STUDIES ON THE PLANKTON OF RAJASTHAN

BITS-CENTRAL LIBRARY
Pilani Campus (Rajasthan)
ACC No.
Date

by

C. K. GOPINATHAN NAYAR, M. Sc.

Thesis Submitted for the Degree of Doctor of Philosophy of

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE,
PILANI (Rajasthan)

ZOOLOGY DEPARTMENT
B. I. T. S.
PILANI, INDIA.

January, 1966.

Supervisor's Note

The thesis entitled "Studies on the Plankton of Rajasthan" is a piece of original work of Shri C.K.Gopinathan Nayar, M.Sc., Lecturer in Zoology, B.I.T.S., Pilani. He worked on this problem under my supervision during the period between July 1962 and December 1965.

(A.K. Datta Gupta)
Professor and Head of
the Department of Zoology
B.I.T.S. Pilani, India.

ACKNOWLEDGEMENTS

I am greatly indebted to Dr. A.K. Datta Gupta, Professor and Head of the Department of Zoology, under whose guidance the present work has been carried out and to Shri P.K.B. Menon, University of Punjab, Chandigarh, for his many valuable suggestions. I am deeply grateful to Dr.W.T.Edmondson, University of Washington, Seattle, U.S.A., to Dr.D.S.Johnson, University of Singapore, Singapore and to Dr. K.K. Tiwari, Zoological Survey of India, Calcutta, for their helpful suggestions.

Thanks are also due to my colleagues, Research Scholars and postgraduate students of the Department and to all those who have helped me in many ways. I am particularly thankful to Mr. B.L. Soni for his help in the collection. Typing of this thesis has been kindly done by Mr. T.C. Gupta.

My grateful thanks are also due to Prof.V.Lakshminarayanan Director, B.I.T.S., and Dr. S.Y. Tiwari, Dean, Science Faculty for encouragement and providing me the necessary facilities. Lastly I am thankful to the Ministry of Education, Government of India, for granting me a Senior Research Scholarship for two years.

A. K. Gupta.

List of Publications of C.K.G. Nayar

1. Morphometric studies on the Rotifer Brachionus calyciflorus Pallas. Curr. Sci. August 1964, 33 No.15, pp.469-470.

2. Cyclomorphosis of Brachionus calyciflorus Pallas Hydrobiologia, 1965 Vol.XXV (3-4) pp.538-544, 1965.

3. Taxonomic notes on the Indian species of Keratella (Rotifera) Hydrobiologia, 1965b (In press).

4. Three new species of Conchostraca (Branchiopoda:Crustacea) from Rajasthan. Bull. Syst.Zool. Vol.1 No.1 Jan. 1965 pp.18-23.

5. On a new Heteropod from Bay of Bengal. Proc.Raj.Acad.Sci. Vol.IX(2) : 56-57, 1962.

6. In collaboration with A.K. Datta Gupta, P.K.B. Menon & C.R. Das. 'An annotated list of fishes of Rajasthan' Proc.Raj.Acad.Sci. Vol.VIII (1 & 2) : 129-134, 1961.

7. In collaboration with J.M. Ghosh and P. Johnson 'On the occurrence of the leech Ozobranchus branchiatus (Menzies 1791) (Hirudinea) in India. J.Bombay Nat.Hist.Soc. August, 1963, pp.469-471.

ABSTRACT

Fresh-water plankton of 32 water bodies (including lakes, ponds and temporary ditches) located in 8 districts of Rajasthan State has been studied. Periodical samples from a few lakes have been analysed. Morphological variation and seasonal abundance of a few zooplankton have been examined. Special stress has been laid upon the study of Branchiopoda and Rotifera. 28 species of branchiopods have been recorded here out of which 3 species have been described as new. Taxonomic discussions of the species have been incorporated. 39 species of rotifers have been described together with a key to the Indian species of Keratella. Cyclomorphosis of Brachionus calyciflorus has been studied.

The relative percentage (out of the total zooplankton) of rotifers has been found high during winter. Temperature is considered to be an important factor in the appearance of Keratella procurva. Dissolved oxygen has been found to influence the population of Brachionus calyciflorus. The cladocera are generally warm water forms. It has been found that the larger bodies of water are more favourable for calanoid copepods while the cyclopoids prefer small bodies of water.

...

CONTENTS

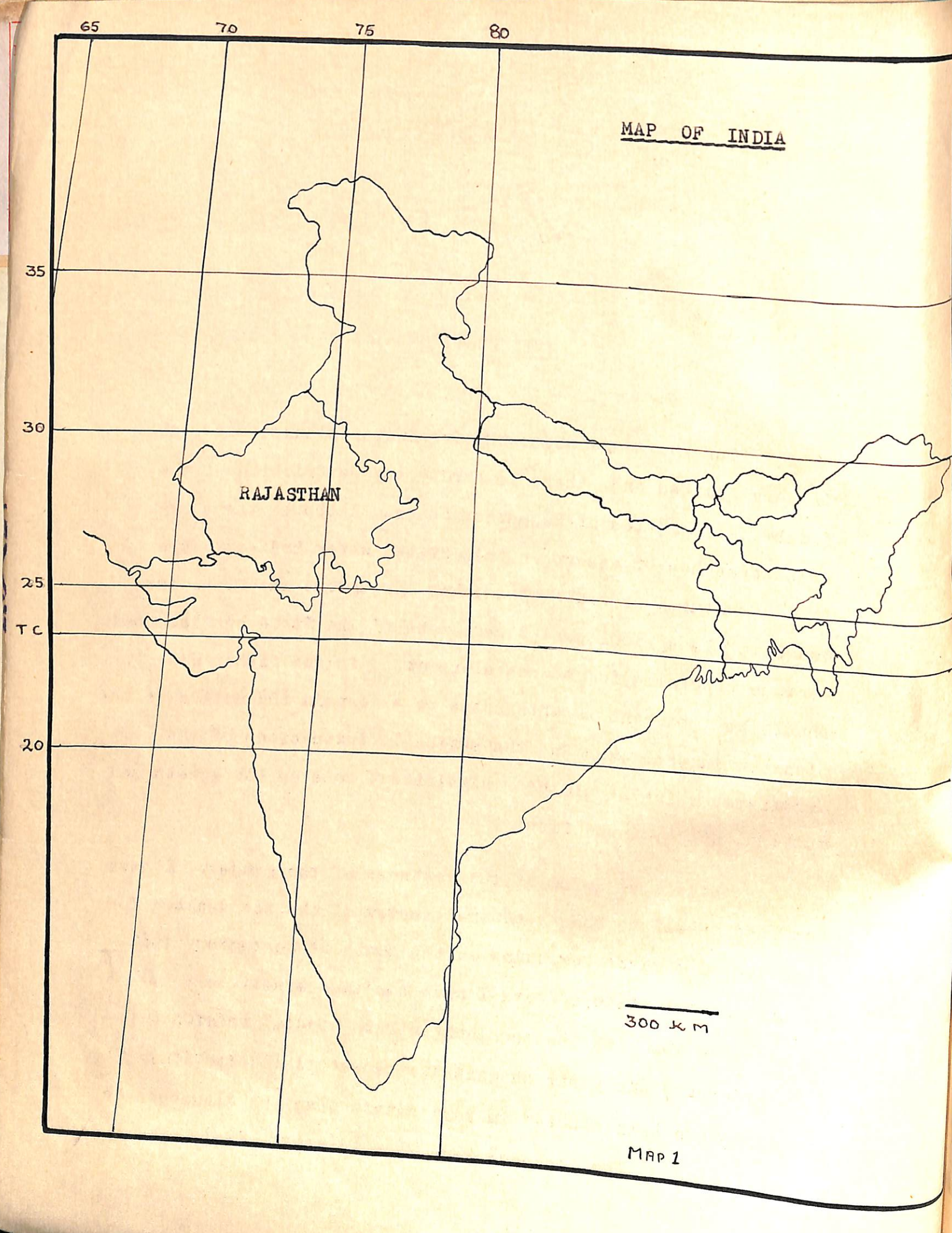
Chapter IV (Contd...)

Part II. Quantitative Study.

Chapter V Seasonal Variation

Chapter V (Contd...)

...

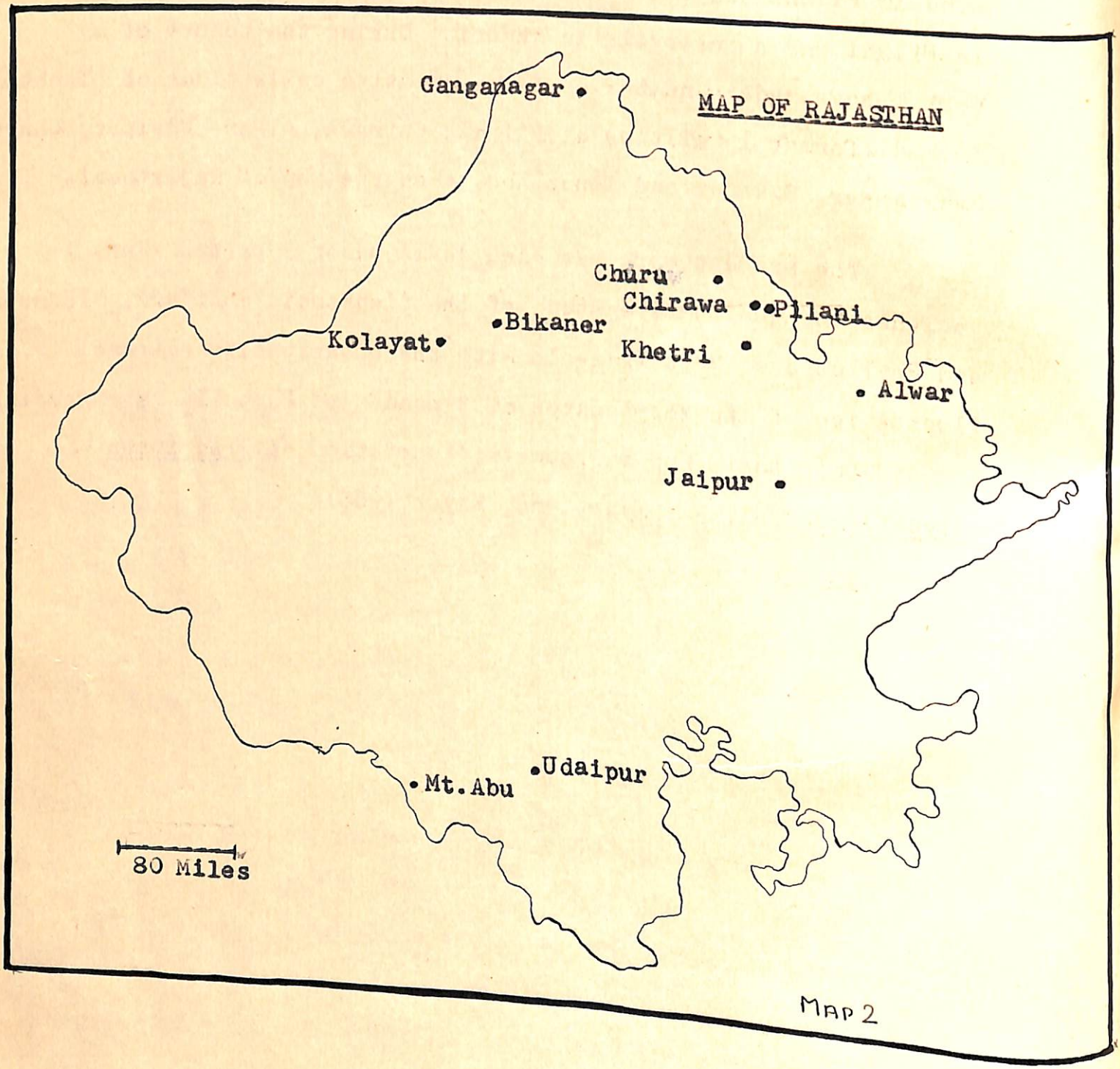


MAP 1

INTRODUCTION

Our knowledge about the freshwater plankton of India is very limited and, there is hardly any description of the freshwater plankton of Rajasthan State. Although there are vast stretches of desert in this State, water bodies in the form of natural or artificial lakes throughout the State are not few. The Agricultural Directorate of the State has launched serious programme for the development of inland fisheries. It should be important at this stage to ascertain the nature of the plankton in the lakes and the seasonal fluctuations of the organisms, which should bear significant role on the growth and multiplication of the fishes.

While I am aware of the vastness of the subject, I have confined myself to only a general survey of the zooplankton for a period of 3 years beginning in the month of September, 1962. In the present piece of work I have confined myself to a qualitative study of the zooplankton with special reference to 3 major groups and their quantitative seasonal fluctuations. The rotifers have been studied in more detail than the Cladocera or the Phyllopoda. The copepods have been identified only upto the


MAP OF RAJASTHAN
Ganganagar
Churu
Chirawa
Pilani
Bikaner
Kolayat
Khetri
Alwar
Jaipur
Udaipur
Mt. Abu
80 Miles

MAP 2

suborder level while the ostracods have been studied as a group. Quantitative study has been done for a period of 2 years from a pond in Pilani and for about one and half years from another pond in Pilani and a reservoir in Khetri. During the tenure of my work I have made a number of representative collections of plankton from different localities of Pilani, Chirawa, Alwar, Udaipur, Churu, Ganganagar, Bikaner and Mount Abu. (See the Map of Rajasthan).

The present work has been dealt under 3 parts. Part I includes the qualitative study of the planktonic Rotifera, Cladocera and Phyllopoda. Part II deals with the quantitative seasonal fluctuation of the zooplankton of 3 ponds and Part III is regarding the cyclomorphosis and morphometric variation of Brachionus calyciflorus Pallas (Nayar 1964, Nayar 1965).

CHAPTER I

Historical Resume Pages 3 to 17

CHAPTER I

Historical Resume

1 General Introduction to Rotifers

Rotifers or the wheel animalcules are known to science since the 17th century. At that time they were classified under Infusoria along with other microscopic animals. Ehrenberg (1838) was the first to separate the rotifers from the Protozoa under the name Rotatoria but regarded them under Infusoria. Interest in this field was enhanced by the contribution of Dujardin (1841) and Huxley (1853) whose accounts on the morphology and anatomy of these animals were significant in determining the affinities of this group Rotifera. Hatschek (1878) promulgated his trochophore theory and recognised the trochophore larva and the rotifers as having the same grade of structure. Other important work of the 19th century is that of Zelinka (1886) and Hudson and Gosse (1886-89). (Hyman 1951).

The classification of the Rotifers proposed by Hudson and Gosse (1886-89) include 4 orders viz. Rhizota, Bdelloidea, Ploima and Scirtopoda. Later Wesenberg Lund (1899) created another order Seisonacea. Harring (1913), however, recognised only 4 orders

namely Ploima, Bdelloidea, Seisonacea and Collothecacea. But Remane (1929) suggested the inclusion of Ploima, Floscullariacea and Collothecacea as suborders under the order Monogononta which has been adopted by Hyman (1951).

