.

10. **Spizaetus cirrhatus** (Gmelin)

Crested Hawk-Eagle

Dates of sighting : 22.8.1986 ; 14.1.1987

This bird was sighted in deciduous and semi-evergreen forest on two occasions—once along the Kombaiar river in August, 1986, and a second time along the Nambiar river in January, 1987.

Family : FALCONIDAE

11. **Falco tinnunculus** Linnaeus

Kestrel

Date of sighting : 4.3.1985

Only one bird was sighted. This was seen hovering over the grassy slopes near the 'view-point' at Sengaltheri.

Order : GALLIFORMES

Family : PHASIANIDAE

12. **Gallus sonneratii** (Temminck)

Grey Junglefowl

Dates of sighting : 20.8.1984 ; 5.3.1985 ; 25.8.1986

Although apparently a very common bird in the sanctuary, found in all kinds of forest from dry-deciduous and moist-deciduous to evergreen, its presence is more easily known by its typical call and a rustling sound as it scurries through the leaf litter, than by visual sighting.

Order : CHARADRIIFORMES

Family : CHARADRIIDAE

Subfamily : CHARADRIINAE

13. **Vanellus indicus** (Boddaert)

Redwattled Lapwing

Date of sighting : 10.1.1987

A sighting of a solitary bird was made in an open grassy area in the vicinity of a water body to the west of Chidambarapuram village adjacent to the sanctuary boundary. The lapwing was seen in the company of Little and Cattle Egret and the Large Pied Wagtail.

Order : COLUMBIFORMES

Family : COLUMBIDAE

14. **Treron pompadora** (Gmelin)

Greyfronted Green Pigeon

Date of sighting : 18.11.1984

Five to six of these birds were seen in the well-wooded area about 3.5 Km. before Sengaltheri on the Kalakad-Sengaltheri road.

15. **Treron phoenicoptera** (Latham)

Green Pigeon

Date of sighting : 23.8.1986

Large flocks of green pigeon were sighted in the huge fruiting trees in the Vallioor R.F. in August, 1986.

16. **Ducula badia** (Raffles)

Jerdon's Imperial Pigeon

Dates of sighting : 18 & 20.8.1984 ; 20.11.1984

This bird of the evergreen biotope was seen only at Sengaltheri and Karumandi Amman temple areas. At the latter area, these birds were sighted flying at a great height in flocks of two to four birds.

17. *Streptopelia chinensis* (Scopoli)

Spotted Dove

Dates of sighting : 8 & 9.2.1986 ; 20 & 22.8.1986 ; 8-16.1.1987

A dove found abundantly in the scrub, thorn and mainly deciduous forest in the foothills and lower elevations. A large number of these birds was found to be present in the Vallioor R.F. and Keeripittam Odai.

18. *Streptopelia senegalensis* (Linnaeus)

Little Brown or Senegal Dove

Dates of sighting : 8 & 9.2.1986 ; 20.8.1986 ; 10 & 12.1.1987

The little brown dove is also a common species of dove in the sanctuary. Although co-existing with the previous species in some areas, the present species appears to be more abundant in scrub, thorn and dry-deciduous jungle than the previous one.

Order : PSITTACIFORMES

Family : PSITTACIDAE

19. *Psittacula krameri* (Scopoli)

Roseringed Parakeet

Dates of sighting : 8-15.2.1986 ; 20-27.8.1986 ; 8-16.1.1987

This parakeet is a common bird in the lower elevations, being found in deciduous forest. In February, 1986 a pair of this parakeet was observed trying to oust a spotted owlet from its hollow in a margosa tree just outside the Forest Range Office at Kalakad. The female parakeet appeared to be the more active of the partners in annoying the spotted owlet.

20. *Psittacula columboides* (Vigors)

Bluewinged Parakeet

Date of sighting : 5.3.1985

Only one bird of this species was sighted in the evergreen forest fringing the tea gardens of the Bombay Burmah Trading Corporation at Manjolai.

21. *Loriculus vernalis* (Sparrman)

Indian Lorikeet

Date of sighting : 27.2.1985

This bird was sighted just once in the moist-deciduous and semi-evergreen forest between the 11 Km. stone and Sengaltheri on the Kalakad-Sengaltheri road.

Order : CUCULIFORMES

Family : CUCULIDAE

22. *Surniculus lugubris* (Horsfield)

Drongo-Cuckoo

Date of sighting : 25.8.1986

The unmistakable call of this bird was first heard and the bird was sighted subsequently deep within the evergreen forest on the way to Nadukani. This was the only record of the bird in the sanctuary.

23. *Eudynamys scolopacea* (Linnaeus)

Koel

Dates of sighting : 8 & 12.2.1986 ; 23.8.1986 ; 9, 13 & 15.1.1987

The koel was seen only in the foothills and low elevations in the vicinity of human habitation.

24. *Rhopodytes viridirostris* (Jerdon)

Small Greenbilled Malkoha

Date of sighting : 21.8.1986

This bird was seen on one occasion only in the dense thickets bordering a canal in Vallioor R.F. close to Kodamadi Estate.

25. *Centropus sinensis* (Stephens)

Crow-Pheasant or Coucal

Dates of sighting : 9.2.1986 ; 23.8.1986

One bird was sighted in almost the same place where the previous species was seen. The call of the coucal was heard in the deciduous jungle at Ombadu Kal Sonai near the boundary of Vallioor R.F. and Kalakad R.F., indicating its presence there.

Order : STRIGIFORMES

Family : STRIGIDAE

Subfamily : STRIGINAE

26. *Bubo zeylonensis* (Gmelin)

Brown Fish Owl

Date of sighting : 10.2.1986

One bird was seen at night in a teak tree between Mudaliruppan and the point where the road to the Thalayanai dormitory branches off from the Kalakad-Sengaltheri road.

27. *Athene brama* (Temminck)

Spotted Owlet

Dates of sighting : 8-15.2.1986

One bird of this species was found to be occupying a hole in a margosa (*Azadiarcta indica*) tree trunk just outside the Forest Range Office compound at Kalakad. A pair of roseringed parakeet, which was obviously keen on appropriating the hole for nesting, was observed annoying the owlet (as mentioned earlier) from morning to dusk. Although the latter vacated the hole once in a way, it perched in a tree about 10 m away, and swooped down on the parakeets whenever it found them approaching the hole too closely.

Order : CAPRIMULGIFORMES

Family : CAPRIMULGIDAE

28. *Caprimulgus asiaticus* Latham

Indian Little Nightjar

The typical call produced by this nightjar was heard at dusk in the scrub jungle adjacent to the Vallioor R.F. Range Office complex, although the bird itself was never sighted.

Order : APODIFORMES

Family : APODIDAE

29. *Cypsiurus parvus* (Lichtenstein)

Palm Swift

Dates of sighting : 20-28.8.1986 ; 8-15.1.1987

This swift was found in abundance in the foothills area where the land had numerous palmyra palm (*Borassus flabellifer*) trees.

Order : CORACIIFORMES

Family : ALCEDINIDAE

30. *Ceryle rudis* (Linnaeus)

Pied Kingfisher

Date of sighting : 8.2.1986

This species of kingfisher was sighted only at Kalakad—not far from the Forest Office complex.

31. *Alcedo atthis* (Linnaeus)

Small Blue Kingfisher

Dates of sighting : 12.2.1986 ; 23.8.1986

Two sightings of this bird were made, one at Pachayar, not very far from Thalayani dormitory, and the other at Thulukkanparai. The hill stream and the surrounding forest in the two locations were similar—swiftly-flowing stream with numerous rocks and boulders and moist-deciduous to semi-evergreen forest. In the Pachayar the bird was observed while it dived into the splashing, foaming waters of the stream and emerged with a fish in its bill. The latter was swallowed by the bird tail first.

32. *Halcyon smyrnensis* (Linnaeus)

Whitebreasted Kingfisher

Dates of sighting : 8.2.1986 ; 25.8.1986 ; 9.1.1987

A commonly found kingfisher in the foothills area of the sanctuary. Not found in forests.

Family : MEROPIDAE

33. *Merops leschenaulti* Vieillot

Chestnutheaded Bee-Eater

Date of sighting : 2.3.1985 ; 21.8.1986 ; 15.1.1987

This species of bee-eater was sighted at three places : one bird at Vallioor R.F. Range Office complex, one perched on an electric wire in a wooded section along the road to Nambikoil from Thirukarngudi, and four birds, two of them probably juveniles, seen for about a minute or so on a tree about 25m in front of the Forest R.H. at Sengaltheri. They flew away down a valley one after another.

34. *Merops orientalis* Latham

Small Green Bee-Eater

A common, frequently-sighted resident bird confined chiefly to the plains and lower elevations. A good number was seen in the Vallioor R.F. and at Kalakad. The species shows a definite preference for scrub and open forest close to cultivation.

Family : CORACIIDAE

35. *Coracias benghalensis* (Linnaeus)

Indian Roller

This bird was seen in biotopes where the previous species (34) was recorded.

Family : UPUPIDAE

36. **Upupa epops** Linnaeus
Hoopoe

Dates of sighting : 8.2.1986 ; 22.8.1986

The hoopoe was sighted only in Vallioor R.F. and near the Kalakad Forest Range Office. It was not sighted in the former locality during January, 1987.

Order : PICIFORMES

Family : CAPITONIDAE

37. **Megalaima viridis** (Boddaert)
Small Green Barbet

Dates of sighting : 1.3.1985 ; 7.9.1985

This bird was more easily heard than seen in various parts of the evergreen and moist-deciduous forest in the sanctuary. Although the call of this barbet is said to be very closely akin to that of the Large Green Barbet, *M. zeylanica* (Gmelin), at least two sightings—one near Kulirattiar on way to Kuliratti Estate from Sengaltheri, and another at Kakachi—confirmed the presence of *M. viridis*.

38. **Megalaima haemacephala** (P.L.S. Muller)
Crimsonbreasted Barbet or Coppersmith

Dates of sighting : 27.2.1985 ; 23.8.1986

A barbet seen in dry and moist-deciduous forested parts of the sanctuary. Call similar to that of this species, heard in evergreen forest, were possibly those of the crimsonthroated barbet, *M. rubricapilla* (Gmelin). The latter species of barbet is said to be "restricted to evergreen biotope" and the "ecological counterpart" of *M. haemacephala*, according to Ali & Ripley, 1983. Since no sighting of either species was made in the evergreen forest in the sanctuary, the presence or absence of *M. rubricapilla* is, at the present time, mere conjecture.

Family : PICIDAE

Subfamily : PICINAE

39. **Dinopium benghalense** (Linnaeus)
Goldenbacked Woodpecker

Dates of sighting : 3.3.1985 ; 9.2.1986 ; 22.8.1986

A woodpecker of light deciduous forest, the Goldenbacked woodpecker was sighted only in the foothills areas.

40. *Dryocopus javensis* (Horsfield)

Indian Great Black Woodpecker

Dates of sighting : 23.11.1984 ; 26.4.1987

Sighting of this woodpecker were made in the dense evergreen forest near Sengaltheri, and on way to Kuliratti Estate from Sengaltheri.

Order : PASSERIFORMES

Family : PITTIDAE

41. *Pitta brachyura* (Linnaeus)

Indian Pitta

Date of sighting : 27.2.1985

Only once was this bird seen in this sanctuary. It was found on the ground close to a little trickle of water in the mixed evergreen and moist-deciduous biotope on the Sengaltheri-Kalakad road near about the 12 km. stone.

Family : HIRUNDINIDAE

42. *Hirundo rustica* Linnaeus

Common Swallow

Dates of sighting : 7.9.1985 ; 8 & 9.1.1987

Several of these birds were seen flying over the water surface at Periakulam tank. A few were also seen at the Kakachi golf course, flying and hawking insects.

43. *Hirundo daurica* Linnaeus

Striated or Redrumped Swallow

Date of sighting : 20.8.1986

Several of this species of swallow were found flying about, hawking insects on the wing, over a massive expanse of bare rock at Ombadu Kal Sonai in the foothills area.

Family : LANIIDAE

44. *Lanius cristatus* Linnaeus

Brown Shrike

Date of sighting : 13.1.1987

One individual was sighted near the Kodamadi Estate at the base of the hills. This species is a winter visitor to India.

Family : ORIOLIDAE

45. **Oriolus oriolus** (Linnaeus)

Golden Oriole

Date of sighting : 14.2.1986

One bird was seen on the Kalakad-Sengaltheri road between Thalayanai and the Forest Range Office at Kalakad. The Golden Oriole is a winter visitor to South India.

Family : DICRURIDAE

46. **Dicrurus adsimilis** (Bechstein)

Black Drongo

Although this common resident was sighted frequently in various parts of the sanctuary, including the mixed moist-deciduous and evergreen forest, it was found more abundantly in the foothills and lower elevations, and was not seen at all elevations above 900 m or so. The bird shows a preference for scrub, cultivation, fallow land and open deciduous forest. It also frequents the neighbourhood of human dwellings.

Family : ARTAMIDAE

47. **Artamus fuscus** Vieillot

Ashy Swallow-Shrike

Date of sighting : 7.9.1985

This species was sighted only in the golf course area at Kakachi, where the birds were seen making aerial sorties from their perch on electric wires, presumably to catch insects.

Family : STURNIDAE

48. **Acridotheres tristis** (Linnaeus)

Indian Myna

A common resident of the foothills near human habitation.

Family : CORVIDAE

49. **Dendrocitta vagabunda** (Latham)

Indian Treepie

Dates of sighting : 20 & 23.8.1986

The treepie was sighted mostly in light deciduous forest at the foot of the hills.

50. **Dendrocitta leucogastra** Gould
Whitebellied Treepie

Date of sighting : 23.4.1987

Three of these treepie were recorded flying from tree to tree in the dense evergreen shola near the 16 Km stone on the Kalakad-Sengaltheri road.

51. **Corvus splendens** Vieillot
Indian House Crow

Dates of sighting : 8-15.2.1986

The house crow was not seen anywhere in the hills. As a matter of fact, it was seen only in the vicinity of the Forest Range Office at Kalakad. It was not to be found in the Vallioor R.F. Range Office complex, where the Jungle Crow, *C. macrorhynchos* was seen.

52. **Corvus macrorhynchos** Wagler
Jungle Crow

Dates of sighting : 8-15.2.1986 ; 28.8.1986

Like the House Crow, the Jungle Crow was also not found in the hills in the sanctuary. But, as mentioned earlier, this was the only crow sighted in the Vallioor R.F. Range Office complex, while both this crow and the previous species (51) co-existed in the vicinity of the Forest Range Office at Kalakad.

Family : CAMPEPHAGIDAE

53. **Hemipus picatus** (Sykes)
Pied Flycatcher-Shrike

Dates of sighting : 3.3.1985 ; 4.9.1985

One male was seen in a cardamom estate (S.S.R. Estate), and about six birds near a stream passing through tea gardens at Nalumukku.

54. **Tephrodornis pondicerianus** (Gmelin)
Indian Wood Shrike

Date of sighting : 9.2.1986

One individual of this species was sighted in the scrub and secondary jungle in the vicinity of a streamlet at Keeripittam Odai.

55. ***Pericrocotus flammeus*** (Forster)

Scarlet Minivet

Dates of sighting : 20.8.1984 ; 20 & 21.11.1984 ; 27.2.1985 ; 5.3.1985 ; 6.9.1985 ; 24.4.1987

This minivet was seen in several places—mostly in evergreen forest and also in moist-deciduous forest. It was sighted near the 11 Km stone on the Kalakad-Sengaltheri road, at Sengaltheri, Karumandi Amman temple, between Kusanguliar and Murunga mottai and near Nalummukku.

Family : IRENIDAE

56. ***Aegithina tiphia*** (Linnaeus)

Common Iora

Dates of sighting : 20-22.8.1986

The Iora was sighted in deciduous forest at several localities at low elevations viz., Vallioor R.F. Range Office complex, Ombadu Kal Sonai, along Nambiar on road to Nambikoil, and along Kombaiar at Thekkadu Charagam.

57. ***Chloropsis aurifrons*** (Temminck)

Goldfronted Chloropsis

Dates of sighting : 21 & 22.8.1986 ; 9.1.1987

Sighted in the deciduous forest in Vallioor R.F. and also on way to Nambikoil. Not sighted in evergreen forest.

58. ***Irena puella*** (Latham)

Fairy Bluebird

Dates of sighting : 24.8.1984 ; 21.11.1984 ; 2.3.1985 ; 22 & 23.4.1987

Sighted only in the evergreen forest around Sengaltheri and S.S.R. Cardamom Estate. In the latter half of April, 1987 this bird was easily observed close to the Sengaltheri Forest R.H. A pair was seen twice or thrice a day for two days on the top branches of some tree or other, uttering their typical calls.

59. ***Pycnonotus melanicterus*** (Gmelin)

Rubythroated Yellow Bulbul

Date of sighting : 23.8.1986

One individual was spotted in the dense forest at Thekkadu Charagam on the bank of Kombaiar. The bird appeared to be shy.

60. *Pycnonotus jocosus* (Linnaeus)

Redwhiskered Bulbul

Dates of sighting : 19.8.1984 ; 19.11.1984 ; 27.2.1985 ; 5.3.1985 ; 4.9.1985 ; 23.4.1987

In the sanctuary these bulbuls were sighted only in the hills. Although they were found in the vicinity of evergreen forest, they were never sighted there ; they were found to be restricted to pockets of more open forest. This bulbul was seen around Sengaltheri, at Manjolai and near Nalumukku. In the first-named locality, a family group of four birds, two of them immature, was seen during November, 1984 in the overgrown grassy area in front of the Forest R.H. The immature birds lacked the red 'whiskers', and their colours were not as striking as those of the adults.

61. *Pycnonotus cafer* (Linnaeus)

Redvented Bulbul

Dates of sighting : 8-15.2.1986 ; 20-28.8.1986 ; 8-15.1.1987

The Redvented Bulbul was sighted only at lower elevations and foothills. It was very abundantly present in the Vallioor R.F. Range Office complex in August, 1986 when they were seen feeding on the surfeit of margosa fruits. The numbers of this bulbul in the aforesaid locality had diminished greatly in January, 1987. In this season, the margosa trees had no fruit. The poorer numbers of the bulbul is probably related to the lack of fruits on the margosa trees. The redvented bulbul was a common bird in light deciduous forest, scrub and secondary jungle. In appropriate biotopes it was found to cohabit with the following species (62), but never was it found to co-exist with *P. jocosus*.

62. *Pycnonotus luteolus* (Lesson)

Whitebrowed Bulbul

Dates of sighting : 20-23.8.1986 ; 8 & 9.1.1987

A common resident, this bulbul was also found, like the previous species (61), at lower elevations in light deciduous forest. Very shy and retiring, unlike *P. cafer*, and not prone to come out in the open, this species makes its presence known by its typical call.

63. *Hypsipetes indicus* (Jerdon)

Yellowbrowed Bulbul

Dates of sighting : 18 & 19.8.1984 ; 20-23.11.1984 ; 23.8.1986 ; 24.4.1987

A shy bulbul, found only in the evergreen forest and sholas. It was also sighted

in the shola below Thalai Odai, at Sengaltheri, near the S.S.R. Cardamom Estate and on the way to Kakachi.

64. ***Hypsipetes madagascariensis* (P.L.S.Muller)**

Black Bulbul

Dates of sighting : 19 & 21.8.1984 ; 20-23.11.1984 ; 27.2.1985 ; 1.3.1985 ; 4-11.9.1985

This was, by far, the commonest bulbul sighted in the evergreen hill forest. The birds showed a distinct liking for the sholas, cardamom and tea plantations, where they were seen in very large numbers in the canopy of the shade trees chasing one another and creating a din. They were seen at Sengaltheri and its neighbourhood, at Kakachi and Nalummukku.

Family : MUSCICAPIDAE

Subfamily : TIMALIINAE

65. ***Turdoides malcolmi* (Sykes)**

Large Grey Babbler

Date of sighting : 12.2.1986

Recorded only once ; one sisterhood close to the dormitory at Thalayanai.

66. ***Turdoides subrufus* (Jerdon)**

Rufous Babbler

Dates of sighting : 24.8.1984 ; 26.11.1984 ; 27.2.1985.

Three sisterhoods, one of six birds in August, 1984, a second of at least four birds in November, 1984, and a third of at least two birds in February, 1985 were seen at the same site, viz., in the grassy, overgrown jungle in front of the Forest R. H. at Sengaltheri. They were found to be shy, flying and hopping away, at the first sign of danger, keeping very low all the time.

67. ***Turdoides affinis* (Jerdon)**

Whiteheaded Babbler

Dates of sighting : 9.2.1986 ; 20-28.8.1986 ; 8-15.1.1987.

A common resident found in several places in scrub and deciduous forest and also in hedgerows in the vicinity of cultivation.

Subfamily : MUSCICAPINAE

68. **Muscicapa latirostris** Raffles
Brown Flycatcher

Date of sighting : 2.3.1985.

A pair was sighted near the Forest R. H. at Sengaltheri in early March, 1985. The birds were seen to make aerial sorties to catch insects in the typical flycatcher fashion.

69. **Muscicapa tickelliae** (Blyth)
Tickell's Blue Flycatcher

Dates of sighting : 13 & 15.1.1987.

One female was seen on the shady bank of the Kombaiar river at Thekkadu Charagam. The forest in this area was of dense deciduous type. A pair of this flycatcher was also seen one evening at the boundary of the thorn forest at the Vallioor R. F. Range Office complex, where they were busy catching winged termites emerging from the soil.

70. **Muscicapa albicaudata** Jerdon
Nilgiri Verditer Flycatcher

Dates of sighting : 21.11.1984 ; 3.3.1985 ; 8.9.1985.

This species of flycatcher was recorded only from dense evergreen forest—between Karumandi Amman Temple and S. S. R. Cardamom Estate, at Cholai Palam aru near Kakachi, and between Yaanai elumbu odai and Netterikal.

71. **Culicicapa ceylonensis** (Swainson)
Greyheaded Flycatcher

Dates of sighting : 24.8.1984 ; 20 & 22.11.1984 ; 1.3.1985 ; 6 & 9.9.1985.

This is a fairly common resident species of flycatcher in the hill evergreen forest and sholas, particularly near streams. It was sighted at various places including S. S. R. Cardamom Estate and its neighbourhood, on way to Yaanai elumbu odai near Nalummukku, and on way to Kuliratti Estate. The birds were found in good numbers and did not appear to be shy of man.

Subfamily : MONARCHINAE

72. **Terpsiphone paradisi** (Linnaeus)
Paradise Flycatcher

Dates of sighting : 23.11.1984 ; 10-15.1.1987.

The adult male of this flycatcher was observed only once in the dense shady shola below Thalai odai, where it was seen flitting about among the trees with a female. Females of this species were seen at Kodamadi Estate, at the boundary of the thorn forest with the Vallioor R. F. Range Office complex, and in the complex itself.

73. *Hypothymis azurea* (Boddaert)
Blacknaped Monarch Flycatcher

Date of sighting : 1.3.1985.

This flycatcher was seen in the forest on way to Kulirattiar from Sengaltheri. As this male bird was turned away from the present author, the black crescentic marking on the throat could not be seen.

74. *Prinia hodgsonii* Blyth
Franklin's Ashy-Grey Wren-Warbler

Dates of sighting : 8.2.1986 ; 20.8.1986.

This species was heard and sighted in the thorn and scrub forest in Vallioor R. F. on way to Ombadu Kal Sonai from the Range Office complex. The call of this bird was also heard in the open deciduous forest off Sengaltheri-Kalakad road, near about the 12 Km. stone, although the bird itself was unseen. This latter area had abundant wait-high grass in bloom and teak trees also in bloom.

75. *Orthotomus sutorius* (Pennant)
Tailor Bird

Dates of sighting : 10.2.1986 ; 20 & 22.8.1986.

The tailor bird was seen in the mixed scrub and deciduous forest at Ombadu Kal Sonai and in the deciduous forest at Thekkadu Charagam (along Kombaiar) and between 6.5 and 9 Km. on Kalakad-Sengaltheri road.

76. *Acrocephalus dumetorum* Blyth
Blyth's Reed Warbler

Dates of sighting : 21.11.1984 ; 27.2.1985 ; 8 & 9.2.1986 ; 8-15.1.1987.

An abundant winter visitor giving itself away by its short, sharp monosyllabic 'check' uttered every now and again. It was found in several places in the sanctuary, right from the plains and foothills, through the deciduous forest, to the evergreen forest in the higher elevations. Everywhere it was found restricted to tall grass, dense bushes and the lower branches of shrubs and trees.

77. **Phylloscopus trochiloides** (Sundevall)

Greenish Leaf Warbler

Dates of sighting : 21.11.1984 ; 2 & 5.3.1985 ; 8.2.1986 ; 8-15.1.1987.

Another common winter visitor found moving about restlessly among the branches of trees, rarely coming to the bushes. This leaf warbler was also sighted in several areas like *Acrocephalus dumetorum*.

Subfamily : TURDINAE

78. **Erithacus brunneus** (Hodgson)

Indian Blue Chat

Date of sighting : 21.11.1984.

A winter visitor to south India, this chat was sighted only once within a large dense shrub near a brook in the evergreen forest between Karumandi Amman temple and S. S. R. Cardamom Estate.

79. **Copsychus saularis** (Linnaeus)

Magpie-Robin

Date of sighting : 15.1.1987.

Only one record—of a pair—in the boundary of the thorn forest with the Vallioor R. F. Range Office complex. The pair was seen one evening feeding on winged termites emerging from the soil, in the company of other birds like the Tickell's Blue Flycatcher, the Black Drongo and the Redvented Bulbul.

80. **Saxicoloides fulicata** (Linnaeus)

Indian Robin

This bird is a fairly common and abundant resident in scrub and thorn forest, dry deciduous forest, fallow land with shrubs scattered here and there. It was sighted frequently in several places in the appropriate biotope.

81. **Myiophonus horsfieldi** (Vigors)

Malabar Whistling Thrush

Strangely, this whistling thrush was never sighted by the present author in the sanctuary, but its unmistakable whistling song was heard very many times in the neighbourhood of rocky hill streams in evergreen forest. From this, its occurrence in the sancturay is amply evident.

82. **Zoothera citrina** (Latham)

Orangeheaded Ground Thrush (Whitethroated Subspecies)

Date of sighting : 23.11.1984.

A solitary bird was recorded from the shola below Thalai odai on road to Kalakad. It was sighted first on a low branch of a tree from where it flew down to the ground.

Family : PARIDAE

Subfamily : PARINAE

83. **Parus xanthogenys** Vigors

Yellowcheeked Tit

Date of sighting : 21.11.1984.

A single bird was sighted in the evergreen forest between Karumandi Amman temple and S. S. R. Estate.

Family : SITTIDAE

Subfamily : SITTINAE

84. **Sitta frontalis** Swainson

Velvetfronted Nuthatch

Dates of sighting : 21-23.11.1984 ; 7-9.9.1985 ; 24.4.1987.

The Velvetfronted Nuthatch was sighted at several places in the evergreen biotope—in the shola near Thalai odai, at Sengaltheri, at and in the vicinity of S. S. R. Cardamom Estate, at Kakachi and Nalumukku.

Family : MOTACILLIDAE

85. **Motacilla cinerea** Turnstall

Grey Wagtail

Dates of sighting : 19-21.11.1984 ; 27.2.1985 ; 7-9.9.1985 ; 8 & 11.1.1987.

This winter visitor was seen always singly near hill streams at several places, mostly in evergreen forest (Sengaltheri, Karumandi Amman temple, Kakachi and its neighbourhood) and twice in moist-deciduous forest—at Vilakennai kasam near Nambikoil, and at Vaithupaarai.

86. **Motacilla maderaspatensis** Gmelin

Large Pied Wagtail

Dates of sighting : 9 & 10.1.1987.

A resident wagtail recorded from moist, grassy areas adjoining the Periakulam

tank and on the way to Karungal kasam from Chidambarapuram village. It was not sighted in the hills or forest.

Family : DICAEDIDAE

87. **Dicaeum erythrorhynchos** (Latham)

Tickell's Flowerpecker

Dates of sighting : 8.2.1986 ; 20-23.8.1986.

Although this and the following species of flowerpecker, viz., *D. concolor* Hume, are both found to occur in several parts of the sanctuary, the present species appears to be the dominant one, if not the only one, in the lower elevations.

88. **Dicaeum concolor** Jerdon

Nilgiri Flowerpecker

Dates of sighting : 21.8.1984 ; 22 & 23.11.1984 ; 27.2.1985 ; 1.3.1985.

This species of flowerpecker was sighted in the evergreen biotope in the higher elevations. One bird was seen in a nest built in a tree about 5m above the ground, close to the Sengaltheri Forest R. H. in the third week of August, 1984. It was also observed to bring nest-building materials every now and again.

It must be emphasized that distinguishing the present species from the previous one in the field, especially when the bird is sitting high up on a tree or is in flight, is impossible. Thus, several sightings of flowerpeckers in flight could not provide more revealing information on their specific identity.

Family : NECTARINIIDAE

89. **Nectarinia zeylonica** (Linnaeus)

Purplerumped Sunbird

Dates of sighting : 21.11.1984 ; 27.2.1985 ; 1.3.1985 ; 5-7.9.1985 ; 8.2.1986 ; 21-23.8.1986.

A widely-distributed, common resident sighted in the plains, foothills, low and higher elevations in the hills, in scrub and thorn jungle, deciduous and evergreen forest and gradens.

90. **Nectarinia asiatica** (Latham)

Purple Sunbird

Dates of sighting : 8.2. 1986 ; 20.8.1986

Although coexisting with the previous species in the foothills and lower eleva-

tions, the present species was found to be lacking in the evergreen forests above 600-650 m. Nichols (1944) has recorded it in the Nilgiris upto 240 m.

Family : ZOSTEROPIDAE

91. **Zosterops palpebrosa** (Temminck)

White Eye

Dates of sighting : 21.8.1984 ; 21.11.1984 ; 6-11.9.1985

In the Kalakad sanctuary this species was encountered only in evergreen forest. These birds were particularly abundant near the S.S.R. Cardamom Estate and Karumandi Amman temple in August, 1984.

Family : PLOCEIDAE

Subfamily : PASSERINAE

92. **Passer domesticus** (Linnaeus)

House Sparrow

Dates of sighting : 8-15.2.1986

Like the House Crow, the House Sparrow was sighted only around the Forest Range Office at Kalakad. The species was, however, present in good numbers in the nearby Kalakad town. It was also absent around the Vallioor R. F. Range Office complex. The sparrow is, undoubtedly, closely associated with man, and is never found far from him or in deep forest. Ali and Ripley (1983) have stated that in winter this sparrow is found in scrub jungle far from human dwellings. There was no evidence to corroborate this view during the present study.

93. **Petronia xanthocollis** (Burton)

Yellothroated Sparrow

Date of sighting : 8 & 9.2.1986

This species of sparrow was recorded from two localities only in the compound of the Forest Range Office at Kalakad, and in the deciduous forest at Keeripittam odai. At the latter locality two of these sparrow were seen sitting high up on a palmyra (*Borassus flabellifer*) palm tree.

Subfamily : ESTRILDINAE

94. **Lonchura malabarica** (Linnaeus)

Whitethroated Munia

Date of sighting : 9.2.1986

A flock of about five of these birds was sighted on a cactus plant in the neighbour

hood of Keeripittam odai. The general vegetation in this area was sparse, with small bushes here and there, and scattered trees.

95. **Lonchura kelaarti** (Jerdon)

Rufousbellied Munia

Date of sighting : 11.9.1985

A flock of 6-8 birds was seen feeding on the grassy area at the boundary of the forest at Kakachi.

Apart from the 95 species of birds actually observed by the present author and close to the boundary of the Kalakad Sanctuary, another 32 species are reported to be occurring in the sanctuary as per the 'Management Plan' of the sanctuary by S. Ramanathan. The following is a systematic list of those species :

Order : FALCONIFORMES

Family : ACCIPITRIDAE

1. **Elanus caeruleus** (Desfontaines)
Blackwinged Kite
2. **Pernis ptilorhyncus** (Temminck)
Crested Honey Buzzard
3. **Accipiter trivirgatus** (Temminck)
Crested Goshawk
4. **Ictinaetus malayensis** (Temminck)
Black Eagle
5. **Spilornis cheela** (Latham)
Crested Serpent Eagle
- Order ; GALLIFORMES
- Family : PHASIANIDAE
6. **Francolinus pondicerianus** (Gmelin)
Grey Partridge
7. **Perdica asiatica** (Latham)
Jungle Bush Quail

8. ***Galloperdix spadicea*** (Gmelin)

Red Spurfowl

Order : CHARADRIIFORMES

Family : CHARADRIIDAE

Subfamily : CHARADRIINAE

9. ***Vanellus malabaricus*** (Boddaert)

Yellow-Wattled Lapwing

Order : COLUMBIFORMES

Family : COLUMBIDAE

10. ***Columba livia*** Gmelin

Blue Rock Pigeon

11. ***Chalcophaps indica*** (Linnaeus)

Emerald Dove

Order : TROGONIFORMES

Family : TROGONIDAE

12. ***Harpactes fasciatus*** (Pennant)

Malabar Trogon

Order : CORACIIFORMES

Family : BUCEROTIDAE

13. ***Tockus griseus*** (Latham)

Malabar Grey Hornbill

14. ***Anthracoceros coronatus*** (Boddaert)

Malabar Pied Hornbill

15. ***Buceros bicornis*** (Linnaeus)

Great Pied Hornbill

Order : PASSERIFORMES

Family : ORIOLIDAE

16. ***Oriolus xanthornus*** (Linnaeus)

Blackheaded Oriole

Family : DICRURIDAE

17. ***Dicrurus leucophaeus*** Vieillot

Grey or Ashy Drongo

18. **Dicrurus paradiseus** (Linnaeus)

Large Racket-Tailed Drongo

Family : STURNIDAE

19. **Acridotheres fuscus** (Wagler)

Jungle Myna

20. **Gracula religiosa** Linnaeus

Hill Myna

Family : CAMPEPHAGIDAE

21. **Pericrocotus cinnamomeus** (Linnaeus)

Small Minivet

Family : IRENIDAE

22. **Chloropsis cochinchinensis** (Gmelin)

Jerdon's Chloropsis

Family : MUSCICAPIDAE

Subfamily : TIMALIINAE

23. **Pellorneum ruficeps** Swainson

Kerala Spotted Babbler

24. **Rhopocichla atriceps** (Jerdon)

Blackheaded Babbler

25. **Turdoides striatus** (Dumont)

Jungle Babbler

26. **Alcippe poioicephala** (Jerdon)

Nilgiri Quaker Babbler

Subfamily : MUSCICAPINAE

27. **Muscicapa nigrorufa** (Jerdon)

Black and Orange Flycatcher

28. **Muscicapa pallipes** Jerdon

Whitebellied Blue Flycatcher

Subfamily : SYLIINAE

29. **Prinia sylvatica** Jerdon

Jungle Wren-Warbler

30. **Phylloscopus magnirostris** Blyth
Largebilled Leaf Warbler

Family : MOTACILLIDAE

31. **Motacilla indica** Gmelin
Forest Wagtail

Family : NECTARINIIDAE

32. **Nectarinia minima** (Sykes)
Small Sunbird

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FIRST RECORD OF THE UROPELT TERETRURUS SANGUINEUS
(BEDDOME 1887) (REPTILIA) SERPENTES FROM
THE NILGIRIS, SOUTH INDIA

T. S. N. MURTHY

Southern Regional Station, Zoological Survey of India, Madras-600 028.

While studying a lot of reptiles collected recently in the Nilgiri District, Tamil Nadu I came across a specimen of an uropeltid snake picked up from underneath a stone in the Longwood Shola off Kotagiri. On detailed examination I have identified the snake as *Teretrurus sanguineus* because of the separate supraocular and postocular shields in the head and the depressed caudal disc ending in a single point.

The specimen, a juvenile, bearing the Register No. 187/SRS. S. measures 105 mm in length and is characterised by 15 rows of scales, 145 ventrals and 8 caudals. Colouration is as follows : Purplish red above and uniformly reddish (in life) and blackish brown and whitish below (in spirit).

Malcolm Smith (1943) has included Wynaad, Anaimalai Hills and Travancore in the range of this species whereas Rajendran (1977) has recorded the snake from Tirunelveli Hills, Tamil Nadu and Munnar in Kerala. The present record, besides constituting the first authentic report of the occurrence of the species in the Nilgiris, extends the known range of the species considerably in the Western Ghats. Attention of the Ophiologists in India must be drawn to the fact that the rarity of several species of uropelts may be illusory since these interesting snakes have been collected at irregular intervals. It is possible that the range of the uropeltid snakes may further be widened provided they are searched for carefully.

I wish to thank Dr. P. T. Cherian, Officer-in-Charge, SRS/ZSI for encouragement.

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OBSERVATIONS ON THE DISTRIBUTION OF SOME OF THE MARINE
ORGANISMS INHABITING THE INTER-TIDAL ZONE ALONG
THE WESTERN CONTINENTAL SHELF OF THE BAY
OF BENGAL, WITH PARTICULAR REFERENCE
TO THE TAMIL NADU COASTAL STRIP.

NAGABHUSHANAM, A. K. AND KRISHNAN, S.

*Marine Biological Station, Zoological Survey of India,
100, Santhome High Road., Santhome, Madras-600 028 (Tamil Nadu), India.*

INTRODUCTION

While there are a number of papers which deal with the distribution of marine life of the coral reefs, littoral flora and fauna, etc., of the Bay of Bengal, there are relatively few describing the inter-tidal zonal marine life ; among the notable exceptions, mention may be made of the following workers : Alcock, 1890, 1892 ; Arora and Banerji, 1957 ; Blyth, 1891 ; Carpenter, 1885 ; Chacko, 1949 ; Day, 1958 ; Gravely, 1941, 1942 ; Jenkins, 1912 ; Koumans, 1941 ; Nagabhushanam, 1972 ; Nagabhushanam & Rao, G. C., 1969 ; Nagabhushanam & Rama Rao, K. V., 1984 ; Russell, 1803 ; Satya-murti, 1952, 1956. However, a detailed and comprehensive survey of the inter-tidal zone has been lacking.

One of us (AKN) had the opportunity between 1959-63, 1966-71 and again 1975-86, to carry out detailed surveys along the Orissa, Andhra and Tamil Nadu coasts ; both of us have, during the period 1979-86 had the chance to deal with the Tamil Nadu surveys, and to study the phytal and faunal components collected during those surveys.

MATERIAL AND METHODS

A minimum of thirty qualitative samples each collected at a large number of stations from Orissa, Andhra and Tamil Nadu (MAP) coasts during the shore surveys through out the year are dealt with under two heads for convenience and as such they are :

(One) Those pertaining to interstitial life, mostly between Mid-Water Mark (MWM) and Low-Water Mark (LWM) ; (Two) Those macro-organisms encountered between High-water Mark (HWM) and LWM. The samples were collected from transects traversing the area between HWM and LWM and brought to the laboratory,

mostly in a live condition, for identification, preserving and cataloguing. The laboratory analyses revealed two facts : (i) the organisms were restricted to such areas which had sand-grains measuring between 150 and 600 μ ; such an ideal habitat occurred chiefly between MWM and LWM, where large pebbles and rocky out-crops were absent. In this optimum strip of the inter-tidal zone, samples were taken from surface down to a depth of approximately 100 cms. below the air/sand interface ; (ii) the surface scrapings revealed the presence of a fine film of diatoms ; and the area between 40-70 cms. below surface was found to harbour the maximum concentrations of interstitial forms. Though a number of observations have been made during the surveys, information pertaining only to the species identified in the collections, and their occurrence in the various niches of the inter-tidal zone are presented in this paper.

OBSERVATIONS

(I) *Shore Characteristics :*

To a major extent the shore is made up of fine, medium and coarse grades of siliceous sand-grains along the Orissa, Andhra and Tamil nadu coastline. This sandy inter-tidal zone is interrupted in Andhra at Visakhapatnam and Bimlipatnam ; and in Tamilnadu at Mahabalipuram, Point Calimere, Mandapam and Kanyakumari by rocky outcrops or the Eastern Ghats descending into the sea as rocky ledges forming rock pools of different sizes. Besides these, there are a large number of sand-bottomed tide pools, a classic example of which is the one at Muttukkadu (Tamilnadu). At a number of points in the inter-tidal zone are located man-made harbours with break-waters. Besides are the natural rocky harbours like the one at Visakhapatnam. In south Tamilnadu coralline growths encroach into the inter-tidal zone.

(II) *Flora and Fauna of the Inter-tidal zone :*

The phytal and faunal components identified from the samples collected during the surveys made are presented in Table 1 under five different headings which represent fairly well marked niches : (1) microscopic interstitial forms occurring in the region between MWM & LWM. Macroscopic components of the regions (2) between HWM & MWM, (3) between MWM & LWM, (4) of rock-pools/tide pools, and (5) of rocky outcrops and break waters.

(1) *Microscopic interstitial components :*

The interstitial forms are characteristically concentrated in a wide belt between the MWM and LWM. Our observations indicated an amazing similarity in species composition all along the Bay of Bengal western sandy coastline. At study of the Table 1 for this niche indicates the presence of not less than 14 species of diatoms,

1 species of alga (Cyanophyceae), 1 species of Dinoflagellate, 20 species of Foraminifera, 10 species of Ciliophora (Holotricha), 1 species of Hydrozoa (Actinulida), 4 species of Rotifera, 10 species of Gastrotricha, 4 species of Kinorhyncha, 31 species of Nematoda, 6 species of Archiannelida, 7 species of Polychaeta, 5 species of Oligochaeta, 7 species of Arachnida, 8 species of Ostracoda, 16 species of Copepoda, 2 species of Isopoda and 2 species of Opisthobranchia. The interstitial microfauna occur in large numbers in the interstices between sand grains so as to dominate the population down to a depth of approximately 50 cms. below which depth, their number fall off abruptly, possibly because of impactation of sand grains which results in practically no interstitial space for the organisms to occupy ; coupled perhaps with such factors as higher hydrostatic pressure, lack of oxygen penetration, lack of food material etc.