Hyman (1951) has put Rotifera, Gastrotricha, Kinorhyncha, Nematoda and Nematomorpha under Phylum Aschelminthes. The Rotifera was given a phylum status by Edmondson (1959) and divided them into 3 classes viz. Seisonidea, Bdelloidea and Monogononta. In the present work Rotifera has been considered as a class and the classification given by Edmondson (1959) has been adopted.

2 Introduction to the Rotifers from India and its Immediate Vicinity

Anderson (1889) reported 47 species of rotifers from Calcutta. His list included 10 new species and 2 uncertain ones. The new forms recorded by him were the following:

Floscularia (Collotheca) tenuilobata
Oechistes (Ptygura) stephanion
Rotifer (Rotaria) mento
Actinurus ovatus
Stephanopus dichthaspis
Metopidia (Lepadella) torquata
Metopidia (Lepadella) angulata
Pterodina intermidia (Testudinella patina f.intermedia)
Brachionus longipes (= B. quadridentata Hermann)
Brachionus bidentata

Out of the 47 species recorded by him only 37 were considered valid by Edmondson and Hutchinson (1934). They considered Pterodina intermedia Anderson as Testudinella patina form intermedia (Anderson). Ahlstrom (1940) regarded Brachionus longipes Anderson as a synonym of Brachionus quadridentatus Hermann.

Murray (1906) listed 32 species of rotifers collected from the slopes of the Sikkim Himalayas at an altitude of 610 to 2440 metres. His list included 7 species of Philodina; 8 of Habrotrocha; 8 of Macrotrachela; 3 of Rotaria and 1 each of Adineta, Proales, Squatinella, Colurella, Lecane, and Brachionus.

Stewart (1908) collected 17 species from the Tibet region at an altitude of 4000 metres. He described 5 new species viz. Rotifer (Rotaria) tridentatus, Mastigocerca auchinleckii, Salpina shape, Cathypna amban and Notholca scaphula. Of these R.tridentatus Stewart and C.amban considered as doubtful species by Harring and Myers (1926). M.anchinelckii Stewart is synonymised by Harring(1913) with Trichcerca longiseta (Schrank) and S.shape Stewart with Mytilina brevispina (Ehrenberg). Harring and Myers (1924) united Proales gibba Ehrenberg and Diaschiza semiaperta Gosse under Cephalodella auriculata (Muller). Edmondson and Hutchinson (1934) considered Notholca scaphula Stewart a synonym of Notholca striata (Muller).

Edmondson and Hutchinson (1934) during their Yale North India Expedition recorded 100 species of rotifers from different localities including Kashmir, Ladak, Punjab and Nilgiri(South India). Their list did not include any new forms. Keratella valga f.valga

and K. valga f. tropica are considered 2 distinct species by Berzins (1955) viz. Keratella procurva (Thorpe) and K. tropica (Apstein) respectively.

Ahløstrom (1940) described 2 new varieties, Keratella quadrata var. edmondsoni from Ootacamund (Madras, S.India) and Keratella quadrata var. pyriformis from Tibet. Keratella quadrata edmondsoni is described as Keratella edmondsoni(Ahlstrom) in the present work (Nayar 1965).

Recent study of the Indian rotifers include that of Brehm (1950), Pasha (1961), George (1961), Arora (1962, 1963) and Nayar (1965). Brehm (1950) reported the following species:

Keratella cochlearis(Gosse)
Keratella tropica (Apstein)
Brachionus falcatus (Zacharias)

Pasha (1961) described 4 species of Lecane and 2 species of Monostyla from the fresh water tanks and the Coovum River in the city of Madras. His list includes:

Lecane papuana (Murray)
Lecane methoria (Harring & Myers)
Lecane crepida(Harring)
Lecane hornemanni (Ehrenberg)
Monostyla bulla (Gosse)
Monostyla hamata (Stokes)

All the species described by him were new records from Madras. George (1961) during the limnological study of fish ponds in Delhi made some notes on the periodicity, species composition and diurnal migration of rotifers. Four species of Brachionus reported by him in that work are the following:

Brachionus calyciflorus Pallas
Brachionus falcatus Zacharias
Brachionus quadridentatus Hermann
Brachionus bidentata Anderson

Although he mentioned about 2 species of Filinia he did not give the name of the species. The other rotifer which he mentioned is Keratella valga f. tropica Apstein (= K.tropica (Apstein)).

Arora (1962) described 7 species of illoricate rotifers from Nagpur which included 1 new variety and 1 new species. The species described by him are the following:

Rotaria ~~rotaris~~ rotatoria (Pallas)
Filinia longiseta Ehrenberg
Tetrmastix (Filinia) opoliensis (Zacharias)
Pedalia (Hexarthra) fennica var. oxyuris Sernov.
Conochiloides dossuarius var. asetosus Arora
Asplanchna intermedia Hudson
Polyarthra multiappendiculata Arora

He also added some notes on their bionomics especially in relation to the physicochemical features of the water. Arora(1963) further

described 3 species of sessile rotifers from Nagpur including a new form Sinantherina triglandularis Arora. The other species recorded by him were Sinantherina spinosa (Thorpe) and Lacinularia flosculosa (Muller).

I have studied the morphometric variation of Brachionus calyciflorus Pallas collected from different localities of Rajasthan (Nayar 1964). I have also studied the cyclomorphosis of B.calyciflorus collected from a pond in Pilani (1965). In my 'taxonomic studies on the Indian species of Keratella, I have considered Keratella quadrata var. edmondsoni Ahlstrom as Keratella edmondsoni (Ahlstrom) (Nayar 1965c in press). Other species reported by me are Keratella tropica (Apstein) and K.procurva(Thorpe)

3 Classification

Class Rotifera

Order 1. Seisonacea

Family 1. Seisonidae

Order 2. Bdelloidea

Family 1. Habrotrochidae

2. Philodinidae

3. Adinetidae

4. Philodinavidae

Order 3. Monogononta Suborder Ploima

Family 1. Brachionidae

Subfamily Brachioninae*

Subfamily Colurinae*

2. Lecanidae*

3. Proalidae
4. Notommatidae
5. Lindiidae
6. Birgeidae
7. Trichcercidae*
8. Gastropidae
9. Dicranophoridae
10. Tylotrochidae
11. Tetrasiphonidae
12. Asplanchnidae
13. Synchaetidae*
14. Microcodonidae

Suborder Floscullariacea

Family 1. Testudinellidae*
2. Hexarthridae*
Family 3. Flosculariidae*
4. Conochilidae

Suborder Collothecacea

Family 1. Collothecidae.

4 General Introduction to Branchiopoda

The Branchiopoda are those crustacea where the thoracic appendages are flattened and modified for both locomotion and respiration. According to the recent classification (Brooks 1959 Fresh Water Biology) the sub-class Branchiopoda is divided into

---

* Represented in the present collection.

five orders viz. Anostraca, Notostraca, Conchostraca, Cladocera and Lipostraca (to include the Devonian Lepidocaris rhyniensis Scourfield). In the earlier classifications Cladocera was separated from the first three orders which were grouped together under Phyllopoda. It was Calman (1909) who indicated that the differences between the three major groups of the Phyllopoda were as great as the differences between the Conchostraca and the Cladocera. Among the five orders the Conchostraca and the Cladocera are related to each other especially in having the bivalve carapace enclosing the body of the appendages. Gerstaecker (1866) proposed the name Diplostraca to include both these orders. Anostraca and Lipostraca can be grouped together while Notostraca forms a separate group. The classification followed in the present work has been adopted from Brooks (1959).

5 Introduction to the Branchiopods from India and its Immediate Vicinity

There are quite a few reports on the Branchiopoda, especially of Phyllopod Crustacea from India. Baird (1859) described a new species of Conchostraca, Estheria hislopi collected from the freshwater pools at Nagpur. He described 2 more new branchiopod from India (1860a) belonging to the Anostraca and the Cladocera. The species described by him were Streptocephalus dichotomus Baird and Daphnia newporti Baird. In the same year (1860a) he reported another new species, Estheria compressa from Nagpur.

In 1906 Gurney reported 19 species of Entomostraca, including 12 branchiopods from the collection of Indian Museum. It included the following species:-

Conchostraca
- Limnetis brachyura (O.F.Muller)
- Estheria davidi Simon
- Estheria indica Gurney
- Cyclestheria hislopi (Baird)(= Estheria hislopi Baird)

Anostraca
- Branchinecta orientalis Sars
- Branchipus pisciformis Schaeffer
- Streptocephalus dichotomus Baird

Cladocera
- Daphnia fusca Gurney
- Simosa elizabethae (King)
- Ceriodaphnia rigaudi Richard (= C.cornuta Sars)
- Scapholebris kingi Sars
- Chydorus sphaericus (O.F.Muller)

Gurney (1907) reported a few more branchiopods from the collection of the Indian Museum. The new records he added to the Indian list included the following Cladocera:-

- Diaphanosoma sarsi Richard
- Diaphanosoma sp.
- Macrothørix triseralis Brady
- Macrothrix tenuicornis Gurney
- Macrothrix goeldi Richard
- Thyocryptus longiremis Sars(?)

Camptocercus australis Sars

Lynceus cambouei (De Guerne and Richard)

Lynceus guttatus (Sars)

Leydigia australis Sars

Leydigia acanthoceroides Fischer

Alonella excisa (Fischer)

Chydorus globosus Baird

Dunhevedia crassa King

Arora (1931) described 27 species of Entomostraca from Lahore (at present in Pakistan) including 13 species of the Cladocera and 1 of Conchostraca. The Cladocera reported by him were:-

Daphnia magna Strauss

Daphnia psittacea Baird

Daphnia pulex (De Geer)

Daphnia hyalina Leydig

Daphnia lumholtzi Sars

Simocephalus vetulus (Muller)

Ceriodaphnia rigaudi Richard

Moina brachiata (Jurine)

Moina flagellata Hudendroff

Macrothrix laticornis (Jurine)

Oxyurella tenuicaudis (Sars)

Mediomoina elliptica Arora

The new genus Mediomoina was erected to include his forms which has the characters of both Moina Baird and Moinodaphnia Herrick.

According to him the new genus ' resembles Moinodaphnia in having the body completely covered by the valves and in the presence of an abdominal process. In the absence of an ocellus this genus agrees with Moina but differs from Moinodaphnia' (Arora 1931 p.72-73).

Bond (1934) in his report on Phyllopod Crustacea collected by the Yale North India Expedition as well as from the Indian Museum made a detailed study of the Anostraca. He reported 7 species of Anostraca:-

Artemia salina (Linnaeus)

Branchinecta orientalis Sars

Pristicephalus priscus Daday

Branchipus stagnalis (Linnaeus)

Branchipodopsis affinis Sars

Streptocephalus simplex (Gurney)
(= S.dichotomus var. simplex Gurney)

Streptocephalus dichotomus Baird.

All the three species of the Conchostraca reported by him were new viz.

Eulimnadia margaretae Bond

Eocyzicus hutchinsoni Bond

Eocyzicus deterrana Bond

The only Notostraca reported by him was Apus cancriformis Schaeffer.

Brehm (1950) while studying the freshwater fauna of India recorded 3 species of Cladocera namely Daphnia lumholtzi Sars, Daphnia

longispina O.F. Muller and D. carinata King. Chacko (1950) collected a single specimen of Apus from Tirunelveli (S.India) and he described the specimen as allied to Apus sudanicus Brauer. Tiwari (1951) in his monograph on the Indian species of Apus described 5 more species which includes 2 new forms. His list contained Apus asiaticus Gurney, A.orientalis Tiwari, A.mavliensis Tiwari, A.cancriformis Schaeffer and Apus sp. prox. sudanicus Brauer. Apus orientalis is a new name given to the forms collected from Panchgani which had been earlier identified as A.asiaticus by Gurney. Apus mavliensis was collected from Jodhpur (Rajasthan).

Mathur and Sidhu (1957) and Sidhu (1958) reported Apus cancriformis Schaeffer, Streptocephalus dichotomus Baird and Caenestheriella annandalei Daday from Pilani. Tiwari (1958) described a new species of Anostraca Branchinella biswasi from Sambar Lake, Rajasthan. Baid (1958) reported the occurrence of Artemia salina (Linnaeus) from the Sambhar Lake. Karande and Inamdar (1959a) described a new species of Conchostraca Leptestheriella gigas from Panchgani. Tiwari (1962) reported 3 new Conchostraca from Rajasthan. They are Caenestheria misrai, Caenestheriella roonwali, and Eocyzicus pellucidus.

Recently Biswas (1964) described a new Cladocera Latona tiwari from Rajasthan. This is the only available report of the Cladocera from Rajasthan.

6 Classification

Class Crustacea

Sub-class Branchiopoda

Order 1. Anostraca

Family 1. Polyartemiidae
2. Artemiidae
3. Branchinectidae
4. Streptocephalidae*
5. Thamnocephalidae*
6. Chirocephalidae.

Order 2. Notostraca*

Order 3. Conchostraca

Family 1. Lynceidae
2. Limnadiidae*
3. Leptestheriidae*
4. Cyzicidae*
5. Cyclestheriidae

Order 4. Lipostraca

Order 5. Cladocera: Sub-order Haplopoda

Family 1. Leptodoridae

Sub-order Eucladocera
Super-family Sidoidea

Family 2. Sidiidae*
3. Holopedidae

Super-family Chydoroidea

Family 4. Daphniidae*
5. Bosminidae

Family 6. Macrothricidae*

7. Chydoridae*

Super-family Polyphemoidea

Family 8. Polyphemidae

7 Seasonal population study of the Plankton

Studies on the seasonal abundance of the plankton have attracted the attention of many workers. In India a good deal of work has been done on the marine and brackish water plankton. But there is only very little information regarding the study of plankton population of fresh water ponds and lakes. Alikunhi et al (1955) while considering the relationship of the abundance of plankton with the survival and growth of fish fry in the nursery ponds made a few observations on the density fluctuation of the plankton. They listed the major groups of plankton and estimated their fluctuation in terms of volume, number and dry weight, for a period of 2 months. The fluctuation of a particular species is not available from that data.

Das and Srivastava (1955) recorded 2 peak periods in their studies on the plankton of Lucknow. They also noted an inverse correlation between the phyto and the zooplankton. Their observations were limited to the estimation of the total phyto and Zooplankton only. This study was made for a period of one year notwithstanding numerical estimation in regard to the major groups and in any ~~species~~ in any species in particular was not made.

---

* Represented in the present collection.

Michael (1962) made a detailed study of the natural population of Ceriodaphnia cornuta for a period of 2 years. He also made some observations on its life cycle and food relationship with ciliates and flagellates. Upadhyaya(1963) made a hydrobiological survey of Gujartal, Jaunpur (U.P.) for a period of one year at monthly intervals. He also made some observations on the percentage composition of the various groups of plankton.

Recently Sreenivasan et al (1964) made some limnological observations of Bhavanisagar Reservoir (Madras). Their work was mainly on the hydrological features and was not apparently intended for a study of the seasonal variation of the zooplankton. He has listed the plankton organisms occurring in different months of the years 1961 and 1962. Nayar (1965 in press) studied the variation in the population of Brachionus calyciflorus and tried to correlate it with the variation in the physicochemical factors of the water. Other available records of such studies are those of Ganapati(1940); Chacko and George (1952) and Chakrabarty (1960).

CHAPTER II

Material and Methods Pages 18 to 27

CHAPTER II

Material and Methods

8 Sites of Collection (MAP 2)

The samples of plankton have been collected from the following water bodies:

P1 College Pond, Pilani

This is a small concrete pond of 10 x 6 x 4 feet in size situated near the College, in a garden. It holds water throughout the year, the depth being 2.5 to 3 ft. The pond does not contain any weeds.

P2 Department Pond, Pilani

This pond is situated very near the College pond and is of the same size. The pond contains an enormous growth of Vallisneria sp.

P3 Concrete Cisterns, Pilani

A large number of concrete cisterns situated in a garden near the College. They are of almost the same size and about

1-2 ft. deep from the water level. Water plants such as Nymphaea and Vallisneria are common in many of the cisterns. Water generally remains less turbid.

P4 Concrete Tank, Central Lawns, Pilani

The concrete tanks of irregular shape situated in the central lawns. It holds water upto a depth of 3 ft. Water usually contain floating algae and other aquatic plants.

p5 Ring-canal, Pilani

This is a concrete canal of 2 furlongs in circumference and 20 ft. wide. The average depth of water is 6 ft. The weeds are completely absent. Fishes like Cyprinus carpio are cultured here.

P6 Pilani Tank, Pilani

This is a concrete tank of 150 x 150 ft. in size, situated about a mile away from the Institute. The depth of the water varies considerably during the different seasons from 6 to 20 ft. The bottom is muddy, and does not have any weeds. Occasionally the surface of the water is covered by bloom of Microcystis.

P7 Monsoon ditches near Bus-stand, Pilani

These are small ditches situated outside the Institute campus. For the major part of the year they remain dry but immediately after the monsoon (July-August) they get filled up with water. The water remains highly turbid.

P8 Monsoon ditches near Police Station, Pilani

This is situated about a mile away from the Institute campus. During monsoon they get filled up with the rain water and the water flowing from the nearby areas.

C9 Tank No.1, Churu

This is a concrete tank (300 x 300 ft.) with sandy bottom. At the time of collection (10 A.M. 12.3.63) the water looked dirty brown in colour. Weeds were present near the bank.

C10 Tank No. 2, Churu

This is situated about 3 miles away from Churu town. It has concrete bottom except for a small area in the middle. At the time of collection the water was very clear and 1-2 ft. deep. The bottom was filled with aquatic weeds and the algae like Spirogyra was also common.

G11 Pond, Ganganagar

This is a big pond of about 50 x 40 ft. size situated in the town area. The water remained dirty and turbid at the time of collection.

G12 Irrigation Canal, Shivpur

This canal brings highly turbid water.

G13 Pond, Shivpur

This is a small concrete pond situated near the irrigation canal.

J14 Amber Lake, Jaipur

This is situated in hilly area about 9 miles away from Jaipur.

J15 Concrete cistern, Amber, Jaipur.

B16 Gajner Lake, Gajner, Bikaner

It is a big lake surrounded by forest. Ophiocepahalus spp is a common fish found in the lake.

B17 Garsisar Pond, Bikaner

This is a shallow pond. At the time of collection the water was highly turbid.

B18 Kolayat Lake, Bikaner

This is a shallow lake of moderate size. Heteropneustes fossilis is the common fish found.

B19 Tank, Bikaner

This is a concrete tank with sandy bottom.

U20 Pichola Lake, Udaipur.

U21 Fatesagar, Udaipur.

U22 Swarupsagar, Udaipur.

A23 Parah Lake, Alwar.

82576

A24 Silisehr Lake, Alwar

This is a big lake surrounded on all sides by rocky mountains. Water remained very clear at the time of collection.

A25 Jaisamund, Alwar

This is a shallow lake extending for a vast area. Many species of fishes were common.

K26 Ajit Sagar (Khetri lake), Khetri

This is a reservoir formed by the construction of a bund (lock gate) against the water passage among the surroudding hills for irrigation. This is located about 40 miles away from Pilani. Aquatic plants are common along the banks. When the water level rises during monsoon many of the plants of the bank get submerged under water. Ophiocephalus punctatus and Heteropneustes fossilis are the only species of fishes collected from this lake.

K27 Pond, Khetri

This is a shallow pond situated near Ajit Sagar. The pond is almost completely filled with aquatic weeds and surrounded by shrubs and trees.

K28 Irrigation canal, Khetri

This is a narrow canal which brings water from the Ajit Sagar to the neighbouring fields.

K29 'Talab', Khetri

This is a concrete tank situated in Khetri town.

K30 Monsoon ditch, Khetri Fort, Khetri

This is a small ditch formed during the rainy seasons. This is situated in the Khetri Fort near Khetri town.

R31 Pond, Chirawa

This is a shallow pond situated near Chirawa town. The water was turbid at the time of collection.

M32 Nakki lake, Mt.Abu

This lake is situated among the hills in Mt.Abu about 3800 ft. above sea level.

9 Equipments for Plankton Collection

Samples of plankton have been collected with the help of tow nets made of nylon cloth. The nets used were of two sizes. The smaller one used for small bodies of water consists of a hollow brass ring of 20.5 cm. in diameter and the conical net of 75 cm. length. To the cod end of the net is attached a widemouthed glass jar in which the concentrated plankton is collected. A long rope is attached to the ring at three equidistant places. The bigger net has a ring of 42 cm. diameter and the net of 135 cm.

10 Method of collection

Collections were made by slowly dragging the net through water at a uniform speed. The net was operated from a boat or a raft in lakes, also by throwing it into the pond and dragging it to the shore. From small ponds and other such water bodies the net was dragged from one end to the other. Collections have been made at different depths in the case of deep ponds and lakes.

To study the seasonal fluctuation of the plankton 3 ponds have been selected. They are the College pond, Pilani tank and Ajit Sagar. From the College pond weekly collections have been made for 2 years from October 1962 to September 1964 between 8.30 and 10.30 A.M. The net was dragged fron one end to the other end of the pond about one foot below the water level. In the Pilani tank the net was operated by releasing it at one corner by one person and dragged by another to the other bank by means of a long rope tied to the net. The dragging was limited to a constant distance throughout the period of collection. Collections have been made from January 1963 to September 1964 at fortnighly intervals. In Ajit Sagar periodical collections were made fairly regularly at monthly intervals from December 1962 to August 1964. The method employed in the Pilani tank has been resorted to for the collection of plankton from Ajit Sagar. Two samples have been collected at every time.

11 Method of Study

Immediately after the collection living samples were brought to the laboratory, if they were from the neighbouring places. Otherwise they were preserved in 4% formaline by adding commercial formaline. The material was centrifuged in an electric centrifuge of 1000 r.p.m. Generally living specimens have been examined for taxonomic study. Specimens stained with eosin or boraxcarmine in the conventional way have also been examined. Microdissections were done under a binocular dissecting microscope. Figures have been drawn to scale with the help of camera lucida.

For numerical estimation of the plankton the method described by Green (1960) has been adopted here with certain modifications. The formaline preserved sample was allowed to stand for 2 to 3 hours in a measuring jar. Centrifuging was done in every case in order to include the floating organisms. The sample was taken in a graduated test tube (10 ml) or a measuring jar (25, 50, or 100 ml.) depending on the volume of the plankton. The sample was made to a known volume by adding water. After thoroughly shaking with the mouth of the tube closed, a suitable volume was pipetted. The same method of sampling was employed throughout. The sub-sample thus obtained is taken in a cavity block. From there the sample was taken drop by drop with the help of a dropper into a specially ruled glass slide. Counting was done under a binocular microscope.

12 Water Analysis

The physicochemical qualities of water were estimated. only for the ponds which have been selected for the study of seasonal variation. Chemical analysis of the water has been done following the standard methods (American Public Health Association 1955, Solvay Technical and Engineering Service 1958).

Temperature

Temperature in centigrade was taken by means of a thermometer keeping it 6" below the water level before collection.

13 Hydrogen ion Concentration

The pH was measured by means of Beckman's pH meter (G.Model).

14 Dissolved Oxygen Content

For the estimation of the oxygen content of the water the water sample was taken in a 100 ml bottle before the plankton collection. Water was filled in the bottle by slowly immersing it under water without any air bubble entering it. The bottle was closed under water. Fixing of water for oxygen content was done in the field itself or brought to the laboratory if the sample was from nearby tanks. 1 ml of Manganese sulphate solution followed by 1 ml of Potassium iodide solution was added to the sample keeping the nozzle of the pipette near the bottom of the bottle. The bottle, after closing was shaken thoroughly and the precipitate

formed was allowed to settle for sometime. Then 1 ml of conc. Sulphuric acid was added to it so that the precipitate dissolved. The bottle was shaken thoroughly and kept in a dark place for about half an hour. Dissolved oxygen content was estimated by titrating the sample against Sodium thiosulphate solution of known normality using starch as the indicator. Titration was repeated for accuracy.

15 Alkalinities

Alkalinity due to carbonate and bicarbonate, calculated in terms of calcium carbonate and bicarbonate was estimated by titrating the pond water against Sulphuric acid of known normality. Phenolphthelin and Methyl orange were used as indicators.

P A R T I

CHAPTER III

Rotifera (Rotatoria) - Pages 28 to 65

P A R T - I

Faunestic and Taxonomic Study

CHAPTER III

ROTIFERA (ROTATORIA)

Order Monogononta

Suborder Ploima

Family Brachionidae

Subfamily Brachioninae

16 Genus *Brachionus* Pallas 1766

1. *Brachionus rubens* Ehrenberg 1838 (Figures 1,2,3 & 5)

Lorica firm, dorsoventrally compressed; anterior dorsal margin with 6 spines, median spines longer than laterals; mental margin markedly elevated leaving a medial cleft; median and intermediate spines of dorsal margin have strengthening ridges. The specimens are light red in colour.

Occurrence:

P7, G11, K30. A large number of them have been found attached to the body of Branchinella kugunemaensis collected from Khetri Fort. In all the localities the water was turbid at the time of collection.

Measurements:

	Pilani Specimen	Ganganagar Specimen
Total length of the lorica	156 µ	188 µ
Maximum width of the lorica	132	152
Width at the anterior margin below the spines	92	-
Foot orifice	-	44

Variation has been observed in the size of the lorica, nature of the median spines, size and shape of the foot opening and in the ornamentation of the lorica. The specimens from Shivpur (Fig. 1) and Ganganagar (Fig. 2) have a V_ shaped sinus between the median occipital spines. Some of the specimens collected from Pilani show a Y_ shaped median sinus (Fig. 5) where the median spines are well developed and distally bent outwards. The occipital margin is markedly elevated in the specimens from Shivpur than in others. The lorica is smooth in specimens from Ganganagar and Shivpur while heavily stippled in those from Pilani.

This is recorded for the first time from India.

2. Brachionus falcatus Zacharias 1898 (Fig. 12)

Lorica compressed dorsoventrally; anterior dorsal margin with 6 spines, intermediate spines longer and bent ventrally, median spines slightly smaller than laterals; mental margin undulate; posterior spines widely separated at their bases and converge at their free ends; foot opening between bases of posterior spines shallow. Lorica stippled. Variation has been noted in the length of the intermediate spines.

Occurrence: K26, M32.

Measurements of Khetri Specimen:

Length of the lorica (Middle region) ...	168 µ
Maximum width	188
Anterior lateral spine	28
Intermediate spines	120
Posterior spines	84

Earlier this has been recorded from India by Brehm (1950) and George (1961).

3. Brachionus caudatus Barrois and Daday 1894

Lorica firm divided into a dorsal and ventral plate somewhat compressed dorsoventrally; anterior dorsal margin with 2 median spines separated by a U_ shaped or V_ shaped sinus; lateral spines developed and intermediates generally rudimentary. Lorica stippled, terminates posteriorly in a pair of stout spines.

Brachionus caudatus var. aculeatus (Hauer) (Figs. 8,9)

This variety can be distinguished from others in having an additional spur like spine on the inner dorsal side of the posterior spine. Lateral and median occipital spines equally developed, intermediates rudimentary; Lorica stippled and has cuticular ridges.

A pair of posterolateral spines has been observed in all the specimens examined, the size of which varies in different individuals.

Occurrence: P6.

Measurements:

Total length	...	...	...	200 μ
Maximum width	...	...	...	136
Posterior spines	...	...	...	44
Posterolateral spine	...	...	...	16

This variety has been known earlier only from Sholavaram Lake and Almati Lakes, Madras (India) (Ahlstrom 1940). The present collection is from the concrete tank in Pilani (P6). They were very common in the samples collected during March-April 1963.

Brachionus caudatus f.majusculus (Fig. 10)

Lateral occipital spines longer than median spines; posterior spines long, stout and unequal; Lorica heavily stippled; foot opening overhung by a projection of the lorica.

Occurrence: P1, J15.

Measurements of Pilani Specimen:

Width of the lorica	...	...	...	132 μ
Anterior margin	...	...	...	84
Anterior lateral spine	...	...	...	20
Anterior median spine	...	...	...	10

This has been found earlier only near Kissimere, Florida (Ahlstrom 1940).

Brachionus caudatus f.apsteini (Fig. 7)

Median and lateral occipital spines developed; posterior spines comparatively short and distally divergent arising at an angle ventrally.

Occurrence: P7

Measurements:

Total length	...	...	...	188 μ
Maximum width	...	...	...	136
Posterior spine	...	...	....	20

4. Brachionus forficula Wierzeski 1891 (Fig. 21)

Body dorsoventrally compressed, occipital margin with 4 spines, laterals longer than medians; spines rounded at their tips. Mental margin with a median sinus; posterior spines unequal, narrow distally and converge towards the middle. There are knee

like swellings on the inner side of the posterior spines near their bases. Lorica heavily stippled.

Occurrence: M32.

Measurements:

Length of the lorica	...	...	...	124 μ
Maximum width of the lorica	...	...		124
Lateral occipital spine	...	...	...	40
Median spine	...	...	...	12
Posterior spines	...	...	...	112, 116.

This is a new record from India.

5. Brachionus angularis Gosse 1851 (Figs. 13-17)

Lorica firm compressed dorsoventrally; anterior dorsal margin with 2 median spines divided by a deep median sinus; mental margin with a shallow median sinus; foot opening large and flanked laterally by cuticular protuberances; dorsal plate with cuticular ridges. Lorica stippled.

Occurrence:

One of the most common forms met with in the samples collected from Pilani and Churu.

Measurements of Pilani specimen:

Length of the lorica	...	...	...	120 μ
Width of the lorica	...	...	...	96

Specimens from different localities and collected during different seasons show variation in their size, nature of the cuticular protuberances flanking the foot opening and in the anterior median spines. In all the specimens the intermediate spines of the occipital margin were completely lacking or very slightly developed.

The specimens collected from Churu (Fig.15) have an elongate body, their width being less than 3/4 of the length. The anterior median spines are small and straight with a deep U shaped sinus inbetween. The anterior half of the lorica is broader, the posterior half is somewhat triangular and narrows posteriorly. The cuticular protuberances of the foot opening are markedly convergent. The lorica is heavily stippled.