(2) *Macroscopic components : HWM to MWM :*

This niche is unique as it is characterised by high desiccation due to direct insolation for extended periods of time (at least six hours between tides) which precludes survival of delicate marine forms. Only those organisms adapted to extremes of exposure and fluctuations of various physical parameters populate this area. In this niche are found 8 species of free-living Polychaetes (Errantia), 6 species of sedentary Polychaetes (Sedentaria). 8 species of Ostracoda, 4 species of Copepoda, 6 species of Amphipoda, 15 species of Anomura, 6 species of Brachyura, 1 species of prosobranch Gastropod (*Bursa spinosa*) 15 species of Lamellibranchia and 2 species of bony fishes (*Sillago* spp.). It is note-worthy that even these hardy organisms prefer the lower reaches of this niche, namely towards the MWM.

(3) *Macroscopic components : MWM to LWM :*

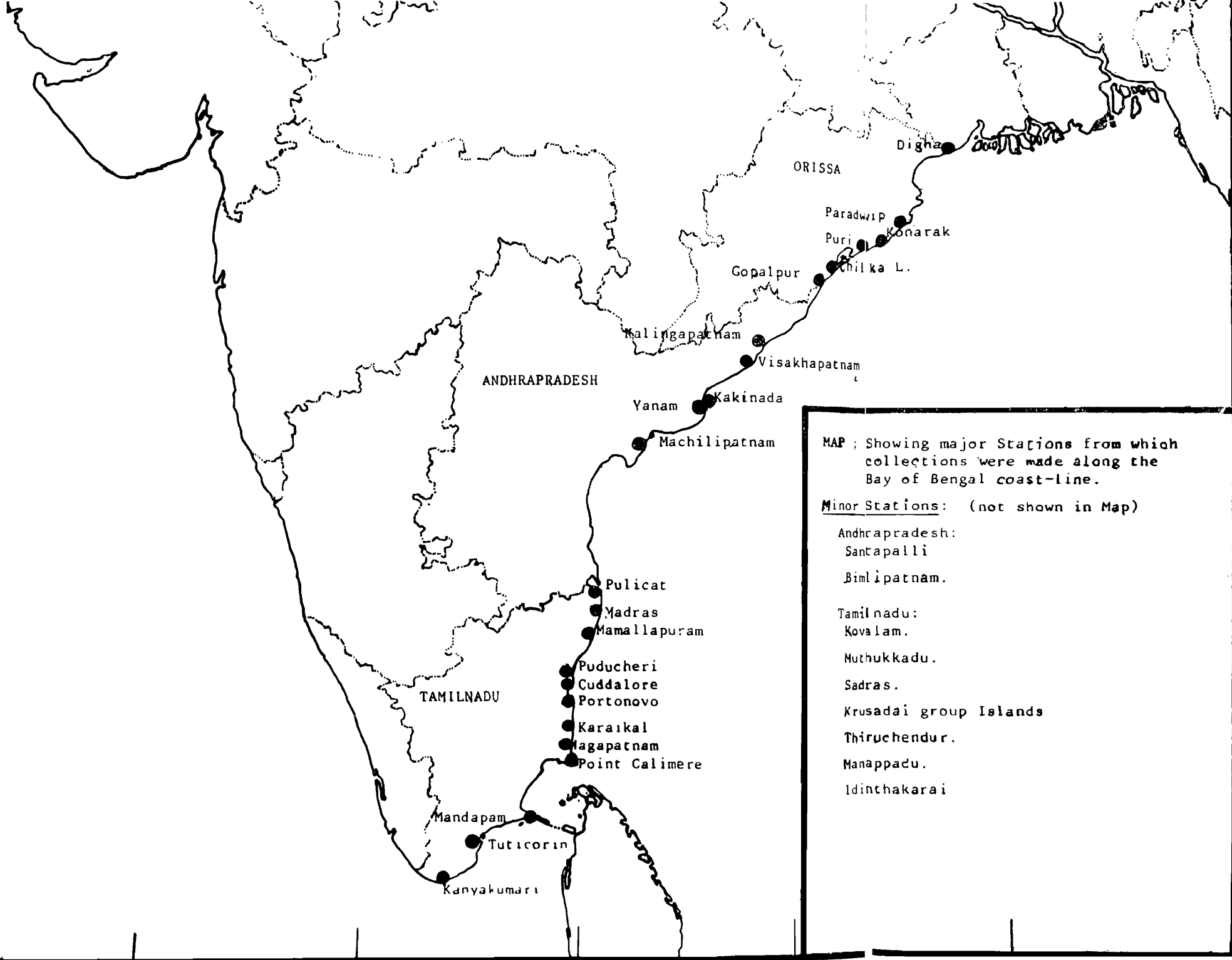
In this niche most of the forms live just under the surface down to a depth of approximately 100 cms. However, the macroflora occur at the air-sand interface. In this niche are found 9 species of Chlorophyceae, 1 species of Dinoflagellate, 1 species of Cystoflagellate, 21 species of Foraminifera, 14 species of holotrich Ciliophora, 1 species of Hydrozoa (*Plumularia setacea*), 1 species of Actinulida, 2 species of alcyonarian Anthozoa, 4 species of zoantharian Anthozoa, 3 species of heteronemertinian Rhynchocoela, 4 species of Rotifera, 10 species of Gastrotrichia, 3 species of Kinorhyncha, 8 species of enoploid Nematoda, 12 species of chromadoroid Nematoda, 4 species of monhysteroid Nematoda, 2 species of axonolaimoid Nematoda, monohysteroid Nematoda, 7 species of Archiannelida, 20 species of free-living Polychaeta, 9 species of sedentary Polychaeta, 4 species of Oligochaeta, 2 species of tardigrade Arachnida, 5 species of acarine Arachnida, 1 species of merostomation Arachnida { (*Tachypleus gigas* (Muller)) which was to be found only along the northern Orissa coast), 8 species of Ostracoda, 16 species of Copepoda, 2 species of Isopoda, 6 species of Amphipoda, 19 species of Anomura, 10 species of Brachyura, 1 species of solenogasteran mollusc (*Chaetoderma* sp.), 78 species of prosobranch Gastropoda, 18 species of opisthobranch

Gastropoda, 2 species of Scaphopoda (*Dentalium* spp), 68 species of Lamellibranchia, 20 species of Holothuria, 17 species of Asteroidea, 18 species of Echinoidea, 21 species of Ophiuroidea, 3 species of Hemichorda, 1 species of Cephalochorda, 2 species of Chondrichthyan Pisces, and 10 species of osteichthyan Pisces.

Small clumps of green algae, in particular, *Ulva* spp. *Enteromorpha*, *Chaetomorpha*, *Cladophora*, *Caulerpa* and *Codium* species occur on the coarser grades of sand. Associated with these clumps are large numbers of very young Nemertines, Nereids and Nephthyid Polychaetes, along with Gastropod, Asteroid and Ophiuroid juveniles, belonging to practically every species of these groups occurring in the zone.

(4) *Rock-pools/Tide-pools* :

In this niche the water contained in the pools showed the presence of five species of Diatoms ; the same five species were represented in films scraped from the rocks, stones, etc., lying in the pools. Also taken were 9 species of Chlorophyceae, 6 species of Phaeophyceae, 15 species of Rhodophyceae, 1 species of Cyanophyceae, 4 species of Dinoflagellata, 1 species of Cystoflagellata, 1 species of sarcodiniian Protozoa, 21 species of Foraminifera, 1 species of Radiolaria, 1 species of Heliozoa, 14 species of holotrichous Ciliophora, 2 species of calcareous Porifera, 17 species of demospongiarian Porifera, 4 species of anthomedusan Hydrozoa, 5 species of leptomedusan Hydrozoa, 1 species of actinulid Hydrozoa, 3 species of Siphonophora, 3 species of Chondrophora, 2 species of milliporan Hydrozoa, 1 species of cubomedusan Scyphozoa, 12 species of alcyonarian Anthozoa, 8 species of zoanthid Anthozoa, 7 species of acoelan Turbellaria, 4 species of alloecoelan Turbellaria, 4 species of polycladid Turbellaria, 1 species of palaeonemertine Rhynchocoela, 3 species of heteronemertine Rhynchocoela, 4 species of Rotifera, 10 species of Gastrotricha, 3 species of Kinorhyncha, 8 species of enoploid Nematoda, 10 species of chromodoroid Nematoda, 1 species of monhysteroid Nematoda, 3 species of axonolaimoid Nematoda, 2 species of desmoscolecoidan Nematoda, 2 species of Entoprocta, 7 species of Archiannelida, 26 species of errant Polychaeta, 14 species of sedentary Polychaeta, 1 species of Oligochaeta, 1 species of Echiuroidea, 5 species of Sipunculida, 1 species of Brachipoda, 1 species of Phoronida, 2 species of Chaetognatha, 15 species of Ectoprocta, 2 species of tardigrade Arachnida, 5 species of acarine Arachnida, 8 species of Ostracoda, 17 species of Copepoda, 4 species of Isopoda, 7 species of Amphipoda, 8 species of Cirripedia, 7 species of Stomatopoda, 2 species of Mysidacea, 1 species of Palaeomonidea, 15 species of Anomura, 3 species of Macrura, 17 species of Brachyura, 5 species of Polyplacophora, 90 species of prosobranch Gastropoda, 27 species of opisthobranch Gastropoda, 37 species of Lamellibranchia, 8 species of octopod Cephalopoda, 7 species of Crinoidea, 4 species of Holothuroidea, 6 species of Asteroidea, 15 species of Echinoidea, 19 species of Ophiuroidea, 10 species of ascidian Tunicata, 4 species of thaliacean Tunicata, 1 species of larvacean Tunicata,



MAP ; Showing major Stations from which collections were made along the Bay of Bengal coast-line.

Minor Stations: (not shown in Map)

Andhrapradesh:
Santapalli

Bimlipatnam.

Tamilnadu:
Kovalam.

Muthukkadu.

Sadras.

Krusadai group Islands

Thiruchendur.

Manappadu.

Idinthakarai

1 species of Cephalochorda, 2 species of chondrichthyan Pisces, 10 species of Anguilliformes, 1 species of Siluriformes, 2 species of Atheriniformes, 5 species of Syngnathiformes, 11 species of Scorpaeniformes, 36 species of Perciformes, 11 species of Gobiesociformes, 7 species of Tetraodontiformes, 2 species of Batrachoidiformes, 4 species of Lophiiformes, and 2 species of ophidian Reptilia.

Most of the species, particularly those of Pisces, were represented by very young juveniles ; and thus, this niche also must be considered to be a "nursery" for many of the animal groups that occur.

(5) *Rocky out-crops and Break-waters :*

The flora and fauna of this niche consisted of not less than 5 species of Diatomacea, 9 species of Chlorophyceae, 6 species of Phaeophyceae, 15 species of Rhodophyceae, 1 species of Cyanophyceae, 1 species of Dinoflagellata, 1 species of Cystoflagellata, 15 species of Foraminifera, 10 species of holotrich Ciliophora, 2 species of calcarean Porifera, 17 species of demospongiarian Porifera, 3 species of anthomedusan Hydrozoa, 6 species of leptomedusan Hydrozoa, 3 species of Siphonophora, 3 species of Chondrophora, 2 species of milliporan Hydrozoa, 1 species of cubomedusan Scyphozoa, 3 species of rhizostomid Scyphozoa, 12 species of alcyonarian Anthozoa, 5 species of acoelan Turbellaria, 2 species of alloeocoelan Turbellaria, 3 species of polycladid Turbellaria, 1 species of palaeonemertine Rhynchocoela, 3 species of heteronemertine Rhynchocoela, 2 species of Rotifera, 6 species of Gastrotricha, 2 species of Entoprocta, 23 species of errant Polychaeta, 8 species of sedentary Polychaeta, 1 species of Echiuroidea, 5 species of Sipunculida, 1 species of Brachiopoda, 1 species of Phoronida, 15 species of Ectoprocta, 2 species of Isopoda, 4 species of Amphipoda, 8 species of Cirripedia, 6 species of Stomatopoda, 2 species of Mysidacea, 1 species of Palaeomonida, 4 species of Anomura, 1 species of Macrura, 5 species of Brachyura, 5 species of Polyplacophora, 78 species of prosobranch Gastropoda, 23 species of opisthobranch Gastropoda, 25 species of Lamellibranchia, 8 species of Octopod Cephalopoda, 7 species of Crinoidea, 2 species of Holothuroidea, 3 species of Asteroidea, 8 species of Echinoidea, 20 species of Ophiuroidea, 10 species of ascidian Tunicata, 8 species of Anguilliformes, 9 species of Scorpaeniformes, 31 species of Perciformes, 11 species of Gobiesociformes, 7 species of Tetraodontiformes, 2 species of Batrachoidiformes, 4 species of Lophiiformes, and 2 species of ophidian Reptilia.

The rocky outcrops and breakwaters show an almost vertical zonation since the rise and fall of the tide is in the vertical plane, unlike the previously mentioned niches where it is more or less horizontal. This means, in effect, that the stress on the organisms inhabiting this niche is incomparably more.

(III) *Species Analyses* :

A study of Table 1 reveals that the diatoms were to be chiefly taken between MWM and LWM, where they dominated both in surface film and interstitial community. However, a few of them occurred in rock-pools/tide-pools and rocky outcrops/breakwaters.

Among the macroscopic algae there is little doubt that the Chlorophyceae have established themselves in three niches, namely MWM-LWM, Rock-pools and breakwaters, while the Phaeophyceae and Rhodophyceae appear to be restricted to the rock-pools and breakwaters. The cyanophycean *Trichodesmium erythraeum* Ehrenberg, occurs in the diatom film and in the films coating rocks, stones, etc., making up the rock-pools and breakwater niches.

With the exception of one Dinoflagellate, namely *Amphidinium pellucidum* Herdman which occurred in four niches, the rest appeared to be restricted to rock-pools. The Cystoflagellate *Noctiluca miliaris* Suriray occurred at LWM, rock-pools and around the breakwaters. *Amoeba verrucosa* Ehrenberg occurred only in the rock-pools. The Foraminifera appeared to be ubiquitous in distribution, occurring in niches below MWM. The radiolarian and Heliozoan occurred only in the rock-pools. The Ciliophora had a similar distribution to that of the Foraminifera, and together they form the bulk of the Protozoan population wherever they occurred. The sponges were limited to the rock-pools and breakwater niches.

The anthomedusan Hydrozoa were also restricted to the rock-pools and breakwaters. The rest of the Hydrozoa also appeared to be concentrated in the same niches, the exceptions being *Plumularia setacea* (Ellis & Solander) which also occurred at LWM, and the actinulid Hydrozoan, *Halammohydra octopodoides* Remane, which was found in the interstitial fauna and LWM and was not taken in the breakwater niche. The Scyphozoa were found stranded in the tide-pools and breakwaters. The alcyonarian Anthozoan were mainly to be collected from the rock-pools and interstices of breakwaters, the exceptions being *Pennatula murrayi* K  lliker and *Pteroides espari* Herklotts which occurred in the MWM-LWM niche only. The zoantharian Anthozoa on the other hand showed a distribution chiefly restricted to the rock-pools with only four sand living forms occurring in the MWM-LWM.

The Turbellaria as a group occurred chiefly in the rock-pools and breakwaters. The Palaeonemertine *Tubulanus* sp occurred in rock-pools and breakwaters, while the Heteronemertines occurred in MWM-LWM niche in addition. The Rotifers and Gastrotricha occurred through out the intertidal zone, except in the HWM-MWM niche. The Kinorhyncha occurred in the interstitial and rock-pool niches. The Nematoda as a group occurred through out except in HWM-MWM and breakwater niches. The Entoprocta occurred in the rock-pools and breakwater niches.

The Archiannelida occurred only in the interstitial, MWM-LWM and rock-pool niches. While the errant Polychaeta occurred mainly in the MWM-LWM, rock-pool and breakwater niches, some of them were found in the HWM-MWM (including *Nereis* sp., and *Nephtys* sp.) ; while others, the microscopic forms, occurred as members of the interstitial community. The sedentary Polychaetes were chiefly restricted to the MWM-LWM, rock-pools and breakwater niches ; however, a few were found in the HWM-MWM niche. Except for *Friedricia bulbosa* (Rosa) which occurred in the rock-pools in addition, the other Oligochaeta were restricted to the interstitial, MWM-LWM niches. The Echiuroid *Thalassema* sp., all Sipunculida, Brachiopoda, Phoronida and Ectoprocta occurred only in the rock-pool and breakwater niches. A few species of Chaetognatha occurred due to stranding in the rock-pool niche. The tardigrade and acarine Arachnida are commonly found occurring in large numbers in the interstitial, MWM-LWM and rock-pool niches.

The Ostracoda form a prominent part of the population in all niches, except the breakwater one. The Copepoda have a distribution pattern identical with the Ostracoda. The Isopoda *Anilocra* spp. and *Cirolana latistylis* Dana are parasites, living attached to young fish. The Isopod *Cymadoce* sp. occurred in the interstices of the breakwater niche. The Amphipoda occurred in all the niches except the interstitial one. The pelagic Amphipod, *Phronima sedentaria* (Forsskal) occurred in the rock-pool niche only, living inside the eviscerated "tests" of *Salpa zonaria* (Pallas). The Cirripedia as a group, occurred only in the rock-pool and breakwater niches where conditions are ideal for their larval settlement and growth. The Stomatopoda, Mysidacea and Palaeomonida occurred only in the rock-pool and breakwater niches. The Anomura chiefly inhabited the HWM-MWM and MWM-LWM niches, with some of them occurring in small numbers in rock-pool and breakwater niches. The Macrura chiefly occurred in the rock-pool niche, with the lobster *Panulirus polyphagus* (Herbst) occurring in the breakwater niche in addition. The Brachyura occurred in the inter-tidal zone generally, particularly towards LWM, but were chiefly represented in the rock-pool niche ; a few inhabited the breakwater niche ; the fiddler crab *Uca* sp. was only found in the HWM-MWM niche on the banks of the larger tide-pools and backwaters.

The aplacophoran Solenogastres *Chaetoderma* sp. occurred in the MWM-LWM niche only. The Polyplacophora (Chitons) were restricted to the rock-pool and breakwater niches. The prosobranch Gastropoda mainly occurred in the rock-pool and breakwater niches ; with a few, particularly the sand living species of the genera *Monilea*, *Umbonium*, *Littorina*, *Neritina*, *Turritella*, *Architectonica*, *Cerithium*, *Triphora*, *Calyptraea*, *Xenophora*, *Strombus*, *Pterocera*, *Natica*, *Cypraea*, *Cassis*, *Murex*, *Thais*, *Nassa*, *Oliva*, *Conus*, and *Terebra*, being found in the MWM-LWM niche. The opisthobranch Gastropoda (with the exception of *Microhedyle* sp. and *Parhedyle* sp. which occur only as members of the interstitial niche) chiefly occurred in the MWM-LWM, rock-pool and breakwater niches. The Aplysians form an important part of the community of

the rock-pool and breakwater niches ; they regularly showed a migratory movement away from the shallow waters during the period January-February. The Scaphopoda are restricted to the MWM-LWM and are found in large colonies in the Gulf of Mannar and Palk Bay areas ; However, they also occurred along most of the coastline of Orissa, Andhra and northern Tamilnadu. The sand-living Lamellibranchia occurred mostly between the MWM and LWM, particularly the following genera, *Modiolus*, *Lithophaga*, *Perna*, *Malleus*, *Pecten*, *Placenta*, *Amussium*, *Cardita*, *Chama*, *Pseudochama*, *Cardium*, *Gafrarium*, *Meretrix*, *Donax*, *Tellina*, *Solen*, *Cuspidaria* etc. ; while rock-living forms like *Limopsis*, *Pinctada*, *Pinna*, *Tridacna*, *Pholas*, *Ostrea*, *Martesia* etc. occurred mainly in the rock-pool and breakwater niches. The octopod Cephalopoda are mainly inhabitants of the rock-pool and breakwater niches.

The Crinoidea are restricted to the rock-pool and breakwater niches. The Holothuroidea prefer a sandy floor and are mainly to be found in the MWM-LWM niche ; However, a few genera like *Holothuria* spp. and *Actinopyga* spp. have been taken from the rock-pool and breakwater niches. The Asteroids occurred commonly in MWM-LWM and rock-pool niches, although *Luidia* sp. have been found in the breakwater niche, in addition. Most of the Echinoidea occurred in the MWM-LWM sandy niche. A large percentage of the forms identified occurred in the rock-pool niche ; whereas a few, including species of the following genera, *Stomopneustes*, *Temnopleurus*, *Salmacis*, *Tripneustes*, *Heterocentrotus* and *Echinometra*, occurred in the breakwater niche. Ophiuroids, as a group, occurred in MWM-LWM, rock-pool and breakwater niches.

The Hemichorda *Balanoglossus* sp. and *Ptychodera* sp. were restricted to the MWM-LWM niche, and were to be collected only on certain islands of the Gulf of Mannar. The ascidian Tunicates were found only in the rock-pools and breakwaters. The Thaliacean and Larvacean Tunicates were found trapped in the rock-pools. The Cephalochordate *Amphioxus* sp. was found in the coarse sand at LWM, a few were found trapped in rock-pools.

The cartilagenous fishes are represented by juveniles of *Narcine* sp. at LWM and in the rock-pools, where they lie buried in the sandy bottom. Among the bony fishes, the bulk occurred in the rock-pool and breakwater niches. However, a few like the fishes of the genera *Ophichthys*, *Plotosus*, *Hemirhamphus*, *Platycephalus*, *Sillago*, *Uranoscopus*, *Ichthyoscopus* live either in the sandy floor in the MWM-LWM niche, or swim as juveniles in the rock-pool niche. It is note-worthy most of the fish-groups taken in the inter-tidal zone are juveniles, and hence it is strongly felt that this zone is a nursery area for most of the fish-species. The two species of sea-snakes were found in the rock-pools and breakwaters. The sea-turtles, *Chelonia mydas* (L.), *Eretmochelys imbricata* (L.) *Caretta (caretta) gigas* Deraniyagala and *Lepidochelys olivacea* (Eschscholtz) come ashore during breeding season (November through February) to lay eggs above HWM.

A variety of birds were found frequenting the sandy shore for foraging during low tides. Mention may be made of the Common Swallow, *Hirundo rustica* L. ; the White-bellied Sea Eagle, *Haliaeetus leucogaster* (Pallas) ; the Brahminy Kite, *Haliastur indus* (Böddaert) ; the White-crested Water-hen, *Amaurornis phoenicurus* (Pennant) ; the Brown-headed Sea gull, *Larus brunnicephalus* Jerdon ; the Common Tern, *Sterna aurantia* Gray ; the Little Ringed Plover, *Charadrius dubius* Scopoli ; the Common Sand-piper, *Actitis hypoleucos* (L.) the Little Cormorant, *Phalacrocorax niger* (Vieillot) ; the Common Grey Heron, *Ardea cinerea* (L.) ; the Little Egret, *Egretta garzetta* (L.) ; the Indian Reef Heron *Demigretta asha* (Sykes) ; the Common Teal, *Anas crecca* (L.) ; the Blue-wing Teal *Anas querquedula* L. ; the Pin-tail, *Anas acuta* L. ; and the Shoveller *Spatula clypeata* (L.). Of these, the swallows were rarely observed, while others, like teals and pin-tails, were migrants seen during October-December.

The species composition of the major groups worked out by us is presented in Table 2 ; from a study of the Table, it would appear that the Mollusca, Arthropoda, Pisces and Echinodermata contribute 60% of the total species populating the inter-tidal zone.

DISCUSSION

The distributions of various marine species is of great interest from both academic and commercial stand-points. The present paper fills in information on distribution of some marine species in the inter-tidal zone of the western continental shelf of the Bay of Bengal, with particular reference to the Tamilnadu coast. Our studies reveal a wealth of flora and fauna particularly in the MWM-LWM part of the sandy sea-floor, whether interstitial-dwelling minute forms or macroflora and macrofauna living at the surface or just below it (as members of sandy-bed infauna). Near LWM the sizes of the animals revealed that this niche (MWM-LWM) was in effect a nursery. Similarly, a study of the rock-pool and tide-pool indicated that they also serve as nurseries.

In conclusion, this study has shown that a large number of marine flora and fauna are colonizing, and thriving, in the inter-tidal zone of the Bay ; future work will have to determine the environmental factors, physical and chemical, which help them, individually and severally, to live in the niches of this zone. There is little doubt that future work will only add to our lists of species populating the inter-tidal zone.

SUMMARY

The bulk of the micro-and macro-fauna of the inter-tidal zone stretching from the False Point Light-house (North Orissa) to Kanyakumari (South Tamil Nadu) is located between the Mid-Water Mark (MWM) and Low-Water Mark (LWM). The micro-flora consists of vast diatom films near MWM and is made up of fourteen (14)

dominant species. The interstitial micro-fauna prefer a sandy habitat where the sand-grains measure between 150 and 600 μ . A large number of interstitial forms belonging to Protozoa, Coelenterata, Platyhelminthes, Nematoda, Gastrotricha, Kinorhyncha, Nemertinea, Rotifera, Annelida (chiefly Polychaeta ; a few Oligochaeta), Crustacea, Arachnida and Mollusca were collected from this niche. The macro-fauna included large groupings of organisms, which have been presented in detail. The occurrence of algae with associated nemertines, polychaetes, etc., have been studied ; as also the peculiar occurrence of some geographically restricted forms, e. g., the Horse-shoe Crab, *Limulus moluccanus* Latr. *Tachypleus gigas* (Muller) The flora and fauna of the rock-pools of the inter-tidal zone, as also the population of the artificial breakwaters at ports have been studied ; a few sightings of birds, turtles which frequent the inter-tidal zone has been reported.

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TABLE 1. Occurrence and distribution of the various components of flora and fauna in the niches of the inter-tidal zone of the western continental shelf of the Bay of Bengal. + Presence, — Absence.

Species / Niche	1 Microscopic Interstitial Froms MWM/LWM	2 Macroscopic Inter-Tidal HWM/ MWM/ MWM LWM	3	4 Rock-Pool/ Tide-Pool	5 Rocky out crops & Break- waters
FLORA : DIATOMACEA :					
<i>Asterionella japonica</i> Cleve & Möler	+	—	—	—	—
<i>Biddulphia chinensis</i> Greville	+	—	—	—	—
<i>B. mobiliensis</i> Bailey	+	—	—	—	—
<i>Chaetoceros affine</i> Lauder	+	—	—	—	—
<i>C. diversum</i> Cleve	+	—	—	—	—
<i>Coscinodiscus centralis</i> Ehrenberg	+	—	—	+	+
<i>Hemidiscus</i> spp.	+	—	—	+	+
<i>Nitzschia seriata</i> Cleve	+	—	—	+	+
<i>Pleurosigma elongatum</i> Smith	+	—	—	—	—
<i>P. aestuarii</i> Smith	+	—	—	—	—
<i>Rhizosolenia robusta</i> Norman	+	—	—	+	+
<i>R. crassispina</i> Schröder	+	—	—	+	+
<i>Thalassionema nitzschoidea</i> Grünow	+	—	—	—	—
<i>Thalassiothrix fraunfeldi</i> Grünow	+	—	—	—	—
: CHLOROPHYCEAE :					
<i>Ulva fasciata</i> Delile	—	—	+	+	+
<i>Ulva lactuca</i> L.	—	—	+	+	+
<i>U. rigida</i> J. Agardh	—	—	+	+	+
<i>U. reticulata</i> Forsskal	—	—	+	+	+
<i>Enteromorpha compressa</i> Greville	—	—	+	+	+
<i>Chaetomorpha sntennia</i> Keutzing	—	—	+	+	+
<i>Cladophora</i> spp.	—	—	+	+	+
<i>Caulerpa sertularoides</i> Howe	—	—	+	+	+
<i>Codium tomentosum</i> Stackhouse	—	—	+	+	+

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
: Phaeophyceae :					
<i>Dictyota dichotoma</i> Lamouroux	—	—	—	+	+
<i>Padina gymnospora</i> Vickers	—	—	—	+	+
<i>Oolpomenia sinuosa</i> Derbis & Solier	—	—	—	+	+
<i>Oystophyllum muricatum</i> J. Agardh	—	—	—	+	+
<i>Sargassum myriocystum</i> J. Agardh	—	—	—	+	+
<i>S. johnstonii</i> Setchell & Gardner	—	—	—	+	+
: Rhodophyceae :					
<i>Porphyra vietnamensis</i> Tanaka & Ho	—	—	—	+	+
<i>Gelidiella acerosa</i> Feldman & Hamel	—	—	—	+	+
<i>Grateloupia lithophila</i> Boergesen	—	—	—	+	+
<i>Gracilaria cortica</i> J. Agardh	—	—	—	+	+
<i>G. lichenoides</i> Harvey	—	—	—	+	+
<i>G. verrucosa</i> Papenfuss	—	—	—	+	+
<i>Sarcocnemum furcellatum</i> Zanardini	—	—	—	+	+
<i>Hypnea musciformis</i> Lamouroux	—	—	—	+	+
<i>Gigartina acicularis</i> Lamouroux	—	—	—	+	+
<i>Rhodymenia dissecta</i> Boergesen	—	—	—	+	+
<i>Gentroceras clavulatum</i> Montague	—	—	—	+	+
<i>Spyridia filamentosa</i> Harvey	—	—	—	+	+
<i>Acanthophora spicifera</i> Boergesen	—	—	—	+	+
<i>Laurencia pappilosa</i> Greville	—	—	—	+	+
<i>L. obtusa</i> Lamouroux	—	—	—	+	+
: Cyanophyceae :					
<i>Trichodesmium erythraeum</i> Ehrenberg	+	—	—	+	+
FAUNA					
PROTOZOA : FLAGELLATA : DINOFLAGELLATA :					
<i>Amphidinium pellucidum</i> Herdman	+	—	+	+	+
<i>Gymnodinium splendens</i> Lebour	—	—	—	+	—
<i>Ceratium brachyceros</i> Daday	—	—	—	+	—

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>C. furcoides</i> Langerhans	—	—	—	+	—
: CYSTOFLAGELLATA :					
<i>Noctiluca miliaris</i> Suriray	—	—	+	+	+
: SARCODINA : LOBOSA :					
<i>Amoeba verrucosa</i> Ehrenberg	—	—	—	+	—
: FORAMINIFERA :					
<i>Allogromia oviformis</i> (Dujardin)	+	—	+	+	—
<i>Lagena striata</i> var. <i>semistriata</i> Williamson	+	—	+	+	+
<i>L. marginata</i> (Walker & Boys)	+	—	+	+	+
<i>Nodosaria japonica</i> Cushman	—	—	+	+	—
<i>Robulus calcar</i> L.	+	—	+	+	—
<i>Loxostomina limbatum</i> Brady	+	—	+	+	+
<i>Discarbis vesicularis</i> Lamarck	+	—	+	+	+
<i>Rotalia pulchella</i> d'Orbigny	+	—	+	+	—
<i>Globigerina bulloides</i> d'Orb.	+	—	+	+	+
<i>Orbulina universa</i> d'Orb.	+	—	+	+	+
<i>Globorotalia menardii</i> d'Orb.	+	—	+	+	+
<i>Nonionella auris</i> (d'Orb)	+	—	+	+	—
<i>Elphidium craticulum</i> Höfker	+	—	+	+	+
<i>Milliammina oblonga</i> Chapman	+	—	+	+	+
<i>Quinqueloculina lamarckina</i> d'Orb.	+	—	+	+	+
<i>Q. vulgaris</i> d'Orb.	+	—	+	+	+
<i>Spiroloculina antillarum</i> d'Orb.	+	—	+	+	+
<i>Triloculina tricarinata</i> d'Orb.	+	—	+	+	+
<i>Amphistegina lessoni</i> d'Orb.	+	—	+	+	+
<i>Trochammina inflata</i> Montague	+	—	+	+	—
<i>Entzia tetrastomella</i> Daday	+	—	+	+	—
: RADIOLARIA :					
<i>Acanthometra</i> spp.	—	—	—	+	—
: HELIOZOA :					
<i>Actinophrys sol</i> Ehrenberg	—	—	—	+	—

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
: CILIOPHORA : HOLOTRICHA :					
<i>Coleps tesselatus</i> Kahl	—	—	+	+	—
<i>Prorodon morgani</i> Kahl	+	—	+	+	+
<i>Lacrymaria olor</i> O. F. Müller	+	—	+	+	+
<i>Geleia decolor</i> Kahl	+	—	+	+	+
<i>Remanella margaritifera</i> Kahl	—	—	+	+	+
<i>Trachelocerca entzi</i> Kahl	—	—	+	+	+
<i>Metopus mathiasi</i> Villeneuve-Brachon	+	—	+	+	+
<i>Folliculina elegans</i> Claparède & Lachmann	+	—	+	+	+
<i>Condyllostoma patens</i> (O. F. Müller)	—	—	+	+	—
<i>Euplotes moebusi</i> Kahl	+	—	+	+	+
<i>Aspidiscus dentata</i> Kahl	+	—	+	+	+
<i>Diophrys appendiculatus</i> (Ehrenberg)	+	—	+	+	—
<i>Epiclintes ambiguus</i> Bütschli	+	—	+	+	—
<i>Keronopsis rubra</i> (Ehrenberg)	+	—	+	+	+
PORIFERA : CALCAREA :					
<i>Grantia compressa</i> (Fabricius)	—	—	—	+	+
<i>Leucosolenia</i> spp.	—	—	—	+	+
: DEMOSPONGIARIA :					
<i>Polymastia mammillaris</i> (O. F. Müller)	—	—	—	+	+
<i>Suberites epiphytum</i> (Lam.)	—	—	—	+	+
<i>S. carnosus</i> (Johnston)	—	—	—	+	+
<i>Rhizaxinella elongata</i> (Ridley & Dendy)	—	—	—	+	+
<i>Clione celata</i> Grant	—	—	—	+	+
<i>Axinella polyploides</i> Schmidt	—	—	—	+	+
<i>Phakellia vermiculata</i> (Bowerbank)	—	—	—	+	+
<i>Aphysilla rosea</i> (Barrios)	—	—	—	+	+
<i>Dysidea fragilis</i> (Montagu)	—	—	—	+	+
<i>Haliclona cancellata</i> (Montagu)	—	—	—	+	+
<i>Gelloides carnosus</i> Dendy	—	—	—	+	+
<i>Reniera</i> spp.	—	—	—	+	+

TABLE 1. (Continued)

Species/Niche	1	2	3	4	5
<i>Amphilectus fucorum</i> Esper	—	—	—	+	+
<i>Desmacidon fruticosum</i> (Montagu)	—	—	—	+	+
<i>Raspailia fruticosa</i> Dendy	—	—	—	+	+
<i>R. hispida</i> (Montagu)	—	—	—	+	+
<i>Halichondrina panacea</i> (Pallas)	—	—	—	+	+
COELENTERATA : HYDROZOA : ANTHOMEDUSAE :					
<i>Sarsia conica</i> (Haeckel)	—	—	—	+	+
<i>Pennaria armata</i> Vanhöffen	—	—	—	+	—
<i>Zanclea</i> (Gemmaria) <i>costata</i> Gegenbaur	—	—	—	+	+
<i>Bougainvillia fulva</i> Agassiz & Mayer	—	—	—	+	+
: LEPTOMEDUSAE :					
<i>Campanularia</i> spp.	—	—	—	+	+
<i>Sertularia operculata</i> (L.)	—	—	—	+	+
<i>S. rugosa</i> Gray	—	—	—	+	+
<i>Plumularia setacea</i> (Ellis & Solander)	—	—	+	+	+
<i>Aglaophenia</i> spp.	—	—	—	+	+
<i>Aequora pensilis</i> (Eschscholtz)	—	—	—	+	+
: ACTINULIDA :					
<i>Halammohydra octopodides</i> Remane	+	—	+	+	—
: SIPHONOPHORA :					
<i>Physalia physalis</i> (L.)	—	—	—	+	+
<i>Diphyes dispar</i> Chamisso & Eysenhardt	—	—	—	+	+
<i>D. bojani</i> (Eschscholtz)	—	—	—	+	+
: CHONDROPHORA :					
<i>Velella velella</i> (L.)	—	—	—	+	+
<i>Porpita parpita</i> (L.)	—	—	—	+	+
<i>Porpema prunella</i> (Haeckel)	—	—	—	+	+
: MILLIPORINA :					
<i>Millipora alccicornis</i> L.	—	—	—	+	+
<i>M. tenera</i> Boschma	—	—	—	+	+

TABLE 1. (Continued)

Species/Niche	1	2	3	4	5
: SCYPHOZOA : CUBOMEDUSAE :					
<i>Chiropsalmus quadrigatus</i> Haeckel	—	—	—	+	+
: RHIZOSTOMEAE :					
<i>Cassiopea andromeda</i> (Forsskål)	—	—	—	+	+
<i>Crambionello orsini</i> (Vanhöffen)	—	—	—	+	+
<i>Rhopilema hispidum</i> (Vanhöffen)	—	—	—	+	+
: ANHOZOA : ALCYONARIA :					
<i>Tubipora musica</i> L.	—	—	—	+	+
<i>Telesto trichostemma</i> Dana	—	—	—	+	+
<i>Alcyonium pachyclades</i> Klünzinger	—	—	—	+	+
<i>Sarcophyton glaucum</i> Quoy et Gaimard	—	—	—	+	+
<i>S. latum</i> Dana	—	—	—	+	+
<i>S. palmatum</i> Pratt	—	—	—	+	+
<i>Melitodes variabilis</i> Hickson	—	—	—	+	+
<i>Solenocaulon ramosa</i> Hickson	—	—	—	+	+
<i>Spongodes flabellifera</i> (W. & S.)	—	—	—	+	+
<i>Juncella juncea</i> Pallas	—	—	—	+	+
<i>Gorgonia</i> spp.	—	—	—	+	+
<i>Gorgonella umbella</i> Esper	—	—	—	+	+
<i>Pennatula murrayi</i> Kölliker	—	—	+	—	—
<i>Pteroeides espari</i> Herklotts	—	—	+	—	—
: ZOANTHARIA :					
<i>Stoichactis giganteum</i> (Forsskål)	—	—	+	—	—
<i>Zoanthus</i> spp.	—	—	+	+	—
<i>Sphenopus marsupialis</i> (Gmelin)	—	—	+	—	—
<i>Cerianthus</i> spp.	—	—	+	—	—
<i>Favia cavernosa</i> (Forsskål)	—	—	—	+	—
<i>F. halicora</i> Klünzinger	—	—	—	+	—
<i>Euphyllia glabescens</i> (Chamisso)	—	—	—	+	—
<i>Fungia danae</i> Ed. & H.	—	—	—	+	—

TABLE 1. (Continued)

Species/Niche	1	2	3	4	5
<i>Acropora digitifera</i> (Dana)	—	—	—	+	—
<i>Porites lichen</i> (Dana)	—	—	—	+	—
<i>Coeloria astraeaformis</i> (Ed. & H.)	—	—	—	+	—
PLATYHELMINTHES : TURBELLARIA : ACOELA :					
<i>Convoluta saliens</i> (Graff)	—	—	—	+	+
<i>C. convolute</i> (Abildgaard)	—	—	—	+	+
<i>Macrostomum appendiculatum</i> (Fabricius)	—	—	—	+	+
<i>Acanthomacrostomum spiculifarum</i> Papi & Swedmark	—	—	—	+	+
<i>Provortex affinis</i> (Jensen)	—	—	—	+	—
<i>Gyrathrix hemaphroditus</i> Ehrenberg	—	—	—	+	—
<i>Fecampia erythrocephala</i> Giard	—	—	—	+	+
: ALLOBOCOELA :					
<i>Plagiosomum sulphureum</i> Graff	—	—	—	+	—
<i>Pseudosomum inerme</i> (Hallez)	—	—	—	+	—
<i>Monocelis lineata</i> (O. F. Müller)	—	—	—	+	+
<i>Otoplana baltica</i> Meixner	—	—	—	+	+
: POLYCLADIDA :					
<i>Leptoplana tremallaris</i> (O. F. Müller)	—	—	—	+	+
<i>Baltoplana magna</i> Karling	—	—	—	+	+
<i>Cycloporus papillosus</i> Lang	—	—	—	+	—
<i>Coelogympora aculeata</i> Ax	—	—	—	+	+
RHYNCHOCOELA : PALAEONEMERTINI :					
<i>Tubulonus</i> spp.	—	—	—	+	+
HETERONEMERTINI :					
<i>Lineus albobittatus</i> Bürger	—	—	+	+	+
<i>Cerebratulus gardineri</i> Punnett	—	—	+	+	+
<i>Baseodiscus (Eupolia) hemprichi</i> (Ehrenberg)	—	—	+	+	+
ASCHELMINTHES : ROTIFERA : MONOGONATA :					
<i>Encentrum</i> spp.	+	—	+	+	+
<i>Synchaeta</i> spp.	+	—	+	+	+

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>Asplanchna</i> spp.	+	—	+	+	—
<i>Testudinella</i> spp.	+	—	+	+	—
: GASTROTRICHA : MACRODASYOIDEA :					
<i>Macrodasys caudatus</i> Remane	+	—	+	+	+
<i>Paradasys turbanelloides</i> Boaden	+	—	+	+	+
<i>Paraturbanella</i> spp.	+	—	+	+	—
<i>Tetrachyroderma megastoma</i> (Remane)	+	—	+	+	+
<i>T. suicica</i> Boaden	+	—	+	+	+
<i>Thaumastoderma heideri</i> Remane	+	—	+	+	+
<i>Pseudostomella roscovita</i> Swedmark	+	—	+	+	+
: CHAETONOIDEA :					
<i>Chaetonotus</i> spp.	+	—	+	+	—
<i>Xenotricula velox</i> Remane	+	—	+	+	—
<i>Aspidophorus marinus</i> Remane	+	—	+	+	—
: KINORHYNCHA : CYCLORHAGAE :					
<i>Echinoderes</i> spp.	+	—	+	+	—
<i>Caterin styx</i> Gerlach	+	—	+	+	—
: CONCHORHAGAE :					
<i>Semnoderes</i> spp.	+	—	—	—	—
: HOMALORHAGAE :					
<i>Pycnophyes dentatus</i> (Reinhardt)	+	—	+	+	—
: NEMATODA : ENOPLOIDEA :					
<i>Anticoma arctica</i> Steiner	+	—	+	+	—
<i>Platycoma africans</i> (Gerlach)	+	—	+	+	—
<i>Enoploides</i> spp.	+	—	+	+	—
<i>Halalaimus longicollis</i> Allgen	+	—	+	+	—
<i>Oncholaimus brachycercus</i> de Man	+	—	+	+	—
<i>Eurystomina ornatum</i> var. <i>indicum</i> Micol & Kreis	+	—	+	+	—
<i>Viscosia</i> spp.	+	—	+	+	—