The outline of the lorica of the specimens collected from Pilani is somewhat circular (Fig.16). The anterior median spines show varying degree of bending towards the middle. The cuticular protuberances of the foot opening are parallel to each other. The lorica is lightly stippled. In the specimens collected from a monsoon ditch in Pilani the median spines were greatly reduced (Fig. 17)

This species has been earlier recorded from India by Edmondson and Hutchinson (1934) and Ahlstrom (1940).

6. Brachionus dimidiatus (Bryce) 1931 (Fig. 18)

Lorica firm not much compressed dorsoventrally; anterior-dorsal margin with 4 small spines of almost equal length, median spines not so pointed as laterals; mental margin straight with a

median sinus; foot opening subsquare dorsally and V shaped ventrally. Lorica smooth.

Occurrence: P3

Measurements:

Length of the lorica	...	...	...	108 μ
Width of the lorica	...	...	...	76
Anterior margin	...	...	...	44

7. Brachionus calyciflorus Pallas 1766 (Figs. 22,23,24,26)

Lorica flexible not divided into a dorsal and ventral plate; anterior dorsal margin with 4 broad based spines, mental margin with a notch in the centre; posterolateral spines commonly present. Lorica smooth.

Occurrence: P1, K26, M32, J14, B16, U22.

Edmondson and Hutchinson (1934) reported this species from the Punjab and Kashmir. Nayar (1964, 1965b) studied the morphometric variation and cyclomorphosis of B.calyciflorus.

8. Brachionus plicatilis Muller 1786 (Fig. 6)

Lorica oval maximum width being behind the middle line; anterior dorsal margin with 6 spines, innermost longer than the others;median spines narrow,markedly above the broad base and have wide cleft between them; intermediate spines not so pointed; mental margin divided into 4 lobes; foot opening with a subsquare aperture dorsally and a longer V_ shaped aperture ventrally. Lorica very lightly stippled.

Occurrence: P3

Measurements:

Length of the lorica	...	...	...	196 μ
Maximum width	...	...	...	164

This has been earlier recorded from India by Edmondson and Hutchinson (1934).

9. Brachionus quadridentatus Hermann 1783 (Fig. 27)

Lorica firm dorsoventrally compressed; occipital margin has 6 spines, medians longest and divergent, laterals longer than the intermediates; mental margin rigid with a median U - shaped notch flanked on either side by tooth like papilla; lorica terminates posteriorly in 2 long lateral spines; foot sheath asymmetric. Lorica heavily pustulated.

Occurrence:

Only one specimen was obtained from the sample collected from Ajit Sagar (K26) on 26.10.1963.

Measurements:

Total length	...	...	...	200 μ
Maximum width of the lorica		...	...	108
Occipital margin	...	...	...	80
Occipital spines	...	...	...	24, 20, 40.
Posterior lateral spines	...	...	...	60
Cuticular process of the foot sheath (right)				40

The present specimen agrees well with the description given by Ahlstrom (1940). He considers Brachionus longipes Anderson 1889 synonymous with B.quadridentatus.

Anderson (1889) reported this species from Calcutta and George (1961) from Delhi.

10. Brachionus diversicornis (Daday) 1883 (Figs. 19,20)

Lorica firm divided into a dorsal and ventral plate; occipital margin with 4 spines, medians much shorter than laterals; mental margin somewhat elevated with a shallow median sinus; lorica narrows posteriorly ending in 2 unequal spines, left one much smaller than the right; foot long with elongated toes. (Fig.20). Lorica not stippled.

Occurrence: A25.

Measurements:

	Specimen 1.	2.
Total length	140 µ	320 µ
Length of the lorica	108	180
Maximum width	60	128
Posterior width	28	48
Anterior spines	6, 22	10, 60
Posterior spines	4, 14	24, 64

In all the specimens examined the left posterior spine was considerably shorter than the right. This species has been known for a long time under the name Schizocerca diversicornis Daday.

Now it has been widely accepted that the bifurcation of the foot, on which this monotypic genus was created, is simply the greatly elongated toes (Ahlstrom 1940).

17 Genus Anuraeopsis Lauterborn 1900

11. Anuraeopsis fissa Gosse 1851 (Fig. 36)

In general the out line and ornamentation of the present specimens agree with the form described by Green (1960) collected from the River Sokoto, North Nigeria, who identified it as Anuraeopsis navicula Rousselet. Berzins (1962) regards it as conspecific to Anuraeopsis fissa coelata Beauchamp.

Occurrence: P1, P6.

Measurements:

Length	... ...	92 μ
Width	... ...	40

Anuraeopsis fissa coelata is a tropical form which has been recorded from East Africa, Nigeria, Madagasker and India. (Berzins 1962). The present collection has been made from 2 localities in Pilani when the water temperature was below 17°C and pH varied between 8 and 8.5. In Pilani tank this form constituted 5% of the total rotifers on 11.12.1963 when the pH was 8.1.

18 Genus Keratella Bory de Vincent

12. Keratella tropica (Apstein) 1907 (Figs. 28, 29)

Three hexagonal plaques on the dorsal plate of the lorica and a small 4 sided one between the posterior border of the lorica and the last hexagon; median occipital spines longer than other occipital spines and curved ventrally at the distal end; posterior spines divergent and unequal, right one longer than left. Specimens with out the left posterior spine were also common in the samples. Maximum width of lorica a little behind middle; breadth at the base of the posterior spines smaller than occipital margin. Lorica heavily pustulated.

Occurrence:

They are found to occur in small ditches, ponds and lakes throughout Rajasthan.

This species has been recorded from India by Edmondson and Hutchinson (1934), Brehm (1950), George (1961) and Nayar (1965c in press).

13. Keratella procurva (Thorpe) 1891 (Figs. 30-32)

Three median plaques on the dorsal plate of the lorica, last one pentagonal terminates in a short median line; posterior margin of lorica smaller than occipital margin; posterior spines small and unequal. In many of the specimens the left posterior spine was absent and specimens lacking both the posterior spines were also present.

Occurrence: P1, B19.

Edmondson and Hutchinson (1934) recorded this form from the Punjab.

14. Keratella edmondsoni (Ahlstrom) 1943* (Fig. 25)

Posterior margin of lorica broader than occipital margin; posterior spines long and divergent; median occipital spines slightly longer than other spines and bent ventrally at the distal end; dorsal plate has ± 3 median plaques, last one pentagonal ending in a median line. Lorica heavily stippled dorsally as well as ventrally.

Occurrence: R31.

The foundation pattern of the lorica is similar to that of K.procurva while it resembles K.quadrata in the broader posterior margin. Measurements of a few specimens (Table I) show that K.edmondsoni is much bigger than K.procurva and are with comparatively longer posterior spines.

This species has been earlier recorded only from Ootacamund (India) (Ahlstrom 1943).

---

* See Nayar 1965c.

Table I

Measurements of Keratella spp*

Species	Lorica Length	Width			Post. spines	
		Occipit.	Max.	Post.	Right	Left.
K.tropica Chirawa	116	56	68	48	64	24
	116	60	76	48	80	40
	112	68	76	48	84	16
	108	60	68	44	60	20
K.procurva Pilani	84	56	64	36	28	8
	84	48	56	36	24	8
	86	52	60	40	20	12
	88	48	52	38	20	8
	88	56	60	36	24	4
	88	52	64	40	20	12
K.edmondsoni Chirawa	108	60	76	64	78	60
	108	60	80	68	78	76
	112	60	84	72	76	68
	116	60	80	72	88	76
	118	60	80	70	72	68
	120	60	-	72	92	88
	120	64	84	76	84	80

* Measurements in microns.

Key to the Indian species of Keratella:

A. Posterior spine single, median ... ... K.cochlearis

B. Posterior spine one or two (sometimes absent) lateral

a. Occipital margin broader than posterior margin

a1. Three median hexagonal plaques and a small 4 sides one on the dorsum ... ... K.tropica

a2. Three median plaques on the dorsum, the last one pentagonal ending in a median line ... K.procurva

b. Occipital margin smaller than posterior margin

b1. Three median dorsal plaques, the last one bordering the posterior margin of the lorica ... K.quadrata

b2. Three median dorsal plaques, the last one pentagonal ending in a median line ... ... K.edmondsoni

19 Genus Macrochaetus Perty

15. Macrochaetus collinsii (Gosse) (Fig. 35)

Body dorsoventrally flattened; lorica as broad as long and heavily spinate, posterolateral angle of the lorica terminates in a spine; one of the spines along the lateral margin of the lorica bigger than others on either side; three pairs of long spines on its dorsal surface and a pair along the posterior margin, one on either side of the foot; claws long tapering distally and pointed at their tips.

Occurrence: P5.

Measurements:

Total length	...	...	...	128 μ
Length of the lorica	...	...	...	88
Maximum width	...	...	...	88
Anterior margin	...	...	...	44
Posterior margin	...	...	...	48
Claw	...	...	...	20

20 Genus Mytilina Bory de Vincent

16. Mytilina ventralis (Ehrenberg) 1832 (Fig. 37)

A good number of this form has been collected. In all the specimens the posterior spines are well developed, lower one being longer than upper. Lorica heavily stippled especially in the anterior region.

Occurrence: P2.

Measurements:

Total length	...	...	...	208 μ
Length of the lorica	...	...	...	180
Width of the lorica	...	...	...	76

The present specimens resemble greatly an unidentified form described by Anderson (1889) (p.354 Figs.8 & 8a) from Calcutta. He considered his specimens an intermediate form between Mytilina macrocantha (Gosse) and M.brevispina Ehrenberg which are now regarded as varieties of M.ventralis (Green 1960). The present specimens correspond with the form brevispina Ehrenberg.

Subfamily Colurinae

21 Genus Lepadella Bory de Vincent

17. Lepadella patella (Mull.) (Fig. 33)

Outline of lorica broadly ovate greatest width being in the middle of the body; anterior dorsal margin slightly convex or straight and ventral margin with a V - shaped sinus; lorica rounded posteriorly; foot groove nearly as wide as long, foot short, terminal segment longer than the first and second segment; toes relatively short and pointed at the apex.

Occurrence: P2.

Size: Total length ... ... 87 μ

18. Lepadella sp. (Fig. 34)

Lorica as wide as long, anterior dorsal margin straight, sides with a shallow notch; terminal segment of the foot considerably longer than the first and second segment; toes relatively long, slender and of equal size.

Occurrence: P5.

Measurements:

Total length	...	...	...	108 μ
Length of the lorica	...	...	...	80
Width	...	...	...	80
Anterior margin	...	...	...	28
Posterior margin	...	...	...	28
Claw	...	...	...	28

Family Lecanidae

22 Genus Lecane Nitzsch

19. Lecane luna (Muller) 1776 (Figures 40, 41)

Outline of lorica subcircular, dorsal plate almost circular its width being nearly equal to its length, ventral plate ovate, both ventral and dorsal plate have lunate anterior sinus; anterior margin of dorsal plate considerably narrower and project beyond the ventral plate in the centre; external angles of the anterior ventral margin cuspidate; second foot joint large and broad; toes parallel sided and slightly bent at the middle ending in claws with basal spicules; toes are two seventh of the total length.

Occurrence: P4.

Measurements:

Total length	168 μ
Length of the ventral plate	140
Dorsal plate	124
Anterior dorsal margin	62
Width of the ventral plate	116
Toe	48
Claw	8

This species has been earlier recorded from India by Anderson (1889) and Edmondson and Hutchinson (1934).

20. Lecane papuana (Murray) 1913 (Figures 42, 43)

Outline of the lorica subcircular its length being slightly more than its width; anterior dorsal margin nearly straight, ventral margin has a broad shallow V shaped sinus rounded posteriorly, sides of the sinus have two rounded lobes outer one projecting considerably beyond the dorsal plate; ventral plate of the same outline as that of dorsal plate; posterior segment small and rounded projecting slightly beyond the dorsal plate; first foot joint pyriform rounded posteriorly and second very broad; toes less than one fourth of total length, nearly parallel sided, straight on their inner edges; claws acutely pointed which has two basal spicules.

Occurrence: P 4.

Measurements:

Total length	156 µ
Anterior margin	72
Length of the dorsal plate	116
Ventral plate	124
Maximum width of the lorica	100
Toe	36
Claw	8

Edmondson and Hutchinson (1934) reported this species from the Punjab and Pasha (1961) from Madras.

21. Lecane tryphema Harring and Myers 1926 (Figures 46,47)

Outline of the lorica broadly oval; anterior dorsal margin nearly straight or slightly convex; anterior ventral margin straight and broader than that of dorsal, external angles of the former projecting beyond the margin; ventral plate a little narrower than dorsal and with illdefined margin; posterior segment projects beyond the dorsal plate; first foot joint overlaps the second and lobate posteriorly, second broader than long; toes about one fourth of total length, straight on their inner edges, tapering at the distal half, without claws.

Occurrence: P4

Measurements:

Total length	84 μ
Length of the ventral plate	64
Width of the ventral plate	56
Width of the dorsal plate	60
Anterior dorsal margin	42
Anterior ventral margin	46
Toes	24

The present specimen differs from the description of Lecane tryphema given by Harring and Myers (1926), in the anterior margin of the dorsal plate. But it appears that the difference is attributable to the mobile and flexible nature of the anterior margin of the lorica.

22. Lecane ploenensis (Voigt) 1902 (Figures 58, 59)

Outline of lorica elongate oval; anterior margin straight and coincident, at the external angles two cusp like spines; dorsal plate truncate posteriorly, ventral narrower than dorsal especially in front with flexible margin; posterior segment rounded and project a little beyond the dorsal plate;first foot joint indistinct, second distinct and broader; toes long and slender, about one third of total length, parallel sided, straight on their inner edges ending in acute points without claws.

Occurrence: P3.

Measurements:

Total length	144 μ
Length of the dorsal plate	112
Ventral plate	120
Width of the dorsal plate	92
Anterior ventral margin	66
Toe	44

23. Lecane nana (Murray) 1913 (Figures 44, 45)

Outline of lorica subcircular; anterior margin of dorsal and ventral plate coincident except in the middle region, anterior dorsal margin more convex in the middle and project beyond the ventral margin; ventral margin slightly convex; dorsal plate sub-circular its maximum width being a little more than its length, ventral plate narrower and longer than dorsal; posterior segment

projects beyond the dorsal plate; first foot joint widest in front, second broader and does not project beyond the posterior segment; toes long, about one fourth of total length, parallel sided half their length, acuminate and straight on their inner edges.

Occurrence: P4.

Measurements:

Total length	78 μ
Length of the dorsal plate	52
Ventral plate	60
Width of the dorsal plate	56
Anterior dorsal margin	52
Toe	18

23 Genus Monostyla Ehrenberg:

24. Monostyla quadridentata Ehrenberg 1832 (Figures 52,53)

Outline of lorica broadly ovate its width being less than three fourth of the length; anterior dorsal margin has a deep sinus flanked by two stout outcurved spines; ventral plate with a deeper V shaped sinus somewhat rounded posteriorly; external angles of the ventral margin project out as prominent cusps; dorsal plate broad and truncate posteriorly; toe very long and a little less than one third of the total length, slender and parallel sided; claw acutely pointed with two basal spicules.

Occurrence: P2.

Measurements:

Length of the dorsal plate	...	...	...	140 μ
Ventral plate	...	...	...	160
Width of the dorsal plate	...	...	...	100
Ventral plate	...	...	...	114
Anterior ventral margin	...	...	...	56
Toe	...	...	...	68

Variation has been noticed in the anterior median sinus of the dorsal margin. The closeness of the spines varies from 4 to 16 in the specimens of the same sample.

This species has been earlier reported from India by Anderson (1889) and Edmondson and Hutchinson (1934).

25. Monostyla punctata Murray 1913 (Figures 48, 49)

Outline of lorica broadly ovate, its width being nearly equal to its length; anterior dorsal margin slightly convex and narrower than the ventral margin; ventral margin concave opposite to the dorsal plate and extends laterally in an obtuse angle; dorsal plate broadly ovate and rounded posteriorly; ventral plate narrower than the dorsal, it has a wider area anteriorly, parallel sided in the middle and tapers posteriorly with illdefined edges; posterior segment small and projects a little beyond the dorsal plate; first foot joint indistinct, second large and broad; toe long nearly one third of the total length; claw acutely pointed with a median groove.

Occurrence: p.

Measurements:

Total length	...	...	...	108 μ
Length of the dorsal plate	...	...		76
Ventral plate	...	...	...	80
Anterior dorsal margin	...	...	...	30
Anterior ventral margin	...	...	...	54
Width of the ventral plate	...	...		64
Toe	...	...	...	28

26. Monostyla hamata stokes 1896 (Figures 50, 51)

Outline of lorica elongate oval its width about two third of its length; anterior margins not coincident; anterior dorsal margin narrower, lunate and project beyond the ventral margin in the middle, ventral margin has a deeper sinus rounded posteriorly; external angles of the ventral margin project as pointed cusps; dorsal plate oval, rounded posteriorly; ventral more elongate and slightly narrower than the dorsal; posterior segment projects beyond the dorsal plate; toe long one fourth of total length, parallel sided more than half its length, tapers gradually to an acute point without claw.

Occurrence: P1, K26.

Measurements:

Total length	...	...	...	112 μ
Length of the ventral plate	...	...		84
Width of the ventral plate	...	...		52
Width of the dorsal plate	...	...	...	60
Toe	...	...	...	28

This has been reported earlier from India by Edmondson and Hutchinson (1934) and Pasha (1961).

27. Monostyla bulla Gosse 1851 (Figures 56, 57)

Body elongate oval its width being slightly less than half of its total length; anterior dorsal margin almost straight with a subsquare notch in the centre; ventral margin has a deep V shaped sinus rounded posteriorly; ventral plate similar in outline of the dorsal plate and of the same width; first foot joint short and broad, second large; toe very long and slender being one third of the total length. It is slightly enlarged in the middle, ends in a long slender acute claw with distinct basal spicules.

Occurrence: P1 , K26.

Measurements:

Total length	...	...	...	180 μ
Length of the ventral plate		...	...	120
Maximum width	...	...	...	84
Anterior margin	...	...	...	48
Toe	...	...	...	60
Claw	...	...	...	20

Pasha (1961) has recorded this species from Madras.

28. Monostyla sp (Figures 54, 55)

Outline of lorica broadly ovate its width being about three fifth of the length; anterior margins coincident except in

the middle region; sinus of the ventral plate very deep, rounded posteriorly and with a slight lateral cusp; two minute frontal spines present; anterior dorsal margin shallower; dorsal plate broadly ovate maximum width being in the middle region; ventral plate narrow and ovate; first foot joint distinct, second robust, project a little beyond the posterior segment, toe long, slender, parallel sided terminating in a claw with basal spicules.

Occurrence: P5.

Measurements:

Length of the lorica	...	...	...	144 µ
Maximum width	...	...	...	88
Anterior ventral margin	...	...	...	56
Toe	...	...	...	64
Claw	...	...	...	16

Although the present form resembles M.decipiens Murray and M.thalera Harring and Myers it differs from them in a few characters. The difference from M.decipiens is in the presence of shallower anterior dorsal margin and the presence of basal spicules. M.thalera differs from the present form in having a subrhomboid dorsal plate and a spindle shaped toe which is enlarged near the middle.

29. Monostyla closterocerca Schmarda 1859 (Figures 60, 61)

Outline of lorica subcircular its width being equal to its length; dorsal plate nearly circular; ventral plate broadly

oval and narrower than the dorsal plate; anterior ventral margin with shallow broadly V shaped sinus; toe slightly less thqm one fourth of total length of total length, parallel sided for half of its length and tapering to slender acute point.

Occurrence: P1.

Measurements:

Total length	...	...	...	104 μ
Length of the dorsal plate	...	...		72
Ventral plate	...	...	...	80
Width of the dorsal plate	...	...	...	72
Ventral plate	...	...	...	60
Anterior margin	...	...	...	40
Toe	...	...	...	24

The present specimen differs from the description given by Harring and Myers (1926) in 2 characters. The anterior margin of the dorsal plate is not coincident with that of the ventral plate. The toe is relatively short.

Family Trichocercidae

24 Genus Trichocerca Lamarck

30. Trichocerca similis (Wierzejski) (Figures 65, 66)

Body slender and narrow posteriorly; a pair of long teeth of equal size at the anterior margin (Fig.66); toes unequal smaller one being more than half the length of the longer.

Occurrence: A24.

Measurements:

Total length	232 μ
Anterior longer tooth	28
Body length (excluding toe and long teeth)...	160
Longer toe	44

The present form was common in the plankton smaple collected from Alwar. They could be easily distinguished by the slender body and nature of the anterior teeth.

31. Trichoceraca sp. (Fig. 63)

Anterior margin without any long teeth; toes unequal, longer one straight; dorsal margin of the body greatly arched.

Occurrence: A24.

Measurements:

Total length	236 μ
Length of the body	172
Longer toe	64

A good number of them was found in the plankton sample from Alwar along with Trichocerca similis.

32. Trichocerca stylata (Gosse) (Fig. 64)

The appearance and size of the present form is very much comparable to the form recorded by Pejler (1957b) from the pond Svandammen, Uppsala.

Occurrence: J15

Measurements:

Length of the body	...	...	...	84 μ
Width in the middle of the body	..	...		40
Longest toe	...	...	...	40

33. Trichocerca sp. (Fig. 62)

A few of the specimens collected from Jaisalmer, Alwar, has only one anterior tooth longer than others. Toes unequal.

Occurrence: J15.

Measurements:

Total length	...	...	...	180 μ
Anterior long tooth	...	...	...	16
Longest toe	...	...	...	36

Family Synchaetidae

25 Genus Polyarthra Ehrenberg

34. Polyarthra multiappendiculata Arora 1962 (Fig. 39)

In general form the present specimen agrees with the description given by Arora (1962). The sword shaped appendages never reach the posterior margin of the body. Length of the filiform appendages have been found to vary; sometimes they are about double the length of the sword shaped appendages. The filiform appendages reach beyond the posterior margin of the body. Of the 6 filiform appendages on each side 3 are stouter than others.

Occurrence: A24.

Measurements:

Length of the body	...	...	...	96 μ
(Maximum size measured	...	...	...	108)
Length of the swordshaped appendages				68
Width	...	...	...	68
Filiform appendage	...	...	...	96

Arora (1962) has described this species from Nagpur, India.

Order Floscullariaceae

Family Testudinellidae

26 Genus Filinia Bory de Vincent

35. Filinia longiseta (Ehrenberg) (Fig. 67)

This is one of the most common limnetic rotifers, characterised by the presence of 2 anterior and 1 posterior appendage which are setiform extensions of the cuticle. The posterior seta is ventral or subterminal in position.

Occurrence: P1, P6, P7.

Measurements:

Length of the lorica	...	...	...	176 μ
Width (Middle)	...	...	...	198
Anterior seta	...	...	...	420
Posterior seta	...	...	...	276

36. Filinia terminalis (Plate) ? Edmondson and Hutchinson 1934 ... (Fig. 68)

The taxonomy of this species has been discussed under discussion (p. 64).

37. Filinia opoliensis (Zacharias) 1898 (Fig. 69)

Four setform appendages, 2 anterior and 2 posterior; one of the posterior spines small; mastax of malleoramate type, manubrium bordering the outer edges of uncus, rami completely hidden by unci, unci have many teeth.

Occurrence: M32, P1, R31.

Measurements:

Total length	...	...	...	400 µ
Length of the body	...	...	...	192
Width of the anterior end	...	...	...	52
Maximum width	...	...	...	76
Posterior spines	...	...	...	208, 30

Arora (1962) has recorded this species from Nagpur.

Family Hexarthridae

27 Genus Hexarthra Schmarda

38. Hexarthra mira (Hudson) = Pedalia mira (Hudson) (Fig. 38)

Dorsal and ventral appendages taper distally and bear 5 plumose setae at its tip, other appendages have 3 plumose setae each.

Occurrence: P1

This specimen has been compared only with the figure (Fig.18.6) given by Edmondson (1959).

Family Flosculariidae

28 Genus Lacinularia Schweigger

39. Lacinularia flosculosa (Muller) 1773 (Fig. 70)

This is a colonial form, usually found attached to floating twigs. Corona heart shaped; oviferon absent.

Occurrence: K26.

The present form agrees with the description given by Arora (1963) who reported it from Nagpur (India).

29 Discussion:

Out of the 39 species of Rotifera, which I have described in the present work, 17 are reported for the first time from India and all of them are reported first time from Rajasthan. They belong to 13 genera of 6 families (Edmondson 1959).

In the present collection the genus Brachionus is represented by 10 species out of 25 species considered valid by Ahlstrom (1940). Although the genus Brachionus is world wide in distribution a number of species have been found in only very few habitats. Brachionus dimidiatus which is recorded from Pilani, has been earlier known only from Africa. Brachionus caudatus var. aculeatus has a

localised geographic distribution. So far this has been recorded only from Madras (India) (Ahlstrom 1940) in addition to the present report. B.caudatus majusculus has been recorded earlier only from Kissimere, Florida (Ahlstrom 1940). The species of Brachionus are characteristically found in hard waters. The occurrence of highly alkaline species such as B.plicatilis, B.calyciflorus, B.dimidiatus, B.angularis, B.caudatus and B.quadridentata can be accounted for the alkaline nature of the water of Rajasthan.

Species of Brachionus have been found to vary considerably. They vary from habitat to habitat, from season to season and sometimes the sample shows considerable variation. B.calyciflorus has been found to be one of the most variable species collected. Variation has been observed in the size of the lorica, in the length of the posterolateral spines, in the length and proportion of the occipital spines (Nayar 1964) and also in the nature of the mental margin. The specimens collected from Khetri and Mt.Abu show a pair of spine like projections one on either side of the deep median sinus of the mental margin. Study of cyclomorphosis of B.calyciflorus (Nayar 1965b) shows that variation in the number and size of the posterolateral spines may be due to the changes in the food available for them. Green (1963) also observed that the length of the head spine of Scapholeberis mucronata was influenced mainly by changes in nutrition.

Unlike Brachionus the distribution of Keratella is not governed by hydrogen ion concentration. The absence of the alkaline species K.quadrata and the ~~composition~~ Cosmopolitan species K.cochlearis in

the present collection shows that there are some other factors controlling their distribution. The genus is represented by 3 species viz. K.tropica (Apstein), K.procurva (Thorpe) and K.edmondsoni (Ahlstrom) in the present collection. Among these K.tropica is the most common which is widely distributed. K.edmondsoni has a localised distribution reported only from India. (Ahlstrom 1943, Nayar 1965c) while K.procurva is reported from Asia, Africa, and Australia. (Ahlstrom 1943, Russell 1949).

Edmondson and Hutchinson (1934) discussed in great detail the taxonomy of Keratella quadrata and K.valga and recognised them as two well defined species. In K.quadrata the posterior width of the body is greater than the anterior width while in K.valga posterior width is less than anterior width. K.tropica and K.procurva have been frequently regarded as varieties of K.valga (Edmondson and Hutchinson 1934, Ahlstrom 1943, Edmondson 1959). But Berzins (1955) considers them as two distinct species based on the characteristic pattern of the dorsum which I have also followed in the present work. (Nayar 1965c). He distinguishes K.valga from others based on the 3 median plaques of which the last one bordering the posterior margin of the lorica. Ahlstrom (1943) pointed out the pattern of the dorsal sculpture on the lorica is of greatest importance in differentiating species of Keratella. Undue importance has been given, by the earlier workers, to the length and proportion of the posterior spines in distinguishing the species and varieties of Keratella. But I find the length of the posterior spines is highly variable and cannot be given much taxonomic value. The relative proportion of the lorica and the foundation pattern of the dorsum

have been found to vary little and can be taken as reliable characters in distinguishing the species.

Thorpe (1891) described Keratella procurva (Anuraea procurva Thorpe) from Ascension island. Edmondson and Hutchinson (1934) collected similar forms from India and considered them as K.valga f.valga. Ahlstrom (1943) regarded them as K.valga var. procurva (Thorpe). This form differs from all the other forms of K.valga in that the median posterior plaque is pentagonal terminating in a short median line. Hence Berzins (1955) considered them a separate species. The specimens of K.procurva which I have collected from Pilani and Bikaner occurred along with K.tropica and could be easily distinguished by means of their smaller size and pattern of the dorsum of procurva. K.edmondsoni (K.quadrata var.edmondsoni Ahlstrom) has a foundation pattern similar to that of K.procurva but in form it is nearer to K.quadrata because of its broader posterior margin. The species of Keratella with 2 posterior spines can be broadly divided into 2 categories; one with broader occipital margin and the other with narrower occipital margin. The former will include forms like K.valga, K.tropica, K.procurva, and the latter include K.quadrata and K.edmondsoni.

The specimens of Mytilina which I have collected from Pilani resembles greatly the unidentified form described by Anderson (1889 p.354 Fig.8). He distinguished them from M.brevispina based on its size and considered them an intermediate form between it and M.macracantha. Now these two species have been regarded as two

distinct varieties of M.ventralis (Ehrenberg) (Green 1960). The specimens of M.ventralis collected by Russell from West Africa (Russell 1956) and Malaya (Russell 1958) have a total length of 280 and 116 respectively. The specimens from Pilani measured about 208. This reveals the highly variable nature in the size of M.ventralis. Therefore, the forms collected by Anderson(1889) cannot be regarded as a new species and I consider them along with mine as belonging to M.ventralis (Ehr.). The specimens collected from Pilani corresponds with the form brevispina.

The family Lecanidae including the 2 genera Lecane Nitzsch and Monostyla Ehrenberg is represented by 11 species in the present collection. Edmondson (1935) proposed to fuse the 2 genera because of the similarity in the structure of the lorica and based on the partly fused toes in some species of Lecane. Later many workers (Berzins 1953, 1961; Green 1960; Hauer 1963) have followed the same. But this has not been widely accepted largely because of the unwieldy nature of the large genus and due to lack of enough transitional species. Moreover, the two names have a clear cut meaning and they have been treated as separate genera in the present work.