TABLE 1. (Continued)

Sepcies / Niche	1	2	3	4	5
<i>Mesacanthion</i> spp.	+	—	+	+	—
: CHROMODOROIDEA :					
<i>Halichoanolaimus robustus</i> Bastian	+	—	+	+	—
<i>Menopostia</i> spp.	+	—	+	+	—
<i>Chromospirina</i> spp.	+	—	+	+	—
<i>Chromodora vulgaris</i> Bastian	+	—	+	+	—
<i>Dichromodora</i> spp.	+	—	+	—	—
<i>Metachromodora clavata</i> Gerlach	+	—	+	—	—
<i>Chromogaster alatum</i> Gerlach	+	—	+	+	—
<i>Sabatiera abyssalis</i> (Filipjev)	+	—	+	+	—
<i>Dasynemella</i> spp.	+	—	+	+	—
<i>Gammanema cancellatum</i> Gerlach	+	—	+	+	—
<i>Metepsilonema</i> spp.	+	—	+	+	—
<i>Pterygonema ornatum</i> Timm	+	—	+	+	—
: MONHYSTEROIDEA :					
<i>Sphaerolaimus pacificus</i> Allgen	+	—	+	+	—
<i>Theristus tortuosa</i> Timm	+	—	+	—	—
<i>Steineria</i> spp.	+	—	+	—	—
<i>Monhystera parva</i> Bastian	+	—	—	—	—
<i>Rhynchonema cinctum</i> Cobb	+	—	—	—	—
<i>Cytolaimus exile</i> Cobb	+	—	+	—	—
: AXONALAIMOIDEA :					
<i>Comacolaimus prytherchi</i> Chitwood	+	—	+	+	—
<i>Bathylaimus</i> spp.	+	—	—	+	—
<i>Cynura papillata</i> Gerlach	+	—	+	+	—
: DESMOSCOLECOIDEA :					
<i>Desmoscolex bengalensis</i> Timm	+	—	—	+	—
<i>Tricoma</i> spp.	+	—	—	+	—
ENTOPROCTA :					
<i>Loxosoma</i> spp.	—	—	—	+	+
<i>Pedicellina</i> spp.	—	—	—	+	+

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
ANNELIDA : ARCHIANNELIDA					
<i>Polygordius madrasensis</i> Aiyar & Alikunhi	—	—	+	+	—
<i>Protodrilus indicus</i> Aiyar & Alikunhi	+	—	+	+	—
<i>P. pierantonii</i> Aiyar & Alikunhi	+	—	+	+	—
<i>Saccocirrus minor</i> Aiyer & Alikunhi	+	—	+	+	—
<i>Diurodrilus benazzi</i> Gerlaeh	+	—	+	+	—
<i>Nerillidium mediterraneum</i> Remane	+	—	+	+	—
<i>Dinophilus taeniatus</i> Harmer	+	—	+	+	—
: POLYCHAETA : ERRANTIA :					
<i>Aphrodite aculeata</i> L.	—	—	—	+	+
<i>Hermione hystrix</i> (Savigny)	—	—	—	+	+
<i>Lepidonotus carinulatus</i> Grube	—	—	—	+	+
<i>Harmathoe indica</i> (Kinberg)	—	—	—	+	+
<i>Pisions complexa</i> Alikunhi	+	—	+	+	—
<i>Ohloeia flava</i> Pallas	—	—	—	+	+
<i>Hesionides arenarius</i> Friedrich	+	—	+	+	+
<i>H. gohari</i> Hartmann-Schröder	+	—	+	+	+
<i>Phyllodoce castanea</i> (Marenzeller)	—	—	+	+	+
<i>Tomopteris elegans</i> Chun	—	—	+	+	—
<i>Syllis spongicola</i> Grube	—	—	+	+	+
<i>Eusyllis homocirratu</i> s Hartmann-Schröder	+	—	+	+	+
<i>Paraspionosyllis</i> spp.	+	—	+	+	+
<i>Sphaerosyllis bengalensis</i> Rao & Ganapati	+	—	+	+	+
<i>Dendronereis arborifera</i> Peters	—	—	+	+	+
<i>Nereis trifasciata</i> Grube	—	+	+	+	+
<i>N. chilkaensis</i> Southern	—	+	+	+	+
<i>N. mirabilis</i> Kinberg	—	+	+	+	+
<i>Nephtys gravieri</i> Augener	—	+	+	+	+
<i>Eunice tentaculata</i> Quatrefages	—	—	+	+	+
<i>Marphysa graveli</i> Southern	—	—	+	+	+
<i>Dioptera neapolitana</i> Della Chiaje	—	+	+	+	+

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>Onuphis eremita</i> Audouin & Milne-Edw.	—	+	+	+	+
<i>Lumbriconereis impatiens</i> Claparède	—	+	+	+	+
<i>Glycera rouxii</i> Aud & M.-Edw.	—	+	+	+	+
<i>Petitia amphophthalma</i> Siewing	+	—	—	+	—
: SEDENTARIA :					
<i>Nerine cirratulus</i> Della Chiaje	—	+	+	+	+
<i>Polydora coeca</i> Öersted	—	—	—	+	+
<i>Prionospio krusadensis</i> Fauvel	—	—	+	+	—
<i>Cirratulus filiformis</i> Keferstein	—	—	+	+	+
<i>Phyllochaetopterus ellioti</i> Crossland	—	+	+	+	—
<i>Maldane sarsi</i> Malmgren	—	—	+	+	—
<i>Sabellaria pectinata</i> Fauvel	—	+	+	+	—
<i>Pectinaria crassa</i> Grube	—	+	+	—	—
<i>Loimia medusa</i> (Savigny)	—	—	+	+	—
<i>Sabella porifera</i> Grube	—	+	+	+	—
<i>Serpula vermicularis</i> L.	—	—	—	+	+
<i>Hydroides norvegica</i> (Gunnerus)	—	—	—	+	+
<i>H. albiceps</i> (Ehrenberg)	—	—	+	+	+
<i>Pomatoceros caerulus</i> (Schmarda)	—	—	—	—	+
<i>Spirorbis foraminosus</i> Moore	—	—	—	+	+
: OLIGOCABTA : LIMIGOLAE :					
<i>Achaeta</i> spp.	+	—	+	—	—
<i>Enchytraeus barkudensis</i> Stephenson	+	—	+	—	—
<i>Friedricia bulbosa</i> (Rosa)	+	—	+	+	—
<i>Mishaelsena</i> spp.	+	—	+	—	—
<i>Propappus</i> spp.	+	—	—	—	—
ECHIUROIDEA :					
<i>Thalassema</i> spp.	—	—	—	+	+
SIPUNCULIDA :					
<i>Sipunculus indicus</i> Peters	—	—	—	+	+
<i>Siphonosoma vastum</i> (Selenka & Bulow)	—	—	—	+	+

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>Aspilosiphon steenstrupii</i> Diesing	—	—	—	+	+
<i>Phascolosoma dentigerum</i> Selenka & de Man	—	—	—	+	+
<i>Physosema rupellii</i> Grube	—	—	—	+	+
BRACHIOPODA : INARTICULATA :					
<i>Lingula</i> spp.	—	—	—	+	+
PHORONIDA :					
<i>Phoronis</i> spp.	—	—	—	+	+
CHAETOGNATHA :					
<i>Krohnitta subtilis</i> (Grassi)	—	—	—	+	—
<i>Sagitta</i> spp.	—	—	—	+	—
ECTOPROCTA : GYMNOLEBENATA : CTENOSTOMATA :					
<i>Bowerbankia caudata</i> (Hincks)	—	—	—	+	+
<i>Alcyonidium polyomm</i> (Hassal)	—	—	—	+	+
: CHEILOSTOMATA :					
<i>Membranipora membranacea</i> (L.)	—	—	—	+	+
<i>Eleuthera bellula</i> (L.)	—	—	—	+	+
<i>Flustra foliacea</i> (L.)	—	—	—	+	+
<i>Micropora coracea</i> (Esper)	—	—	—	+	+
<i>Bugula neritina</i> (L.)	—	—	—	+	+
<i>B. flabellata</i> (Thompson)	—	—	—	+	+
<i>Hippothoa divaricata</i> Lamouroux	—	—	—	+	+
<i>Hippoporina porcellana</i> (Esper)	—	—	—	+	+
<i>Microporella ciliata</i> (Pallas)	—	—	—	+	+
<i>Adona violacea</i> (Johnston)	—	—	—	+	+
<i>Parasmittina trispinosa</i> (Johnston)	—	—	—	+	+
: CYCLOSTOMATA :					
<i>Crisia elongata</i> Harmer	—	—	—	+	+
<i>C. aculeata</i> Hassall	—	—	—	+	+
ARTHROPODA : ARACHNIDA : TARDIGRADA :					
<i>Stygarcus bradypus</i> Schütz	+	—	+	+	—
<i>Batillipes carnonensis</i> Fize	+	—	+	+	—

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
: ACARINA :					
<i>Actacarus pygmaeus</i> Schültz	+	—	+	+	—
<i>Copedognathus</i> spp.	+	—	+	+	—
<i>Halacarus anomalus</i> Trouessart	+	—	+	+	—
<i>Rhombognathus</i> spp.	+	—	+	+	—
<i>Simognathus sculptus</i> (Brady)	+	—	+	+	—
: MEROSTOMATA :					
<i>Tachypleus gigas</i> (Muller)	—	—	+	—	—
: CRUSTACEA : OSTRACODA :					
<i>Polycope areolata</i> Sars	+	+	+	—	—
<i>P. orbicularis</i> Sars	+	+	+	+	—
<i>Oythereis runcinata</i> (Baird)	+	+	+	+	—
<i>Microcythere subterranea</i> Hartmann	+	+	+	+	—
<i>Loxoconcha tamarindus</i> (T. R. Jones)	+	+	+	+	—
<i>L. guttata</i> (Norman)	+	+	+	+	—
<i>Xestoleberis depressa</i> Sars	+	+	+	+	+
<i>X. aurantia</i> (Baird)	+	+	+	+	—
: COPEPODA :					
<i>Paracalanus</i> sp.	—	—	—	+	—
<i>Ameira trisetosa</i> Krishnaswamy	+	—	+	+	—
<i>Arenopontia indica</i> Rao	+	—	+	+	—
<i>A. subterranea</i> Künz	+	—	+	+	—
<i>Arenostella germanica</i> Künz	+	—	+	+	—
<i>Harpactica</i> spp.	+	—	+	+	—
<i>Kleionychocamptoides remanei</i> Noodt	+	—	+	+	—
<i>Laophonte</i> spp.	+	—	+	+	—
<i>Leptopscyllus</i> spp.	+	—	+	+	—
<i>Paramesochra pseudogracilis</i> (Krishnaswamy)	+	—	+	+	—
<i>P. wilsoni</i> Krishnaswamy	+	—	+	+	—
<i>Pararenosetella</i> spp.	+	—	+	+	—
<i>Psammopscyllus operculatus</i> Nicholls	+	+	+	+	—
<i>Schizopera</i> spp.	+	—	+	+	—

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>Sewellina reductus</i> Krishnaswamy	+	+	+	+	—
<i>Stigmatidium arenosetelloides</i> Noodt	+	+	+	+	—
<i>Tisbe</i> spp.	+	+	+	+	—
: ISOPODA :					
<i>Anilocra</i> spp.	—	—	—	+	—
<i>Cirolana latistylis</i> Dana	—	—	—	+	—
<i>Cymadoce</i> spp.	—	—	—	—	+
<i>Angeliera phraeticola</i> Chappuis et Delamare	+	—	+	+	+
<i>Microcerebrus predatoris</i> (Gnanamuthu)	+	—	+	+	—
: AMPHIPODA :					
<i>Cymadusa filosa</i> Savigny	—	+	+	+	+
<i>C. microphthalma</i> (Chevrèux)	—	+	+	+	+
<i>Gammaropsis atlanticus</i> Stebbing	—	+	+	+	+
<i>Leucothoe farina</i> (Savigny)	—	+	+	+	—
<i>Melita</i> spp.	—	+	+	+	—
<i>Paragrubia vorax</i> Chevrèux	—	+	+	+	+
<i>Phronima sedentaria</i> (Forsskal)	—	—	—	+	—
: CIRRIPIEDIA :					
<i>Balanus tintinnabulum</i> (L.)	—	—	—	+	+
<i>B. amphitrite</i> Darwin	—	—	—	+	+
<i>B. longirostrum</i> Hoek	—	—	—	+	+
<i>Chthamalus</i> spp.	—	—	—	+	+
<i>Lepas anserifera</i> L.	—	—	—	+	+
<i>L. anatifera</i> L.	—	—	—	+	+
<i>Lithotrya</i> spp.	—	—	—	+	+
<i>Pyrogoma grande</i> (Sowerby)	—	—	—	+	+
: STOMATOPODA :					
<i>Gonodactylus chiragra</i> (Fabr.)	—	—	—	+	+
<i>G. falcatus</i> (Forsskal)	—	—	—	+	+
<i>Oratosquilla nepa</i> Latrielle	—	—	—	+	+

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>O. woodmasoni</i> (Kemp)	—	—	—	+	+
<i>Lysiosquilla</i> spp.	—	—	—	+	—
<i>Pseudosquilla ciliata</i> (Fabr.)	—	—	—	+	+
<i>Odontodactylus brevisrostris</i> (Miers)	—	—	—	+	+
: MYSIDACEA :					
<i>Acetes dispar</i> Hansen	—	—	—	+	+
<i>Gastrosaccus</i> spp.	—	—	—	+	+
: PALAEMONIDEA :					
<i>Leander</i> spp.	—	—	—	+	+
: ANOMURA :					
<i>Albunea symnista</i> (L.)	—	+	+	—	—
<i>A. microps</i> Miers	—	+	+	—	—
<i>Calcinus elegans</i> (Milne-Edwards)	—	+	+	+	—
<i>C. herbstii</i> De Man	—	+	+	+	—
<i>C. gaimardi</i> (Milne-Edwards)	—	+	+	+	—
<i>Olibanarius humilis</i> Dana	—	+	+	+	+
<i>Dardanus deformis</i> (Milne-Edwards)	—	+	+	+	+
<i>D. scabrimanus</i> (Dana)	—	+	+	+	+
<i>D. varipes</i> (Heller)	—	+	+	+	+
<i>Diogenes gardineri</i> Alcock	—	—	+	+	—
<i>D. custos</i> Fabr.	—	—	+	+	—
<i>D. diogenes</i> (Herbst)	—	—	+	+	—
<i>D. avarus</i> Heller	—	—	+	+	—
<i>Emerita asiatica</i> (Milne-Edwards)	—	+	+	—	—
<i>Hippa</i> spp.	—	+	+	—	—
<i>Pagurus</i> spp.	—	+	+	+	—
<i>Eupagurus</i> spp.	—	+	+	+	—
<i>Remipes pacificus</i> Dana	—	+	+	+	—
<i>Spiropagurus spirifer</i> (De Haan)	—	+	+	+	—

TABLE 1. (Continued)

Species/Niche	1	2	3	4	5
: MACRURA :					
<i>Solenocera melantho</i> De Man	—	—	—	+	—
<i>Trachypenaeus curvirostris</i> Stimpson	—	—	—	+	—
<i>Panulirus polyphagus</i> (Herbst)	—	—	—	+	+
: BRACHYURA :					
<i>Acarina septumspinoso</i> (Fabricius)	—	—	—	+	—
<i>Calappa hepatica</i> (L.)	—	—	—	+	—
<i>C. lophos</i> (Herbst)	—	—	—	+	—
<i>Charybdis annulata</i> (Fabr.)	—	—	—	+	—
<i>Carpilius convexus</i> (Forsskal)	—	—	—	+	—
<i>Actaedes tomentosus</i> (Milne-Edwards)	—	—	—	+	—
<i>Dorippe facchino</i> (Herbst)	—	—	+	+	+
<i>D. frascione</i> (Herbst)	—	—	+	+	+
<i>Doclea hybrida</i> (Fabr.)	—	—	+	+	+
<i>Grapsus albolineatus</i> Lam.	—	+	+	+	—
<i>Heteropilumnus angustifrons</i> Alcock	—	—	—	+	—
<i>Matuta lunaris</i> (Forsskal)	—	—	—	+	—
<i>Scylla serrata</i> (L.)	—	—	+	+	—
<i>Pachygrapsus planifrons</i> De Man	—	+	+	+	—
<i>Pinnotheres tenuipes</i> Bürger	—	—	—	+	+
<i>Pseudozius caystrus</i> (Ad. & Wh.)	—	—	—	+	—
<i>Sesarma</i> spp.	—	+	+	+	+
<i>Shaeozius nudus</i> (Milne-Edw.)	—	—	—	+	—
<i>Ocypode cordimanus</i> Desmarest	—	+	+	—	—
<i>O. platytarsus</i> Milne-Edw.	—	+	+	—	—
<i>Uca (Celuca) lactea annulipes</i> (Milne-Edwards)	—	+	+	—	—
: MOLLUSCA : SOLENOGASTRES : APLACOPHORA :					
<i>Choetoderma</i> sp.	—	—	+	—	—

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
: POLYPLACOPHORA (=LORICATA)					
<i>Craspidochiton laquetns</i> (Sowerby)	—	—	—	+	+
<i>Acanthochitona mahensis</i> Winckworth	—	—	—	+	+
<i>Ischnochiton herdmani</i> Sykes	—	—	—	+	+
<i>I. aequigranuiatus</i> von Knorre	—	—	—	+	+
<i>Schizochiton incisus</i> Sowerby	—	—	—	+	+
; GASTROPODA : PROSOBRANCHIA :					
<i>Haliotis varia</i> L.	—	—	—	+	+
<i>Diodora singaporensis</i> (Reeve)	—	—	—	+	+
<i>D. lima</i> (Sowerby)	—	—	—	+	+
<i>Emarginula planulata</i> Adams	—	—	—	+	+
<i>E. incisura</i> Adams	—	—	—	+	+
<i>Scutus unguis</i> (L.)	—	—	—	+	+
<i>Cellana radiata</i> (Börn)	—	—	—	+	+
<i>Calliostoma tranquebarici</i> (Röding)	—	—	—	+	+
<i>Gibbula pulcherrima</i> Adams	—	—	—	+	+
<i>Cantharidus interruptus</i> (Wood)	—	—	—	+	+
<i>Clanculus microdon</i> Adams	—	—	—	+	+
<i>Trochus pustolusus</i> Philippi	—	—	—	+	+
<i>T. maculatus</i> Lam.	—	—	—	+	+
<i>T. obesus</i> Reeve	—	—	—	+	+
<i>T. stellatus</i> Gmelin	—	—	—	+	+
<i>Mouilea solandri</i> (Philippi)	—	—	+	+	—
<i>Umbonium vestitum</i> (L.)	—	—	+	+	+
<i>Turbo argyrostoma</i> L.	—	—	+	+	+
<i>Astraea semicostata</i> (Kiener)	—	—	—	+	+
<i>Nerita histrio</i> L.	—	—	—	+	+
<i>N. plicata</i> L.	—	—	—	+	+
<i>N. polita</i> L.	—	—	—	+	+
<i>N. rumphii</i> Récluz	—	—	—	+	+

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>N. chameleon</i> L.	—	—	—	+	+
<i>N. squamulata</i> Le Guillon	—	—	—	+	+
<i>Neritina oualaniensis</i> Lesson	—	—	—	+	+
<i>Littorina glabrata</i> Philippi	—	—	+	+	+
<i>L. scabra</i> L.	—	—	+	+	+
<i>Rissoina clathrata</i> Adams	—	—	—	+	+
<i>Turritella acutangulo</i> (L.)	—	—	+	+	+
<i>T. attenuata</i> Reeve	—	—	+	+	+
<i>Architectonica perspectiva</i> (L.)	—	—	+	+	+
<i>Torinia dorsuosa</i> (Hinds)	—	—	+	+	+
<i>Vermetus</i> spp.	—	—	—	+	—
<i>Vermicularia inopertus</i> (Rüppell)	—	—	—	+	+
<i>Cerithidea fluviatilis</i> (Potlèz & Michaud)	—	—	—	+	+
<i>Cerithium morus</i> Lam.	—	—	+	+	+
<i>C. scabridium</i> Philippi	—	—	+	+	+
<i>C. splendens</i> Sowerby	—	—	+	+	+
<i>C. rugosum</i> Wood	—	—	+	+	+
<i>C. trailii</i> Sowerby	—	—	+	+	+
<i>Triphora corrugata</i> (Hinds)	—	—	+	+	+
<i>T. violacea</i> (Quoy & Gaimard)	—	—	+	+	+
<i>Janthina globosa</i> Swainson	—	—	—	+	—
<i>Calyptraea extintorium</i> Lam.	—	—	+	+	+
<i>Xenophora corrugata</i> (Reeve)	—	—	+	+	+
<i>Strombus dentatus</i> L.	—	—	+	+	—
<i>S. marginatus</i> L.	—	—	+	+	—
<i>Pterocera lambis</i> (L.)	—	—	+	+	—
<i>Natica marochiensis</i> Gmelin	—	—	+	+	+
<i>Natica tigrina</i> (Röding)	—	—	+	+	+
<i>N. ala-papilionis</i> (Röding)	—	—	+	+	+
<i>Polynices mamilla</i> (L.)	—	—	+	+	+

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>Sinum planulatum</i> (Récluz)	—	—	+	+	+
<i>Cypraea argus</i> L.	—	—	+	+	—
<i>C. caput-serpentis</i> L.	—	—	+	+	—
<i>C. tigris</i> L.	—	—	+	+	—
<i>C. ocellata</i> L.	—	—	+	+	—
<i>C. moneta</i> L.	—	—	+	+	—
<i>C. arabica</i> L.	—	—	+	+	—
<i>Ovulum formosum</i> Adams & Reeve	—	—	+	+	—
<i>Phalium areola</i> (Lam.)	—	—	+	+	+
<i>Cassis rafa</i> Lam.	—	—	+	—	—
<i>Cymatium cingulatum</i> (Lam.)	—	—	+	+	+
<i>Bursa spinosa</i> (Lam.)	—	+	+	+	+
<i>Murex trapa</i> Röding	—	—	+	+	+
<i>M. ramosus</i> L.	—	—	+	+	+
<i>M. aculeatus</i> Lam.	—	—	+	+	+
<i>Drupa tuberculata</i> (Blainville)	—	—	+	+	+
<i>Marginella dens</i> Reeve	—	—	+	+	+
<i>Vasum cornigera</i> (L.)	—	—	+	—	—
<i>Phos roseatus</i> Hinds	—	—	+	—	—
<i>Thais bufo</i> (Lam.)	—	—	+	—	—
<i>T. rugosa</i> (Börn)	—	—	+	+	+
<i>Pyrene versicolor</i> (Sowerby)	—	—	+	+	+
<i>Engina trifasciata</i> Melvill	—	—	+	+	+
<i>E. zonata</i> (Reeve)	—	—	+	+	+
<i>Babylonis spirata</i> (L.)	—	—	+	—	—
<i>Hemifusus pugilinus</i> (Börn)	—	—	+	—	—
<i>Bullia melanoides</i> (Deshayes)	—	—	+	+	+
<i>Nassa echiuata</i> Adams	—	—	+	+	+
<i>N. granifera</i> Kiener	—	—	+	+	+
<i>N. ornata</i> Kiener	—	—	+	+	+

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>Penisternia pulchella</i> (Reeve)	—	—	+	+	+
<i>Fasciolaria filamentosa</i> Lam.	—	—	+	—	—
<i>Fusinus toreuma</i> (Lam.)	—	—	+	—	—
<i>Oliva gibbosa</i> (Börn)	—	—	+	—	—
<i>O. oliva</i> (L.)	—	—	+	—	—
<i>Mitra acuminata</i> Swainson	—	—	+	—	—
<i>M. insculpta</i> Adams	—	—	+	—	—
<i>Xancus pyrum</i> (L.)	—	—	+	—	—
<i>Harpa conoidalis</i> Lam.	—	—	+	—	—
<i>Turris tigrina</i> (Lam.)	—	—	+	+	+
<i>Turricula tornata</i> (Dillwyn)	—	—	+	+	+
<i>Conus acuminatus</i> Bruguière	—	—	+	+	+
<i>C. lividus</i> Hwass	—	—	+	+	+
<i>C. coronatus</i> Dillwyn	—	—	+	+	+
<i>Rhizoconus lineatus</i> Chemnitz	—	—	+	+	+
<i>Lithoconus eburneus</i> Hwass	—	—	+	+	+
<i>Conus zonatus</i> Hwass	—	—	+	+	+
<i>Duplicaria duplicate</i> (L.)	—	—	+	+	+
<i>Terebra subulata</i> (L.)	—	—	+	+	+
<i>T. crenulata</i> L.	—	—	+	+	+
<i>T. comaticulata</i> Gmelin	—	—	+	+	+
<i>Ficus ficus</i> (L.)	—	—	+	—	—
<i>Pustularia icercula</i> (L.)	—	—	+	—	—
: OPISTHOBEANCHIA :					
<i>Pupa tessellata</i> Reeve	—	—	+	+	+
<i>Hydatina velum</i> (Gmelin)	—	—	+	+	+
<i>Bulla ampulla</i> L.	—	—	+	+	—
<i>Atys cylindricus</i> (Helbling)	—	—	+	—	—
<i>Microhedyle</i> spp.	+	—	—	—	—
<i>Parhedyle</i> spp.	+	—	—	—	—

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>Aplysia benedicti</i> Eliot	—	—	—	+	+
<i>A. corigera</i> Sowerby	—	—	—	+	+
<i>A. lineolata</i> Adams & Reeve	—	—	—	+	+
<i>Dolabella rumphii</i> Cuv.	—	—	+	+	+
<i>Polybrachia orietalis</i> (Kelaart)	—	—	—	+	+
<i>Elysia grandifolia</i> Kelaart	—	—	—	+	+
<i>Euseleops winckworthi</i> Satyamurti	—	—	+	+	+
<i>Marionia pambanensis</i> O'Donoghue	—	—	+	+	+
<i>Armina paucidentata</i> (O'Donoghue)	—	—	+	+	+
<i>Glossodoris humberti</i> (Kelaart)	—	—	+	+	+
<i>Chromodoris pustulana</i> (Börn)	—	—	+	+	+
<i>Discodoris pardalis</i> (Alder & Hancock)	—	—	+	+	+
<i>Dendrodoris indica</i> Stimpson	—	—	+	+	+
<i>Notodoris gardineri</i> Smith	—	—	+	+	+
<i>Doto indica</i> Stimpson	—	—	—	+	+
<i>Trippa ornata</i> Börn	—	—	—	+	+
<i>Thordista crosslandi</i> Eliot	—	—	+	+	+
<i>Eubbranchus proliuctus</i> (Farran)	—	—	+	+	—
<i>Hervia ceylonica</i> Farran	—	—	+	+	+
<i>Phylliroe</i> spp.	—	—	—	+	—
<i>Pseudovermes salamandrops</i> Marcus	—	—	+	+	+
<i>Glaucus marinus</i> (Dupont)	—	—	—	+	—
<i>Siphonaria stellata</i> (Helbling)	—	—	—	+	+
<i>Onchidium verruculatum</i> Cuv.	—	—	+	+	+
: SCAPHOPODA : DENTALIIDAE :					
<i>Dentalium octangulatum</i> Donovan	—	—	+	—	—
<i>D. manaarense</i> Winckworth	—	—	+	—	—
: LAMELLIBRANCHIA : TAXODONTA :					
<i>Arca inaequalis</i> Bruguière	—	—	+	—	—

TABLE 1. (Continued)

Species/Niche	1	2	3	4	5
: DYSODONTA :					
<i>Limopsis belcheri</i> (Adams & Reeve)	—	—	+	+	+
<i>Modiolus perfragilis</i> (Duncker)	—	—	+	+	+
<i>M. trailii</i> (Reeve)	—	—	+	+	+
<i>M. arborescens</i> Chemnitz	—	—	+	+	+
<i>M. modiolus</i> (L.)	—	—	+	+	+
<i>M. tulipa</i> (Lam.)	—	—	+	+	+
<i>M. argentea</i> Reeve	—	—	+	+	+
<i>Musculus nana</i> (Duncker)	—	—	+	+	+
<i>Lithophaga gracilis</i> (Philippi)	—	—	+	+	+
<i>L. cinnamonea</i> (Lam.)	—	—	+	+	+
<i>Perna legumen</i> (Gmelin)	—	—	+	+	+
<i>P. viridis</i> (L.)	—	—	+	+	+
<i>Malleus malleus</i> (L.)	—	—	+	+	+
<i>Pteria chinensis</i> (Leach)	—	—	+	+	+
<i>Pinctada margaritifera</i> (L.)	—	—	—	+	—
<i>P. vulgaris</i> (Schumacher)	—	—	—	+	+
<i>Pinna bicolor</i> Gmelin	—	—	+	+	+
<i>P. muricata</i> (L.)	—	—	+	+	+
<i>P. serrata</i> Solander	—	—	+	+	+
: PSEUDOLAMELLIBRANCHIA :					
<i>Pecten tranquebaricus</i> (Gmelin)	—	—	+	+	—
<i>P. (Chlamys) crassicostratus</i> Sowerby	—	—	+	+	—
<i>P. (C.) irregularis</i> Sowerby	—	—	+	+	—
<i>Semipecten forbesianus</i> Adams & Reeve	—	—	+	+	—
<i>Spondylus imperialis</i> Chenu	—	—	+	+	—
<i>Lima inflata</i> Chemnitz	—	—	+	+	—
<i>L. fragilis</i> Chemnitz	—	—	+	+	+
<i>Placenta placenta</i> (L.)	—	—	+	+	—
<i>Ammusium paucilirata</i> Smith	—	—	+	+	+

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
: OSTRAEIFORMES :					
<i>Ostrea forsskali</i> Gmelin	—	—	—	+	+
<i>O. madrasensis</i> Preston	—	—	—	+	+
: EULAMELLIBRANCHIA :					
<i>Cardita bicolor</i> Lam.	—	—	+	—	—
<i>Lucina edentula</i> (L.)	—	—	+	—	—
<i>L. vesteula</i> Gould	—	—	+	—	—
<i>Divaricella eumingii</i> (Adams & Angas)	—	—	+	—	—
<i>Codakia divergens</i> (Philippi)	—	—	+	—	—
<i>Chama imbricata</i> Broderif	—	—	—	+	+
<i>Pseudochama cristella</i> (Lam.)	—	—	—	+	+
<i>Cardium asiaticum</i> Brugière	—	—	+	—	—
<i>C. papyracea</i> Chemnitz	—	—	+	—	—
<i>C. maculosum</i> Wood	—	—	+	—	—
<i>Tridacna tridacna</i> L.	—	—	+	+	—
<i>T. cummingii</i> Reeve	—	—	+	+	—
<i>Circe scripta</i> (L.)	—	—	+	—	—
<i>Gafrarium tumidum</i> Röding	—	+	+	—	—
<i>G. dispar</i> (Chemnitz)	—	+	+	—	—
<i>Meretrix casta</i> (Chemnitz)	—	+	+	—	—
<i>Pitar alabastrum</i> (Reeve)	—	+	+	—	—
<i>Sunetta scripta</i> (L.)	—	+	+	—	—
<i>Dosinia cretacea</i> (Reeve)	—	+	+	—	—
<i>Venus reticulata</i> L.	—	+	+	—	—
<i>Antigona lamellaris</i> Schumacher	—	—	+	—	—
<i>Ohione calophylla</i> (Philippi)	—	—	+	+	—
<i>Venerupis macrophylla</i> Deshayes	—	—	+	+	—
<i>Paphia ala-papilionis</i> Röding	—	+	+	—	—
<i>Mesodesma trigona</i> Deshayes	—	+	+	—	—
<i>Mactra cuneata</i> Chemnitz	—	+	+	—	—

TABLE 1. (*Continued*)

Species/Niche	1	2	3	4	5
<i>M. violacea</i> Chemnitz	—	+	+	—	—
<i>Lutrarir philippinarum</i> Deshayes	—	—	+	—	—
<i>Donax cuneatus</i> L.	—	—	+	—	—
<i>D. aperittus</i> Melvill	—	—	+	—	—
<i>Psammobia bipartita</i> Philippi	—	—	+	—	—
<i>Tellina angulata</i> Gmelin	—	+	+	—	—
<i>T. pristis</i> Lam.	—	+	+	—	—
<i>T. rugosa</i> Börn	—	+	+	—	—
<i>Siliqua radiata</i> (L.)	—	+	+	—	—
<i>Solen lamarckii</i> Deshayes	—	—	+	—	—
<i>S. annandale</i> Preston	—	—	+	—	—
<i>Cultellus maximus</i> (Gmelin)	—	—	+	—	—
<i>Corbula modesta</i> Hinds	—	—	+	—	—
<i>Gastropoda gigantea</i> (Deshayes)	—	—	+	—	—
<i>Pholas orientalis</i> Gmelin	—	—	+	+	+
<i>Martesia striata</i> (L.)	—	—	—	—	+
<i>Laterula anatina</i> (L.)	—	—	+	—	—
: SEPTIBRANCHIA :					
<i>Cuspidaria elegans</i> Hinds	—	—	+	—	—
: CEPHALOPODA ; OCTOPODA :					
<i>Octopus hongkongensis</i> Hoyle	—	—	—	+	+
<i>O. rugosus</i> (Bosc)	—	—	—	+	+
<i>O. arborescens</i> Hoyle	—	—	—	+	+
<i>O. horridus</i> (d'Orb.)	—	—	—	+	+
<i>O. cyaneus</i> Gray	—	—	—	+	+
<i>O. fusiformis</i> Brock	—	—	—	+	+
<i>O. macropus</i> Risso	—	—	—	+	+
<i>Cistopus indicus</i> (Férussac et d'Orb.)	—	—	—	+	+
: ECHINODERMATA : CRINOIDEA : ARTICULATA :					
<i>Comatula pectinato</i> (L.)	—	—	—	+	+
<i>Capillaster multiradiata</i> (L.)	—	—	—	+	+
<i>Amphimetra milberti</i> (J. Müller)	—	—	—	+	+
<i>Dichrometra palmata</i> (J. Müller)	—	—	—	+	+
<i>Tropiometra encrinus</i> (Lütken)	—	—	—	+	+
<i>Antedon indica</i> Carpenter	—	—	—	+	+
<i>Iridometra nana</i> (Hartlaub)	—	—	—	+	+

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
: HOLOTHUROIDEA : DENDROCHIROTA :					
<i>Calochirus violaceus</i> Theel	—	—	+	—	—
<i>Cucumaria echinata</i> Marenzeller	—	—	+	—	—
<i>C. imbricata</i> (Semper)	—	—	+	—	—
<i>C. ardens</i> Koehler & Vaney	—	—	+	—	—
<i>Psolus monacaria</i> Lesson	—	—	+	—	—
: ASPIDOCHIROTA :					
<i>Holothuria atra</i> Jäeger	—	—	+	—	—
<i>H. edulis</i> Lesson	—	—	+	—	—
<i>H. impatiens</i> Forsskal	—	—	+	—	—
<i>H. pardalis</i> Selenka	—	—	+	—	—
<i>H. kurti</i> Lampert	—	—	+	+	—
<i>H. billa</i> Lesson	—	—	+	—	—
<i>H. marmorata</i> (Jäeger)	—	—	+	+	+
<i>H. scabra</i> Jäeger	—	—	+	+	+
<i>Actinopyga mauritiana</i> (Quoy & Gaimard)	—	—	+	+	—
<i>Stichopus variegatus</i> Semper	—	—	+	—	—
<i>Thelenota ananas</i> (Jäeger)	—	—	+	—	—
<i>Microthele nobilis</i> (Selenka)	—	—	+	—	—
: MOLPADONIA :					
<i>Haplodactyla molpadioides</i> Semper	—	—	+	—	—
: APODA :					
<i>Synapta maculata</i> (Cham. & Eysen.)	—	—	+	—	—
<i>Chiridota rufescens</i> Brandt	—	—	+	—	—
: ASTEROIDEA : PHANEROZONIA : PAXILLOSA :					
<i>Astropecten indicus</i> Döderlein	—	—	+	+	—
<i>A. monacanthus</i> Sladen	—	—	+	+	+
<i>A. polyacanthus</i> Müller & Troschel	—	—	+	+	—
<i>A. nobilis</i> Koehler	—	—	+	+	—
<i>A. pugnax</i> Koehler	—	—	+	—	—
<i>Lurdia limbata</i> (Sladen)	—	—	+	+	+
<i>L. maculata</i> Müller & Troschel	—	—	+	+	+
: VALVATA :					
<i>Archaster typicus</i> Müller & Troschel	—	—	+	—	—
<i>Craspidaster hesperus</i> (M. & Tr.)	—	—	+	—	—
<i>Goniodiscus forficulatus</i> Perrier	—	—	+	—	—
<i>Stellaster inaei</i> Gray	—	—	+	—	—

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>Pentaceros regulus</i> (M. & Tr.)	—	—	+	—	—
<i>P. iudicus</i> Koehler	—	—	+	—	—
<i>P. superbis</i> Möbius	—	—	+	—	—
<i>Asterina cephea</i> (Müller & Troschel)	—	—	+	—	—
<i>A. exigua</i> (Lam.)	—	—	+	—	—
<i>A. lorioli</i> Koehler	—	—	+	—	—
: ECHINOIDEA : REGULARIA : AULODONTA :					
<i>Astropyga radiata</i> (Leske)	—	—	+	—	—
: STIRODONTA :					
<i>Stomopneustes variolaris</i> (Lam.)	—	—	+	+	+
: CAMARODONTA :					
<i>Temnopleurus torematicus</i> (Klein)	—	—	+	+	+
<i>Salmacis bicolor</i> Agassiz	—	—	+	+	+
<i>S. virgulata</i> Agassiz	—	—	—	+	+
<i>S. roseo-viridis</i> Koehler	—	—	—	+	+
<i>Tripneustes gratilla</i> (L.)	—	—	—	+	+
<i>Heterocentrotus mammillatus</i> (L.)	—	—	—	+	+
<i>Echinometra mathaei</i> (Blainville)	—	—	—	+	+
: IRREGULARIA : CASSIDULOIDA :					
<i>Echinolampus ovatus</i> (Leske)	—	—	+	—	—
: CLYPEASTROIDA :					
<i>Olypeaster annandalei</i> Koehler	—	—	+	+	—
<i>C. humilis</i> (Leske)	—	—	+	—	—
<i>C. rarispinus</i> (Meijère)	—	—	+	+	—
<i>Echinocyamus crispus</i> Mazetti	—	—	+	—	—
<i>Fibularia volvo</i> Agassiz & Desor	—	—	+	+	—
<i>Lagenum decagonale</i> (De Blainville)	—	—	+	+	—
<i>L. depressum</i> (Lesson)	—	—	+	+	—
<i>Echinodiscus auritus</i> (Leske)	—	—	+	—	—
<i>E. biperforatus</i> (Leske)	—	—	+	—	—
: SPATANGOIDA :					
<i>Pseudomaretia alta</i> (Agassiz)	—	—	+	+	—
<i>Lovenia elongata</i> (Gray)	—	—	+	+	—
<i>Brissopsis luzonica</i> (Gray)	—	—	+	—	—
<i>Metalia maculosa</i> (Gmelin)	—	—	+	—	—
: OPHIUROIDEA : OPHIURAE :					
<i>Ophiomyxa brevispina</i> Martens	—	—	+	+	+

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>Ophiacantha decora</i> Koehler	—	—	+	+	+
<i>O. vagans</i> Koehler	—	—	+	+	+
<i>Amphiura duncani</i> Loriol	—	—	+	+	+
<i>Amphiopholis squamta</i> (Della Chiaje)	—	—	+	+	+
<i>Ophiocnida echinata</i> (Ljungman)	—	—	+	—	—
<i>Ophiactis affinis</i> Duncan	—	—	+	+	+
<i>Ophiolepis rugosa</i> Koehler	—	—	+	+	+
<i>Ophiura</i> (<i>Ophioglypha</i>) <i>sinensis</i> Lyman	—	—	+	+	+
<i>Ophiothela danae</i> Verrill	—	—	+	+	+
<i>Ophiothrix comata</i> Müller & Troschel	—	—	+	+	+
<i>O. nereidina</i> (Lam.)	—	—	+	+	+
<i>O. speciosa</i> Koehler	—	—	+	+	+
<i>O. trilineate</i> Lütken	—	—	+	+	+
<i>Ophiocoma brevipes</i> Peters	—	—	+	+	+
<i>O. scolopendrine</i> Agassiz	—	—	+	+	+
<i>Ophiocomella sexradiata</i> (Duncan)	—	—	+	+	+
<i>Ophiomastix annulosa</i> (Lam.)	—	—	+	+	+
<i>Ophiarthrum pium</i> (Müller & Troschel)	—	—	+	+	+
<i>Pectinura gorgonia</i> (M. & Tr.)	—	—	+	+	+
<i>Ophionereis porrecta</i> Lyman	—	—	+	—	+
: CHORDATA : HEMICHORDA :					
<i>Balanoglossus carnosus</i> (Willey)	—	—	+	—	—
<i>Ptychodera flava</i> Eschscholtz	—	—	+	—	—
<i>P. viridis</i> Punnett	—	—	+	—	—
: TUNICATA : ASCIDIACEA :					
<i>Ecteinascidia bombayensis</i> Das	—	—	—	+	+
<i>E. thurstoni</i> Herdman	—	—	—	+	+
<i>Herdmania pallida</i> Labille	—	—	—	+	+
<i>H. ennurensis</i> Das	—	—	—	+	+
<i>Styela areolata</i> Heller	—	—	—	+	+
<i>Ascidella aspersa</i> (O. F. Müller)	—	—	—	+	+
<i>Polyclinum indicum</i> Sebastian	—	—	—	+	+
<i>Phallusia mammillata</i> (Cuv.)	—	—	—	+	+
<i>Glossophorum indicum</i> Das	—	—	—	+	+
<i>Perophora</i> spp.	—	—	—	+	+
: THALIACEA :					
<i>Pyrosoma atlanticum</i> Péron	—	—	—	+	—

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>Doliolum nationalis</i> Borgert	—	—	—	+	—
<i>D. (Dolioletta) gegenbauri</i> Uljanin	—	—	—	+	—
<i>Salpa (Iasis) zonaria</i> (Pallas)	—	—	—	+	—
: LARVACEA :					
<i>Oikopleura dioica</i> Fol	—	—	—	+	—
: CEPHALOCHORDA :					
<i>Amphioxus (Branchiostoma) spp.</i>	—	—	+	+	—
: PISCES : CHONDRICHTHYES : TORPEDINIFORMES :					
<i>Narcine brunnea</i> Annandale	—	—	+	+	—
<i>N. timlei</i> (Bloch & Schneider)	—	—	+	+	—
: OSTEICHTHYES : ANGUILLIFORMES :					
<i>Anguilla bicolor bicolor</i> Mc Clelland	—	—	—	+	—
<i>A. bengalensis bengalensis</i> (Gray & Hardwicke)	—	—	—	+	—
<i>Echidna nebulosa</i> (Ahl)	—	—	—	+	+
<i>E. delicatula</i> (Kaup)	—	—	—	+	+
<i>Gymnothorax reticularis</i> Bloch	—	—	—	+	+
<i>G. pseudothyrsoides</i> (Bleeker)	—	—	—	+	+
<i>Sideria picta</i> (Ahl)	—	—	—	+	+
<i>Uropterygius marmoratus</i> (Lacépède)	—	—	—	+	+
<i>Urocyngus lepturus</i> (Richardson)	—	—	—	+	+
<i>Conger cinereus</i> Rüppell	—	—	—	+	+
<i>Ophichthys apicalis</i> (Bennett)	—	—	+	—	—
<i>O. altipinnis</i> (Kaup)	—	—	+	—	—
: SILURIFORMES :					
<i>Plotosus limbatus</i> Val.	—	—	+	+	—
: ATHERINIFORMES :					
<i>Hemirhamphus lutkei</i> Val.	—	—	+	+	—
<i>Hyporhamphus affinis</i> (Günther)	—	—	—	+	—
: SYNGNATHIFORMES :					
<i>Fistularia petimba</i> Lacépède	—	—	—	+	—
<i>Centricus scutatus</i> L.	—	—	—	+	—
<i>Ichthyocampus carce</i> (Hamilton-Buchanan)	—	—	—	+	—
<i>Urocampus southwelli</i> Duncker	—	—	—	+	—
<i>Hippocampus kuda</i> Bleeker	—	—	—	+	—
: SCORPAENIFORMES :					
<i>Platycephalus scaber</i> (L.)	—	—	+	+	—

TABLE 1. (Continued)

Species / Niche	1	2	3	4	5
<i>P. crocodilus Tilesius</i>	—	—	+	+	—
<i>Pterois volitans</i> (L.)	—	—	—	+	+
<i>P. miles</i> Bennett	—	—	—	+	+
<i>Scorpaenodes gaumensis</i> (Quoy & Gaimard)	—	—	—	+	+
<i>Parascorpaena erostris</i> (Alcock)	—	—	—	+	+
<i>P. bleekeri</i> (Day)	—	—	—	+	+
<i>P. picta</i> (Cuv.)	—	—	—	+	+
<i>P. armata</i> (Sauvage)	—	—	—	+	+
<i>Choridactylus multibarbus</i> Richardson	—	—	—	+	+
<i>Minous monodactylus</i> (Bloch & Schneider)	—	—	—	+	+
: PERCIFORMER :					
<i>Ambassis commersoni</i> Cuv.	—	—	—	+	—
<i>A. gymnocephalus</i> (Lacépède)	—	—	—	+	—
<i>A. interruptus</i> Bleeker	—	—	—	+	+
<i>Epinephelus areolacus</i> (Forsskal)	—	—	—	+	+
<i>E. flavocaerulus</i> (Lacépède)	—	—	—	+	+
<i>E. tauvina</i> (Forsskal)	—	—	—	+	+
<i>Pelates quadrilineatus</i> (Bloch)	—	—	—	+	+
<i>Terapon jarbua</i> (Forsskal)	—	—	—	+	+
<i>T. theraps</i> Cuv.	—	—	—	+	+
<i>Apcgonichthys ellioti</i> (Day)	—	—	—	+	+
<i>Apogon enneastigma</i> (Rüppell)	—	—	—	+	+
<i>A. quadrifasciatus</i> Cuv.	—	—	—	+	+
<i>Sillago maculata</i> Quoy & Gaimard	—	+	+	—	—
<i>S. sihama</i> (Forsskal)	—	+	+	—	—
<i>Pseudochromis fuscus</i> M. & Tr.	—	—	—	+	+
<i>Uranoscopus fuscomaculatus</i> Kner	—	—	+	+	+
<i>Jchthyoscopus lebeck</i> (Bloch)	—	—	+	+	+
<i>Blennichthys breviceps</i> Cuv.	—	—	—	+	+
<i>Salarias leoparpus</i> Day	—	—	—	+	+
<i>Istiblennius unicolor</i> (Rüppell)	—	—	—	+	+
<i>Dascyllus trimaculatus</i> (Rüppell)	—	—	—	+	+
<i>Cheiloprion labiatus</i> (Day)	—	—	—	+	+
<i>Abudefduf septumfasciatus</i> (Cuv.)	—	—	—	+	+
<i>Coris gaimardi</i> (Quoy & Gaimard)	—	—	—	+	+
<i>Aprion virescens</i> Val.	—	—	—	+	+
<i>Paracaesio sordidus</i> Ade & Shinohara	—	—	—	+	+

TABLE 1. (Concluded)

Sepcies / Niche	1	2	3	4	5
<i>O. erythrogaster</i> Cuv.	—	—	—	+	—
<i>Gerres abbreviatus</i> Bleeker	—	—	—	+	+
<i>G. filamentosus</i> Cuv.	—	—	—	+	+
<i>G. oblongus</i> Cuv.	—	—	—	+	+
<i>Pomadasys hasta</i> (Bloch)	—	—	—	+	+
<i>Scatophagus argus</i> (L.)	—	—	—	+	+
<i>Parachaetodon ocellatus</i> (Cuv.)	—	—	—	+	+
<i>Chaetodon vagabundus</i> L.	—	—	—	+	+
<i>C. trifasciatus</i> Mungo Park	—	—	—	+	+
<i>Liza parsia</i> (Ham.-Buch.)	—	—	—	+	+
<i>Mugil cephalus</i> L.	—	—	—	+	+
<i>Ctenochaetus strigosus</i> (Bennett)	—	—	—	+	+
: GOBIESOCIFORMES :					
<i>Eleotriodes muralis</i> (Val.)	—	—	—	+	+
<i>Gobiodon citrinus</i> (Rüppell)	—	—	—	+	+
<i>Stenogobius malabaricus</i> (Day)	—	—	—	+	+
<i>Oxyurichthys microlepis</i> (Bleeker)	—	—	—	+	+
<i>O. tentacularis</i> (Val.)	—	—	—	+	+
<i>Cottogobius bilobatus</i> Koumans	—	—	—	+	+
<i>Glossogobius biocellatus</i> (Val.)	—	—	—	+	+
<i>Acentrogobius ornatus</i> (Rüppell)	—	—	—	+	+
<i>Mugilogobius valigouva</i> (Deriyanaagala)	—	—	—	+	+
<i>Stigmatogobius javanicus</i> (Bleeker)	—	—	—	+	+
<i>Parapocryptes macrolepis</i> (Bleeker)	—	—	—	+	+
: TETRAODONTIFORMES :					
<i>Triacanthus brevirostris</i> Schlegel	—	—	—	+	+
<i>Lactoria cornuta</i> (L.)	—	—	—	+	+
<i>Ostracion tuberculata</i> L.	—	—	—	+	+
<i>Tetrosomus gibbosus</i> (L.)	—	—	—	+	+
<i>Abalistes stellaris</i> (Bloch)	—	—	—	+	+
<i>Diodon hystrix</i> L.	—	—	—	+	+
<i>Tetradon inermis</i> Temminck & Schlegel	—	—	—	+	+
: BATRACHOIDIFORMES :					
<i>Halophryne dussumieri</i> (Val.)	—	—	—	+	+
<i>H. gangene</i> (Hamilton)	—	—	—	+	+
: LOPHIIFORMES :					
<i>Histrio histrio</i> (L.)	—	—	—	+	+
<i>Antennarius commersoni</i> (Cuv.)	—	—	—	+	+
<i>A. leprosus</i> Eydoux & Souleyet	—	—	—	+	+
<i>A. hispidus</i> (Bloch)	—	—	—	+	+
: REPTILIA : OPHIDIA :					
<i>Hydrophis cantoris</i> Günther	—	—	—	+	+
<i>Microcephalopholis gracilis</i> Shaw	—	—	—	+	+

TABLE 2. Contribution of species by each major group to the population of the inter-tidal zone.

	Major Group	No. of species
FLORA :	Diatomacea	14
	Chlorophyceae	9
	Phaeophyceae	6
	Rhodophyceae	15
	Cyanophyceae	1
FAUNA :	Protozoa	43
	Porifera	19
	Coelenterata	48
	Platyhelminthes	19
	Aschelminthes	49
	Entoprocta	2
	Annelida	53
	Echiuroidea	1
	Sipunculida	5
	Brachiopoda	1
	Phoronida	1
	Chaetognatha	2
	Ectoprocta	15
	Arthropoda	105
	Mollusca	227
	Echinodermata	88
	Hemichorda	3
	Tunicata	15
	Cephalochorda	1
	Pisces	95
	Reptilia	5
	Aves	16
TOTAL		858 species

SYSTEMATIC STATUS OF THE GENERA *ADINDA*, *PERISCYPHIS*,
PARAPERISCYPHIS AND *TORADJIA*

CRUSTACEA—ISOPODA—ONISCOIDEA—ARMADILLIDAE

G. RAMAKRISHNA, AND BHANUDEB SINHA

Zoological Survey of India, Calcutta.

INTRODUCTION

The genus *Toradjia* was established by Dollfus during 1898 on the collection of Dutch East Indies. During 1904, Budde-Lund created the genus *Adinda* to include *Periscyphis Weberi* Dollfus, but gave no description of generic characters. This genus is undoubtedly the same as *Paraperiscyphis* Stebbing 1911 according to Omer-Cooper (1926).

Paraperiscyphis was set up in 1911 by Stebbing to include his new species *Paraperiscyphis travancorensis* from Madathorai, formerly from travancore state now in Kerala.

The authors agree with the views expressed by Omer-Cooper, that there has been no valid character by which the four genera can be separated namely *Toradjia*, *Adinda*, *Periscyphis* and *Pavaperiscyphis*, and according to law of priority genus *Toradjia* stands valid to accomodate under other genera namely *Adinda*, *Periscyphis* *Paraperiscyphis*.

While the senior author was studying the Oniscid Isopod in connection with the preparation of "Fauna of India—Oniscidae", he came across these interesting genera and felt this fact should be cleared in the interest of science and compelled him to write an account. Besides, fortunately all the type of the species of *Tradja* are represented in the Zoological Survey of India collection.

The genus includes the following species from Indian region namely :

1. *Toradjia gigas* (Collinge)
2. *Toradjia pulcher* (Collinge)
3. *Toradjia scabrus* (Collinge)
4. *Toradjia stebbingi* (Collinge)

and 5. *Toradjia travancorensis* (Stebbing)

Toradjia Dollfus

1898. *Toradjia* Dollfus, Prof, Max Weber's Publ. *Zool. Ergebnisse einer Reise in Niederlandisch Ost-Indien*, 4 (2) : 357-382 (1907).
1904. *Adinda* Budde-Lund. *A Revision of the Crustacea Isopoda Terrestria. pt. 2, Spherilloninae pt. 3, Armadillo, Copenhagen.*
1911. *Paraperiscyphis*, Stebbingi, *Rec. Indian Mus.*, Calcutta 6 (4) : 184.
1914. *Paraperiscyphis* Collinge, *Rec. Indian Mus.*, Calcutta 10 (3) : 207-209.
1915. *Periscyphis* Collinge, *Rec. Indian Mus.*, Calcutta 11 (2) : 148.
1916. *Paraperiscyphis* Collinge, *Rec. Indian Mus.*, Calcutta 12 (2) : 115-117.
1922. *Toradjia* Richardson, *Proc. United States Nat. Mus.*, 60 (24) : 3-4.
1926. *Toradjia* Omer-Cooper, *Proc. Zool. Soc. London*, 1 : 349-400
1936. *Adinda* Jackson, *Bull. Raffles Mus., Singapore* 12 : 84.

Characters : Body oblong-oval, smooth or with tubercles slightly convex ; cephalon small, flanked on either side by the lateral plates of the first thoracic segment ; lateral lobes well developed, median lobe present but small ; eyes sub-dorsal. In the second antennae, the first joint of the flagellum shorter than the second. The telson, obtuse, triangular and not narrowly produced at the apex. The inner branch of the uropod attached not to the projection of the peduncle's base but to a notch far below the inner margin, while still further below attached the outer branch ; both branches extending beyond the peduncle itself extending beyond the telson.

This genus was established by Dollfus during 1898 on the collection from Dutch East Indies, During 1904, Budde-Lund formed the genus *Adinda* to contain *Periscyphis weberi* Dollfus, but gave no description of the generic characters. This genus is undoubtedly the same as *Paraperiscyphis* Stebbingi, 1911 according to Omer-Cooper (1926). The genus *Paraperiscyphis* was established by Stebbingi to include his new species *P. travancorensis* from Maddathorai, former Travancore (Kerala). The author agrees with the views expressed by Omer-Cooper, that there has been no valid characters by which the three genera can be separated viz. *Toradjia*, *Adinda* and *Paraperiscyphis* and according to law of priority, the genus *Toradjia* stands valid to accommodate species described later under genera *Adinda* and *Paraperiscyphis*.

Type-Species : *Periscyphis weberi* Dollfus, 1898.

Distribution : Indonesia, India, Sri Lanka, East Africa, and Malaysia.

Keys to the Indian Species of the Genus Toradjia (Paraperiscyphus)

1. Body surface smooth length about twice its greatest width.
 - 1a. Body surface tubercular.
2. Lateral lobes of head raised in an angle.
 - 2a. Lateral lobes well developed.

3. Eyes small with three longitudinal rows of ocelli 17 in member.
... *Toradjia gigas* (Collinge).
- 3a. Eyes larger with 13 ocelli arranged in three longitudinal rows.
... *Toradjia pulcher* (Collinge).
4. Surface richly tubercular eyes with 11 ocelli arranged in three rows.
... *Toradjia Scabrus* (Collinge).
- 4a. Surface with rows of tubercles well arranged, eyes with 22 ocelli arranged in four rows.
... *Toradjia Strebbing* (Collinge).
- 4b. Surface with minutely Setose warts, eyes with 16 ocelli arranged in four rows.
... *Toradjia travancorensis* (Strebbingi).

***Toradjia gigas* (Collinge)**

Text-Fig. 1 & 2 (1-8)

1898. *Toradjia* Dollfus, Prof. Max Weber's Publ. Zool. *Ergebnissener. Reise in Niederlandisch Ost-Indien* 4 (2) : 357-382 (1907).

1915. *Periscyphis gigas* Collinge, *Rec. Indian Mus.*, 11 (2) : 141-149.

1916. *Paraperiscyphis gigas* Collinge, *Rec. Indian Mus.*, 12 (3) : 116.

General : Body oblong oval (Text fig. 1) very strongly convex and surface practically smooth. Length nearly double the greatest breadth.

Cephalon : Head (Text fig. 2-1) about two and half times wider than long, completely embedded within the lateral plates of the 1st thoracic somite. Anterior edge folded in the centre, with a triangular spine on its ventral surface. Lateral edges slightly raised in an angle. Central portion of posterior border depressed. Eyes small compared to the size of the specimen, with three longitudinal rows of ocelli 17 in number.

Thorax : Mesosomatic somites broad, strongly convex and gradually decreasing in size towards the posterior end. Lateral plates of first thoracic somite covering the lateral sides of the head. The first somite widest of all. All other somites sub-equal in width.

Abdomen : Abdomen about one-third in length of the mesosome, almost of the same width as the last thoracic somite. The first two segments small, covered by the last thoracic somite. Lateral plates of third to fifth somites expanded distally. Telson (Text fig. 1) broadly triangular, convex and smooth, its distal being rounded.

Appendages : First antenna (Text fig. 2-3) short and stout, 3 jointed, its distal end being pointed. Mandibles consisting an outer cutting edge with three blunt teeth and a blunt process on the inner edge beneath which is tuft of setae.

First maxilla (Text fig. 2-5) outer lobe terminating in four curved spines and five finer and straighter ones on the inner side. Second maxilla thin and plate-like, the inner lobe terminating in a mass of setae, while the outer lobe is more robust and tooth-like.

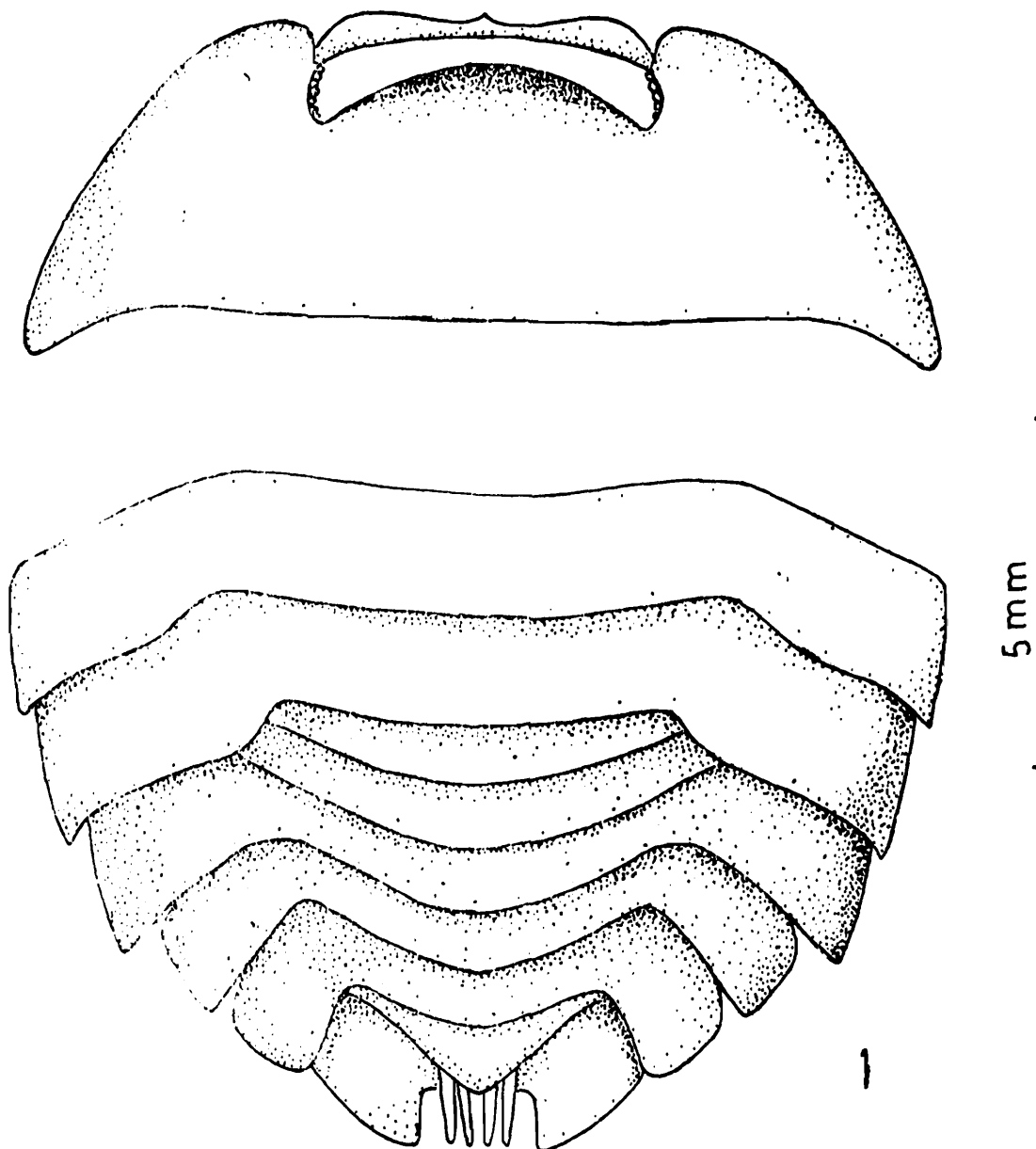


Fig. 1. *TORADJIA gigas* (Collinge) DORSAL VIEW
Head with Paereon Segment Paereon and Pleon.

Maxillipedes (Text fig. 2-4) inner lobe palp-like with setae on the inner side and two rows across the distal side, the outer palp terminating in three multispinous processes.

Thoracic appendages (Text fig. 2-7) robust and fringed with numerous spines with trifid terminal portion and smaller spines.

Uropoda (Text fig. 2-6) with a large basal plate, extending beyond the telson. Outer margin subcrenate ; expodite articulating on the middle inner border, endopodite

slightly longer than the exopodite and articulating at the top of the inner border of the basal plate.

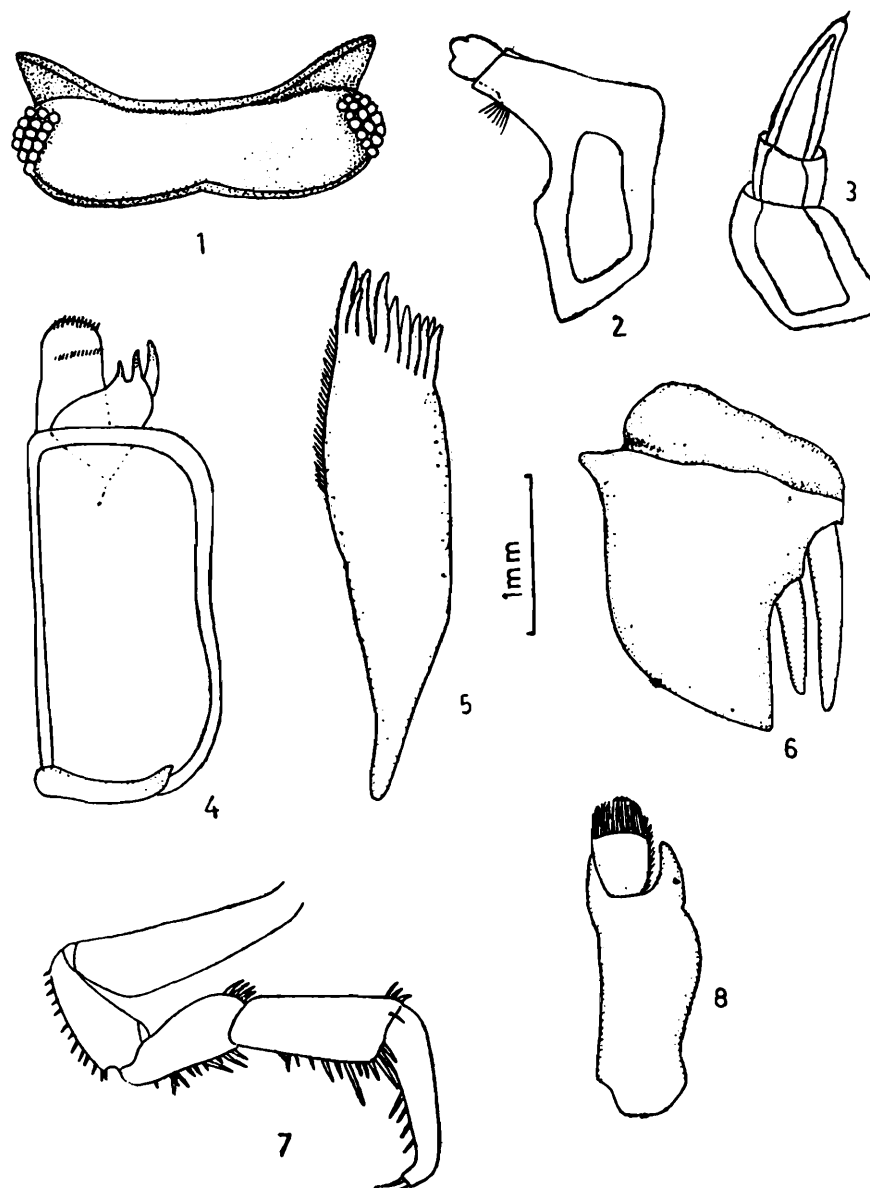


Fig. 2 (1-8). *TORADJIA gigas* (Collinge)

1. Dorsal view of Cephalon, 2. Right mandible, 3. First antenna, 4. Maxillipede,
5. Outer lobe of first maxilla, 6. Left uropod, 7. Second thoracic leg, 8. Second maxilla.

Colour horny-brown with the lateral plates of the 1st fifth and sixth mesosomatic and the third and fourth metasomatic segments yellow.

Length and breadth of female specimen 24 mm. and 13 mm. respectively.

Type-locality : Ponmudi near Trivandrum, Kerala, INDIA, September, 1893, Coll. H. S. Ferguson.

Syntypes : A male and female in the National Collections of the Zoological Survey of India, Calcutta. Regd. No. 8626/10.

Distribution : This species is known, so far, from its type locality only.

Remarks : Since either of the two specimens do not possess the second antennae, it has not been possible to furnish particulars of the same.

Toradjia pulcher (Collinge)

Text-Fig. 1 & 2 (1-8)

1893. *Toradjia* Dollfus, Prof. Max Weber's Publ. *Zool. Ergebnissener. Reise in Niederlandisch Ost-Indien* 4 (2) : 357-382 (1907).

1916. *Parapericyphis pulcher* Collinge, *Rec. Indian Mus.*, 12 (3) : 116.

1975. *Paraperiscyphis pulcher* Ramakrishna, *Rec. zool. Surv, India*, 68 : 297-303.

General : Body elongate oval (Text-fig. 1) strongly convex, about two and half times longer than broad. Surface smooth all through.

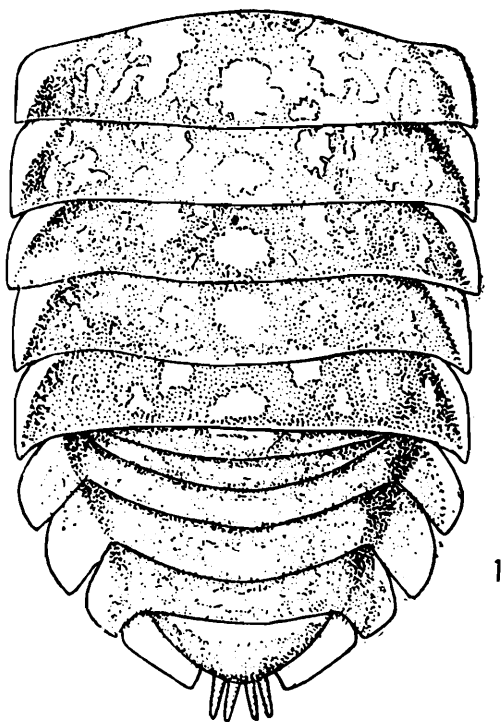
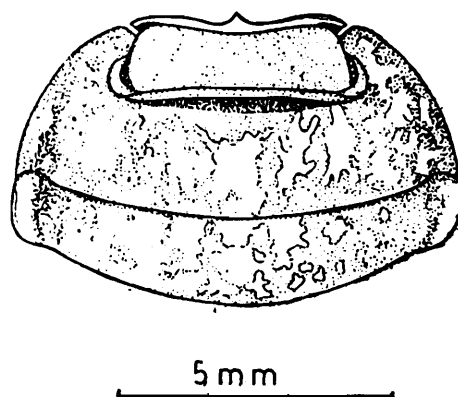


Fig. 1. *TORADJIA pulcher* (Collinge) Dorsal View.

Cephalon : Head almost three times wider than long, oval shaped. Frontal margin folding inwards with its middle portion deep, its ventral part forming a well developed, large and blunt spine. Antero-lateral lobes well developed. Posterior margin smooth and rounded postero-laterally. Eyes large, dorso-lateral, placed well behind the lateral lobe of the head with thirteen ocelli arranged in three longitudinal rows.

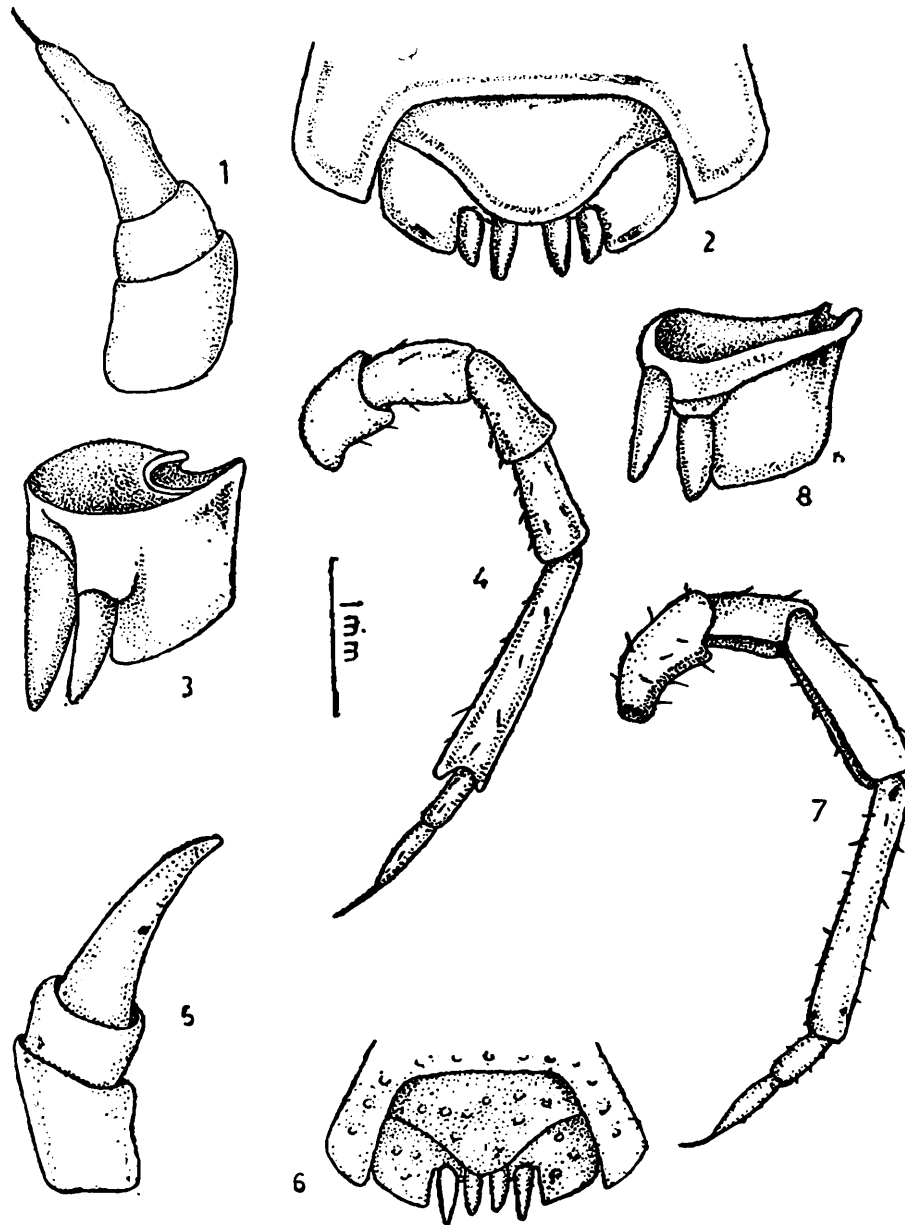


Fig. 2 (1-8). *TORADJIA pulcher* (Collinge)

1. Right antenna, 2. Telson with uropoda, 3. Right uropoda—dorsal view, 4. Right antenna (second antenna).

TORADJIA scabrus (Collinge)

5. Left antennule (first antenna), 6. Telson with uropoda, 7. Right antenna (second antenna), 8. Right uropoda, dorsal view.

Thorax : The first thoracic somite widest of all. Lateral plates of the first thoracic segment covering the head both laterally and posteriorly and its posterior part drawn out into an acute spine. The lateral plates of the second somite ending with a blunt

process, those of the third and fourth somites drawn posteriorly into a broad pointed spine. Lateral plates of the 5th to 7th segments not at all drawn but ending in a blunt process similar to that of the second somite. All the thoracic somites strongly convex.

Abdomen : Metasome about a third of the body. The first two somites, small, narrow and covered laterally by the lateral plates of the last thoracic somite. Third to fifth somites large with lateral plates expanding posteriorly. Telson large (Text fig. 2-2), broadly triangular with its apex slightly rounded.

Appendages : Antennule (Text fig. 2-1) small, and three-jointed, the distal longer than the basal two joints with its terminal portion ending in a style. The inner side of the fistal joint indented. Antennae (Text fig. 2-4) moderately stout and long, second to fourth joints almost subequal, the fifth joint longest. Flagellum two jointed, the proximal shorter than the distal, the latter ending in a fine style.

Uropoda (Text fig. 2-3) extending beyond the telson, basal plate short and stout with anterodorsal surface expanded, convex dorsally, concave ventrally. Exopodite and endopodite extending beyond the basal plate, both articulating on the inner margin, exopodite flat and blade-like, endopodite three sided.

Colour greyish green with regular yellow patches all through the mesosome and metasome, arranged in the median line and laterally.

Length and greatest breadth of the ovigerous female 18 and 7.5 mm. respectively.

Type-locality : Peradeniya, (Ceylon), Sri Lanka, 28.5.1910, coll. Dr. F. H. Gravely.

Holotype : An ovigerous female specimen (in two parts) in the National Collections of the Zoological Survey of India, Calcutta. Regd. No. 8603/10.

Distribution : In addition to its type locality viz. Peradeniya, Sri Lanka, this species is, so far, reported for the first time from the Silent Valley in Kerala, India.

Remarks : In the form of Cephalon, antennae, Uropoda and the size and shape of the specimen, this species differs from others of the genus.

Taradjia scabrus (Collinge)

(Text-Fig. 1)

1898. *Toradjia* Dollfus, Prof. Max Weber's Publ. *Zool. Ergebnissener. Reise in Niederlandisch Ost-Indien* 4 (2) 357-382 (1907).

1916. *Paraperiscyphis scabrus*, Collinge, *Rec. Indian Mus.*, 12 (3) : 117.

1975. *Paraperiscyphis scabrus* Ramakrishna, *Rec. Zool. Surv, India*, 68 : 297-303,

General : Body oblong oval, highly convex, (Text fig. 1) about two times longer than broad. Surface richly tubercular all through.

Cephalon : Head small, flanked on the lateral and posterior side by the lateral plates of first mesosomatic segment, its anterior frontal portion raised laterally into prominent lobes, the middle portion raised ventrally into a broad pointed process, almost looking like a spine. Posterior border with slight depression in the middle. Eyes dorso-lateral well behind the lateral lobes, with eleven ocelli arranged in three rows.

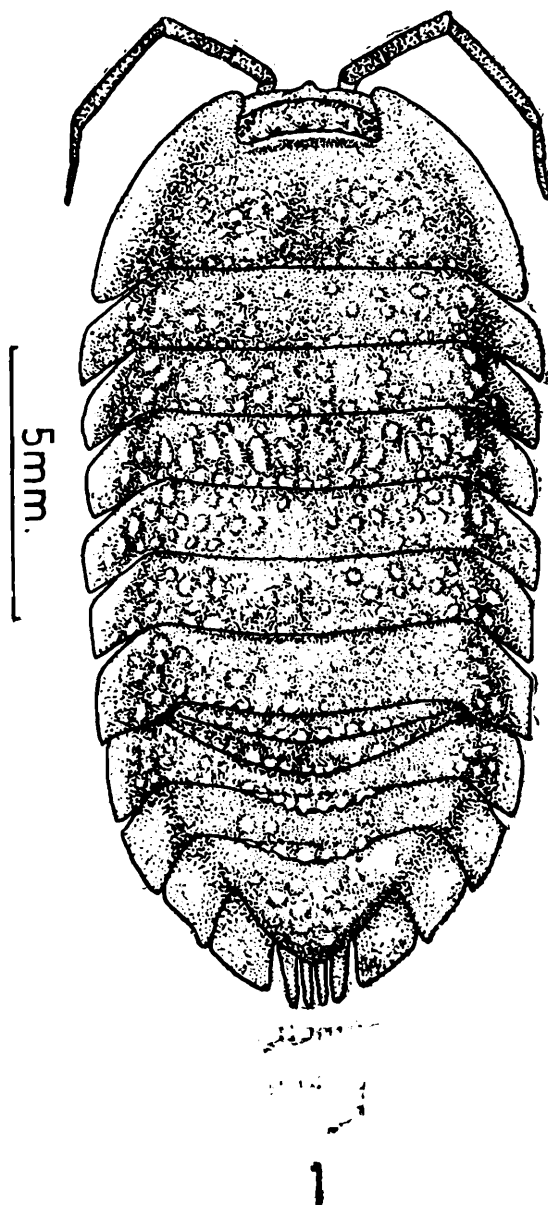


Fig. 1. *TORADJIA scabrus* (Collinge) Dorsal View.

Thorax : The first thoracic somite widest of all, the others being almost subequal. Lateral plates of all thoracic somite expanding posteriorly and ending in a blunt process, except the first one in an acute point.

Abdomen : Metasome about one third in length of the total body. The first two somites small, narrow in width and covered laterally by the lateral plates of the last thoracic segment. Third to fifth segments wider, prominent and their lateral plates

expanding posteriorly in an obtuse point. Telson (Text fig. 2-6) triangular with its apex broadly rounded.

Appendages : First antenna (Text fig. 2-5) small, three jointed, the distal joint terminating as a cone. Second antenna (Text fig. 2-7) short and stout, second and third joints subequal, fourth nearly double the size of the 2nd and fifth longest, about three times longer as the 2nd joint. Flagellum of two joints, with its proximal shorter than distal and the latter ending in a terminal style. The entire appendage being sparsely covered by blunt setae.

Uropoda (Text fig. 2-8) extending beyond telson, basal plate short and stout, with antero-dorsal surface expanded, convex dorsally with thickened antero-dorsal margin bounding the antero-dorsal surface, concave ventrally with groove. Exopodite and endopodite both extending beyond the basal plate and articulating on the inner margin.

Colour greenish brown with irregular yellow patches spread throughout the body.

Measurements of egg-bearing female specimen being 12 and 6 mm. in length and breadth respectively.

Type-locality : Peradeniya, (Ceylon), Sri Lanka, 26.5.1980, Coll. Dr. F. H. Gravely.

Holotype : An egg-bearing female in the National Collections of the Zoological Survey of India, Calcutta. Regd. No. 8585/10.

Distribution : In addition to its type locality, *Paraperiscyphus scabrus* is known to occur for the first time from Karnataka and Silent Valley in Kerala in India.

Remarks : *Paraperiscyphus scabrus* has some resemblance with regard to form of the telson and uropoda with *P. pulcher*, but it is distinct from it by the striking difference in the shape and development of the lateral and median lobes of the cephalon, antennule, antenna, number and rows of ocelli in the eye, and size and shape of the body.

Toradjia stebbingi (Collinge)

(Text figures a-f)

- 1898. Toradjia Dolifus, Prof. Max. Weber's Publ. Zool. *Ergebnisse der Reise in Niederländisch Ost-Indien* 4 (2) : 357-382 (1907),
- 1914. *Paraperiscyphus stebbingi* Collinge, *Rec. Indian Mus.*, 10 (3) : 207-209.
- 1916. *Paraperiscyphus stebbingi* Collinge, *Rec. Indian Mus.*, 12 (3) : 115.

General : Body oblong oval (Text fig. a) strongly convex, nearly twice as long as the greatest breadth. Surface with rows of tubercles well arranged.

Cephalon : Head small, flanked laterally and posteriorly by the lateral plates of the first thoracic somite. Frontal margin laterally expanding to two lateral lobes with its anterior extremity ending in an obtuse angle. The middle portion of the front depressed deeply and folded with a raised triangular apex giving the appearance of an obtuse spine. Eyes dorso-lateral, prominent, with 22 ocelli arranged in four rows.

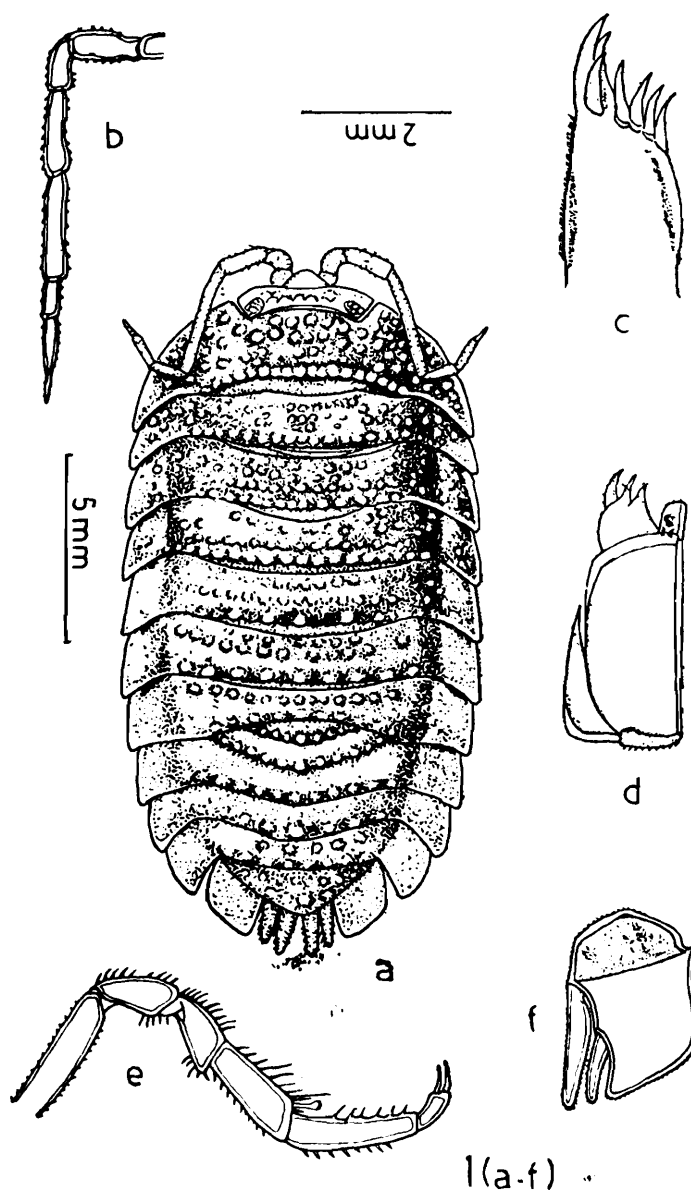


Fig. 1 (a-f). *TORADJIA stebbingi* (Collinge).