The shape of the lorica especially of the anterior margin has been greatly used in the taxonomy of the species of Lecane and Monostyla. But it has been realised now that the anterior margins of the lorica are very mobile and flexible and cannot be taken as a diagnostic character. Russell (1957) suggested that 'the anterior margin appears to be an irreliable specific characteristic for the identification of the Lecanes'. He even suggested that Lecane papuana

can be only a variety of L.luna based on some of his observations on the rotifers collected from Fiji. But the observations I have made do not indicate that L.papuana is a variety of L.luna. Although both the species were present in the same sample the anterior ventral margin was characteristic and no intermediate stages could be observed. Therefore, I regard them as two distinct species. Moreover, L.luna is a cosmopolitan species (Green 1960) while L.papuana is a tropicopolitan form (Edmondson and Hutchinson 1934).

The family Testudinellidae is represented in the present collection by 3 species belonging to the genus Filinia Bory de Vincent. Edmondson (1959) included the genera Tetramastix and Fadeewella under the genus Filinia. Edmondson and Hutchinson (1934) reported F.longiseta from the Punjab, Kashmir, Tibet and Ootacamund. They found the ventral seta is attached terminally or subterminally in the specimens collected from Kashmir and Tibet while forms from Ootacamund the seta was terminal. In my collection all the specimens have a ventrally attached seta. Solminski(1926) has shown that this species showed cyclomorphosis and that the distance between the posterior end and the attachment of the seta varies considerably. Therefore, the variation in the attachment of the seta is probably due to its seasonal polymorphism.

The fact that Plate (1886) has not given any illustration for his Filinia terminalis has brought much confusion regarding its identification. Edmondson and Hutchinson (1934) collected two species of Filinia from Ootacamund lake. One of them was undoubtedly F.longiseta Ehr. and the other was identified as

F.terminalis (Plate) on the basis of its 'small spindle shaped body' and terminal seta. Pejler (1957a) is of opinion that all forms with terminal posterior process which have been figured have a broad body the form of Edmondson and Hutchinson being the only exception. He suggests that only those specimens of Filinia with broad body should be called Filinia terminalis and he considers F.maior (Colditz) as a synonym of F.terminalis (Pejler 1957a) while F.terminalis of Edmondson and Hutchinson is probably representing a new form. A few specimens of Filinia collected from Pilani are comparable to F.terminalis described by Edmondson and Hutchinson (1934). They were found to occur along with F.longiseta but could be easily distinguished from the latter by means of its small slender body and terminal attachment of the seta. No intermediate forms occurred in these samples. Therefore, it is probable that this form represents a new species differing from its European form, F.terminalis mainly in its small size and localised distribution. This form has been known so far only from India.

CHAPTER IV

Branchiopods - Pages 66 to 98

CHAPTER IV

Faunestic and Taxonomic Study

BRANCHIOPODA

Class Crustacea

Subclass Branchiopoda

Order Anostraca

Family Streptocephalidae

30 Genus Streptocephalus Baird 1852

1. Streptocephalus dichotomus Baird 1860 (Figures 72, 73)

Male:

In general form and colour it agrees with the original description given by Baird (1860a). Antenna elongated, twisted and divided distally the main branch of which bifurcates distally; several small spinules present along the outer margin of the longer branch and a few on others; finger notch deep and open.

Female:

Antenna of female simple, blade like, bluntly rounded at the tip.

Occurrence:

Large number of male and female specimens have been collected from rainy pools in Pilani after the monsoon rains.

The males agree well with the original description(Baird 1860a). He did not have any females. Bond (1934) says that in all the 16 females he has examined the second antennae are folded and wrinkled to a greater or lesser degree. The antennae of the females of my specimens do not agree in that respect. They agree with the description given by Sars (1900). Gurney (1906) considers Streptocephalus bengalensis Alcock as synonym of S.dichotomus Baird.

This species has been recorded earlier from many places in India: Viz. Madras, Tanjore, Mirzapur, Bangalore and Calcutta.

2. Streptocephalus simplex (Gurney) 1906 (Fig. 71)

Male:

They are relatively small forms of milky white colour in formaline. Male antenna has only 3 fleshy processes in the middle joint; finger notch well marked, proximal edge of it a little produced; main branch of the finger undivided, provided with prominent spinules on its outer margin; sickle shaped branch of the finger without any teeth; dorsal process of the thumb reduced, ventral process well developed; first antenna 2 jointed with a small basal segment and a long distal one, distal segment has 3 long and a few short setae at its end.

Female:

Second antenna of female broad and blade like.

Occurrence: B17

Gurney (1906) identified the specimens collected from Kutch (India) as variety simplex of S.dichotomus based on differences in the nature of the male antenna. Bond (1934) raised Gurney's variety to the rank of a species. He also described 3 new sub-species of S.simplex. According to his description the present forms belong to S.simplex arabicus Bond which is hitherto recorded only from Arabia.

Family Thamnocephalidae

31 Genus Branchinella Sayche 1903

3. Branchinella kugenumaensis Ischikawa (Figures 77,78,79)

Male:

Frontal appendage twice as long as second antenna. In preserved specimens it is bent and coiled ventrally. Basal undivided part of frontal appendage as long as rest, distal half bifurcated, each bifurcation again divided into 3 branches on each side; branches symmetrically placed; each branch beset with a large number of scattered spinules of different size, basal ones longer than others; second antenna also provided with small spinules in one of the branches; first antenna long and slender; penis coiled beset with numerous short spines.

Female:

Females resemble males; second antenna with a narrow pointed apex; ovisac large extending up to the middle of abdomen.

Size: Male 25 mm; Female 21 mm.

Occurrence: K30

4. Branchinella sp. (Figures 74, 75, 76)

Only 3 specimens, 1 male and 2 females, of this species have been collected. Frontal appendage of male about twice as long as the second antenna; distally it divides into 2, each one again dividing into small branches; first antenna unsegmented and filamentous.

Second antenna of female broad and somewhat triangular with rounded apex; caudal furca stout with uniformly arranged setae.

Size: Male 30 mm.; Female 22 mm.

Occurrence: K30 August 1962.

Since the specimens are not in a good condition any further observations could not be made. The nature of the frontal appendage does not resemble either of Branchinella biswasi Tiwari or B.kugenumaensis Ischikawa, the only known species of Branchinella from India.

Order Notostraca

32 Genus Apus Schaeffer 1756 (Triops Schrank 1803)

5. Apus cancriformis Schaeffer 1756 (Fig. 80)

A few specimens of this species have been collected from Khetri (K30). The observations made on 3 female specimens are given in the following Table II.

Carapace oval slightly longer than broad; nuchal organ oval as seen from above situated between posterior margins of the compound eyes; posterior margin of the carapace (Posterior sulcus) beset with a varying number (35-40) of short spines; external angles of the posterior sulcus drawn out into pointed corners; fourth endite of the first leg as long as the rest of the body or longer than it; dorsal surface of telson has a few stout spines the arrangement of which varies.

Table II

	sp.1	2	3
Length excluding caudal furca	22 mm	22.5 mm	23 mm
Posterior width of carapace	4.5 mm	4.5 mm	5 mm
Median length	14 mm	13 mm	15.5 mm
Maximum	14 mm	12.5 mm	13 mm
Exposed segments	14 mm	18 mm	16 mm
Apodal segments	7 mm	7 mm	7 mm

This species has been earlier recorded from, Gujarat and the Punjab. (Tiwari 1951).

Order Conchostraca

Family Leptestheriidae

33 Genus Leptestheria Sars

6. Leptestheria longispinosa Nayar 1965 (Figures 81-93)

Female:

Shell oblong, with 8-9 lines of growth (Fig. 82); umbone rounded, situated near anterior extremity of the shell; hinge-line

straight, forming a blunt angle at the junction with the posterior margin; shell more arched in the posterior margin than in the anterior; its lower margin nearly parallel to the hinge-line and the entire free margin fringed with stiff, unequal hairs which are more in number along the posterior margin. Rostrum with sinuous dorsal and ventral margin, provided with a long pointed spine; the latter slightly bent upwards distally; supraorbital margin arched (Fig. 87).

First antenna with 12-15 sensory lobes and second with branches of 14 and 12 segments; 18-22 peraeopods; sixth endite of the first peraeopod projecting beyond the flabellum; the well developed palp on the fifth endite reaching as far as the tip of the sixth endite (Fig. 88). In the tenth peraeopod the sixth endite as well as the dorsal lobe of the flabellum much broader than in the first; the palp of the fifth endite narrower and not reaching the tip of the sixth endite (Fig. 90); first endite with a few spines on its dorsal margin. Telson well developed, dorsal margin provided with 55-60 closely set short spines (Fig. 83), each spine serrated at its base on both the margins (Fig. 84); the immovable spine of the telson about half the length of the claw; furcal claw beset with about 20 spines on its dorsal margin, serrated only along the anterior margin(Fig.85).

Male:

Shell shorter (Fig. 81) and with its posterior margin (Fig. 81) more arched than in the female; lower margin sub-parallel to the hinge-line. Supraorbital margin and ventral margin of the rostrum somewhat straight; rostral spine similar

to that of female (Fig. 86); first two pairs of peraeopods prehensile (Figures 89,92). The 'hand' of the first peraeopod with 2 small spines a little below its middle region, that of the second with only a well developed one (Fig. 93); third peraeopod similar to the first of female but without lamina epipoditalis; the immovable spine of the telson more than half the length of the claw (Fig. 91).

Size: Female 4.5 mm.; Male 3.5 mm.

Occurrence: K30.

Leptestheria jaisalmerensis Tiwari (1962) is the only other species of the genus Leptestheria recorded from India. The present species can be distinguished from that by the lesser number of growth lines on the shell. L.jaisalmerensis has 18-21 lines of growth on the shell while the present one shows only 8-9 lines. Moreover, the rostral spine is much bigger than that of L.jaisalmerensis.

34 Genus Eocyzicus Daday 1915

7. Eocyzicus acuta Nayar 1965 (Figures 94-97)

Female:

Shell thin ovate with a prominent umbone situated a little away from the anterior extremity (Fig. 94); hinge-line straight making an angle with the posterior margin which is more arched than the anterior margin; shell with 9 lines of growth; the free margin of the shell as well as the growth

lines fringed with hairs. Head with a triangular rostrum ending in acute spinule (Fig. 95); supraorbital margin straight;occipital angle rounded forming a deep notch at the junction of the head and the trunk; second antenna with branches of 10 segments.

Trunk with 15 pedigerous segments armed dorsally. Spine formula from behind forwards 1,1,2,3,4,3,4,4,5,2,2,1,1,1. In the first peraeopod the sixth endite projecting beyond the flabellum (Fig. 97); the palp of the 5th endite exceeding half of its length; in the tenth peraeopod the sixth endite not projecting beyond the flabellum, palp on the fifth endite reduced. Dorsal margin of the telson armed with 11-12 unequal denticles, the posterior one being the longest (Fig. 96); all the denticles provided with small spinules, an unforked filament behind the anteriormost spine; dorsal inner margin of the claw with minute denticles in the distal half and a prominent lateral one below the middle; four plumose setae near the base of the claw. Male not known.

Maximum size of female : 4.0 mm.

Occurrence: Pilani

The present species differs from all the other known Indian species of Eocyzicus in having an acutely pointed rostrum. Although the telson resembles very much that of E.deterrana Bond (1934), the present species can be easily distinguished by the nature of the rostrum.

35 Genus Eulimnadia Packard 1874

8. Eulimnadia ovata Nayar 1965 (Figures 98-102)

Female:

Shell thin, transparent, oval with the maximum width anterior to the middle (Fig.98); anterior half of the shell broader, narrowing posteriorly. In bigger specimens 4-5 growth lines visible. Rostrum rounded; dorsal organ subglobular and the eye conspicuous (Fig.99); first antenna with about 8 sensory lobes; second with branches of 8 and 9 segments; trunk with 18 pairs of legs; ninth and tenth peraeopods with a much elongated lower lobe for the flabellum (Fig.101); posterior 14 segments of the trunk with groups of setae on the dorsal margin. telson with 14-15 unequal spines on its dorsal margin, the first and the last bigger than the others. A forked filament present between the second and the third spine from anterior (Fig.102); lower distal angle of the telson produced into a rounded or pointed spine; furcal claw 2 jointed, the proximal longer segment with 16 plumose setae in bigger specimens; less in smaller specimens. The smaller distal segment slightly bent dorsally and serrated on its dorsal margin in the middle. Male not known.

Length of the Female: 7.5 mm.

Occurrence: K30.

The present specimen resembles Eulimnadia margaretae Bond (1934), but can be distinguished by the more elongated shape of the shell and the fewer number of spines along the dorsal margin of the telson in the present species.

Order Cladocera

Family Sididae

36 Genus Diaphanosoma Fischer 1850

9. Diaphanosoma excisum Sars 1885 (Figures 158-162)

Female:

Body elongated; head large; relatively small eyes; ventral margin of the valve inturned; ventral one third of the posterior margin of the carapace provided with a number of small teeth, usually numbering about 40. Antenna small; olfactory setae terminal with a slender flagellum. The reflexed antenna does not reach the posterior margin of the carapace; post-abdomen narrow; claw with 3 basal spines.

Male:

Smaller than female with a long antennule and laterally placed olfactory setae.

Occurrence: K26, P6

Measurements: Female 1.6 mm., Male 0.9 mm.

Although the large head, small eye and the rather narrow posterior part of the carapace inflection suggest D.excisum, the large number of teeth on the posterior margin of the carapace is similar to that of D.sarsi Richard. The number of teeth on the posterior margin is highly variable, sometimes differing on the 2 sides of one specimen (Green 1962). Moreover, it has been found that wide gaps occur sometimes in between the adjacent teeth.

Family Daphniidae

37 Genus Daphnia O.F. Muller 1785

10. Daphnia similis Claus 1876 (Figures 112-119)

Female:

They are thick bodied forms with relatively small head without a crest. Fornix developed with a distinct posterior angle; secondary fornix extends far back; ocellus distinct; antennules projecting, olfactory setae do not project beyond the rostrum; dorsal spinules arise from the head-shield and extend to the tip of the shell spine; a group of fine feathered setae on the inner margin of the valves; shell spine well developed, arising above the axis of the body and slightly bent upwards; dorsal margin of postabdomen not sinuate with 11-12 anal denticles; claws with two distinct combs the distal one with more than 15 teeth; first abdominal process without any setae; anus opens before the last anal spine.

Male:

They are much smaller than females. Shell-spine arising from the dorsal margin of variable length; anterior ventral margin of the valvular part of the carapace has a few long setae arranged in a group; rostrum blunt; antennule well developed, terminal seta being inbetween the flagellum and the olfactory setae; terminal seta only nearly half the length of the olfactory seta; flagellum about as long as the basal segment; postabdomen long, with a distal inflation along the dorsal margin; anal denticles are about 12 in number divided into 2 groups with an indentation inbetween; distal

group of 6 spines smaller than that of the proximal group, post-anal bulge has a few hair groups below the anal denticles; abdominal processes reduced.