- a. Dorsal view, b. Second antenna, c. First maxilla, d. Maxillipede.
e. Second thoracic leg, f. Uropoda.

Thorax : First thoracic somite nearly double in width of the second, all others almost subequal. The lateral plates of the first somite covering the Cephalon laterally and posteriorly. The lateral plates of all other somites expanding towards their posterior end terminating distally in a blunt process. All the thoracic somites convex with regular rows of tubercles.

Abdomen : Metasome convex and about one-fourth the length of the body, somites wider than long. The first two somites broadly rounded posteriorly and smaller compared with third to fifth, its terminal end covered by the lateral plates of the last thoracic somite. Third to fifth somites well expanding posteriorly and its distal end terminating in an obtuse process. Telson broadly triangular with its apex terminating in a rounded obtuse process.

Appendages : First antenna small, three jointed. Located between the ventral side of the cephalon and the base of the second antennae. Second antenna (Text fig. b) moderately stout, its basal joint small, second and third subequal, fourth longer than the third and the fifth longest of all. The flagellum with two joints, the proximal shorter than the distal, the latter terminating in a thick style. Mandibles with three stout teeth at the outer cutting edge and a blunt process on the inner side. First maxilla (Text fig. c) with an outer lobe oblong and somewhat triangular in shape, distally terminating in seven incurved spines. Inner lobe small and narrow. Second maxilla slender, terminating distally in two setose plumes. Maxillipedes (Text fig. d) broad, the inner plate with numerous short simple setae, the outer palp terminating in three teeth. Thoracic appendages (Text fig. e) fringed with numerous spines, 2nd appendage terminating in two incurved spines.

Uropods (Text fig. f) basal plate large, extending beyond the telson, expanded and plate-like laterally, outer margin subcrenate fringed with hair-like setae and tuberculated. Exopodite on the inner margin, endopodite longer than exopodite and located at the top of the inner margin of the basal plate, both covered with fine setae and extending slightly beyond the basal plate.

Colour uniform dark-brown with the lateral plates yellowish.

Length and greatest width of the male specimen designated Lectotype are 19 and 10 mm. respectively.

Type-locality : Annamalai Hills, 4000 ft., Tamil Nadu, INDIA, 22.1.1912, coll. T. B. Fletcher.

Lectotype : A male specimen in the National Collections of the Zoological Survey of India, Calcutta, Regd. No. C.

Paralectotypes : Two males and two females (broken into parts) from the same locality as above, in the National Zoological Collections of the Zoological Survey of India. Regd. No. 8612/10

Distribution : This species is, so far, known from its type locality viz. Annamalai Hills, Tamil Nadu and Kavalai Hills, (Cochin State), Kerala between altitudes 1300 to 4000 ft. respectively.

Remarks : *Paraperiscyphus stebbingi* is the second species described under the genus *Paraperiscyphus* from India, the first being *P. travancorensis* Stebbing.

Toradjia travancorensis (Stebbingi)

(Text-Fig. 1-7)

1898. *Toradjia* Dollfus, Prof. Max. Weber's Publ. Zool. *Ergebnissener. Reise in Niederlandisch Ost-Indien* 4 (2) : 357-382 (1907).

1911. *Paraperiscyphis travancorensis* Stebbing, *Rec. Indian Mus.*, 6 (4) : 184-185.

1975. *Paraperiscyphis travancorensis* Ramakrishna, *Rec, zool, Surv. India*, 68 : 297-303.

General : Body elongate-oval, convex, (Text fig. 1) narrow anteriorly and wider in the posterior region. Length about double the width. Body not smooth but covered with minutely setulose warts.

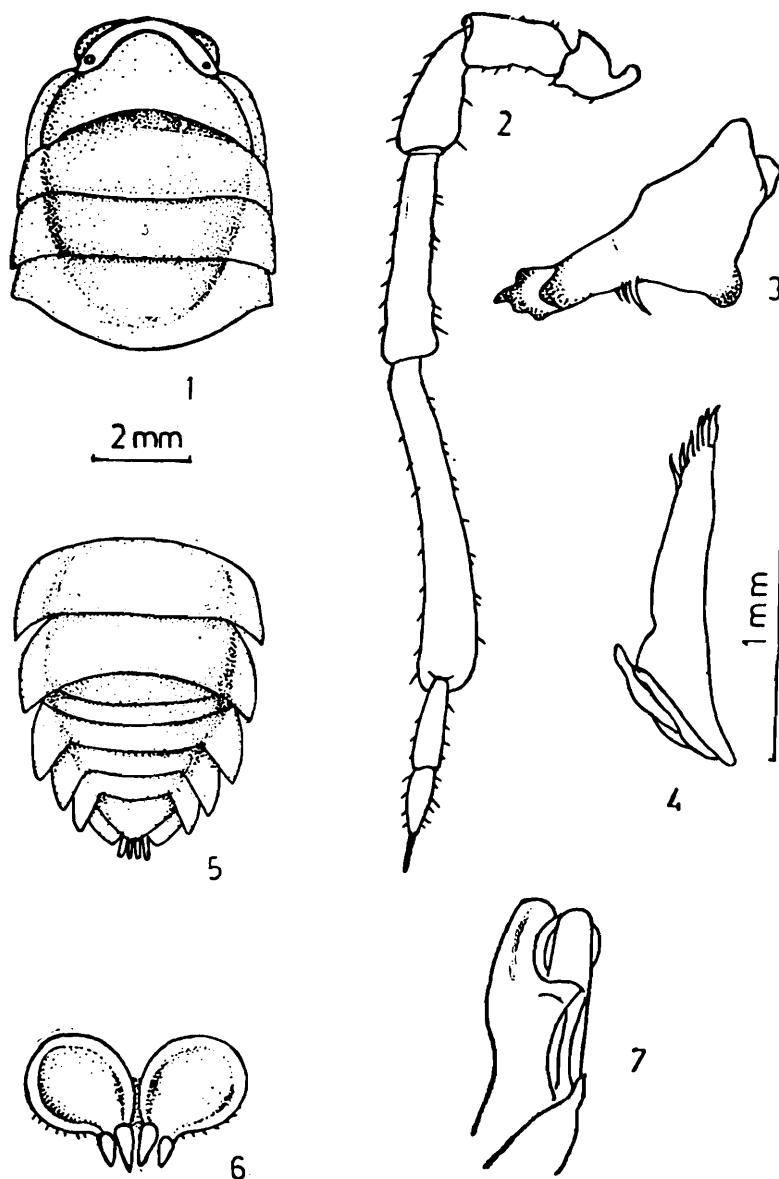


Fig. (1-7). *TORADJIA travancorensis* (Stebbingi).

1. Dorsal view : Head and anterior portion of Paereon, 2. Second antenna with terminal spine more magnified, 3. Mandible, 4. First maxilla,
5. Dorsal view : Posterior portion of Paereon and Pleon, 6. Uropods, 7. Second maxilla.

Cephalon : Head wider than long, about three times wider than long. Frontal portion raised. Antero-lateral lobe angular, folding in the centre giving the appearance of a depression. Posterior border almost straight, except for the depression in the middle. Eyes dorso-lateral, prominent and consisting of 16 ocelli arranged in four rows. Cephalon covered posteriorly and laterally by the first thoracic somite.

Thorax : Thorax widest at the sixth somite, strongly convex and its lateral plates/ending posteriorly in an obtuse process. First somite wider than others covering the posterior portion of the head. Surface also with setulose warts.

Abdomen : Metasome (Text fig. 6) about one-third of the body. The first two segments narrower but as wide as the last thoracic somite and the lateral plates of the same covering the two segments. Third to fifth somites prominent and its lateral plates extending posteriorly pointing backward. Telson triangular and its apex being rounded.

Appendages : Second antenna (Text fig. 2) the basal joint is shortest of all, the 2nd and 3rd joints almost sub-equal, fourth as long as end and 3rd together and fifth longest of all. Flagellum two jointed, the distal shorter than the proximal, the apical seta being well formed.

Mandible (Text fig. 3) with two teeth and three sharp spines of which the third one longest and stout, placed within the inner side.

Maxilla (Text fig. 4) outer lobe with eight apical spines, with peculiar dumbbell shaped process at its proximal end.

The maxillipedes broad as in the genus *Periscyphis*. The thoracic legs fringed with numerous spines, most of them pointed, but one on the apical border of the fifth joint having an obtuse plumose apex.

Uropoda (Text fig. 6) with graceful curves of both the inner and outer margins. The endopods longer than the exopods and pointed distally.

Colour light-brown all through the body.

The length and width of the larger of the two specimens measuring 11 mm. and 6 mm. respectively.

Type-locality : Maddatharay, western base of the Western Ghats, Travancore, Kerala, INDIA, 18. 11. 1908, Coll. N. Annandale.

Syntypes : Two specimens (one female) damaged, in the National Collections of the Zoological Survey of India, Calcutta. Regd. No. 7931/10.

Distribution : This species, is so far, known to occur from its type locality only.

Remarks : The other mouth parts could not be dealt with as the material at the disposal do not have them, besides what ever available is badly damaged.

Paraperiscyphis traavancorensis Stebbingi has close resemblance to *Paraperiscyphis scabrus* Collinge, but differs from it by its shape and size of the body, cephalon, eyes, abdomen, and the mouth parts specially second antenna, maxilla and the uropoda.

SUMMARY

This paper includes details of the genus *Toradjia*, keys to the Indian species of *Toradjia* together with detailed synonyms and the description of the species *Toradjia gigas* (Collinge) together with illustrations of the five species wherever it was required.

CESTODES OF VERTEBRATES OF RAJASTHAN

M. HAFEEZULLAH

Zoological Survey of India, Calcutta

INTRODUCTION

The cestode fauna of the vertebrates of the Indian Desert is not sufficiently known as yet. The only praiseworthy work has been done from there by Mukherjee (1970), Gupta (1976), Nama and Khichi (1972-80) and Wason and Johnson (1977).

The present work is based on the cestode material collected at Jodhpur, Jaisalmer and their surrounding areas in Rajasthan from lizards, birds and rodents. Although all the cestodes have been identified to be the known forms, the study is marked by concise descriptions, important synonymies and interesting remarks.

The host animals were collected by the staff of the Desert Regional Station, Z. S. I., Jodhpur (Rajasthan) including the author himself. The hosts examined for the cestode parasites were wall lizards, garden lizards, Monitor lizards, Great Indian Bustard, hedgehogs and house rats. The cestodes thus recovered were processed to prepare permanent mounts according to the standard method. The measurements are in millimeters unless otherwise stated. The drawings have been made with the aid of a camera lucida. All the material will be submitted to the National Helminthological Collections of Z. S. I., Calcutta. Figs. 10 and 15a from Nama (1975) and Gupta (1976) respectively have been included for the complete description of the species.

SYSTEMATIC ACCOUNT

Order CYCLOPHYLLIDEA Benden in Braun, 1900

Family ANOPLOCEPHALIDAE Cholodkovsky, 1902

Subfamily LINSTOWIINAE Fuhrmann, 1907.

Genus 1. *Oochoristica* Lühe

1898. *Oochoristica* Lühe, *Zool. Anz.*, Leipzig, 21 : 650-652.

1932. *Diochetos* Harwood, *U. S. nat. Mus.*, 81 : 1-71.

1948. *Skrjabinochora* Spassky, *Dokl. Akad. Nauk SSSR*, n. s. 59 (2) : 409-412.

The genus *Diochetos* Harwood, 1932 was erected against the genus *Oochoristica* Lühe, 1898 on the basis of the position of the genital pore and the larger ratio of the length of the gravid segment with its width. It was stated that in *Diochetos* the genital pore is formed at a level of 2/5th of the length of the segment from the anterior segmentation and the gravid segments are 2-6 times longer than broad. Spassky (1951)

considered that these are variable characters and therefore he synonymised *Diochetos* with *Oochoristica*. Schmidt (1970, 1986) does not seem to agree with this synonymy and maintains *Diochetos* as distinct entity from that of *Oochoristica*. The present author has collected a number of this anoplocephalid cestode from wall lizard, garden lizard and Monitor lizard from the desert areas of Rajasthan. On study and analysis of the entire material, he is convinced that the differences between *Diochetos* and *Oochoristica* are untenable. Therefore he is inclined to concur with Spassky (1951) who has also considered his own genus *Skrjabinochora* as a synonym of *Oochoristica*.

1. *Oochoristica karachiensis* (Bilqees and Siddiqui) n. comb.
(Figs. 1-3)

1975. *Diochetos karachiensis* Bilqees and Siddiqui, *Pakistan J. Sci. Ind. Res.*, 18 (6) : 261-264.

1977. *Oochoristica jodhpurensis* Nama, *Rev. Bev. Brasil. Biol.*, 37 (1) : 121-123.

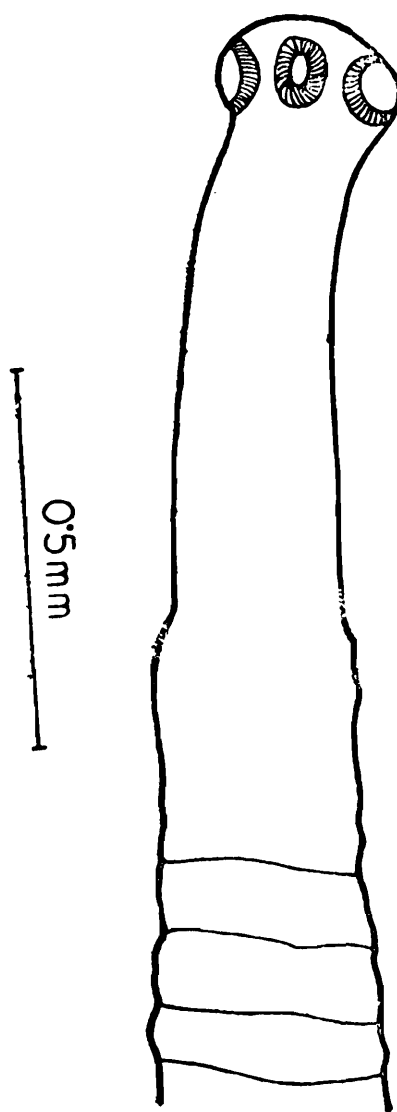


Fig. 1

Oochoristica karachiensis :
Fig. 1. Scolex with neck.

Material : *Host :* *Hemidactylus brooki*, (Squamata : Sauria : Gekkonidae) and an unidentified gekkonid lizard ; location—intestine ; localities—Paota and Lal Sagar (Jodhpur) respectively ; specimens—on 7+9 slides ; collected in August, 1981 and September, 1982.

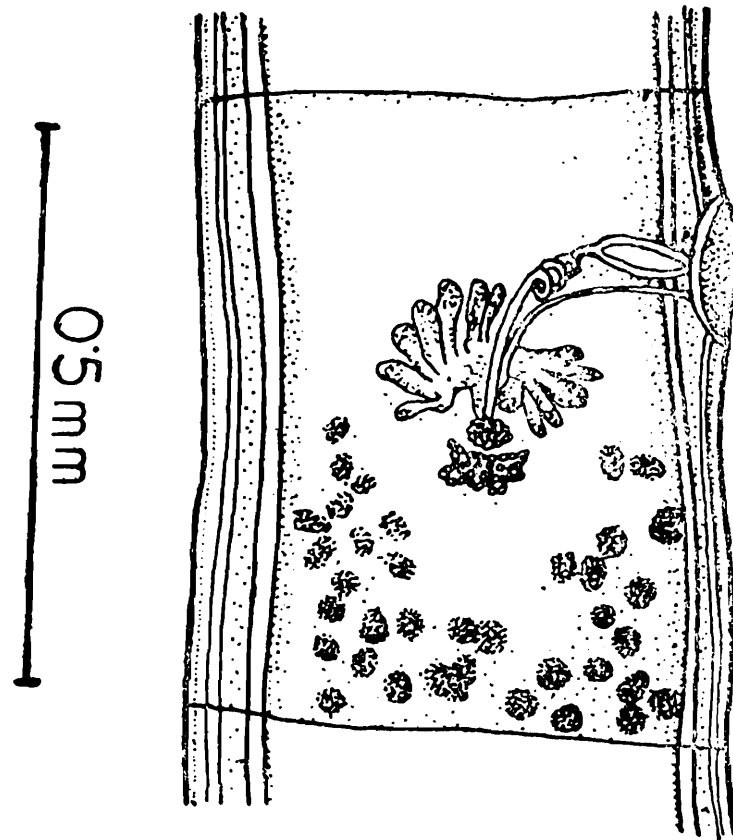


Fig. 2

Fig. 2. Mature segment.

Description : Strobila acraspedote, velum not formed. Scolex subglobular, small, 0.10-0.22 in diametere. Suckers four, with weak musculature. Neck present, long. In beginning proglottids narrow, rectangular, wider than long, free from internal organs. First maturing proglottids squarish ; fully mature ones longer than wide : gravid proglottids cylindrical, much longer than broad. Genital organs not extending into space anterior to level of genital atrium. Genital atrium deep, muscular, irregularly alternating, situated at a level about $\frac{1}{4}$ th to $\frac{1}{3}$ from anterior segmentation. Testes 26-38 in number, arranged in two groups in posterior half of proglottid in lateral fields posterior to ovary, tending to coalesce in middle near posterior segmentation. Vas deferens a narrow duct coiled at turning level, eventually opening into cirrus sac. Cirrus sac elongate, almost spindle-shaped, horizontal in disposition, extending much beyond excretory canals to less than half width of proglottids, opening into genital atrium. Ovary bilobed, lobes being unequal consisting of several lobulations. Vagina

horizontal, posterior to cirrus sac, opening into genital atrium just behind male pore. Shell gland irregularly globular, median, immediately posterior to ovary. Vitellarium compact, irregularly semilunar, larger than and immediately posterior to shell gland. Traces of male and female ducts seen in some of gravid proglottids near remnant of genital atrium. Parenchymatous capsules formed, each one having a single egg. Whole of gravid proglottid filled with evenly distributed such capsules. Onchospheres with hooks formed.

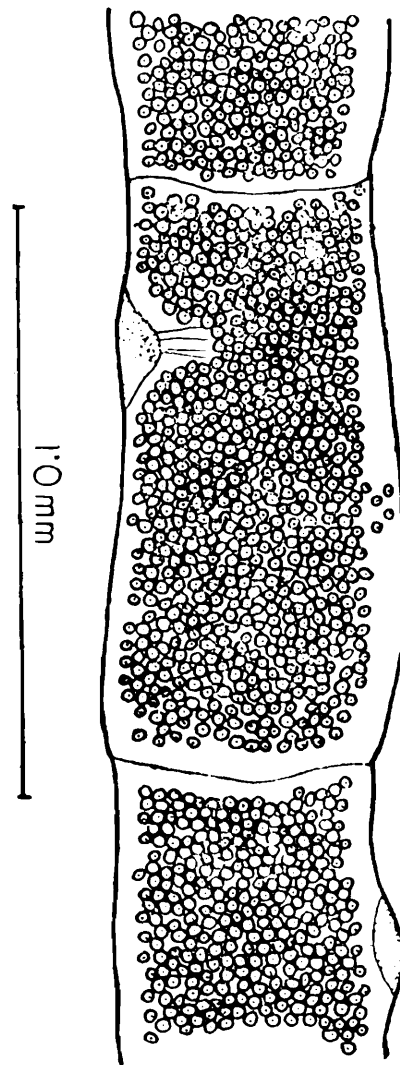


Fig. 3

Fig. 3. Gravid segment.

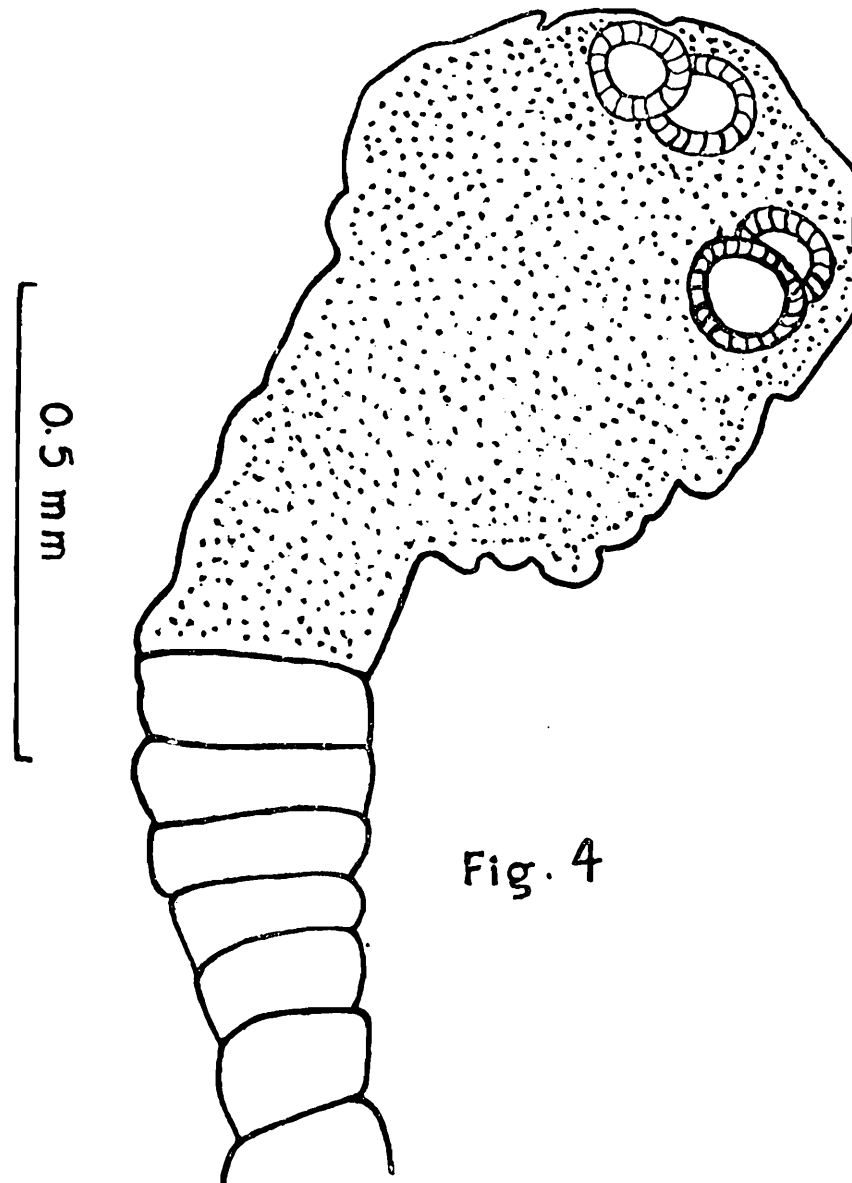
Remarks : The above description closely resembles that of *Oochoristica karachiensis* (Bilques and Siddiqui, 1975) and *O. jodhpurensis* Nama, 1977. Nama (1977) did not compare his species with that of Bilques and Siddiqui (1975). The author is inclined to refer his present material to *O. karachiensis*, and to consider *O. jodhpurensis* as a synonym of *O. karachiensis*.

2. *Oochoristica calotes* Nama and Khichi

(Figs. 4-6)

1974. *Oochoristica calotes* Nama and Khichi, *Folia Parasitol., Praha*, 21 : 373-375.

Material : Host—*Calotes versicolor*, (Squamata : Sauria : Agamidae) ; location—intestine ; locality—Ramgarh (Jaisalmer, Rajasthan) ; specimens—on 3 slides ; collected in September, 1982.



Oochoristica calotes :

Fig. 4. Scolex with neck.

Description : Scolex simple, small, with four suckers. Neck present. Segmentation of strobila very faint, in some cases not seen at all. Immature proglottids squarish, slightly wider than long. With development of gonads, proglottids increase

in length, so much so that fully mature proglottids becoming rectangular, i. e., longer than broad. Gravid proglottids much longer than broad. Genital atrium deep, thickly muscular, extending up to dorsal excretory canal, irregularly alternating, situated at a level $\frac{1}{3}$ or $\frac{2}{5}$ from anterior segmentation of proglottid. Space of proglottid anterior to level of genital atrium devoid of any internal organs.

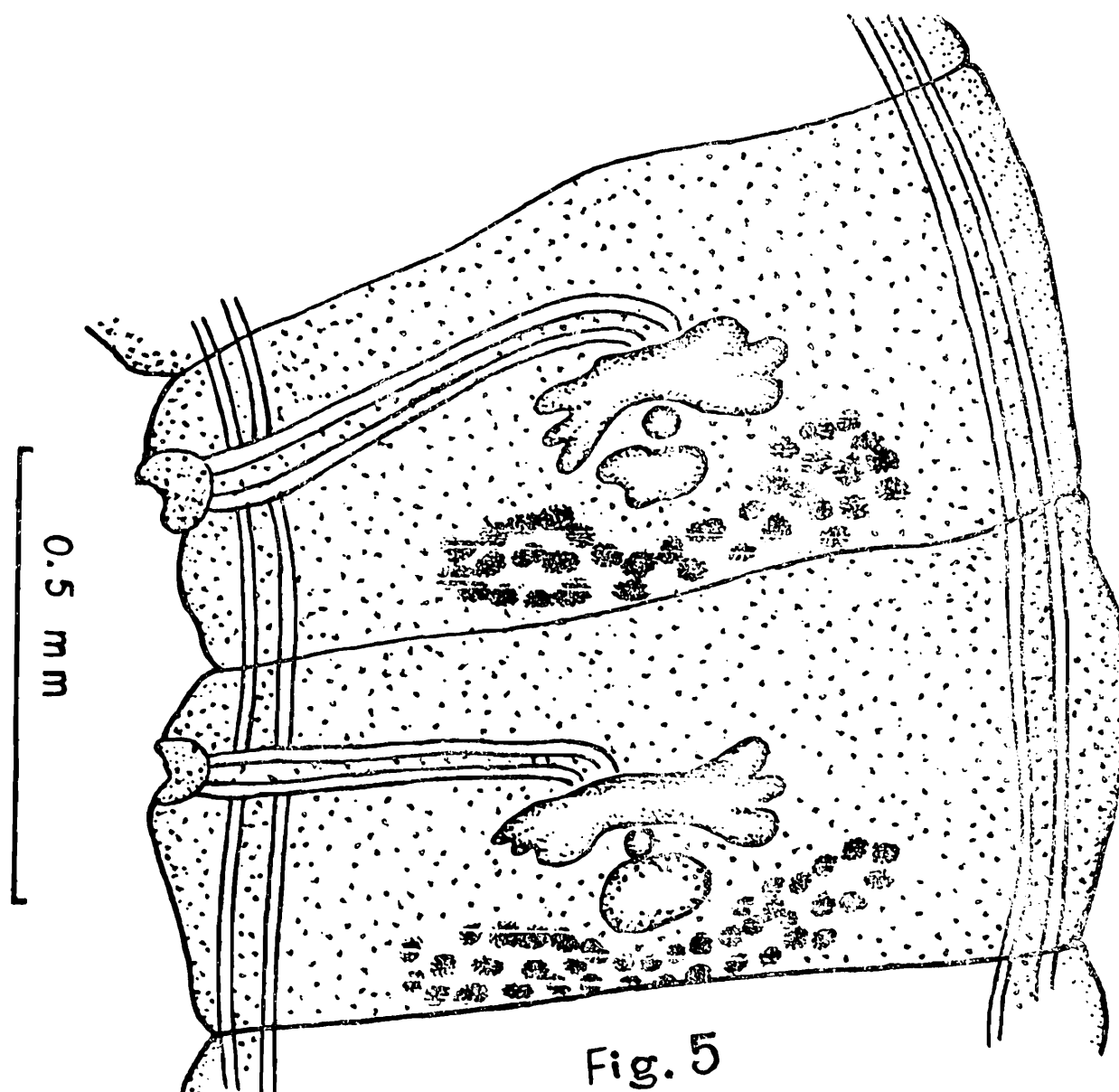


Fig. 5. Mature segment.

Tests 50-60 in number, postovarian, arranged in two lateral fields, tending to meet each other near posterior segmentation. Vas deferens much coiled. Cirrus sac long, wide, occasionally ovate, extending almost up to ventral excretory canal. Ovary median, bilobed, each lobe being further divided into many smaller lobes, smaller lobe poral, larger one aporal. Vagina a narrow straight tube running parallel posterior to cirrus sac, opening into genital atrium beside male pore. Shell gland a small roundish body medianly situated at level of posterior end of poral half of ovary. Vitellarium follicular, immediately behind shell gland.

Gravid proglottids rectangular, all internal organs gradually disintegrated except traces of genital ducts and genital atrium. Parenchymatous capsules formed around each egg, latter developing into onchosphere. Whole gravid proglottid filled with such parenchymatous capsules each containing single onchosphere.

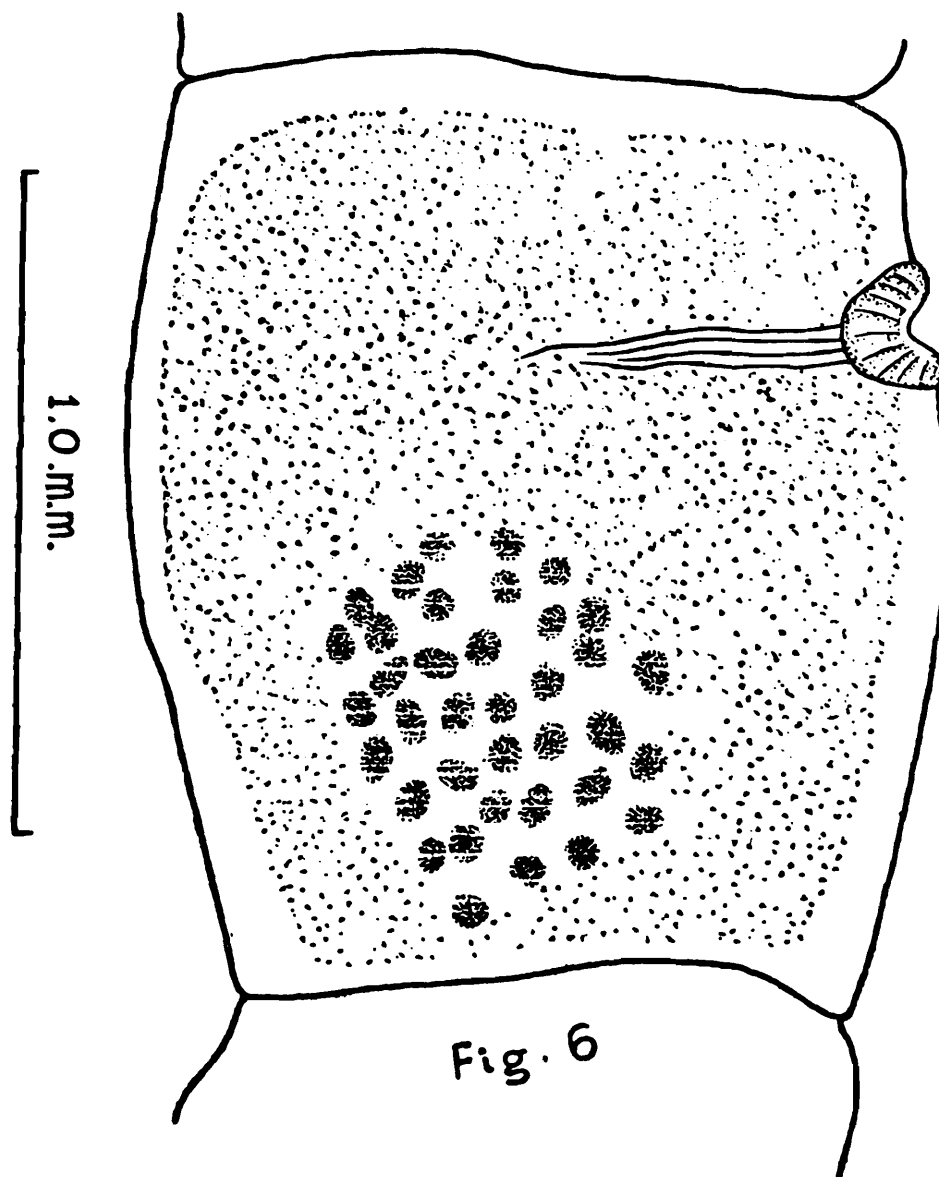


Fig. 6. Gravid segment.

Remarks : So far five species have been reported from India from the intestine of *C. versicolor*. They are : *Oochoristica sigmoides* Moghe, 1926 ; *O. thapari* Johri, 1934 ; *O. indica* Misra, 1945 ; *O. mandapamensis* Johri, 1958 ; and *O. calotes* Nama and Khichi, 1974. The present specimens collected from the same ecosystem and host as those of *O. calotes* Nama and Khichi, 1974 and in broad details they agree with their species.

3. *Oochoristica varani* Nama and Khichi (Figs. 7-9)

1972. *Oochoristica varani* Nama and Khichi, *Proc. natl. Acad. Sci. India*, B. 42 : 240-241.

Material : Host—*Varanus monitor* (L.), (Squamata : Sauria : Agamidae) ; location intestine ; locality—Kalyanpur (Jodhpur, Rajasthan) ; specimens—on 13 slides, collected in September, 1982.

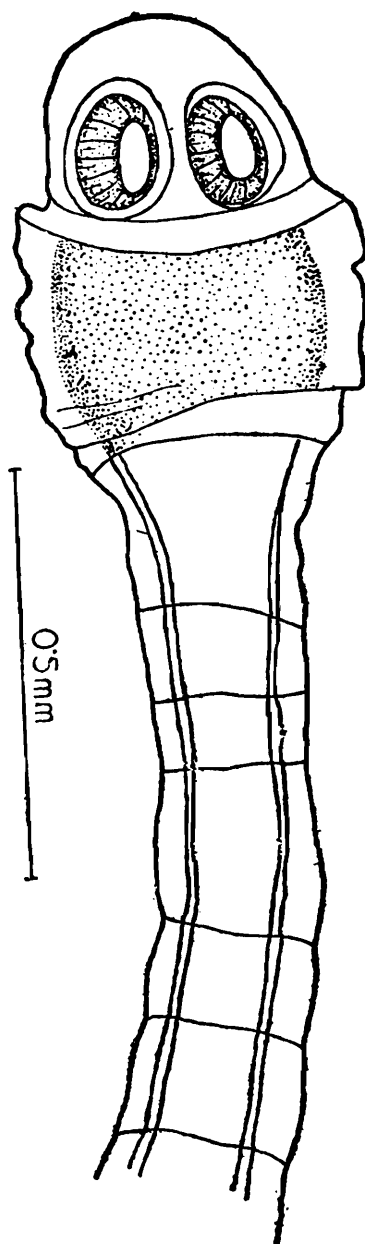


Fig.7

Oochoristica varani :

Fig. 7. Scolex with neck.

Description : Strobila acraspedote ; proglottids without velum. Initial segments squarish, without development of any organs. Genital atrium prominent, muscular, deep but not extending upto excretory canal, situated at a level about $\frac{2}{5}$ th from anterior segmentation, irregularly alternate. A pair of ventral and a pair of dorsal excretory canal present. Scolex subglobular, 0.45-0.5 in diameter, prominent, with large suckers.

Fully mature segments squarish, slightly longer than wide. No organs anterior to level of genital atrium. Testes 50-60 in number, arranged in two groups in lateral fields posterior to ovary, tending to coalesce near posterior margin of proglottid. Vas deferens convoluted, surrounded by faint prostate gland cells. Cirrus sac quite wide,

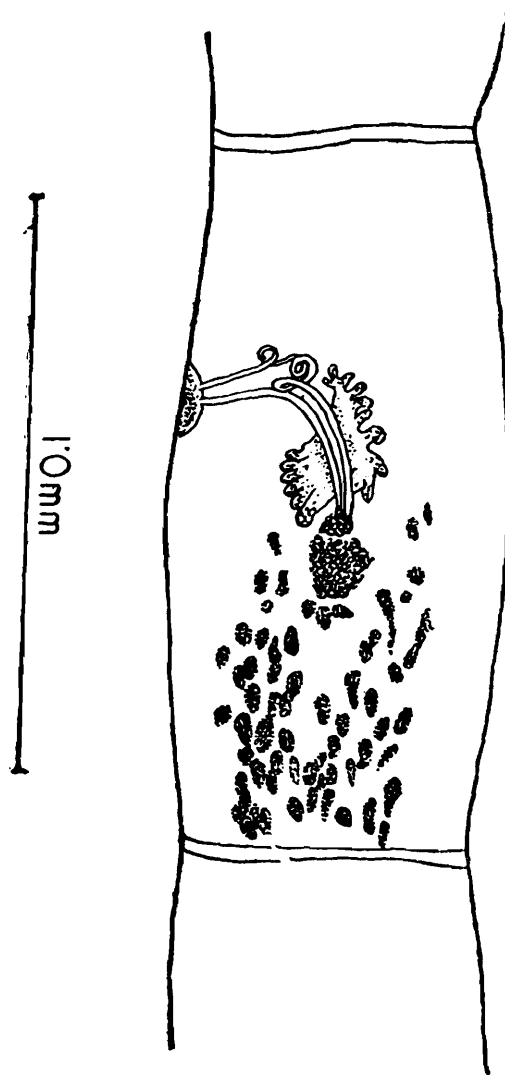


Fig.8

Fig. 8. Mature segment.

elongate, extending beyond ventral excretory canal, opening into genital atrium. Ovary median, bilobed, poral half comparatively smaller than aporal half, each half consisting of several small lobes. Vagina prominent, running posterior to male tube, opening into genital atrium behind male pore. Seminal receptacle formed behind convolutions of male tube. Shell gland small, globular, median, postovarian. Vitellarium large, compact mass of follicles, situated immediately behind shell gland. Gravid segments squarish to rectangular, much longer than broad, all internal organs

disintegrated leaving traces of genital atrium and ducts, filled with innumerable parenchymal capsules, each surrounding a single egg. Onchospheres present.

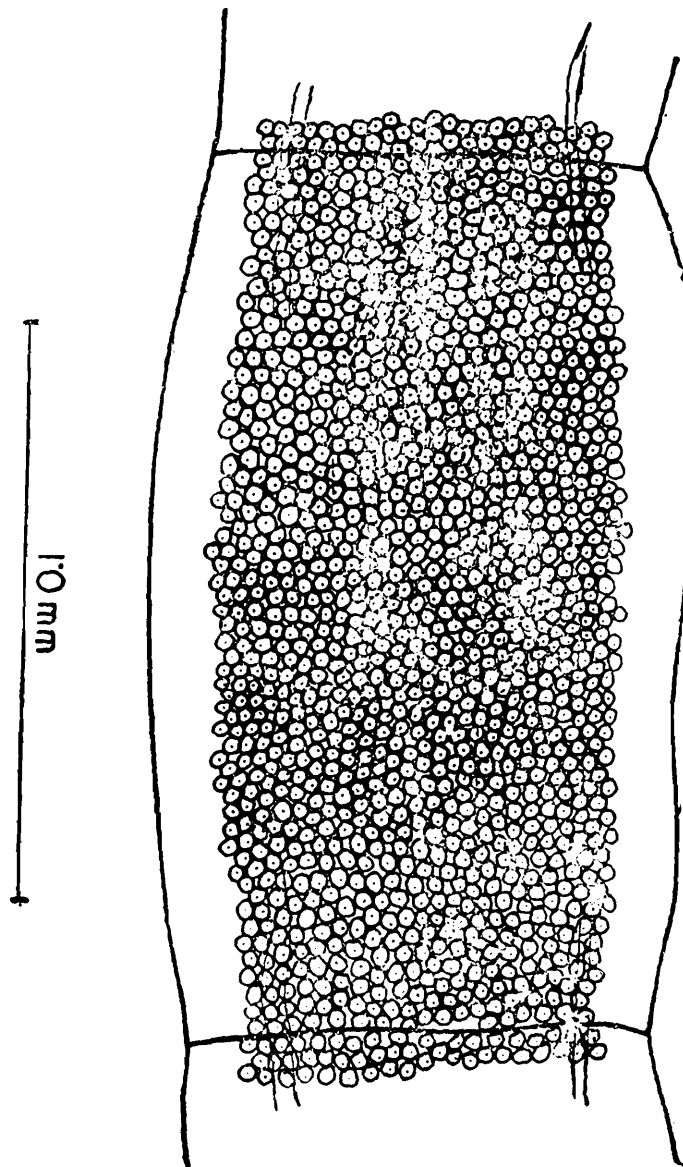


Fig. 9

Fig. 9. Gravid segment.

Remarks : Mukherjee reported *Oochoristica tuberculata* (Rudolphi, 1819) from *Varanas monitor* from Bikaner and Jaisalmer districts, Rajasthan. Nama and Khichi (1972) described *Oochoristica varani* from the same monitor lizard from Jodhpur, Rajasthan. They held their species distinct from *O. tuberculata* in larger scolex, suckers and cirrus pouch, smaller size of embryonal hooks and 40-45 testes instead of 25-30. On the basis of the present material I concur with them that *O. varani* is distinct from *O. tuberculata*.

Genus 2. *Mathevotaenia* Akhumian

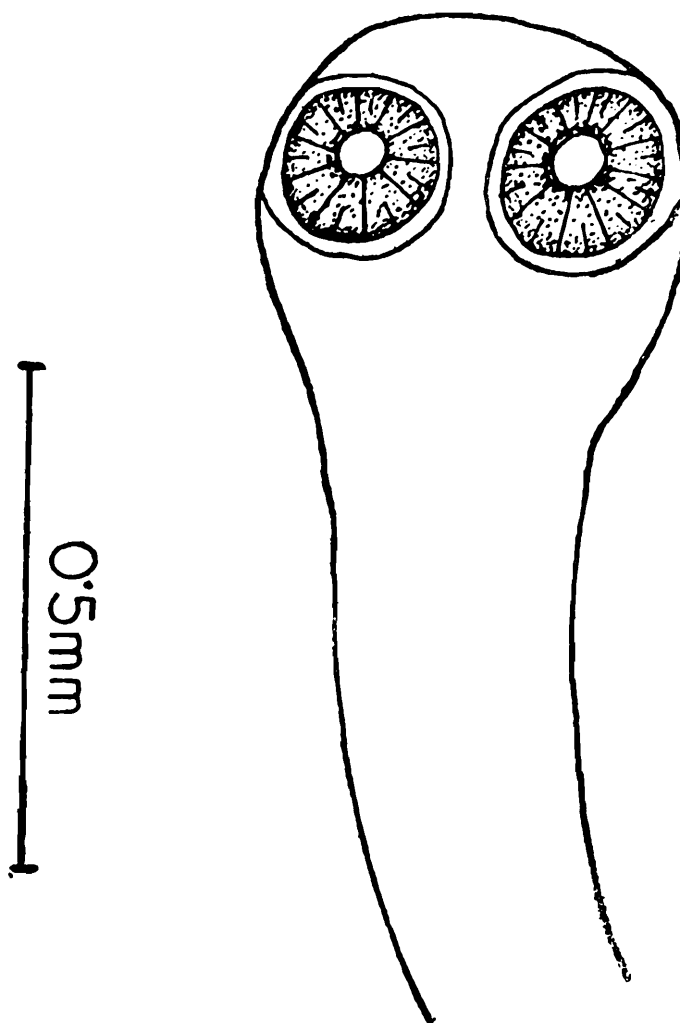
1946. *Mathevotaenia* Akhumian, *Gelmin. Sborn., Let. Deiatelnost Skrjabin*, Akademiya Nauk SSSR, Moscow : 37-41.

4. *Mathevotaenia paraechinis* Nama

(Figs. 10-12)

1975. *Mathevotaenia paraechinis* Nama, *Rev. Brasil. Biol.*, 35 (1) : 117-120.

Material : Host—*Paraechinus micropus micropus* Blyth, Hedgehog, (Insectivora : Exinaceidae) ; location—intestine ; locality—Chopasni (Jodhpur, Rajasthan) ; specimens—on 7 slides ; without scolex.



117

Fig.10

Mathevotaenia paraechinis :

Fig. 10. Scolex with neck. (after Nama, 1975)

Description : Strobila craspedote, proglottids without velum. Neck short. Initial segments behind neck without any internal organs. Mature segments broader than

long, posterior most gravid segments either squarish or slightly longer than broad. Genital pores irregularly alternate, situated on margin near anterior segmentation of of proglottid. Genital atrium shallow. Testes 50-60 in number, arranged in two groups in lateral fields behind ovary. In last maturing proglottids, two groups of

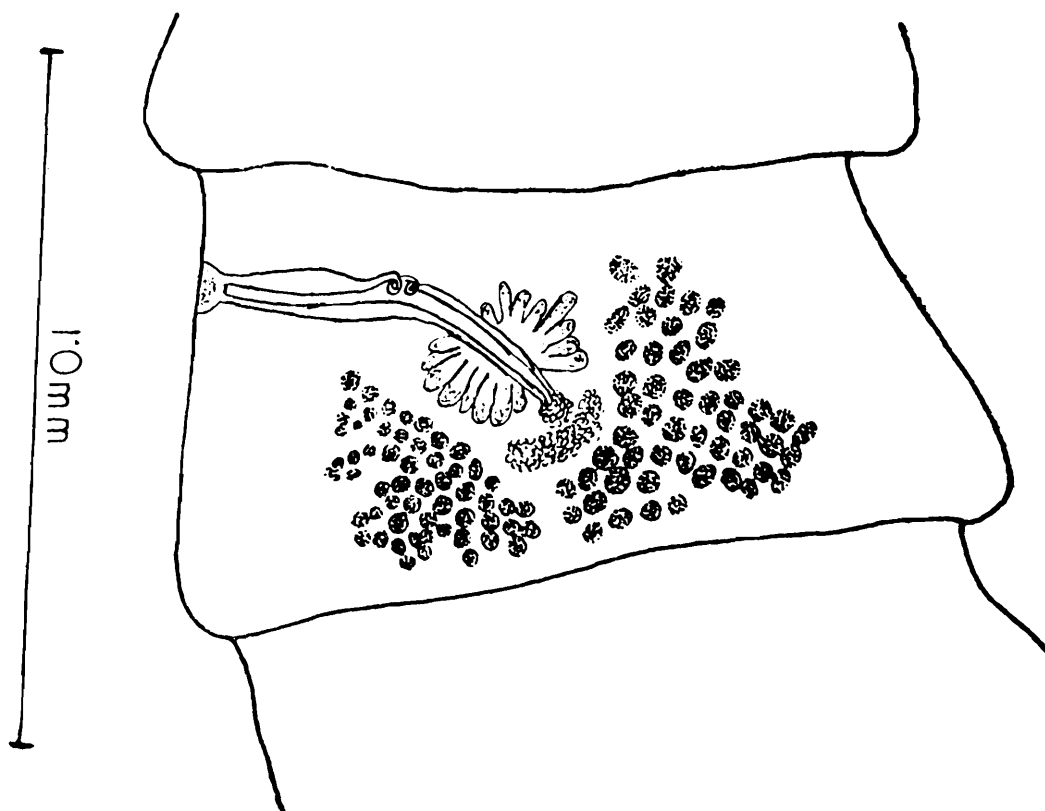


Fig. 11

Fig. 11. Mature segment.

testes separate, in older ones testes near posterior segmentation tending to meet. Seminal vesicle absent. Vas deferens coils before entering cirrus sac. Cirrus sac extending beyond dorsal excretory canal. Ovary bilobed, each lobe being further divided into several smaller lobes. Vagina straight, running behind male duct, opening into genital atrium behind male pore. Shell gland globular, median and postovarian. Vitellarium compact, almost semilunar, surrounding shell gland posteriorly. Gravid proglottids full of parenchymatous capsules, each having a single egg, traces of genital atrium seen. Onchospheres formed in eggs.

Remarks : Three species of *Mathevotaenia* have been described from Rajasthan from three different mammals. They are : *M. sanchorensis* Nama and Khichi, 1973 from *Herpestes* sp. (mongoose) ; *M. paraechinis* Nama, 1975 from *Paraechinus micropus micropus* (hedgehog) ; and *M. symmetrica* Akhumian, 1946 from *Rattus rattus* (house rat).

The present specimens come very close to *M. paraechinis* Nama, 1975 in respect of host, number and size of testes and the size of eggs.

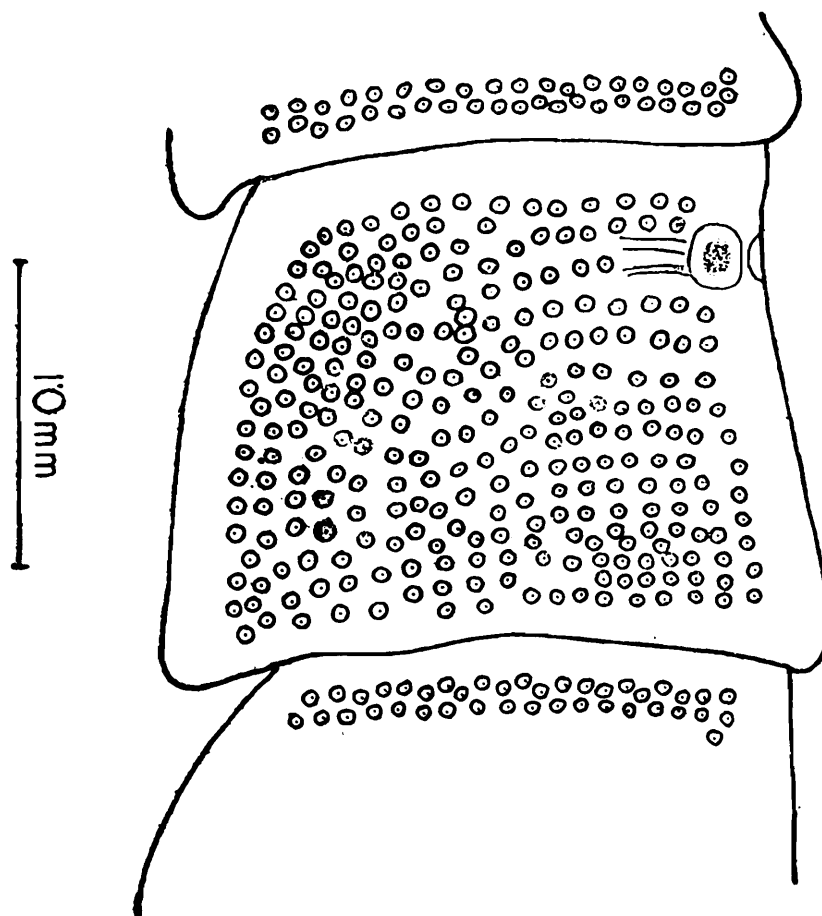


Fig. 12

Fig. 12. Gravid segment.

Family DAVAINIDAE Fuhrmann, 1907

Subfamily IDIOGENINAE Fuhrmann, 1932

Genus 4. *Otiditaenia* Beddard

1912. *Otiditaenia* Beddard, *Proc. zool. Soc. London*, 1912 : 194-221.

1912. *Schistometra* Cholodkovsky, [Explanatory catalogue of the collection of parasites of the Imperial Military Academy of Medicine, I. Tapeworms (Cyclophyllidae)], St. Petersburg, 1912 (in Russian) : 1-96.

1930. *Paraschistometra* Woodland, *Parasitology*, 22 : 214-229.

5. *Otiditaenia ntgriceps* (Gupta) Schmidt (Figs. 13-15)

1976. *Schistometra nigriceps* Gupta, *J. Bombay nat. Hist. Soc.*, 73 : 188-186.

1986. *Otiditaenia nigriceps* : Schmidt, *CRC Handbook of Tapeworm Identification* : 240.

Material : Host—*Choriotis nigriceps* (Vigors), (Gruiformes : Otididae) ; location—intestine ; locality—Jaisalmer (Rajasthan) ; specimens—several, on 17 slides.

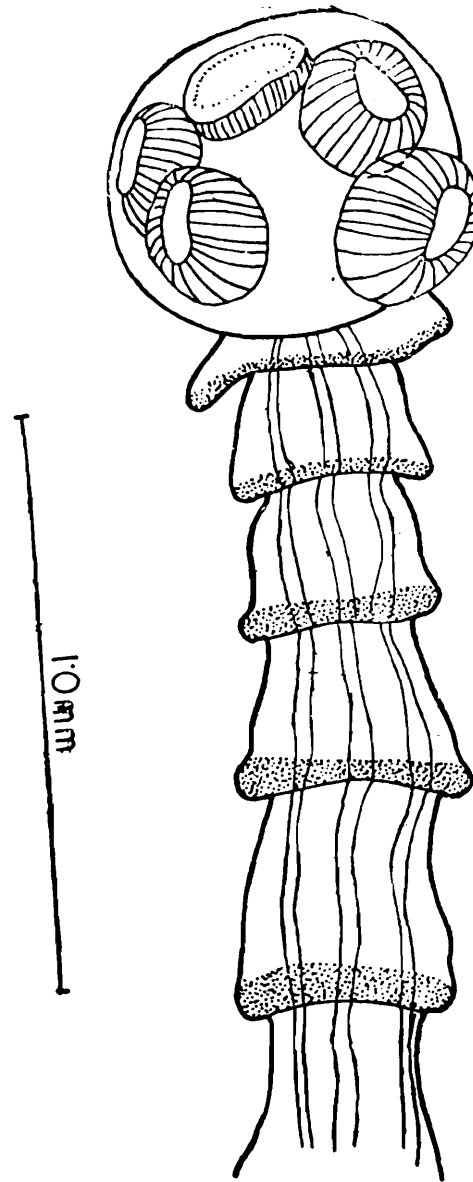


Fig. 13

Otiditaenia nigriceps :

Fig. 13. Scolex with a part of strobila.

Description : Strobila craspedote with velum. Proglottids squarish or slightly longer than broad behind neck, devoid of any internal organs, becoming much wider than long with development of gonads, last few gravid proglottids very narrow. Scolex globular, quite prominent, distinctly marked off from neck behind. Suckers four, prominent, each having unarmed margin but with two muscular lappets. Two circles of minute rostellar hooks present, but can be seen with difficulty. Genital pores irregularly alternating, genital atrium present, submarginal, situated in anterior half of lateral margin.

Testes 60-80 in number, arranged along posterior border of proglottids between excretory canals of two sides. Cirrus sac extending inside beyond ventral excretory canal, with eversible cirrus.

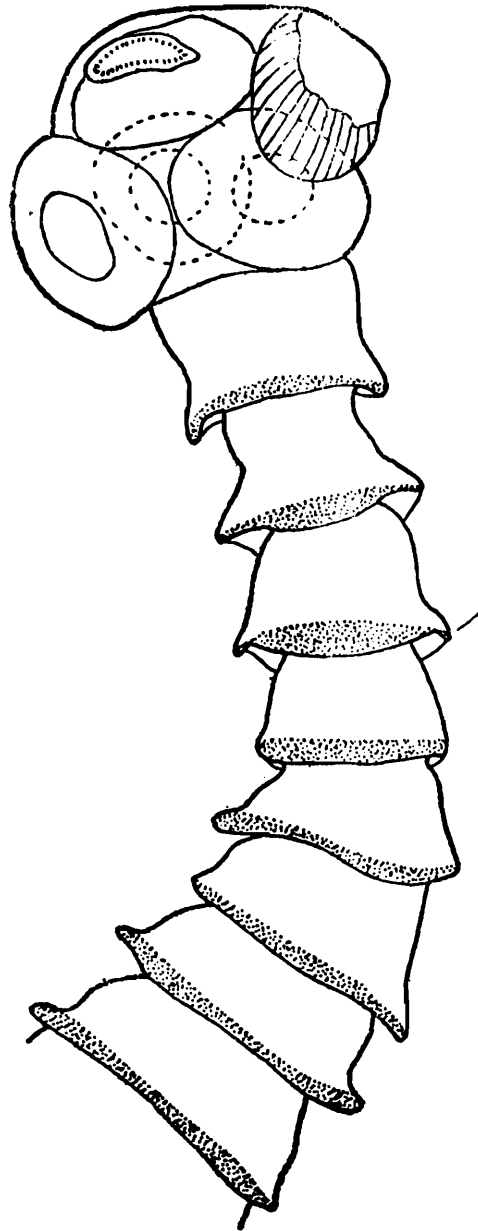


Fig.14

Fig. 14. Scolex with a part of strobila of another specimen.

Female glands poral. Ovary globular or ovoid, poral. Vagina opening into genital atrium, ventral or dorsal to cirrus sac. Vitellarium compact mass, occasionally crescent-shaped. Uterus a transverse tube or sac parallel to posterior border of segments. Paruterine organ not seen,

Remarks : Gupta (1976) described his species from the Great Indian Bustard received from Pokharan (Jaisalmer, Rajasthan). The present author also collected the

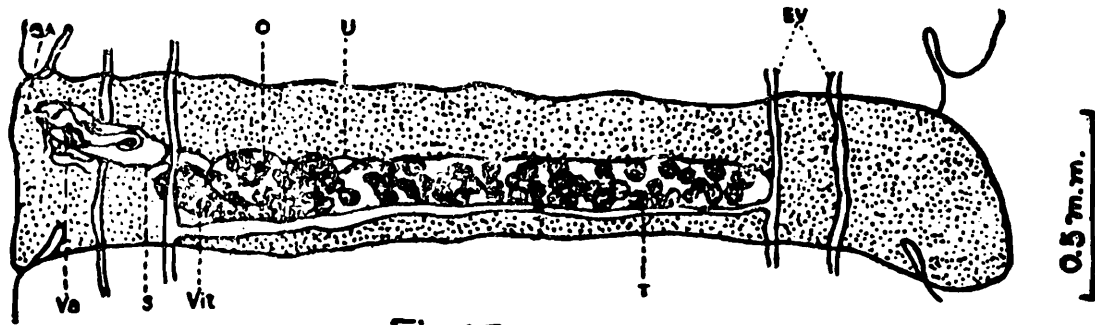


Fig. 15a

Fig. 15a. Mature segment. (after Gupta, 1976)

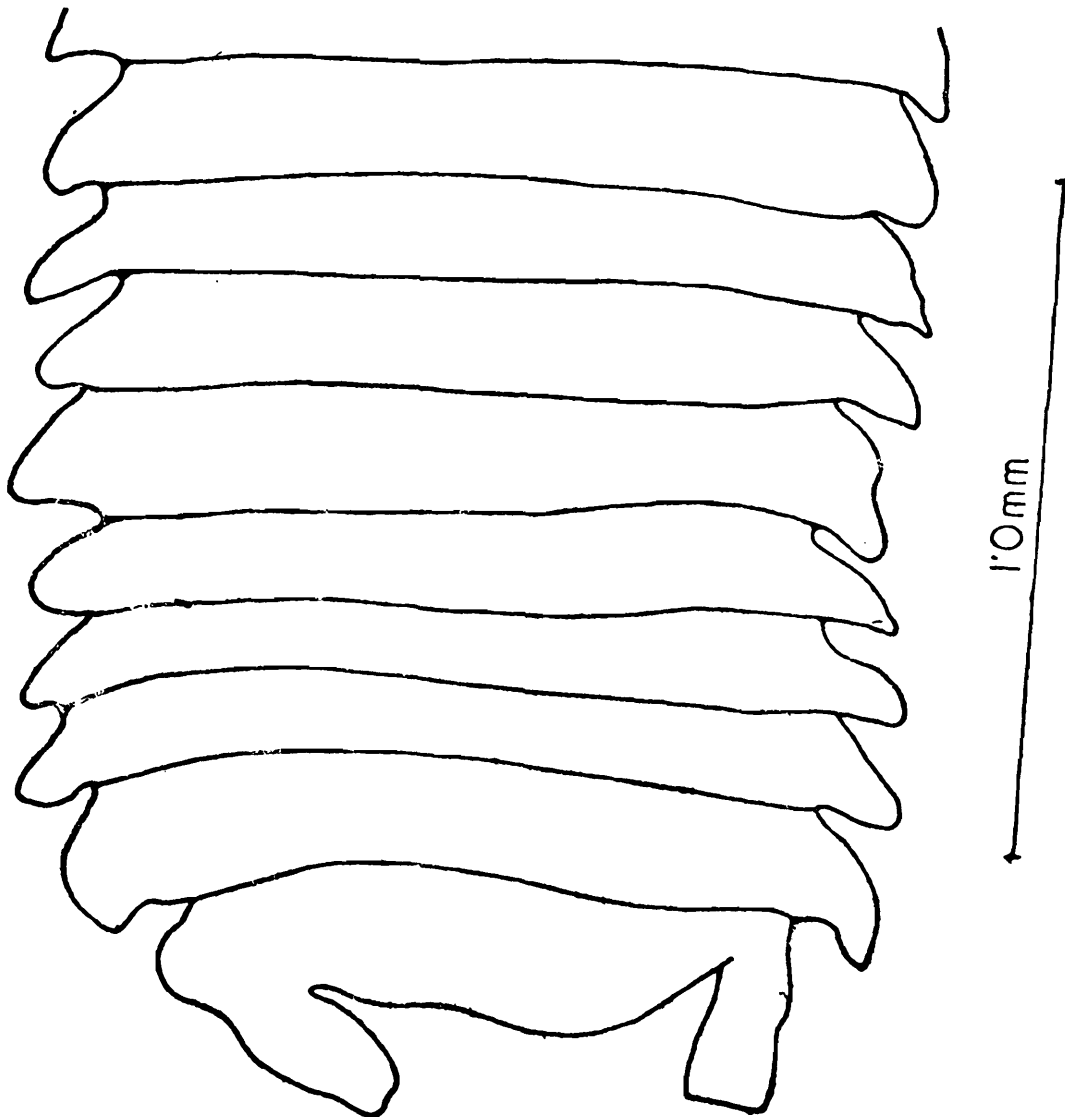


Fig. 15b

Fig. 15b. Posterior part of strobila showing narrow segments with velum.

material from a dead bird of the same species from Jaisalmer. Gupta (*loc. cit.*) placed this species in the genus *Schistometra* Cholodkovsky, 1912 but Schmidt (1986) transferred it to the genus *Otiditaenia* Beddard, 1912. Fuhrmann (1932) and later on Schmidt (1986) considered *Schistometra* Cholodkovsky, 1912 and *Paraschistometra* Woodland, 1930 as identical and consequently synonymised them with *Otiditaenia* Beddard, 1912.

Family HYMENDEPIDIDAE Railliet and Henry, 1909

Subfamily HYMENOLEPIDINAE Perrier, 1897.

Genus 5. *Hymenolepis* Weinland

1858. *Hymenolepis* Weinland, *Proc. Boston Soc. nat. Hist.*, 6 : 300-301.

1903. *Triorchis* Clerc, *Rev. Suisse zool.*, 11 : 241-368.

6. *Hymenolepis diminuta* (Rudolphy) Weinland

(Figs. 16-19)

1819. *Taenia diminuta* Rudolphi, *Entozoorum synopsis cui accident mantissa duplex et indices locupletissimi*, Berolini, x+811 pp.

1858. *Hymenolepis diminuta* (Rudolphi) : Weinland, *An essay on tapeworms of man*, x+93 pp.

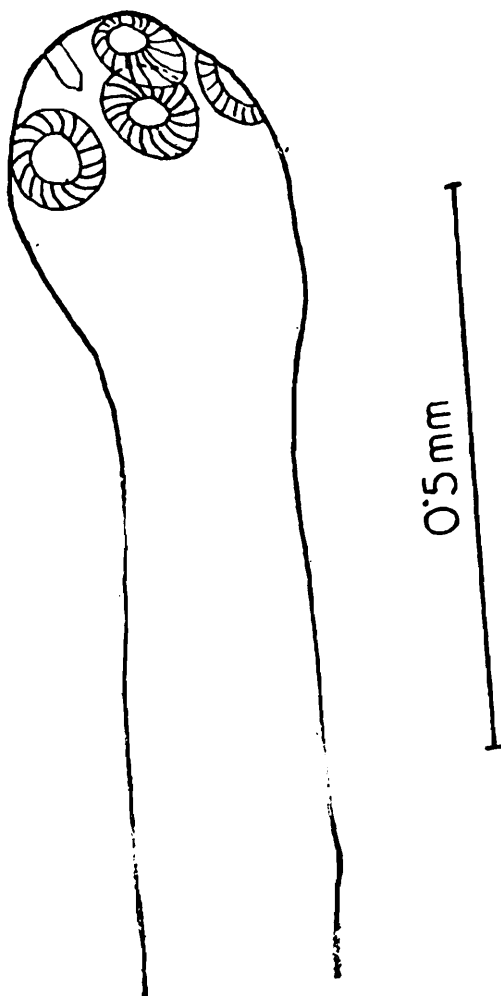


Fig. 16

Hymenolepis diminuta :

Fig. 16. Scolex with neck.

Material : Host—*Rattus rattus*, House rat, (Rodentia : Muridae) ; location—intestine ; locality—Jodhpur (Rajasthan) ; specimens—on 6 slides, collected in November, 1982.

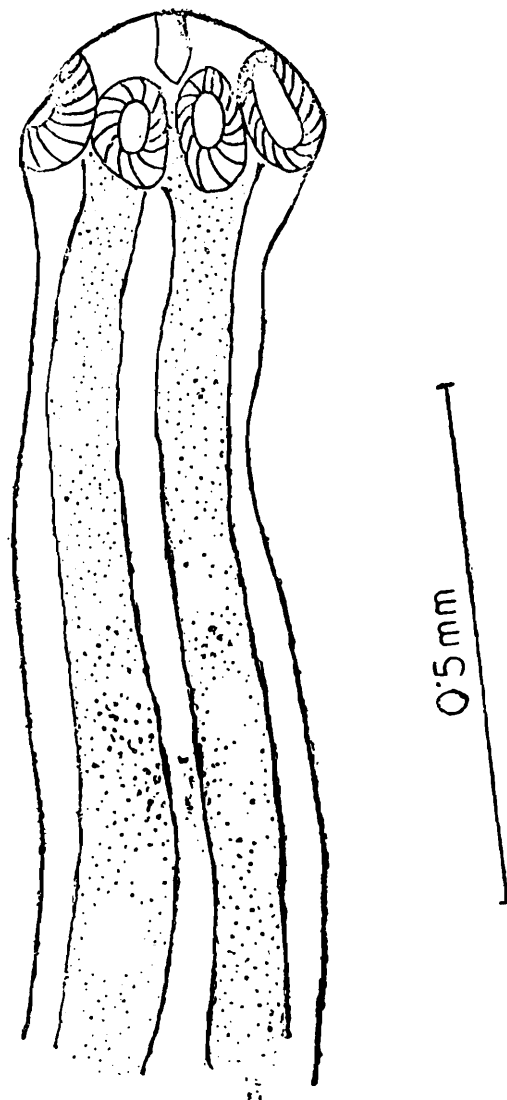


Fig. 17

Fig. 17. Scolex with neck of another specimen

Description : Strobila craspedote but no velum formed. Scolex small, club-shaped, 0.2-0.4 in diameter, with a rudimentary apical rostellum without hooks ; suckers 4, small, unarmed. Neck long. Mature and gravid proglottids much broader than long, 0.25-0.3 long, 1.60-1.75 broad. Genital pores unilateral, in middle of lateral margin of proglottids. Testes 3, 0.04-0.05 in diameter, arranged in straight line or triangle, always one poral and two aporal, variously arranged with respect to ovary when not in straight line. Seminal vesicle present. Cirrus sac spindle-shaped, 0.135-0.152 in length, extending beyond excretory canal. Ovary single, median, having several lobules, situated nearer to the posterior segmentation, always between poral and next

aporal testes. Seminal receptacle formed near ovary. Vagina opening into genital atrium behind male pore. Gravid proglottids filled up with various sizes of egg-capsules, each containing several developed ova.

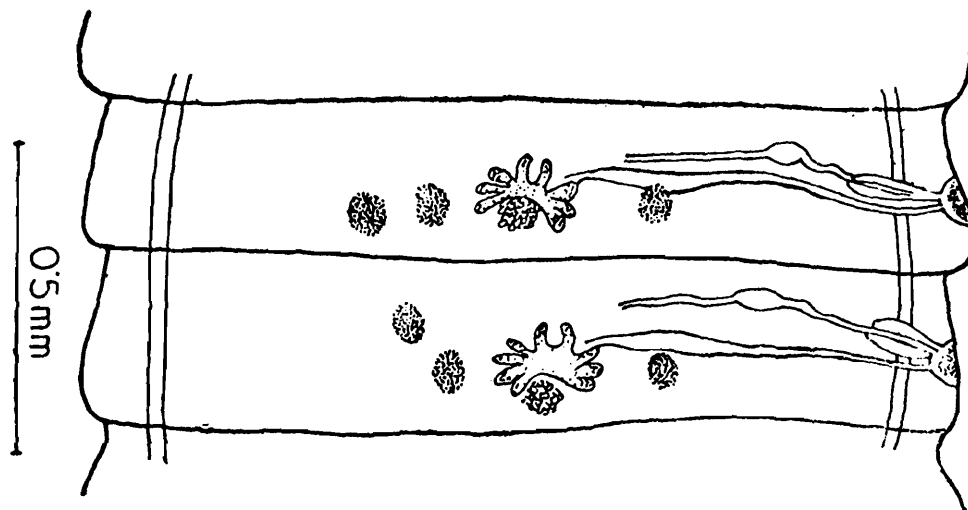


Fig. 18

Fig. 18. Mature segment.

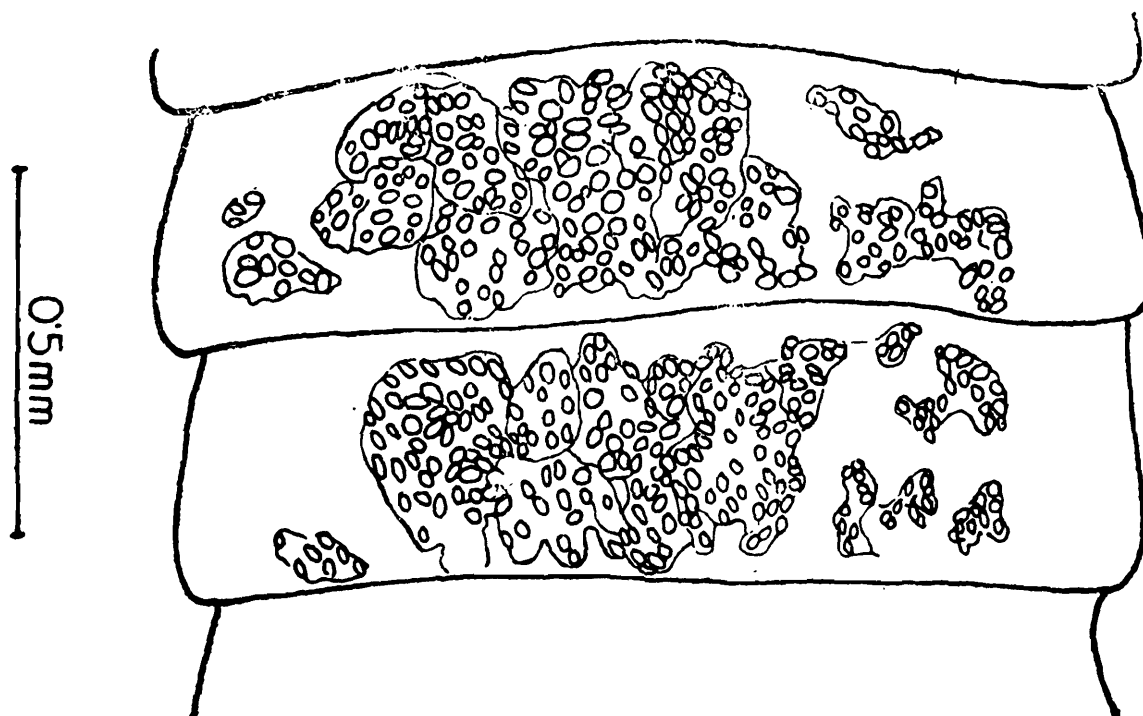


Fig. 19. Gravid segment.

Remarks : It is a common tapeworm parasiting house rat, mouce and shrew. Mukherjee (1970) has listed it from *Rattus rattus* and *Gerbillus gleadowi* from Rajasthan. Nama and Khichi (1975) reported it from *Rattus rattus* from Jodhpur (Rajasthan) and

recorded variations from Johri's (1950) description of this species. The present report also shows that the species exhibits morphological variations.

Primarily it is the parasite of the rodents as noted above, but man may also accidentally gets infected by it by eating food contaminated with the infected material.

SUMMARY

The cestode material for the present study was collected from arid zones of Rajasthan from lizards, birds and rodents during 1981-82. It comprises 6 known species belonging to 5 genera and 3 families of the Order Cyclophyllidea. The species are : *Oochoristica karachiensis* (Bilqees and Siddiqui, 1975) n. comb. from *Hemidactylus brooki* and an unidentified lizard, considering *O. jodhpurensis* Nama, 1974 from *Calotes versicolor* as synonym of *O. karachiensis* ; *O. varani* Nama and Khichi, 1972 from *Varanus monitor* ; *Mathevotaenia paraechinis* Nama, 1975 from *Paraechinus micropus micropus* ; *Otiditaenia nigriceps* (Gupta, 1976) from *Choriotis nigriceps* ; and *Hymenolepis diminuta* (Rudolphi, 1819) from *Rattus rattus*. Concise descriptions of the species, important synonymies and interesting remarks are additional features of the present study.

ACKNOWLEDGEMENTS

The author is thankful to Dr. A. K. Ghosh, Director, Zoological Survey of India, Calcutta, for providing laboratory and library facilities to study the material. He is also thankful to Dr. S. K. Bhattacharya, Additional Director, for taking interest in the present study.

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A NOTE ON THE TEMPERATURE PREFERENCE IN *MESOBUTHUS TAMULUS*
TAMULUS (FABR.) (ORDER : SCORPIONIDA. FAMILY : BUTHIDAE)

B. E. YADAV AND R. H. KAMBLE

Zoological Survey of India,

Western Regional Station,

1182/2, F. C. Road,

Shivajinagar,

Puna—411005.

INTRODUCTION

Mesobuthus tamulus tamulus is commonly occurring yellow scorpion in Maharashtra. Very scanty information is available on its behavioural patterns except scorpion poisoning and venom studies (Ramamurthi & Jangi, 1987, Tare 1981), while a comprehensive account on its taxonomy by Tikadar & Bastawade (1983) is worth mentioning. In January, experiments were conducted by keeping an illuminated electric bulb in the cage. Scorpions responded towards this stimulus. The present paper deals with one month's observations on *Mesobuthus tamulus tamulus* (Fabr.). Various experiments yielded similar results.

Scorpions, inhabitants of warmer part of the globe, show great adaptability as tolerance for higher temperatures. Few authors, Cloudsley-Thompson (1962) ; Alexander & Ewer (1958) ; Warburg & Ben Horin (1981) and Hadley (1970) have demonstrated the ability of several species of scorpions to withstand higher temperatures, e. g. *Leiurus quinquestriatus* (L.). *Hadrurus arizonensis*, *Centruroides sculpturatus*, *Opisthophthalmus latimanus*, *B. judaicus*, *Buthotus minax*.

MATERIALS AND METHODS

Five specimens of *Mesobuthus tamulus tamulus* were collected from Pashan, in the vicinity of Pune. The specimens brought to the laboratory were kept for a week to acclimatize them. They were kept in a wooden cage of 45 cms×30 cms×30 cms size having a glass top. The sides were fitted with iron mesh. The cage was supported by four, 7.5 cm. high wooden blocks, which were immersed in plastic containers filled with water to prevent the attack of ants. Sand and dry soil was spread in the cage. Few pieces of dry coconut shells and smaller stones were kept here and there for shelter. Insects were given as food, twice a week and a petridish filled with water was kept in the cage.

An illuminated electric bulb of 60 w. was arranged in the cage for a period of one hour. Initial temperature in the cage and temperature surrounding scorpions was noted. After half an hour temperature surrounding scorpions was recorded. Orientation—approach and the sitting posture of scorpions were observed.

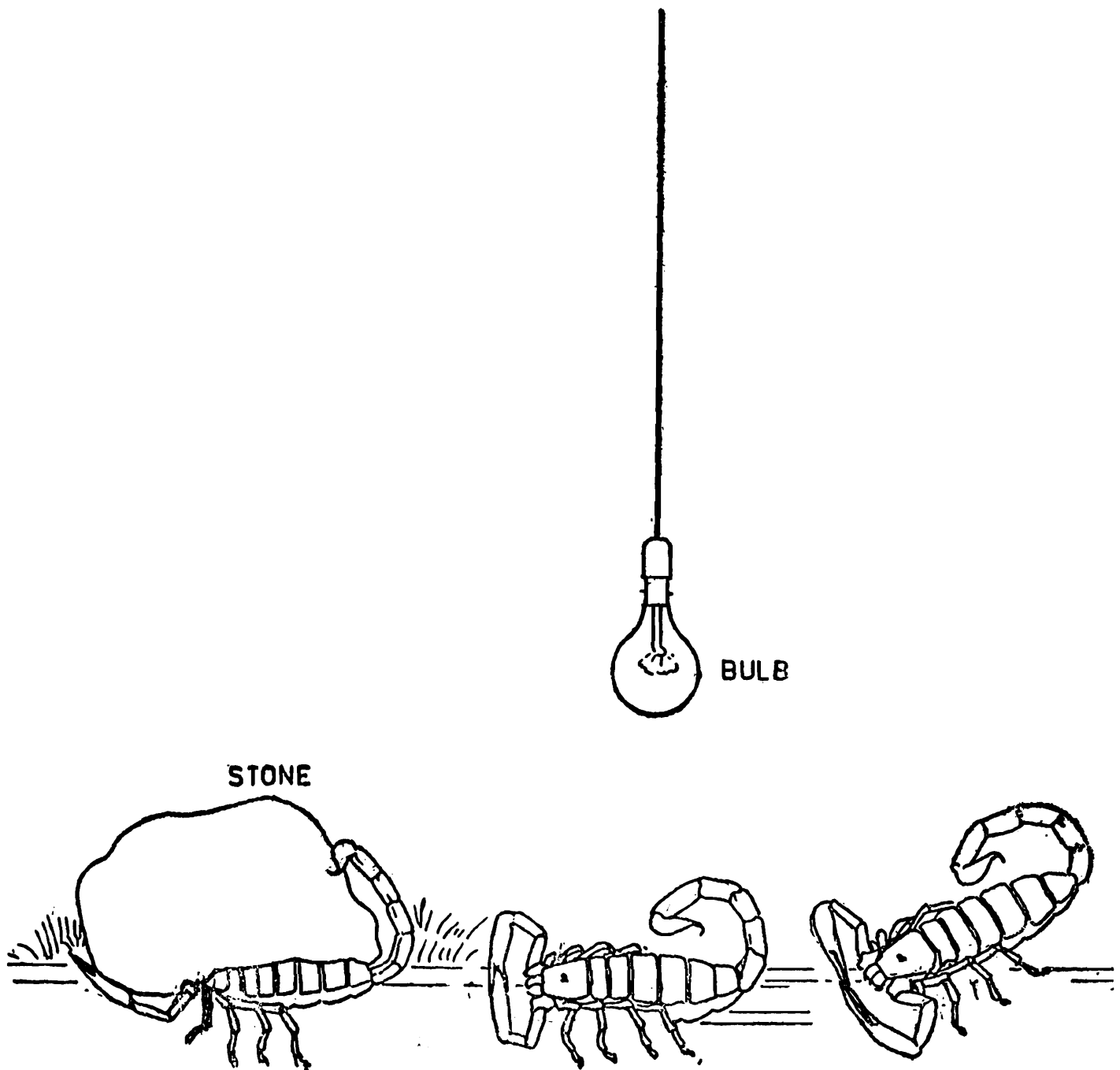


FIG.1 RESPONSE TO THE SOURCE OF HEAT

In an another set of experimtn, a beaker containing the illuminated candle was kept in the cage. Temperature was recorded. The experiment was repeated by shifting the beaker and the reaction of scorpions was noted.

OBSERVATIONS

1. *Response to electric bulb* :—

In the month of January 1981, 3 sets of experiments were conducted on 5 scorpions. All scorpions reacted positively. They oriented with projected open pincers from below the stone, within 5-10 minutes, gradually scorpions approached with the movement of pedipalps.

Real sign whether scorpions realised the sense of heat was that they opened and extended their pedipalps. In one instance, scorpion just extended its pedipalps from below the stone.

When the light was put on, scorpions gradually came out from beneath the coconut shell. After few minutes march, scorpions attained particular sitting position some distance away from the bulb. Their prosoma were facing away from the bulb and metasoma were towards the bulb. Tails were curled over back and pedipalps were held very close to chelicerae.

Few scorpions just shifted their previous sitting position and remained concealed beneath stones. Scorpions sat in this position for more than hour, when the light was made off, they did not change their place, scorpions had acquired a temperature surrounding them 33-35°C.

TABLE I : Showing the sitting position of scorpions.

Scorpion	Distance of sitting away from bulb	Position of sitting
A	4 cms away	Posterior end facing towards the bulb sting upwards
B	8 cms away	—do—
C	4 cms above on the inner side of cage	—do— Pedipalps closed near chelicere
D	8 cms away in the corner of cage	—do—
E	7 cms away	Below a stone.

TABLE II Showing the response of scorpions towards the source of heat

Date : 6.1.1981

Time of light on : 11.00 a.m.

Initial temp.

Time of light off : 12.00 noon

in the cage 25°C.

Scorpion	Time of orientation	Initial Temp. surrounding scorpions	Time required to come near bulb	Time of sitting	Distance	After $\frac{1}{2}$ hr. temp. acquired by scor.	Sitting position of scorpions
A	11.05 a.m.	24°C	2 minutes	11.07 a.m.	4 cms	30°C	Below stone, near bulb, prosoma towards bulb.
B	11.07 a.m.	24°C	3 minutes	11.10 a.m.	6 cms	30°C	Sting towards bulb, in the corner of cage
C	11.12 a.m.	25°C	8 minutes	11.20 a.m.	8 cms	29°C	Scorpion was in the gap between two stones, sting towards the bulb.
D	11.20 a.m.	25°C	Immediately	11.20 a.m.	8 cms	29°C	—do—
E	11.45 a.m.	25°C	—do—	11.45 a.m.	10 cms	30°C	On the inner side of cage. Just it reverted the position. Prosoma towards bulb.

(1) After one hour temperature surrounding scorpions was in the range of 33-35°C.

(2) At 1.20 p. m. all the scorpions changed their sitting places.

(II) *Response of Scorpions towards illuminated candle :*

Fifteen minutes after keeping the beaker containing illuminated candle in the cage, 3 out of 5 scorpions displayed similar orientation—approach response to those observed by keeping illuminated bulb. Scorpions came closer to beaker and sat with their pedipalps closed near chelicerae.