Occurrence: P6, K26.

Measurements:

	Female	Male
Total length ...	2.7 mm	1.7 mm
Shell spine ...	0.8 mm	0.22 mm
Maximum width ...	1.1 mm	0.7 mm
Biggest specimen measured	3.0 mm	

The present specimens agree well with the account of D.similis Claus given by Brooks (1959). In the presence of a few hair groups on the anal bulge in the male and in the clearly separated groups of anal denticles the present specimens differ from the earlier descriptions.

11. Daphnia magna Straus 1820 (Figures 120-128)

Female:

Carapace thin and transparent with its valvular part broadly oval on lateral view; shell spine usually short, somewhat upturned arising well above the median axis of the body; spinules on the dorsal and ventral margin of the valve extend anteriorly only a little beyond the middle of the valves; head-shield of moderate size has a ridge parallel to the dorsal margin; fornix prominent with a pointed angle; dorsal margin of

the head evenly curved ending ventrally in a pointed rostrum; antennules small but well defined with the olfactory setae do not projecting beyond the tip of the rostrum; ocellus distinct and the eyes of moderate size.

Postabdomen tapering, ending in stout curved claws with combs. The number of anal denticles along the dorsal margin varies from 7 to 12. Many of the specimens have only less than 10 anal denticles. Postabdomen has a sinuate dorsal margin dividing the anal denticles into 2 groups, distal group has always fewer spines than the proximal group and generally with 2 spines; size of the denticles of the distal group increases greatly towards the distal end so that the posteriormost is the longest. When there are only a few anal denticles there is a wide gap separating the two groups.

Male: Males are smaller than females; shell-spine short, originating from the dorsal margin of the valves; carapace (including the head-shield) is somewhat rectangular in outline; spinules on the shell margin extend only to the middle as in the female; anterior half of the ventral margin of the valves provided with a row of long setae; eyes big; rostrum blunt; antennules well developed, terminal seta situated between the flagellum and the olfactory setae, flagellum as long as the basal segment. Postabdomen with a deep indentation along the dorsal margin; proximal group of anal denticles with 5-7 spines.

Occurrence: G11.

the head evenly curved ending ventrally in a pointed rostrum; antennules small but well defined with the olfactory setae do not projecting beyond the tip of the rostrum; ocellus distinct and the eyes of moderate size.

Postabdomen tapering, ending in stout curved claws with combs. The number of anal denticles along the dorsal margin varies from 7 to 12. Many of the specimens have only less than 10 anal denticles. Postabdomen has a sinuate dorsal margin dividing the anal denticles into 2 groups, distal group has always fewer spines than the proximal group and generally with 2 spines; size of the denticles of the distal group increases greatly towards the distal end so that the posteriormost is the longest. When there are only a few anal denticles there is a wide gap separating the two groups.

Male: Males are smaller than females; shell-spine short, originating from the dorsal margin of the valves; carapace (including the head-shield) is somewhat rectangular in outline; spinules on the shell margin extend only to the middle as in the female; anterior half of the ventral margin of the valves provided with a row of long setae; eyes big; rostrum blunt; antennules well developed, terminal seta situated between the flagellum and the olfactory setae, flagellum as long as the basal segment. Postabdomen with a deep indentation along the dorsal margin; proximal group of anal denticles with 5-7 spines.

Occurrence: G11.

Measurements:

		Female	Male
Total length	...	2.3 mm	2.0 mm
Shell spine	...	0.37 mm	0.28 mm

See discussion. p.95.

12. Daphnia lumholtzi Sars 1885 (Figures 129-138)

Female:

Specimens collected from Udaipur have thin carapace, head often drawn out into a point anteriorly, the length of the head spine varies in different specimens; fornix very well developed with a pointed posterior angle; a cervical sinus present in all the specimens; dorsal margin of the valves arched in forms with embryos, otherwise somewhat straight; shell-spine well developed, a little upturned, originating above the axis of the body; spinules along the margin of the valves big, the distance between the adjacent spinules being more than the length of the spinule. They are present only on the posterior half of the valves and along both the margins of the shell-spine. Rostrum pointed; antennules prominent with olfactory setae projecting well beyond the tip of the rostrum; eyes of moderate size; postabdomen has a sinuate dorsal margin with 11-13 anal denticles, ending in well developed claws; a distinct comb lacking; abdominal processes 1 and 2 well developed, generally without any hairs.

Specimens from Mt.Abu have longer head-spine; shell spine much elongated sometimes as long as the rest of the body excluding the head-spine.

Male:

The males collected from Udaipur are of almost same size as the females. Antennules well developed, longer than head; flagellum as long as the basal joint and 3 times longer than half of the olfactory setae; lateral seta terminal, less than half of the olfactory setae in length; rostrum blunt; eyes quite big. There are a few long setae along the anterior ventral margin of the valves. Postabdomen tapering distally ending in stout claws; dorsal margin of the postabdomen somewhat sinuate, with about 13 denticles, becoming smaller distally except the last which is the stoutest.

Occurrence: U21, M32. There was no male in the samples collected from Nakki Lake, Mt.Abu.

Although the antennules of the male resemble that of Daphnia similis they can be distinguished by the nature of the fornix, shape of the values and the nature of the post-abdomen.

13. Daphnia cucullata G.O. Sars 1861 (Figures 139-145)

Female:

They are of smaller forms than many of the species observed. All the specimens examined have a pointed crest on the head; ventral head margin slightly convex or almost straight; rostrum short and blunt; antennules vestigeal; olfactory setae

arising directly from the rostrum; eyes of moderate size with regularly arranged lenses; carapace very hyaline; dorsal spinules extend up to the cervical region; ventrally the spinules do not extend beyond the middle of the valves; shell-spine arising from the dorsal margin, strongly developed and in all cases deflected upwards; anal denticles generally 10 in number.

Male:

They are of the same size as the females and are broader. In the nature of the crest, spinules, shell-spine and the post-abdomen the male resembles the female. Antennules distinct in the male but always smaller than the head; flagellum smaller than the olfactory setae; terminal seta lateral in position.

Occurrence: P6.

14. Daphnia sp. (Figures 146-153)

Female:

Relatively small forms with thin, transparent valves; shell-spine originates from the dorsal margin, well developed and deflected upwards; dorsal spinules extend up to the cervical region; rostrum somewhat pointed and a little bent inwards and applied to the margin of the valves; olfactory setae of the antennule project a little beyond the tip of the rostrum; fornix pointed and projecting; postabdomen with about 10 anal denticles and claw with 2 combs; abdominal processes greatly reduced.

Male:

They are of the same size as the females; males resemble the females in the general shape of the body, nature of the

shell-spine and the spinules; antennules well developed,flagellum only a little longer than the olfactory setae; postabdomen with 9-10 anal denticles similar to that of females. In both the sexes the distal spine is longer than others.

Occurrence: P6.

The present specimens differ from the others in size and shape of the head, nature of the rostrum and the antennule. The nature of the fornix suggests Ctenodaphnia.

38 Genus Ceriodaphnia Dana 1853

15. Ceriodaphnia cornuta Sars 1885 (Figures 103-108)
(Ceriodaphnia rigaudi Richard 1894)

Female:

They are very common in the samples collected from Pilani and Khetri. Valves generally rounded in outline with the upper and lower margins arched, posteriorly produced into a blunt and short spine; valves conspicuously reticulated; free edges of the carapace devoid of hairs or spines. Forms without eggs in their brood pouch have a straight dorsal margin (Fig.104); posterior spine arising from the posterodorsal angle. All the specimens examined from Pilani and Khetri are without horn on the head, but are provided with a horn like process in front of the antennules; eyes moderately big filling the anterior ventral margin of the head; antennules small, lateral setae somewhat distal to the middle; post-abdomen with 7 anal denticles; claws smooth.

Many of the specimens collected from Mt.Abu (Figures 106,107) have head horn of variable length, pointed fornix and carapace ending in a bifid process. The horn at the rostrum is more developed than that of the specimens from Pilani. The shape and size of the antennule is different from that of Pilani specimens. The lateral seta is much longer and project beyond the olfactory setae.

Occurrence: P1, P6, K26 and M32.

Measurements: Size 0.35-0.45 mm.

16. Ceriodaphnia reticulata (Jurine) 1820 (Figures 109-111)

Female:

Carapace rounded with a deeply arched ventral margin, posteriorly ending in a small protuberance arising above the axis of the body; reticulation of the shell not distinct; valves appear pustulated, their edges smooth; eyes moderately big; antennules small, broad with the lateral seta being terminal; ocellus distinct; postabdomen with 3-7 anal denticles, outermost one smaller than others; claw with a proximal comb of 5 teeth at some distance from the base.

Occurrence: Pilani

Size: 0.5 mm.

Scourfield and Harding (1941) recognises 3 varieties based on the nature of the fornix, shell and size. Accordingly the

present specimen falls under C.reticulata var. kurzi because of the indistinct reticulation on the shell, smooth edges of the valves and size.

39 Genus Moina Baird 1850

17. Moina brachiata (Jurine) 1820 (Figures 163-67)

Female:

Stout bodied forms with large and broad carapace; in gravid females carapace distended dorsally; anterior half of the lower margin of the valves has distantly placed spinules; posterior half has closely placed minute spinules; head of moderate size with a very prominent supraocular depression; lower edge of the head convex at the insertion of the antennule; eyes of moderate size; postabdomen conically tapered provided with 9 ciliated anal denticles and a nonciliated bident; claws pectinate.

Male:

Smaller than females with well developed antennules, provided with 3 hooks at its end, sense hairs situated a little behind the middle.

Occurrence: They have been collected from a number of pools in Pilani and Khetri.

Size: Female 1.1 mm., Male 0.7 mm.

Moina brachiata is nearly allied form to Moina rectirostris and M.dubia making the identification a little difficult. The present

forms have been assigned to M.brachiata mainly on its size, nature of the postabdomen and the number of anal denticles. Arora's(1931) description of M.brachiata from Lahore (Pakistan) shows 3 & non-ciliated anal denticles. The number of denticles (excluding the bident) in M.brachiata varies from 7-11 (Brooks 1959), that of rectirostris from 10-15 (Brooks 1959) and in M.dubia it is 7 (Sars 1916).

40 Genus Simocephalus Schødler 1858

18. Simocephalus vetulus Schødler 1858 (Figures 154-157)

Female:

Relatively big forms with laterally flattened body; valves somewhat oblong or rectangular ending in a blunt posterior angle; dorsal margin of the valves slightly arched or sometimes straight especially in smaller forms; a few minute spinules present along the posterodorsal margin and a few on the inner midventral margin of the valves; valves marked with oblique striae; head small; cervical sinus present; ocellus large and elongate; postabdomen broad, deeply emarginate with 9-12 anal denticles which increases in their length distally; claws slender with fine teeth along the entire length.

Occurrence: P7, K26.

Size:

Maximum size measured. Length 2.5 mm., Width 1.5 mm.

Family MACROTHRICIDAE

41 Genus Macrothrix Baird 1843

19. Macrothrix goeldii Richard 1897 (Figures 168-171)

Female:

General form of the body round ovate; dorsal edge of the valve serrate with fine teeth especially in the posterior half; shell ends posteriorly in a small knob; ventral margin of the valve has small and long setae, and short spine inbetween; antennule broadens distally and a little curved backward; it has slight notches along the anterior margin with clusters of hairs in the distal notches; 2 long and 6 short sensory setae at the end of the antennule and a few spinules in addition; postabdomen has strong denticles along its dorsal margin; proximal part of postabdomen arched.

Occurrence: K26.

Length: 0.4-0.5 mm.

The present forms agree with the description given by Harding (1957) from Africa. The serration on the head could not be observed in the specimens from Ajit Sagar and there were no hairs visible along the dorsal margin of the postabdomen.

Family CHYDORIDAE

42 Genus Alona Baird 1850

20. Alona pulchella King 1853 (Figures 172-174)

(= Alona cambouei Guerne and Richard 1893)

Female:

Shell somewhat quadrangular with an evenly arched dorsal margin and a straight ventral margin; posterior margin of the shell almost straight with a rounded ventral angle; surface of the shell sculptured with about 20 parallel longitudinal striae; ocellus smaller than the eye, located nearer to it than to the tip of the rostrum; distal margin of the postabdomen somewhat rounded; postanal denticles increase in size distally and generally with accessory denticles; lateral fascicles present; supra-anal angle prominent, situated above the middle of the tail; claws slender, ciliated and with a basal spine of moderate size.

Occurrence: C10.

Measurements:

Length	... ...	0.36-0.38 mm.
Width	... ...	0.23-0.24 mm.

21. Alona verrucosa Sars 1901 (Figures 175, 176)

Female:

A single specimen of this species was found in the sample taken from a concrete tank in Churu. Dorsal margin of the carapace

arched; ventral margin emarginate; wavy longitudinal striations, 'verrucae' and punctations on the carapace distinct; labrum w has a rounded ventral keel, an indistinct notch in the anterior margin of the labrum; postabdomen has a distal rounded corner; distal bristles of each fascicle projects beyond the margin of the post-abdomen; claw with a basal spihule and a fine comb.

Occurrence: C10.

Size: 0.32 mm.

The form collected from Churu agrees with the description given by Johnson (1956). Although the characteristic tooth on the labrum is indistinct I have included the present specimen under A.verrucosa mainly based on the emarginate ventral carapace margin, wavy striations on the valves and the 'verrucae'. Harding (1957) has also got a few specimens with indistinct notch on the labrum. The distal corner of the postabdomen is rounded but not so protube-rant as in the specimens from Lake Tanganyaka (Harding 1957). In the form and armature of the postabdomen it agrees closely with that of the specimens figured by Johnson (1956 Fig. 6b) collected from North Sumatra.

22. Alona rectangula Sars 1861 (Figures 177-179)

Female:

Dorsal margin of the shell evenly arched; ventral margin somewhat convex; valves reticulated; a group of setae along the anterior ventral margin of the valve longer than others; ocellus smaller than the eye situated half way between it and the tip of

the rostrum; supra-anal angle of the postabdomen almost in the middle and prominent; distal part of the postabdomen rounded, with about 8 groups of marginal denticles; proximal to these denticles a row of smaller denticles; lateral fascicles in 6 groups, distal ones longer and project well beyond the margin of the postabdomen; a small but stout spinule at the base of the claws.

Occurrence: K26.

Size: 0.35 mm.

The armature of the postabdomen of the present specimen is similar to that of Alona rectangula var.pulchra figured by Birge (see Brooks 1959). Johnson (1956) regards A.rectangula var.pulchra Matile as the European form of A.verrucosa. The specimens from Khetri differs from A.verrucosa in the absence of emarginate ventral margin of the carapace, wavy longitudinal striations and the 'verrucae'.

43 Genus Chydorus Leach 1843

23. Chydorus eurynotus Sars 1901 (Figures 180-184)

Female:

Nearly spherical or somewhat oval bodied forms reaching up to 0.5 mm. in length; surface of the shell with hexagonal markings; rostrum acutely pointed; antennules short and thick with the olfactory setae do not projecting beyond the rostrum; ocellus small, nearer to the eye than to the tip of the rostrum; labrum generally

with a shallow rounded keel, sometimes slightly pointed, but never with elongated keel; postabdomen with 10-11 anal denticles; claw with 2 basal spinules.