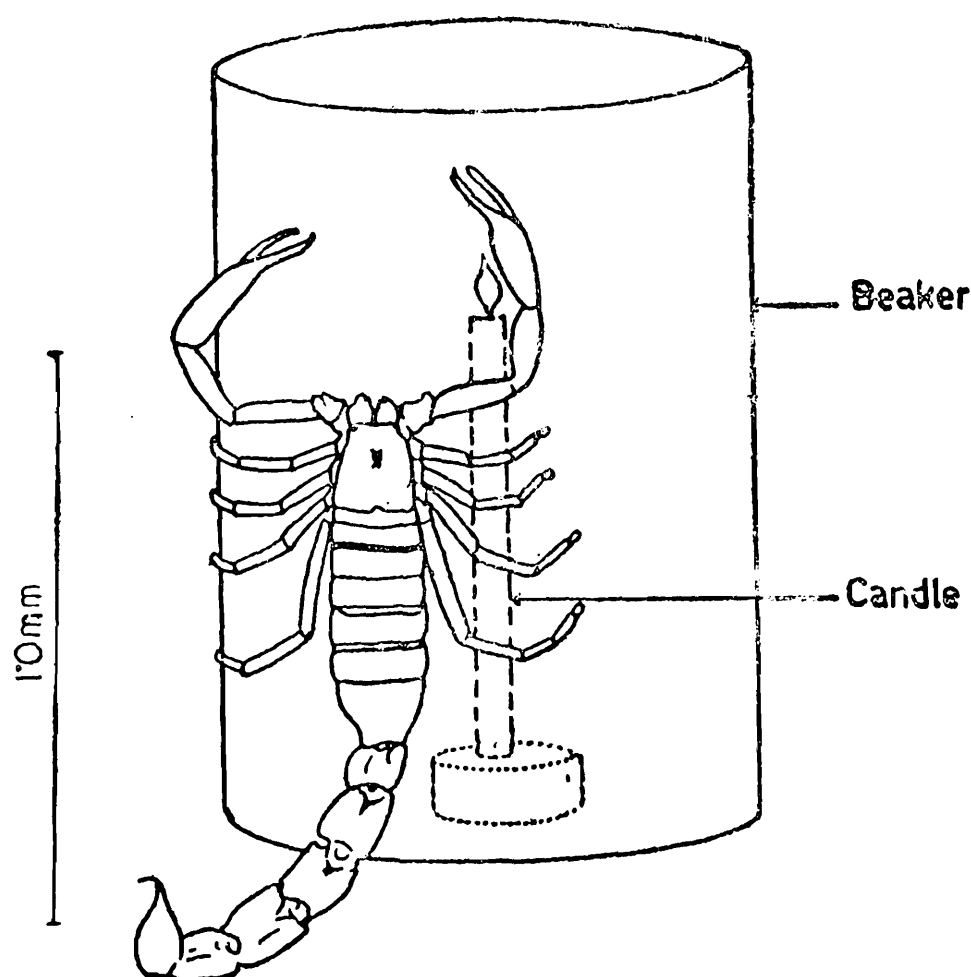


Fig 1 RESPONSE TO ILLUMINATED CANDLE

Three females came in close contact with beaker and sat in the gap between inner side of cage and the beaker. One gravid female twice attempted to climb on the beaker. Her pedipalps were touching the upper edge of beaker and she stood in erect position.

After shifting a beaker at other place again she approached and tried to climb over beaker. Two females sat in a position such that they were in close contact with beaker. Two males did not show response towards this stimulus. Temperature surrounding scorpions was 29-30°C.

When the candle was made off, scorpions did not change their sitting position.

DISCUSSION

In January, *Mesobuthus tamulus tamulus* showed affinity towards the source of heat (Illuminated bulb and candle) and preferred a temperature surrounding their body 30-35°C with particularly sitting away from the bulb at the distance (4 to 10 cms) and their stings were facing towards the bulb. However in case of candle experiment, scorpions sat in close contact with beaker regardless of their strictly nocturnal habit.

Results of the present study are in agreement with the investigations made by earlier authors (Cioudsley-Thompson, 1962); Abushama (1984) and Alexander and Ewer (1958) stating that the upper lethal limit of temperature for the scorpion *Leiurus quinquesriatus* (H & E) to be 47°C and *Buthotus minax* was 45°C, after 24 hours exposure. *Opishophthalmus latimanus* preferred a temperature range 32-38°C. More over Warburg & Benhorin (1981) reported that two *Buthids*; *Buthotus judaicus* and *Leiurus quinquestriatus* remained in the warmer zones of the gradient (25-27°C) for longer period.

As the experiments on *Mesobuthus tamulus tamulus* were conducted in January; cold climate of this month may be a factor inducing this behaviour in *Mesobuthus tamulus tamulus*. Recent studies indicate scorpions are also able to behaviourally regulate their temperature through vertical movements within the burrow (Hadley 1970).

As soon as keeping the illuminated bulb in the cage, *Mesobuthus tamulus tamulus* opened fingers of their padipalps—This observation suggests that the pedipalp receptors may possess some cues informing about physical conditions of the environment.

Further scorpions sat in a particular position—avoiding the direct light and stings facing towards the bulb—this observation supports the views of Abushama (1964) that receptors perceiving the heat are located on hairs of poison bulb of scorpions.

Field observations indicate that *Mesobuthus tamulus tamulus* occupied a range of temperature 25-35°C in natural habitats.

SUMMARY

Although *Mesobuthus tamulus tamulus* is a nocturnal species, in captivity it displayed affinity towards the source of heat (Electric bulb and illuminated candle) in cooler month (January), scorpions reacted by sitting in a particular position. Their prosoma was facing away from the direct light for longer period. Temperature surrounding scorpions was recorded in the range of 30—35°C.

Response of scorpions towards the electric bulb was within a period of 5—10 minutes. While in case of illuminated candle the response was not so fast. The sitting distance of scorpions from the source of heat was directly related to the intensity of heat.

ACKNOWLEDGEMENT

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Thanks are due to Shri P. W. Garde, for preparing some illustrations and to Mrs. K. K. Kathawde for typing the manuscript.

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TREMATODES OF VERTEBRATES OF RAJASTHAN

M. HAFEEZULLAH

*Zoological Survey of India, M-Block, 535-New Alipore,
Calcutta-700053.*

INTRODUCTION

The present study is based on the digenetic trematodes of garden lizards, snakes and bats collected from Jodhpur (Rajasthan) and the nearby areas during 1980-82. They belong to the families Dicrocoeliidae, Lecithodendriidae and Plagiorchiidae and are all known forms. Therefore, only their diagnostic features are included in this paper with interesting remarks on variability, zoogeography, host and locality records and synonymies.

The specimens were processed according to the standard methods of collection i. e. flattening under cover glass pressure, killing and fixing with the fixative AFA, preserving in 70% alcohol, staining with borax carmine, differentiation with acid alcohol, dehydration with higher grades of alcohol, clearing with xylol and clove oil, mounting in Canada balsam, and finally drying the permanent mounts on temperature regulated hot plate.

The drawings have been made with the aid of a camera lucida. The material has been deposited with the National Collections of Zoological Survey of India, Calcutta.

Family DICROCOELIIDAE Odhner, 1910

Subfamily DICROCOELINAE Looss, 1899

Genus 1. *Paradistomum* Kossack

1910. *Paradistomum* Kossack, *Ctbl. Bakt. I. Orig.*, 56 (2) : 114.

1944. *Paradistomoides* Travassos, *Mem. Inst. Oswaldo Cruz*, 2 : 263.

1960. *Paradistomum* : Arora and Agarwal, *Bull. zool. Soc. College Sci., Nagpur*, 3 : 51.

1960. *Paradistomoides* : Arora and Agarwal, *Bull. zool. Soc. College Sci., Nagpur*, 3 : 51.

Arora and Agarwal (1960) have studied intra-specific variations in *Paradistomum orientalis* (Narain and Das, 1929) in detail in 157 specimens collected from the gall-bladder of *Calotes versicolor* Daud. They have made systematic study of the digenean trematode on the basis of five pure populations, each of one, sixteen, eight and fifty-one specimens while a sixth sample of mixed population of sixty-seven parasites was also included in the study. They have noted marked variations in shape (broad and leaf-like, slender, elongated) and size of the body, width of intestinal caeca

(extremely broad to narrower), length of oesophagus in broad to narrower forms, lobation of testes (from ovoid to indented). positions of ovary and genital pore, etc. in specimens recovered from a single gall-bladder. The most significant variation they have noted is in the anterior extent of vitellaria with respect to the level of the anterior margin of the testes or the ventral sucker-intergrading variations in the gravid individuals collected from the same gall-bladder. On this evidence, they do not agree with the separation of *Paradistomoides* Travassos, 1944 from *Paradistomum* Kossack, 1910. The author has also studied six pure populations (16, 5, 8, 1, 2, 2) recovered from the gall-bladder of *Calotes versicolor* and *Hemidactylus brooki* examined at Jodhpur, Rajasthan. He has also come to the same conclusion that *Paradistomoides* should be considered as a synonym of *Paradistomum*.

1. *Paradistomum orientalis* (Narain and Das)

(Figs. 1, 2)

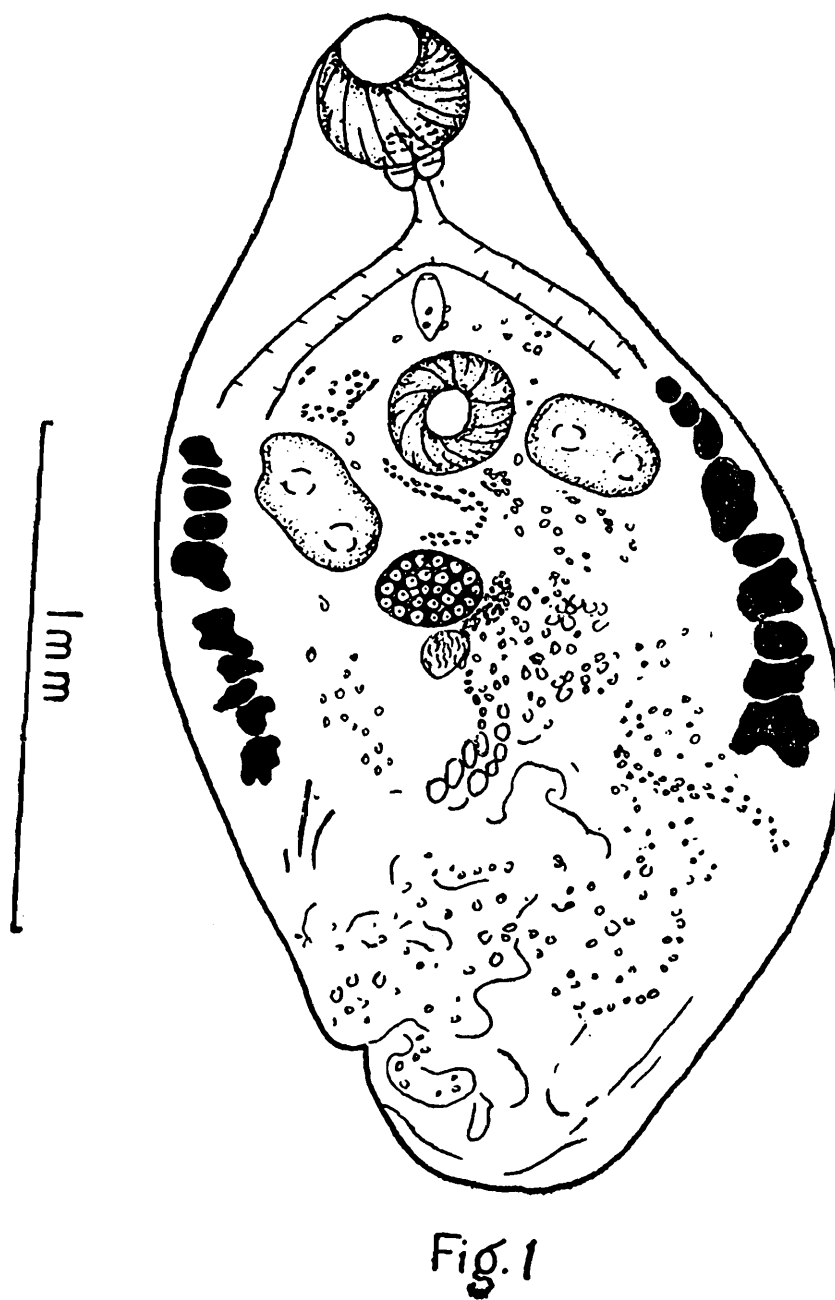
1929. *Dicrocoelium orientalis* Narain and Das, *J. Bombay nat. Hist.*, 33 (2) : 250.
 1936. *Paradistomum orientalis* : Bhalerao, *J. Helminth.*, 14 : 173.
 1936. *Paradistomum moghei* Bhalerao, *J. Helminth.*, 14 : 170.
 1957. *Paradistomum banarasensis* Baugh, *Proc. natl. Acad. Sci. India*, B, 26 (6) : 417.
 1978. *Paradistomoides orientalis* : Nama and Khichi, *Z. Angew. Zool.*, 60 : 258.
 1973. *Paradistomoides medius* Nama and Khichi, *Z. Angew. Zool.*, 60 : 258. (syn. nov.)
 1973. *Paradistomoides brevis* Nama and Khichi, *Z. Angew. Zool.*, 60 : 259 (Syn. nov.)

Material : Hosts—*Calotes versicolor* Daud., (Squamata : Sauria : Agamidae) ; *Hemidactylus brooki*, (Squamata ; Sauria : Geckonidae) ; location—Gall-bladder ; locality—Jodhpur (Rajasthan) ; no. of specimens—16+5+8+1+2+2=34, on slides, collected in May and October, 1981.

Diagnosis : Body narrow elongated to leaf-like with narrow anterior end and broadly rounded posterior end. Suckers equal to subequal. Prepharynx indistinct pharynx small ; oesophagus slender ; intestinal caeca narrow to fairly broad. Testes ovoid to globular, immediately posterolateral to acetabulum, caecal. Cirrus sac cylindrical to fusiform, lying between acetabulum and intestinal bifurcation. Genital pore at level of intestinal bifurcation. Ovary globular to ovoid, immediately behind testes, median or submedian. Seminal receptacle smaller or subequal or even larger than ovary. Uterine coils filling all available postacetabular space. Vitelline follicles variable in anterior extent being post-testicular to testicular or even pretesticular.

Remarks : *Paradistomum moghei* (Bhalerao, 1936) was recovered from the liver of *Calotes versicolor* and was described as distinct from *P. orientalis*, but Krishnaswamy

and Anantaraman (1956), while studying variations in 91 specimens recovered from the gall-bladder of *C. versicolor*, arrived at the conclusion that it should be a synonym of *P. orientalis*, in spite of differences in body shape, size, vitellaria not extending anteriorly beyond the anterior border of testes, in the contents of the cirrus sac and



Figs. 1. *Paradistomum orientalis* from *Hemidactylus brooki*. Entire worms.

wide intestinal caeca. Arora, Agarwal and Agarwal (1962) studied the occurrence of intra-specific variations in *P. orientalis* from the liver [18 (N=18ex.)] and intestine [27 (N=27ex.)] of *C. versicolor*. As a result of this study, they considered *P. moghei* and *P. banarasensis* as synonymous with *P. orientalis*. The authors gave an emended diagnosis of this species.

Nama and Khichi (1973) did not consult Krishnaswamy and Anantaraman (1956), Arora and Agarwal (1960) and Arora, Agarwal and Agarwal (1962) and maintain *Paradistomoides* Travassos, 1944 distinct from *Paradistomum* Kossack, 1910 and *P. moghei* (Bhalerao, 1936) and *P. orientalis* as distinct species. They further added 2 more new

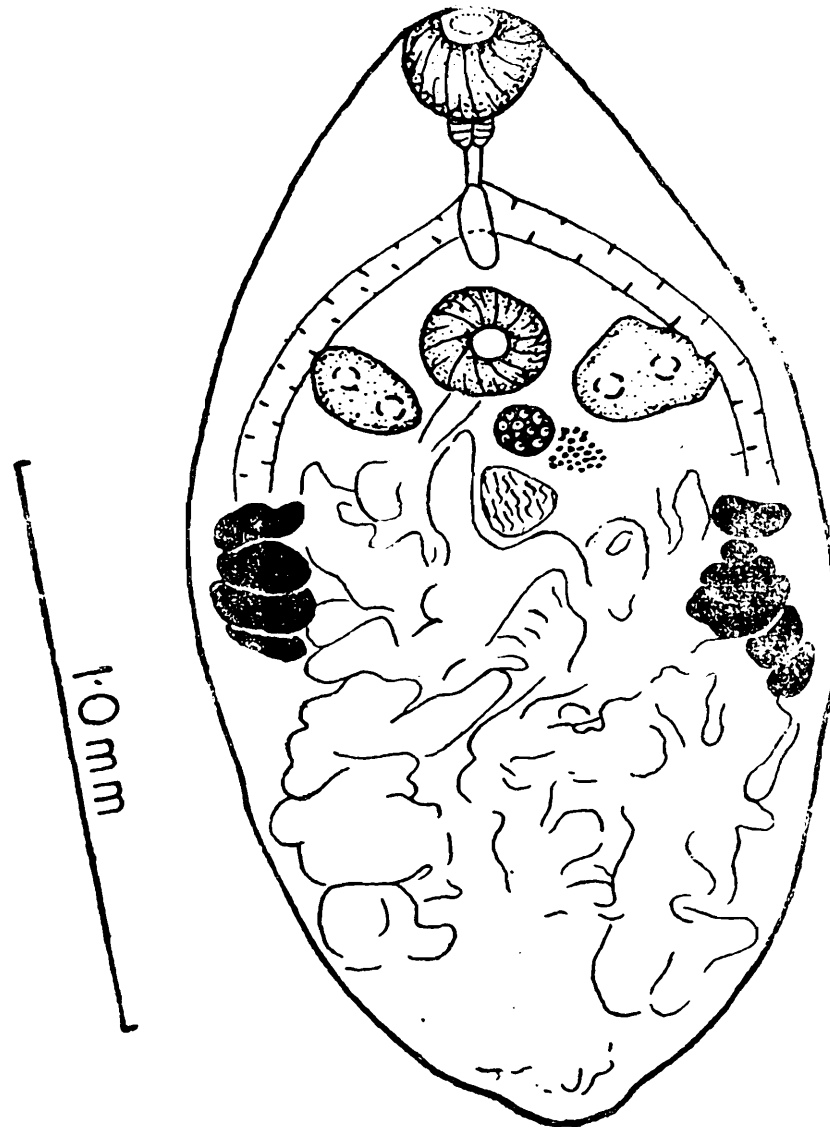


Fig. 2

Fig. 2, *Paradistomum orientalis* from *Hemidactylus brooki*. Entire worms.

species in the genus *Paradistomoides* which were collected from the gall-bladders of *Hemidactylus flaviviridis* from Jodhpur, Rajasthan. The two new species *P. medius* and *P. brevis* fall within the great range of intraspecific variations of *Paradistomum orientalis*. The present author therefore considers both the species as synonyms of *P. orientalis*.

2. *Paradistomum spatulum* (Simha) n. comb.

(Figs. 3, 4)

1958. *Paradistomoides spatulus* Simha, *Z. Parasitenkd.*, 18 : 193.

1973. *Paradistomoides diminutus* Nama and Khichi, *Z. Angew. Zool.*, 60 : 260. (n. syn.)

1978. *Paradistomoides intermedius* Nama and Khichi, Z. Angew. Zool., 60 : 263. (n. syn.)

1978. *Paradistomoides elongatus* Nama and Khichi, Z. Angew. Zool., 60 : 265. (n. syn.)

Material : Hosts—*Calotes versicolor*, (Squamata : Sauria : Agamidae) ; *Eryx conicus*, (Ophidia : Boidae) ; location—Gallbladder ; locality—Jodhpur (Rajasthan) ; no. of specimens—6+4+2=12, on slides, collected in May and October 1981.

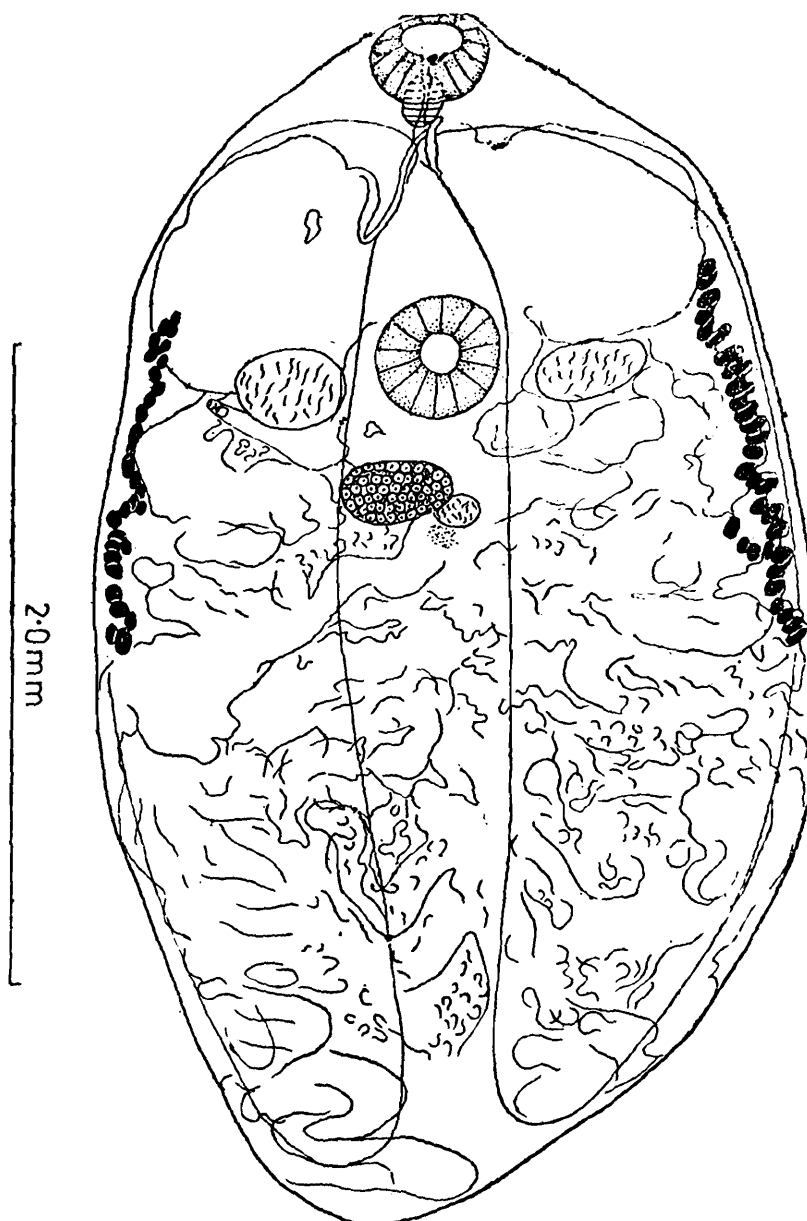


Fig 3

Fig. 3. *Paradistomum spatulum* from *Calotes versicolor*. Entire worm.

Diagnosis : Body large, oblong or spatulate. Oral sucker terminal. Acetabulum in middle of anterior half of body, larger than oral sucker. Pharynx muscular. Oesophagus very short. Caeca much wide, distended, extending slightly short of posterior end of body. Testes symmetrical, one on either side immediately behind acetabulum, smaller or almost equal to latter. Cirrus sac small. Genital opening ventral to

intestinal bifurcation. Ovary entire or of irregular margin, post-testicular, median or submedian. Seminal receptacle and shell gland present near ovary. Vitelline follicles extending from about equatorial plane to level of anterior margin of acetabulum or beyond it, definitely post testes. Dense and close coils of uterus filling entire hind body.

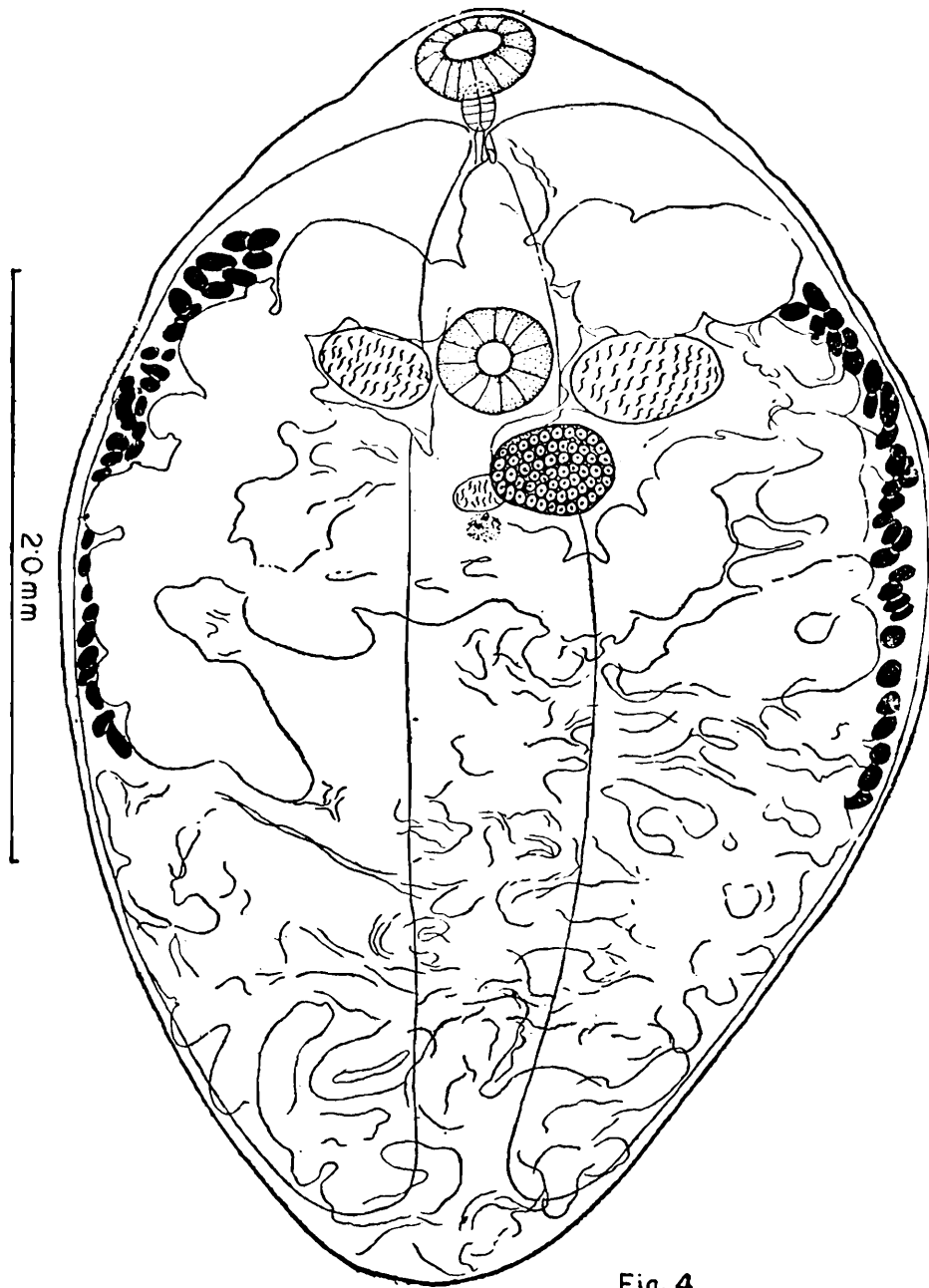


Fig. 4

Fig. 4. *Paradistomum spatulum* from *Eryx conicus*. Entire worm.

Remarks : Simha (1958) described this species from the gall-bladder of the rock lizard, *Calotes numbericola*, from Hyderabad. The present specimens from the gall-bladder of the garden lizard, *Calotes versicolor*, and the snake, *Eryx conicus*, from Jodhpur (Rajasthan), closely resemble Simha's description except in smaller eggs. The body also is not uniformly broad and spatulate in all the specimens from both the

hosts. The present specimens also come very close to *Paradistomum couteleni* (Deblock, Capron and Brygoo, 1962) in body size, extent of vitellaria, small cirrus sac, greatly distended caeca and egg size. It is quite possible that further study may prove *P. couteleni* as synonym of *P. spatulum*. Nama and Khichi (1973) did not compare their species *Paradistomoides diminutus*, *P. intermedius* and *P. elongatus* with *Paradistomoides spatulus* Simha, 1958, and did not consult the papers of Arora and Agarwal (1960) and Arora, Agarwal and Agarwal (1962). In the light of these investigations and study of the present material, *P. diminutus*, *P. intermedius* and *P. elongatus* fall as synonyms of *Paradistomum spatulum* (Simha, 1958).

Family LECITHODENDRIIDAE Odhner, 1911

Subfamily LECITHODENDRIINAE Looss, 1902

Genus 2. *Prosthodendrium* Dollfus

- 1896. *Lecithodendrium* Looss, (*Partim*), *Mem. Inst. Egypt*, 3 : 86.
- 1931. *Prosthodendrium* Dollfus, *Ann. Parasit.*, 9 : 484.
- 1943. *Skrjabinodendrium* Skarbilovich, *Dokl. Acad. Nauk SSSR n. s.*, 38 (7) : 223.
- 1943. *Chiroptodendrium* Skarbilovich, *Dokl. Acad. Nauk SSSR n. s.*, 38 (7) : 224.
- 1943. *Travassodendrium* Skarbilovich, *Dokl. Acad. Nauk SSSR n. s.*, 38 (7) : 224.
- 1954. *Longitrema* Chen, *Acta zool. Sinica*, 6 : 150.

The genus *Prosthodendrium* was erected by Dollfus (1931) with *Prosthodendrium dinanatum* (Bhalerao, 1962) as its type species. With the passage of time, a large number of species was added under it. It included species with lobed and unlobed ovaries. Dollfus (1937) divided this genus into two subgenera, viz., *Prosthodendrium* Dollfus, 1931 with *Prosthodendrium (Prosthodendrium) dinanatum* (Bhalerao, 1926) as type species, and *Paralecithodendrium* Odhner, 1911 without a type species. The former lecithodendriid trematodes included with unlobed ovaries while the latter trematodes with lobed ovaries. This arrangement is generally accepted by other workers. Dubois (1960, 1962) revised the subgenera *Prosthodendrium* and *Paralecithodendrium* respectively, reducing the number of species to 23 in the former and 6 in the latter through synonymisation. Later on, a few more species were added to each subgenus. Yamaguti (1971) accepted the validity of *Skrjabinodendrium* on the basis of the characters of *Lecithodendrium orospinosa* Bhalerao, 1926 only, and that of *Longitrema* on the basis of *Prosthodendrium piriforme* Yamaguti, 1939, as the type species, (other species being *Lecithodendrium bhaleraoi* Pande, 1935, *Prosthodendrium chilostomum* (Mehlis, 1831) Macy, 1936, *Prosthodendrium chilostomum madagascariense* Richard, 1966, *Lecithodendrium longiforme* Bhalerao, 1926, *Lecithodendrium longiforme allahabadi* Pande, 1935 and *Lecithodendrium luzonicum* Tubangui, 1928). However, there appears to be no pronounced generic difference between these two genera and others listed above.

3. *Prosthodendrium* (*Prosthodendrium*) *longiforme* Bhalerao

(Fig. 5)

1926. *Lecithodendrium longiforme* Bhalerao, *J. Burma Res. Soc.*, **15** : 183.
 1928. *Lecithodendrium luzonicum* Tubangui, *Philippine J. Sc.*, **36** : 366.
 1931. *Prosthodendrium longiforme* : Dollfus, *Ann. Parasit.*, **9** : 484.
 1935. *Lecithodendrium bhaleraoi* Pande, *Proc. Acad. Sc. U.P. Agra Oudh*, **5** (1) : 91.
 1935. *Lecithodendrium langiforme* var *allahabadi* Pande, *Proc. Acad. Sc. U. P. Agra Oudh*, **5** (1) : 93.
 1937. *Prosthodendrium* (Pr.) *longiforme* : Dollfus, *Bull. Mus. Roy. Hist. Nat. Belgique*, **13** : 1-21.
 1939. *Lecithodendrium kitazawai* Ogata, *Dobutsugaku Zasshi*, **51** (8) : 625.
 1955. *Prosthodendrium* (Pr.) *longiforme* : Dubois, *Rev. Suisse Zool.*, **62** : 498.
 1956. *Prosthodendrium magnum* Rysavy, *Cosk. parasitol.*, **3** : 167.
 1973. *Prosthodendrium longiforme* : Manskasi, *Parasit. Hung.*, **6** : 84.

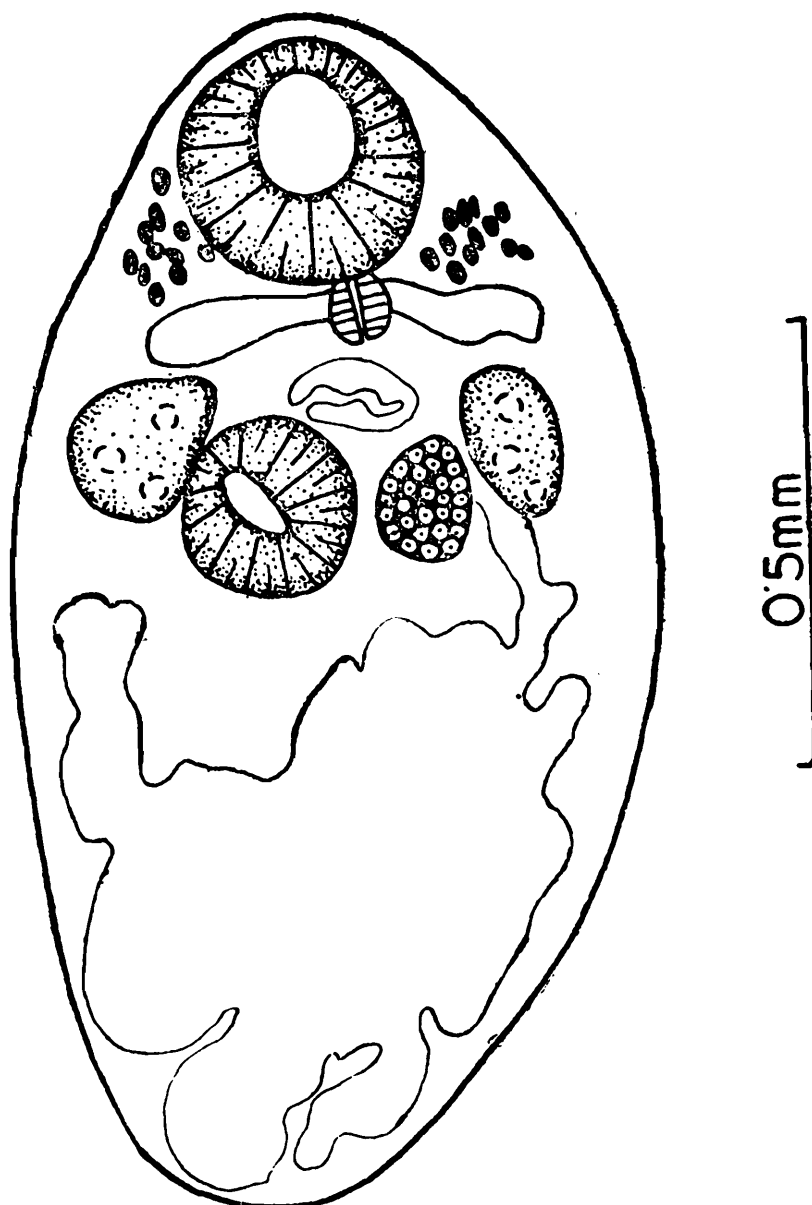


Fig 5

Fig. 5. *Prosthodendrium longiforme*. Entire worm.

Material : Host—*Tadarida aegyptica* Geoffroy, (Family Molossidae) ; location—intestine ; locality—Jodhpur ; no. of specimens—2, on one slide.

Diagnosis : Body elliptically elongated, about 1.30 mm. long. Oral sucker large, subterminal. Oesophagus indistinct. Intestinal caeca wide, extending laterally and obliquely to anterior margins of testes. Acetabulum smaller than oral sucker. Testes on either side of acetabulum. Pseudocirrus sac between acetabulum and intestinal bifurcation. Ovary unlobed, position variable in acetabular zone. Vitelline follicles on either side of hinder part of oral sucker. Uterus occupying whole of postacetabular space.

Remarks : Bhalerao (1926) originally described this species from a bat, *Nyctinomus plicatus*, in Burma and placed it under the genus *Lecithodendrium* Looss, 1896. Dollfus (1931) transferred it to his genus *Prosthodendrium*. Later on, Bhalerao (1936) agreed to it. Pande (1935) described *Lecithodendrium longiforme* var. *allahabadi* and *L. bhaleraoi* from the bat *Nycticejus kuhli* which were synonymised with *P. (Pr.) longiforme* by Dubois (1955). Matskasi (1973) recorded it from 9 different species of bats from Birsivpur, Calcutta, Nalbani (West Bengal), Bhubaneswar, Konark, Udaygiri (Orissa), Mahableshwar (Maharashtra) and Cherrapunjee (Meghalaya) in India. It was also reported from Malaysia, Philippines, Japan, Czechoslovakia, Hungary, U. S. S. R., Poland, Egypt and Afghanistan. Recently, Wason and Johnson (1978) reported it from the bat, *Taphozus perforatus perforatus* from Jodhpur (Rajasthan, India).

4. *Prosthodendrium (Prosthodendrium) parvouterus* (Bhalerao) Dubois

(Fig. 6)

- 1926. *Lecithodendrium cordiforme parvouterus* Bhalerao, *J. Burma Res. Soc.*, **15** : 182, 183.
- 1930. *Lecithodendrium cordiforme* of Mödhinger (nec Braun, 1900), *Zool. R. Sc. Univ. Heng.*, Budapest **1** (3) : 191-203.
- 1936. *Prosthodendrium pushpai* Bhalerao, *J. Helminth.*, **14** (4) : 212.
- 1936. *Prosthodendrium cordiforme* : Bhalerao, *Ibid*, **14** (4) : 218.
- 1639. *Lecithodendrium pyramidum* Lukasiak (nec Looss, 1896), *Fragm. Faun. Mus. Zool. Polon.*, **4** (5) : 93-106.
- 1942. *Prosthodendrium pyramidum orientale* Yamaguti and Asada, *Bull. Inst. Sci. Res.*, Manchoukuo, **6** : 498-512.
- 1954. *Prosthodendrium cordiforme* of Chen (nec Brunn, 1900), *Acta zool. Sinica*, **6** : 159.
- 1955. *Prosthodendrium (Prosthodendrium) parvouterus* : Dubois, *Rev. Suisse Zool.*, **62** : 490, 493, 498, 502, 469-506.
- 1957. *Prosthodendrium cordiforme* of Yeh (nec Braun, 1900), *J. Helminth.*, **31** (3) : 121-125.
- 1973. *Prosthodendrium parvouterus* : Matskasi, *Parasit. Hung.* **6** : 86.

Material : Host—*Tadarida aegyptica* Geoffroy, (Family Molossidae) ; location—intestine ; locality—Luni (Jodhpur, Rajasthan) ; no. of specimen—32, on slides.

Diagnosis : Ovoid to pyriform ; small, about 1.0 mm long, occasionally broader than long. Suckers almost equal. Intestinal caeca extending obliquely to anterior margins of testes. Testes large, larger than acetabulum, situated on either side of it. Pseudocirrus sac usually dorsal to acetabulum, larger than latter. Ovary postacetabular, larger than acetabulum, smaller than testes. Vitelline follicles anterior to intestinal caeca or overlapping it. Uterus occupying whole of postacetabular space.

Positions of pseudocirrus sac and ovary with respect to acetabulum slightly variable. Shape and size of gonads variable.

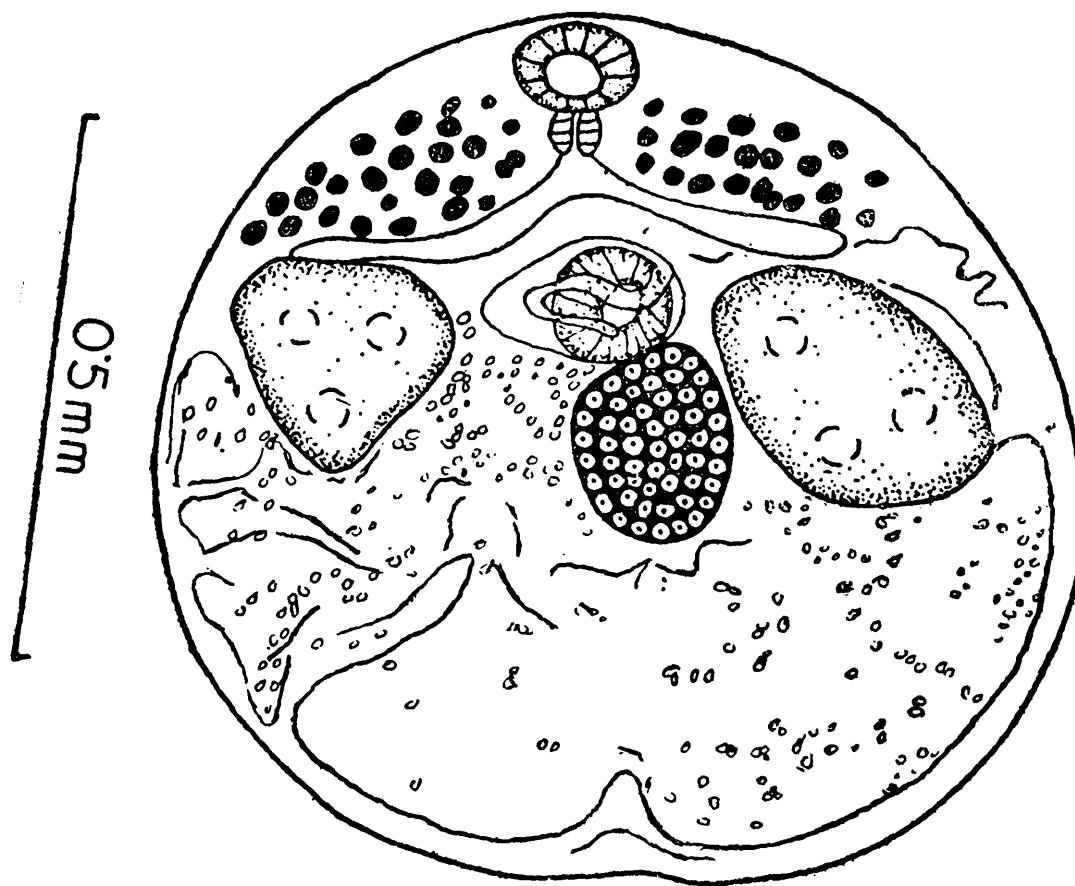


Fig. 6

Fig. 6. *Prosthodendrium parvoutherus*. Entire worm.

Remarks : The species was described by Bhalerao (1926) from a bat, *Nyctinomus plicatus* (= *Tadarida plicata*) and placed it in the genus *Lecithodendrium* as a subspecies of *L. cordiforme* Braun, 1900. Dubois (1955) raised the subspecies *parvoutherus* to the rank of a species distinct from *L. cordiforme* Braun and transferred it under the genus *Prosthodendrium*. It was later recorded from Hungary, Malaysia, Czechoslovakia, Bulgaria, Poland, Morocco, Zambia, Vietnam, India and Afghanistan. Soud and Ramadan (1977) redescribed it from the bats *Taphozus nudiventris*, *Asellia tridens tridens* and *Otonycteri hemrichi* from Egypt. The details of the present specimens agree

with those given by Bhalerao (1926) and Saoud and Ramadan (1977). However, the body shape may vary from round to oval and the positions of the cirrus sac and ovary may also vary with respect to the ventral sucker. The shape and size of the gonads are also variable. Kifune and Sawada (1980, 1982) and Kifune (1980a, 1982b) recorded it from various places in Japan. Kifune and Lee (1983) collected it from Korea. Matskasi (1973) recovered it from four species of bats from Birsivpur, Calcutta (West Bengal), Ricchai (M. P.) and Ellora caves (Maharashtra).

5. Prosthodendrium (Paralecithodendrium) ovimagnosum (Bhalerao) Dollfus

(Figs. 7, 8)

- 1926. *Lecithodendrium ovimagnosum* Bhalerao, *J. Burma Res. Soc.*, 15 : 188.
- 1931. *Prosthodensrium ovimagnosum* : Dollfus, *Ann. Parasit.*, 9 : 483-484.
- 1936. *Prosthodendrium ovimagnosum* : Bhalerao, *J. Helminth.*, 14 (4) : 218.
- 1938. *Lecithodendrium asadai* Fukui and Ogata, *Zool. Mag. (Japan)*, 51 : 98-99.
- 1954. *Prosthodendrium hepaticum* Chen, *Acta zool. Sinica*, 6 : 153.
- 1958. *Paralecithodendrium magnioris* Gupta and Bhardwaj, *Res. Bull. Panjab Univ.*, 141 : 75-79.

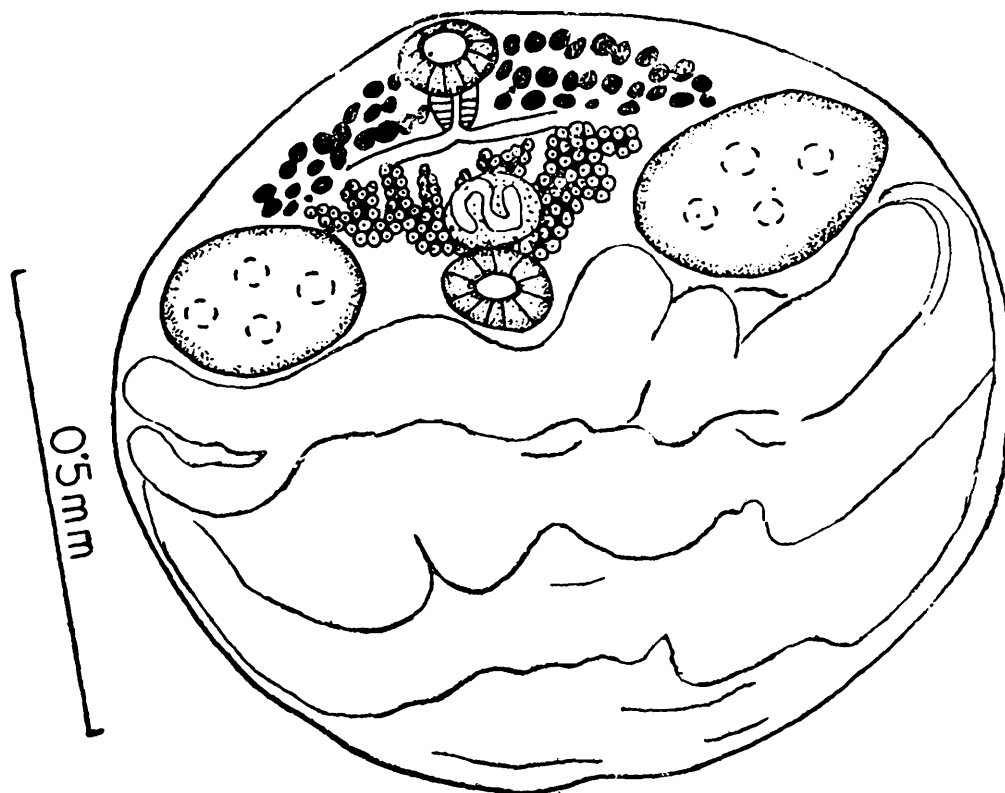


Fig 7

Fig. 7. *Prosthodendrium ovimagnosum*. Entire worm.

Material : Host—*Rhinopama hardwickei* Gray, Family Rhinopomatidae) ; location—intestine ; locality—Bhim Bharak (Jodhpur) ; no. of specimens—17, on slide.

Diagnosis : Body ovoid, small, wider than long. Suckers almost equal. Intestinal caeca extending obliquely to testes. Testes much larger than suckers, situated on either side of acetabulum. Pseudocirrus sac preacetabular. Ovary large, much lobed, preacetabular, extending almost from one testes to other. Vitelline follicles on either side of oral sucker and pharynx, anterior to and occasionally overlapping intestinal caeca. Uterus occupying all available space in hindbody.

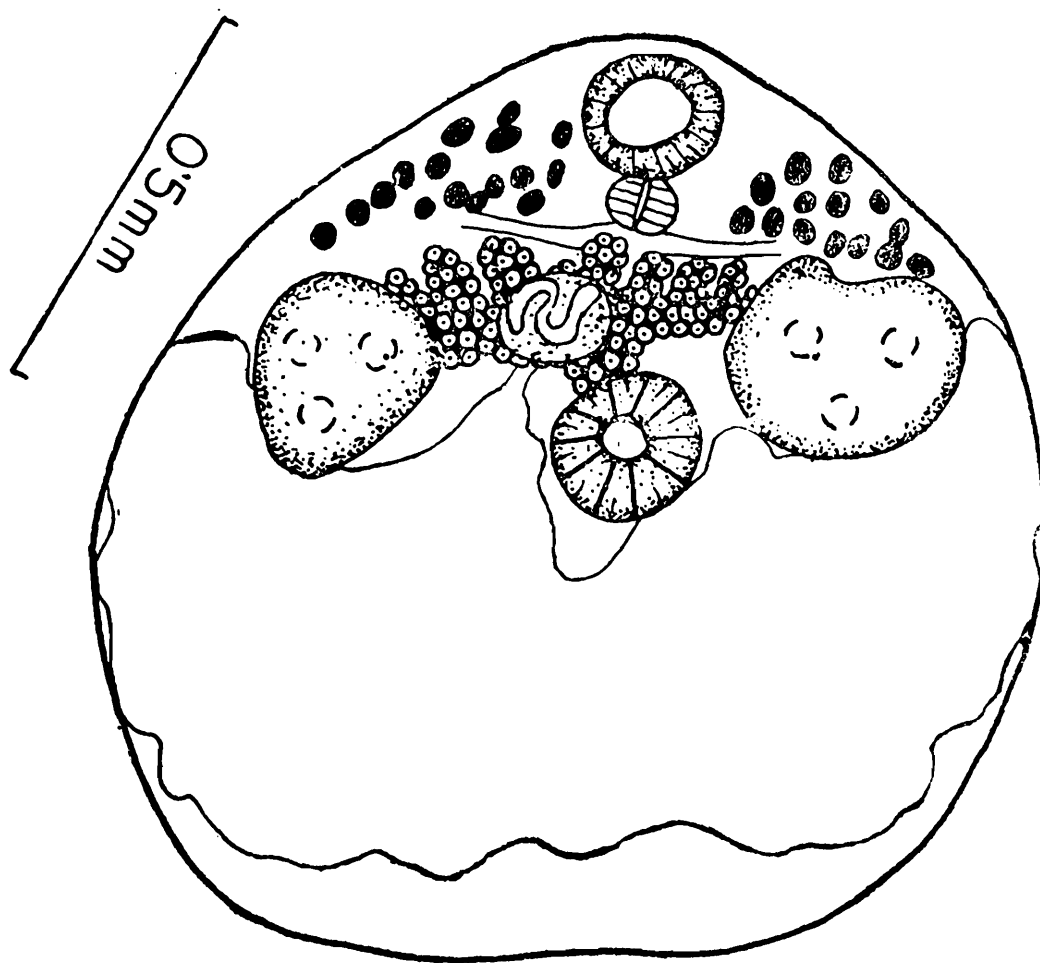


Fig. 8

Fig. 8. *Prosthodendrium ovimagnosum*. Entire worm.

Remarks : Bhalerao (1962) described it as *Lecithodendrium ovimagnosum* from the bat *Nyctonomus plicatus* in Burma. Dollfus (1931) transferred it in the genus *Prosthodendrium* while reviewing the subgenus *Paralecithodendrium* Odhner, 1911. Dubois (1962) accepted the validity of only six species under it and *Prosthodendrium* (Par.) *ovimagnosum* was one of them. He further synonymised *Lecithodendrium asadai* Fukui and Ogata, 1938 and *Paralecithodendrium magnioris* Gupta and Bhardwaj, 1985 with Bhalerao's species. *Prosthodendrium hepaticum* Chen, 1954 was also enumerated as one of the six valid species in the subgenus *Paralecithodendrium* by Dubois (*loc. cit.*), but Matskasi (1973) regarded it as a synonym of *P. ovimagnosum* on the basis of Vietnamese material.

He further recorded it from Birsivpur, Nalbani, Barkalikapur, Calcutta (West Bengal), Bhubaneswar, Konarak, Udaygiri (Orissa), Richai (M. P.), Elephanta caves and Mahabaleshwar (Maharashtra) in India from the intestine of eight species of bats including *Rhinopoma hardwickei*. Although the present specimens vary in the measurements of various organs as well as in the positions of the ovary and pseudocirrus sac with respect to the ventral sucker, the broadly and essentially conform to the original description. It was also reported from the Philippines, China and North Somaliland.

Family PLAGIORCHIIDAE Lühe, 1901

Subfamily PLAGIORCHINAE Pratt, 1902

Genus 3. *Plagiorchis* Lühe

1899. *Plagiorchis* Lühe, *Zool. Anz., Leipzig*, 22 : 531, 532, 533, 534.

1959. *Renoldstrema* Cheng, *Am. Midl. Nat.*, 6 : 84, 85.

6. *Plagiorchis koreanus* Ogata

(Figs. 9-12)

1938. *Plagiorchis koreanum* Ogata, *Annot. Zool. Japan*, 17 : 581-587.

Material : Host—*Rhinopoma hardwickei* Gray, (Family Rhinopomatidae) ; *Tadarida aegyptica* Geoffroy, (Family Molossidae) ; location—intestine ; locality—Jodhpur ; no. of specimens—3+1, on two slides ; collected on 12.11.1981 and 13.11.1981.

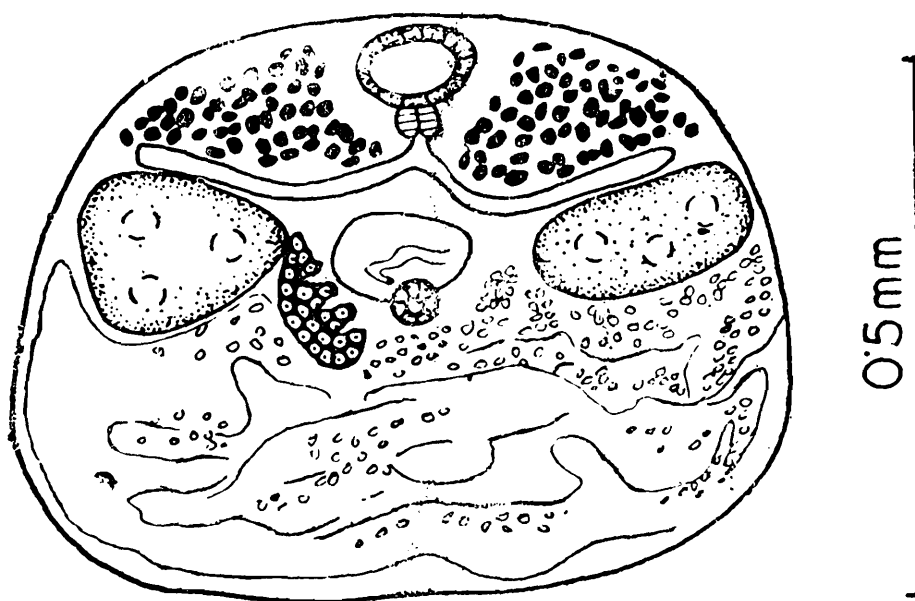


Fig. 9

Fig. 9. *Plagiorchis koreanus* from *Rhinopoma hardwickei*. Entire worm. Dorsal View.

Diagnosis : Body small, less than 2.0 mm long. Oral sucker much larger than ventral sucker. Testes and ovary also larger than ventral sucker. Testes larger than

or equal to or smaller than ovary. Anterior extent of vitellarium in level with anterior or posterior margin of ventral sucker or remaining behind it. Uterus completely descending into caudal space or not.

Remarks : Ogata (1938) first described this species from the bat *Nyctalus aviator* from Korea. Later on, he (1943) reported it from the same host as well as *Rhinopoma ferrumeguium nippon* from Japan. Groschaft and Tenora (1973) reported it from eight

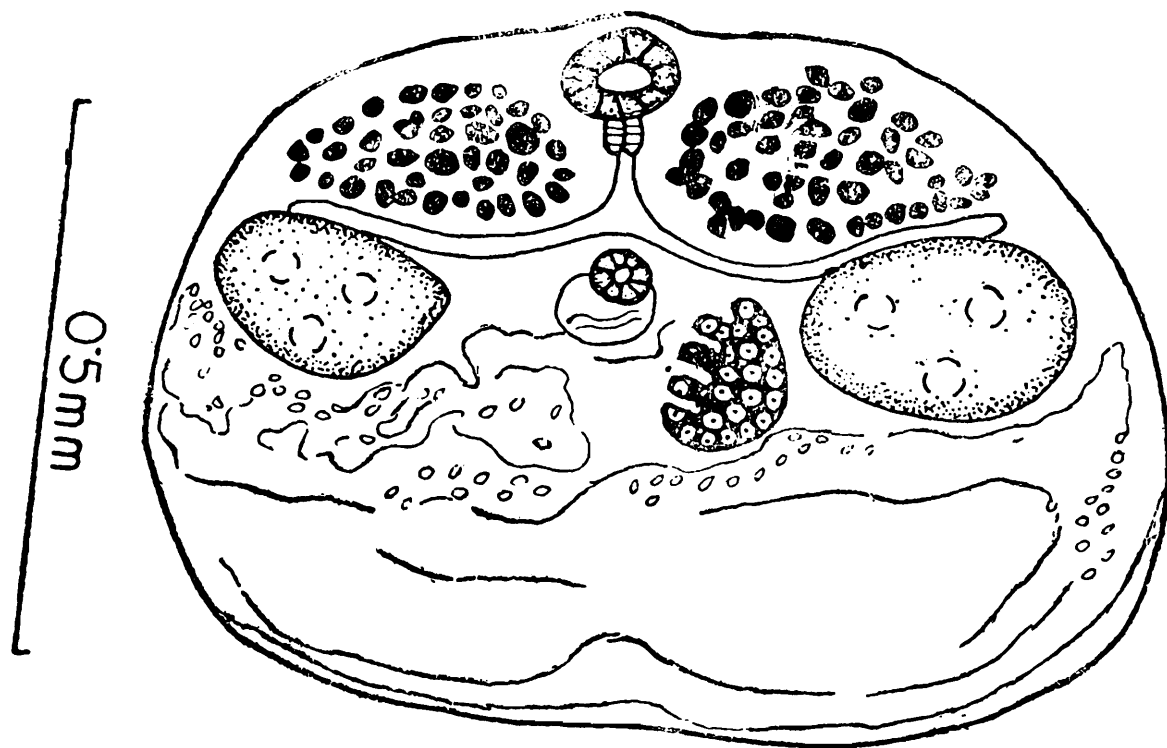


Fig. 10

Fig. 10. *Plagiorchis koreanus* from *Rhinopoma hardwickei*. Entire worm. Dorsal View.

species of bats from Afghanistan, viz., *Eptesicus serotinus*, *E. nasutus*, *Pipistrellus coromandra*, *Mgotis longipes*, *Nyctalus montanus*, *Rhinopoma microphyllum*, *R. hardwickei* and *Rhinolophus lepidus*. Wason and Johnson (1978) recorded it from bats—*Tophozous perforatus* and *Rhinopoma microphyllum*. Kifune and Sawada (1979, 1982) from Japan and Kifune, Sawada and Lee (1983) from Korea recorded it from various species of bats. This is the second report of *Plagiorchis koreanus* from Jodhpur (Rajasthan) and *Tadarida aegyptica* appears to be the new host record.

Some workers including Dubois (1960) considered *Plagiorchis koreanus* Ogata as a synonym of *Plagiorchis vespertilionis* (Muller, 1784) Braun, 1900, the type species of the genus *Plagiorchis* Lühe, 1899, which was accepted by Timofeeva (1962), Hurkova (1962), Hurkova (1963) and Richard (1966) but Sogandares-Bernal (1956), Groschaft and Tenora (*loc. cit.*), Kifune and Sawada (*loc. cit.*) Kifune, Sawada and Lee (*loc. cit.*)

and Wason and Johnson (*loc. cit.*) do not agree with this view and consider Ogata's species distinct from *P. vespertilionis*. The present author concurs with these workers.

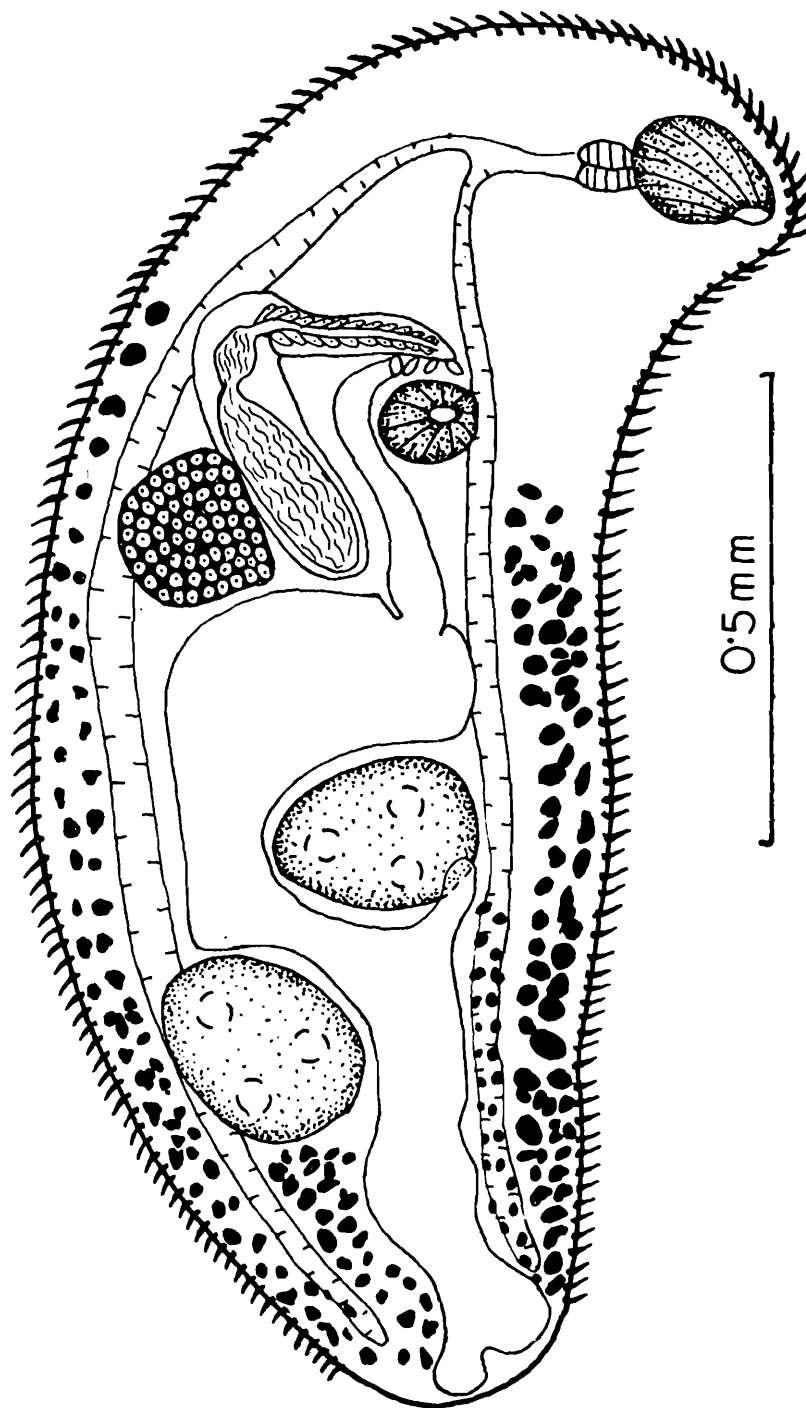


Fig. II

Fig. 11. *Plagiorchis koreanus* from *Rhinopoma hardwickei*. Entire worm. Ventral View.

Plagiorchis vespertilionis is characterised by a much longer body than that of *P. koreanus*, oral sucker is equal or subequal to ventral sucker and ovary is always smaller than

ventral sucker. Sogandras-Bernal (1956) not only accepted the validity of *P. koreanus* against *P. vespertilionis* but also pointed out that *P. vespertilionis* of Shtrom and Sondak

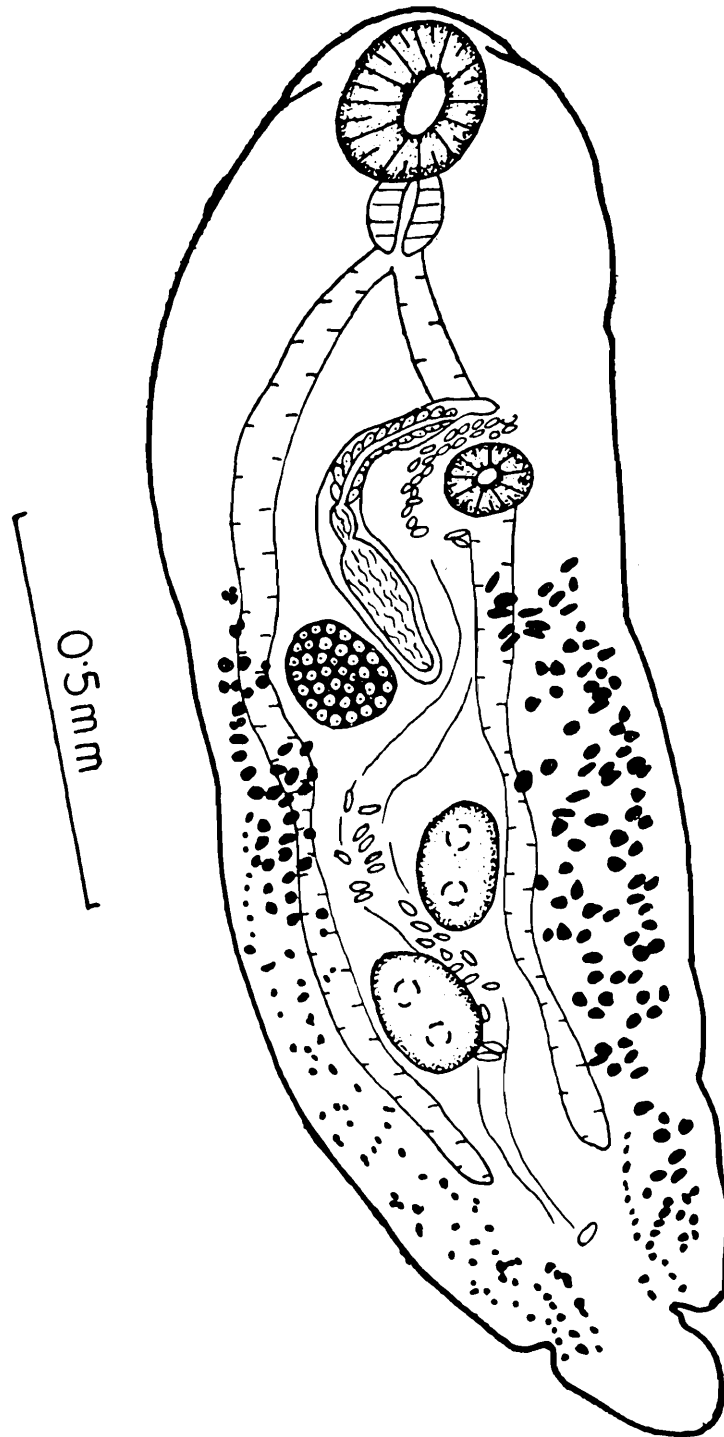


Fig.12

Fig. 12. *Plagiorchis koreanus* from *Tadarida aegyptica*. Entire worm. Ventral View.

(1935) from the bat *Pipistrellus pipistrellus* was misidentified and opened that it is actually *P. koreanus* Ogata, 1938. He came to the conclusion on the basis of body length (1.53 mm) and oral sucker larger than ventral sucker.

SUMMARY

The material for the present study was collected from lizards, snakes and bats from Jodhpur and its environs. The genus *Paradistomoides* has been considered as indistinct from *Paradistomum*. *Paradistomoides medius* Nama and Khichi and *Paradistomoides brevis* Nama and Khichi are considered as synonyms of *Paradistomum orientalis* (Narain and Das). *Paradistomoides diminutus* Nama and Khichi, *P. intermedius* Nama and Khichi and *P. elongatus* Nama and Khichi are synonymised with *Paradistomum spatulum* (Simha). *Prosthodendrium* (*Prosthodendrium*) *longiforme* Bhalerao, *Prosthodendrium* (*Prosthodendrium*) *parvouterus* (Bhalerao), *Prosthodendrium* (*Paralecithodendrium*) *ovimagnum* (Bhalerao) and *Plagiorchis koreanum* Ogata have been reported from new hosts and locality. Intra-specific variations and synonymies have been discussed.

ACKNOWLEDGEMENTS

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POPULATION SURVEY OF NON-HUMAN PRIMATES (MAMMALIA) OF TRIPURA

R. P. MUKHERJEE, S. CHAUDHURI AND A. MURMU

Zoological Survey of India, Calcutta.

INTRODUCTION

A variety of primate species inhabit the northeastern and southern India and some of the species are restricted in their distribution in these areas. Rhesus macaque and hanuman langur are widely distributed in India and are found in a variety of habitats and have been intensively studied in the field. The other species of non-human primates that are found in northeastern and southern India have not been received attention so far. The field studies of non-human primates of Tripura have been initiated by Mukherjee in the year 1976 and it resulted in a series of papers and scientific reports. In 1990 a fresh census was conducted under a joint venture involving the Forest Department of Tripura and the Zoological Survey of India to find out the trend of population changes in the non-human primates in this state.

The small state of Tripura is inhabited by three species of macaques *viz.* rhesus macaque (*Macaca mulatta*), stump-tailed macaque (*Macaca arctoides*) and pig-tailed macaque (*Macaca nemestrina*), two species of leaf monkeys *viz.* capped langur (*Presbytis pileatus*) and Phayre's leaf monkey (*Presbytis phayrei*), one species of ape, the hoolock gibbon (*Hylobates hoolock*), and slow loris (*Nycticebus coucang*). In recent years golden langur (*Presbytis geei*) has been introduced in Sepahijhola and Trishna Wildlife Sanctuaries.

STUDY METHOD

The present report is based on the survey conducted in February 1990. The census were conducted in all the possible habitat of monkeys in the forests, villages, towns and cities. In this state the non-human primates inhabited mostly in the forests. The observations were carried out on foot and by a vehicle. The surveys were conducted from morning to late evening. The methods that were applied to census the areas were roadside, transect and point methods. For transect, forest roads and trails were used and at places the forest routes were also cut. The point methods was used to locate the groups occupying the undulating and hilly tracts. In the forest the procedure adopted was to move slowly with least noise and stop at regular intervals or at suitable places and scan the areas for the presence of monkeys. For survey of roadside, villages, towns and cities a slow moving vehicle (Jeep) was used. Three to four observers were engaged to conduct the survey. The disturbance caused by the

movement of the monkeys and the calls were also utilised for locating the monkeys. Once a group was observed, notes on their social structure, habitat, interaction, etc., were noted down. The mechanical aids that were used in the field were binoculars and camera.

RESULTS

The survey reveals that unlike other places in India the non-human primates in Tripura are inhabited the forested areas and are totally depended upon the forest produce for their food and shelter. The rhesus macaque invade cultivated fields and causes damage to the crops. Table I and II show the distribution and social structure of non-human primates that were recorded during the survey in the three districts.

The rhesus macaque, *Macaca mulatta*, was recorded from all the three districts of the state. A total of 23 groups were encountered out of which the maximum number of 15 groups with 280 monkeys were recorded from the south district. Three groups with 50 and five groups with 46 rhesus were recorded from north and west

TABLE I. Non-human primates sighted and counted in the censusing districts.

Common name & Scientific name	District	Total No. of groups	Total No. of monkeys	Group size	Total No. ♂ ♂	Total No. ♀ ♀	Total No. JJ	Total No. II
Rhesus macaque (<i>Macaca mulatta</i>)	South	15	280	2-33	37	138	57	48
	North	3	50	1-33	8	28	7	7
	West	5	46	4-19	7	26	7	6
Pigtailed macaque (<i>Macaca nemestrina</i>)	South	1	16	—	1	10	3	2
Phayre's leaf monkey (<i>Presbytis phayrei</i>)	South	8	75	5-14	11	39	14	11
	North	5	41	4-12	7	26	5	3
	West	8	148	7-42	15	82	31	20
Capped langur (<i>Presbytis pileatus</i>)	South	10	62	3-14	12	36	7	7
	North	1	15	—	2	6	4	3
	West	5	31	5-8	5	17	4	5
Hoolock gibbon (<i>Hylobates hoolock</i>)	North	2	6	3	2	2	1	1
	West	2	5	2-3	2	2	1	—

TABLE II. Total number of groups and total number of sex and age class of different non-human primates.

Common name & Scientific name	District	Total No. of groups	Total No. of monkeys.	Total No. of ♂	Total No. of ♀	Total No. of JJ	Total No. of II	♂ : ♀	♀ : I
1	2	3	4	5	6	7	8	9	10
Rhesus macaque (<i>Macaca mulatta</i>)	South	15	280	37	138	57	48	1 : 3.72	1 : 0.34
	Mean	—	18.66	2.46	9.20	4.75	4.00		
	S. D.*	—	10.16	1.06	5.07	1.60	2.66		
	North	3	50	8	28	7	7	1 : 3.50	1 : 0.25
	Mean	—	16.66	2.66	9.33	2.33	2.33		
	S. D.	—	16.01	1.52	10.69	2.52	2.08		
	West	5	46	7	26	7	6	1 : 3.71	1 : 0.23
	Mean	—	9.20	1.40	5.20	1.40	1.20		
	S. D.	—	6.10	0.55	3.83	0.55	1.64		
Pigtailed macaque (<i>Macaca nemestrina</i>)	South	1	16	1	10	3	2	1 : 10.00	; 0.20
Phayre's leaf monkey. (<i>Presbytis phayrei</i>)	South	8	75	11	39	14	11	1 : 3.54	1 : 0.28
	Mean	—	9.38	1.37	4.88	1.75	1.38		
	S. D.	—	3.38	0.52	2.03	1.28	0.51		
	North	5	41	7	26	5	3	1 : 3.71	1 : 0.11
	Mean	—	8.20	1.40	5.20	1.00	0.60		
	S. D.	—	3.19	0.55	2.95	1.00	0.55		
	West	8	148	15	82	31	20	1 : 5.46	1 : 0.24
	Mean	—	18.50	1.87	10.25	3.87	2.50		
	S. D.	—	11.07	1.36	5.39	2.90	2.39		
Capped langur. (<i>Presbytis pileatus</i>)	South	10	62	12	36	7	7	1 : 3.00	1 : 0.19
	Mean	—	6.20	1.20	3.60	0.70	0.70		
	S. D.	—	3.58	0.42	2.11	0.67	1.06		
	North	1	15	2	6	4	3	1 : 3.00	1 : 0.50
	West	5	31	5	17	4	5	1 : 3.40	1 : 0.29
	Mean	—	6.20	1.00	3.40	0.80	1.00		
	S. D.	—	1.30	0.00	1.14	0.44	0.71		
Hoolock gibbon (<i>Hylobates hoolock</i>)	North	2	6	2	2	1	1	1 : 1.00	1 : 0.50
	Mean	—	3.00	1.00	1.00	0.50	0.50		
	S. D.	—	—	—	—	0.71	0.71		
	West	2	5	2	2	1	—	1 : 1.00	—
	Mean	—	2.50	1.00	1.00	0.50	—		
	S. D.	—	0.71	—	—	0.71	—		

* S. D.—Standard Deviation

districts respectively. The groups in south district on an average contained 18.67 individuals, with 2.47 adult males, 9.20 adult females, 3.80 juveniles and 3.20 infants. The groups of the north district on an average contained 16.66 individuals with 2.67 adult males, 9.33 adult females, 2.33 juveniles and 2.33 infants. The smallest group size with an average of 9.20 individuals with 1.40 adult males, 5.20 adult females, 1.40 juveniles and 1.20 infants were recorded from the west district. The sex ratio of adult male to adult female in south, north and west districts was 1 : 3.72, 1 : 3.50 and 1 : 3.71 and the ratio of adult female to infant was 1 : 0.34, 1 : 0.25 and 1 : 0.23 respectively.

Only one group of pigtailed macaque, *Macaca nemestrina*, was observed at Paratia in the south district during the present survey. The group contained a total of 16 monkeys with 1 adult male, 10 adult females, 3 juveniles and 2 infants. The adult female to infant ratio was 1 : 0.20. However, pigtailed monkey was reported to be present at Sepahijhola, Trishna and Gumti forests. Similarly stump-tailed macaque, *Macaca arctoides*, though not observed in the present survey but was reported to be present in certain forests of Tripura by local people and the staff of the forest department.

The Phayre's leaf monkey, *Presbytis phayrei*, is found in Tripura and in certain areas of south Cachar district of Assam in India. In the present survey this monkey was recorded from all the three districts of Tripura. A total of 21 groups were recorded out of which south and west districts each contained 8 groups and the remaining 5 groups were encountered in the north district. The average group size in the south, north and west districts were 9.38, 8.20 and 18.50 respectively. The average group size in the west district was much more than the other two districts. The adult male to adult female and the adult female to infant ratios in the south, north and west districts were 1 : 3.54, 1 : 3.71, 1 : 5.46 and 1 : 0.28, 1 : 0.11, 1 : 0.24 respectively. There are more adult females in proportion to adult males in the west district.

The other leaf monkey, the capped langur, *Presbytis pileatus*, which is widely distributed in northeastern India and is sympatric with Phayre's leaf monkey (Mukherjee, 1982b) was recorded from all the three districts of the state in this survey. It is apparent from Table I that they are more common and abundant on south district than in other two districts. The average group size in south, north and west districts were 6.20, 15.00 and 6.20 respectively. The sex ratios of adult male to adult female in south, north and west districts were 1 : 3.00, 1 : 3.00 and 1 : 3.40 respectively. The average group size of the south and west districts were the same and the sex ratio of adult male to female in all the three districts were almost the same. However, the average group size in the north is much more than the other two districts.

The only ape that is found in India is the hoolock gibbon, *Hylobates hoolock*, and is distributed to south and southeast of Brahmaputra river in the states of Assam, Meghalaya, Manipur, Tripura, Mizoram and in the districts of Tirap, Lohit and Dibong

(east of Dibong river) in Arunachal Pradesh. In the present survey this ape were encountered in the forests of Atubtang, Baramura and Juri. They were also reported to be present at Trishna, Gumti and New Kamti Bari. The group size varies from 2.50 to 3.00.

DISCUSSION

In the present survey the non-human primates that were recorded from Tripura are rhesus and pigtailed macaques, Phayre's leaf monkey, capped langur and hoolock gibbon. The stumptailed macaque was not recorded in the present survey. In the earlier survey (Mukherjee, 1982b) 5 groups of stumptailed macaque with 62 monkeys and one group of pigtailed monkey with 16 members were observed. Mukherjee (1982b) recorded 6 groups of hoolock gibbon. It is apparent from these surveys that the two macaques, stumptailed and pigtailed and hoolock gibbon are rare and threatened in Tripura and needs immediate protection. The three species of non-human primates viz. rhesus macaque, Phayre's leaf monkey and capped langur are common and are found in all the three districts. However, when the present survey is compared with the earlier survey (Mukherjee, 1982b) it is noticed that the group number and the populations of all these three species have declined to great extent.

The total number of 376 rhesus monkeys were recorded in 23 groups whereas in earlier survey a total of 931 rhesus monkeys were recorded in the 28 groups. In all the districts the groups contained immature population much less than 50%. For long term maintenance of population 50% immature are necessary (Southwick and Siddiqi, 1977, Southwick *et al*, 1980, 1982 and Teas *et al* 1980).

The decline in population of capped langur is also apparent from the present survey. In the earlier survey 15 groups with 138 langurs were recorded. In the present survey a total of 16 groups with 108 monkeys were observed. The average group size has come down from 9.20 to 6.20, The concentration of this langur is more in the south district. The adult female to infant ratio varies from 1 : 0.19 to 1 : 0.50. The colour on the ventral side and the tip of the hands and legs and the tail varies from population to population and from season to season. The ventral parts are brownish yellow or orange and the tip of the tail, legs and hands may be blackish. At times the local people confuse this species with that of the common langur.

The Phayre's leaf monkey population has also declined. In the earlier survey 36 groups with 409 monkeys were counted whereas in the present survey 21 groups with 264 langurs were recorded. The reduction of population was more on the south district.

Hoolock gibbon groups have also declined. The groups at Khasi Bari, Pechartal, Baramura and a group at Longthorai which were encountered in the earlier surveys were not seen in the present survey and appeared to have been lost.

TABLE—III. Comparative table of social structure of non-human primates of Tripura recorded during two surveys.

Species	Total No. of groups	Total No. of monkeys	Average group	Total No. of adult Males	Total No. of adult Females	Total No. of Juveniles	Total No. of Infants	Year of Survey
Rhesus macaque	28	931	33.2	123 (4.4 ± 2.6)	432 (16.0 ± 10.8)	203 (7.8 ± 4.6)	173 (7.2 ± 5.5)	1982
	23	376	16.3	52 (2.26 ± 1.0)	192 (8.7 ± 5.5)	71 (3.7 ± 2.0)	61 (3.6 ± 2.0)	1990
Pigtailed macaque	1	9	—	1	4	3	1	1982
	1	16	—	1	10	3	2	1990
Stumptailed macaque	5	62	12.4	6 (1.2 ± 0.2)	34 (7.2 ± 2.8)	15 (3.0 ± 1.2)	7 (1.4 ± 0.9)	1982
	36	409	11.36	73 (2.0 ± 0.2)	169 (4.7 ± 0.4)	92 (2.5 ± 0.4)	75 (2.1 ± 0.3)	1982
Phayre's leaf monkey	21	264	12.5	33 (1.5 ± 0.9)	147 (7.4 ± 4.5)	50 (2.7 ± 2.2)	34 (2.0 ± 1.6)	1990
	15	138	9.2	26 (1.7 ± 0.7)	63 (4.8 ± 1.1)	31 (2.6 ± 1.6)	18 (1.8 ± 1.0)	1982
Capped langur	16	108	6.75	19 (1.2 ± 0.4)	59 (3.7 ± 1.8)	15 (1.3 ± 0.9)	15 (1.6 ± 0.8)	1990
	5	16	3.2	5 (1.0 ± 0.0)	5 (1.0 ± 0.0)	4 (1.0 ± 0.0)	2 (1.0 ± 0.0)	1982
Hoolock gibbon	4	11	2.75	4 (1.0 ± 0.0)	4 (1.0 ± 0.0)	2 (1.0 ± 0.0)	1 (1.0 ± 0.0)	1990

Forests destruction due to illicit felling, 'Jhuming' and encroachment are the main factors for the loss of habitat of the non-human primates at Tripura.

Leaf eating monkeys and hoolock gibbon are affected much due to the loss of potential food trees and disruption of their canopy pathways. The loss of habitat is the main factor for the decline in group density and group size.

CONCLUSION

In the present survey the non-human primates that were recorded in Tripura are rhesus macaque, pigtailed macaque, Phayre's leaf monkey, capped langur, and hoolock gibbon. The presence of stump-tailed macaque and slow loris have been reported by local people. The golden langur has been introduced in Sepahijhola and Trishna Wildlife Sanctuaries. When compared with the earlier survey (Mukherjee, 1982b) all the species show a decline in population and group size. The three species of non-human primates *viz.* pigtailed and stump-tailed macaques and hoolock gibbon are now rare and are in danger of extinction in Tripura. The decline in the population of Phayre's leaf monkey which is mostly found in Tripura, has also been noticed. The main factor for the decline of different species of non-human primates is the destruction of their habitats.

SUMMARY

A survey of non-human primates of Tripura was conducted in the year 1990. The present survey when compared with the survey of 1982 revealed the decline in population of all the species. The three species, the pigtailed and stump-tailed macaques and hoolock gibbon, are now rare and are in danger of extinction in this state. The population of Phayre's leaf monkey has also shown a decline in population.

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