Occurrence: K26.

Size: 0.3-0.5 mm.

There seems to be much variation in this species. The labral keel of C.eurynotus is variable in form. Harding (1957) draws various types of labrum with rounded and flattened ventral keel. He considers that flattened ventral keel is typical of African forms. The samples from Khetri do not show any with flattened keel. Gauthier (1939) shows reticulated pattern of wavy lines, but Harding (1957) and Green (1962) observed forms without such carapace sculpture. Harding (1957) shows that body form is also carapace sculpture. Harding (1957) shows that body form is also variable in this species.

Gauthier (1939) and Green (1962) consider Chydorus kallipygos Brehm as synonym of C.eurynotus. Harding (1955) maintains the two as separate species. His figures of C.kallipygos show certain differences from that of C.eurynotus especially in the armature of the postabdomen and form of the keel. It seems that C.kallipygos is much smaller than the other. (See Figs.95 and 101 of Harding 1955).

24. Chydorus sp. (Figures 185-187)

Female:

Shell somewhat oval shaped with a very prominent rostrum; eye near the shell margin, much bigger than the ocellus; antennule

short and stout with the olfactory setae do not projecting beyond the rostrum; postabdomen somewhat elongated; distal denticles longer than proximal ones; a few lateral fascicles present; claws with 2 basal spinules, proximal one very short, distal one long and slender; claws pectinate. Colour brownish yellow.

Occurrence: K26.

Size:

A single specimen collected measured only less than 0.4 mm in length and 0.3 mm. in width.

The elongated, narrow pleuroxus-like postabdomen resembles that of Chydorus globosus Baird. But the present form is too small for an adult C.globosus. In the form of the body also the present specimen differs from C.globosus which is almost spherical.

44 Genus Pleuroxus Baird 1843

25. Pleuroxus trigonellus (O.F.Muller) 1785 (Figures 188-191)

Female:

Body somewhat elongated, infraposteal angle has 4 minute and a middle bigger spine; rostrum narrow, pointed, curved slightly backwards; labrum with a narrow rounded keel; ocellus nearer to the eye than to the tip of the rostrum; dorsal margin of the post-abdomen slightly convex; series of marginal denticles longer than the anal emargination; apex somewhat rounded; claws bent dorsally and have 2 basal spinules.

Occurrence: K26.

Size: 0.5 mm.

26. Pleuroxus sp. (Figures 192-196)

Female:

Transparent white bodied forms with hexagonal markings on the shell; dorsal margin of the shell convex; ventral margin straight, In gravid females the dorsal margin is deeply arched. Posterior margin short and less than half of the height; infraposteal angle with 2 teeth; rostrum long and pointed; in young specimens slightly bent backwards; antennule excluding the olfactory setae not extending beyond the middle of the rostrum; a small peg-like prominence at the base of the antennule; ocellus situated more nearer to the eye than to the tip of the rostrum; labral keel varies in shape, pointed or rounded;postanal region of the postabdomen somewhat convex and narrows distally; marginal denticles vary in number, usually 10, claws with 2 basal spinules, proximal one smaller.

Occurrence: P2.

Measurements:

	Biggest Specimen.	Smallest Specimen.
Length ...	0.58 mm	0.37 mm
Width ...	0.46 mm	0.25 mm
Posterior margin	0.12 mm	0.1 mm

Variation has been noticed also in the nature of the rostrum which may be straight and projecting or a little bent backwards especially in young forms. In all the specimens examined the antennule has a knob (peg) at its base. Generally the labral

keel is rounded at its ventral margin, sometimes slightly pointed. The postanal portion of the postabdomen is very characteristic although the marginal denticles vary in their number and arrangement.

The genus Pleuroxalonella can be distinguished from Pleuroxus by its relatively small size, body little longer than high, prominent preanal angle and reticulated or granulate carapace (Johnson - 'Water fleas'). The present forms differ from Pleuroxalonella in that it reaches more than half a millimeter in length. Moreover, the measurements made on mature and immature females clearly show that the carapace proportions can vary greatly. The maximum width of the young forms is about 2/3 or less of its length and that of old forms exceeds 2/3. The dorsal margin narrows gradually towards the posterior end in young specimens. In the gravid females the dorsal margin is deeply arched.

45 Genus Leydigia Kurz 1874

27. Leydigia ciliata (Gauthier) 1939 (Figures 200-202)

Female:

Shell evenly founded behind; dorsal margin passing into the posterior without any interruption; greatest hight of the body a little behind the middle; ocellus triangular, larger than the eye, situated nearer to eye than to the tip of the rostrum;granular markings on the surface of the shell; minute granules run parallel to the posteroventral margin; labrum carries hairs throughout the length of its anterior margin; ventral margin of the labrum either evenly rounded or with a small posterior shallow notch; postabdomen

very large, semi-elliptical in form, with many clusters of spines, distally the spines increase in length; claws slender, with fine comb and a minute spinule.

Occurrence: P2, K26.

Size: 0.6 mm.

The present specimens agree well with the description given by Harding (1955) especially in the nature of the ocellus which is distinctly larger than the eye and the absence of any striations on the shell.

28. Leydigia acanthoceroides (Fischer) 1854 (Figures 197-199)

Female:

Dorsal margin of the shell not evenly rounded at the posterior angle; ocellus triangular and larger than eye; punctae on the carapace arranged parallel to the shell margin; setae along the ventral margin of the shell of two types, anterior setae relatively short, posterior ones long and fine; antennule not reaching the tip of the rostrum;hairs on the labral keel decreases in size posteriorly; no spinule at the base of the claws.

Occurrence: P6.

Measurements:

Length	...	...	...	0.7 mm
Width	...	...	...	0.45 mm

46 Discussion:

Out of the 28 species of branchiopods described in the present work 8 belong to phyllopoda and the rest to Cladocera. Among the plankton crustacea of India, the Phyllopods form a comparatively known group. Although 5 species of Apus so far known from India I could not get only one species in my collection, namely, Apus cancriformis Schaeffer. Apus mavliensis Tiwari (Tiwari 1951) is the other species reported from Rajasthan. Among the Anostraca Artemia salina (Linnaeus) (Baird 1958), Streptocephalus dichotomus Baird (Sidhu 1959) and Branchinella kugenumaensis Ischikawa and B.biswasi Tiwari (Tiwari 1958) are the species reported earlier from Rajasthan. Of the 7 species of Conchostraca known from Rajasthan 6 are described new from Rajasthan (Tiwari 1962 and Nayar 1965). The other species reported is Caenestheriella annandalei Daday (Sidhu 1959).

The Cladocera of India is very little known and the present study reveals that the group requires more attention in order to understand the morphological variations in many of the species. Among the Cladecera the genus Daphnia needs a detailed study because of the variability observed in the different species. Although Daphnia magna Straus thought to be a well defined form, the specimens I have collected differ from the earlier descriptions in many respects. The present form is certainly close to D.magna. The average size of the female measured from the sample is about 3 mm (including the shell-spine) which is considerably smaller than any of the known D.magna. The European and the American form

grow well to 5 mm. and the African forms show a length of 4.2 mm (without shell-spine) (Sars 1916). Morevoer, the body form is also more slender in the present specimens. The small number of anal denticles especially in the post anal group is right outside the normal range. In the African form (Sars 1916) as well as in the North American form (Brooks 1959) the dorsal spinules extend to the cervical region while in the present forms they never extend beyond the middle of the valves. The size of the male is comparable to that of North American and European forms. The male resemble that of D.similis but can be distinguished by the presence of long setae of the anterior ventral margin of the valves extending to nearly half the distance along the ventral margin. Moreover, the dorsal spinules do not extend beyond the middle of the valves and the terminal setae of the antennule is more than half the length of the olfactory setae in the present form. Although the specimens from Ganga-Nagar differ from the normal D.magna to a great extent, because of the presence of longitudinal ridges on the head-shield and the dorsal sinuate margin of the post-abdomen I included them under D.magna. But, the smaller and slender form, arrangement of the dorsal spinule and less number of anal denticles claim at least a subspecific status to the present forms.

The present study supports the view, which has been accepted by many (Harding 1942, Johnson 1956, Rzoska 1956), that Ceriodaphnia rigaudi Richard is only a horn less form of C.cornuta Sars. Although there were no individuals with head-horn in specimens from Pilani, both the variants occurred side by side with intermediate forms in

the samples from Mt.Abu. The specimens from Khetri showed both the forms with and without bifid process although all of them were without head-horn. The specimens from Khetri are similar to that of Mt.Abu in the nature of the rostrum, antennule and the bifid process but differ from it in the absence of head-horn.

In the present collection, the genus Alona is represented by 3 species, viz., A.pulchella King, A.verrucosa Sars and A.rectangula Sars. A.pulchella collected from Churu shows distinct resemblances to the cambouei-pulchella group. Harding (1957) considers A.combouei Guerne and Richard and A.glabra Sars as synonyms of A.pulchella King. These three forms were distinguished each other based on the sculpture of the carapace and nature of the postabdomen. A.pulchella has striated carapace and an angular post-dorsal corner to the postabdomen; A.cambouei has reticulated shell and more rounded corner to the postabdomen and A.glabra is without any striations and the distal corner of the postabdomen is not rounded. Johnson (1956) considers A.glabra as distinct from others especially based on the nature of the postabdomen, arrangement of the anal denticles and on the absence of any striae on the carapace valves. Based on these characters given by him I excluded A.glabra.

The two species of Leydigia, viz., L.acanthoceriodes (Fischer) and L.ciliata (Gauthier), described in the present work remarkably resemble each other. The differences which could be observed are in the nature of the dorsal margin of the shell, and the absence of any spinule at the base of the claws. The longitudinal striations, a distinctive character of L.acanthoceriodes were

not visible in the present specimens. But the punctae arranged parallel to the shell margin were clearly visible. Johnson (personal communication) considers L.ciliata a synonym of L.acanthoceriodes. He writes 'the distinguishing feature on which it was originally based (the long ciliate labral keel) is present in European L.acanthoceriodes. The small basal spine is inconstant and can be found in occasional individuals of L.acanthoceriodes from Europe'. It is noteworthy that the arrangement of the granular elements of the carapace, nature of the ocellus and the postabdomen of the two forms agree very closely.

P A R T II

Quantitative Study

CHAPTER V

Seasonal Variation - Pages 99 to 119

P A R T - II

CHAPTER V

Seasonal Variation

Physico-chemical Factors

47 Temperature and pH:

In all the 3 ponds the difference in temperature between summer and winter months is considerable. The range of temperature of the College pond was from 7°C to 32°C (at the time of collection). During the 2 years' study the minimum temperature was recorded in December of both 1962 and 1963; temperature went up to the maximum during July to September. The rise and fall of the temperature in almost all the cases was gradual.

In Pilani tank and Khetri Lake the minimum temperature observed was 11°C and 16°C respectively. In the former the collection was made usually between 9 and 10 A.M. while in the latter it was at 11.30 A.M. In all the three ponds the maximum temperature has been about 32°C. The differences in the size of the 3 ponds may be responsible for the difference in the water temperature.

Small water bodies are subjected to more variation in water temperature affected by the variation in the atmospheric temperature.

The pH of the water of the College pond and Khetri Lake was above 7, the range being between 7.9 and 10.9 and 7.4 and 9.9 respectively. Generally the pH remained between 8 and 9 in the College pond. In Pilani tank the pH showed variation from 6 to 9.5. During the period between July and September 1964 the water was acidic in the Pilani tank, it was alkaline during the rest of the period.

48 Dissolved Oxygen Content:

The oxygen content of the water was much variable throughout the period of observation in all the 3 ponds. The details of the estimated oxygen content is given in Appendix Tables I,II,III. In the College pond it varied from 0.64 to 17.2 ppm and in Pilani tank from 2.1 to 16.3 ppm. In Khetri Lake the oxygen content was as high as 29.2 ppm in Sept.,1963 and minimum was 3 ppm in Feb.,1963. Alikunhi et al (1955) also observed an oxygen content of 24 ppm during July-September. Upadhyaya (1963) reported a variation of 0 to 3.5 ppm. in Gujaratal. He observed complete absence of oxygen during April and March 1960.

49 Alkalinities

In the College pond the alkalinity was due to the presence of both carbonate and bicarbonate throughout the period of collection. In Pilani tank and Khetri Lake the carbonate was generally absent or only traces were found. Pilani tank and Khetri Lake are usually

rich in phytoplankton such as Microcystis. Therefore, due to excessive carbon dioxide all the carbonates might have been converted into bicarbonates (Upadhyaya 1963).

PLANKTON

50 Total Zooplankton:

The seasonal variation in the population of the total zooplankton of College pond is shown in Fig.203. Monthly average has been taken on the basis of weekly collections. There was a gradual increase in the number of plankton from October, 1962 to April, 1963 when it attained a peak of abundance. In 1964 during the period between March and July the water was very rich in plankton with its maximum being in July. The samples of October, 1962, January, 1964 and September, 1964 were very poor in plankton.

During the period of 21 months the total zooplankton of Pilani tank showed marked fluctuation in their number (Fig. 212).. The plankton was particularly abundant in the year 1963 compared with that of the succeeding year. During both the years the plankton was maximum in number during February, although the 1963 maxima was much greater than that of 1964. The minimum quantity of the plankton has been observed during October to December,1963. The period from January to April, 1963 was comparatively rich in plankton. There was a gradual fall in the total number from July, 1963 to December, 1963.

The quantitative fluctuation of the zooplankton of Khetri Lake is shown in Fig. 1. During 1963 the highest peak of abundance

of the zooplankton has been observed in May. In June there was a sudden fall in the zooplankton which showed an increasing tendency in July and attained another maxima in August. The second maxima was considerably smaller than the first. During September to December the plankton was at their minimum number with a slight increase in November. In February, 1964 the total zooplankton was more than 10 times that of the previous year. The plankton estimation from February to May, 1964 showsthat the March-April collections show a prominent peak of abundance over that of March, 1963.

51 CRUSTACEA:

The plankton Crustacea constituted generally a very high percentage in the total zooplankton, especially in the Khetri lake and in the Pilani tank. It has been observed that in Khetri Lake, throughout the period of collection, plankton Crustacea constituted more than 80% except in July, 1963 when it was only 52% (Fig.217). During the months of April, May, 1963 and March, 1964, the sample constituted almost entirely of Crustacea.

In Pilani tank the percentage of Crustacea in the total zooplankton was generally more than 65% except during January-February, 1963 and January to March, 1964 (Fig.225). During April, 1963, September, 1963 and July, 1964, the percentage of Crustacea was more than 90%. The Crustacea percentage showed much variation in the College pond. (Fig. 207.) During December, 1962 to February, 1963, its percentage was as low as 15 and in March, 1963, it showed a sharp rise and constituted 88% of the total plankton. There was

a sharp fall in their percentage in April, 1963, and in May it reached 98.5%. During 1964 the maximum percentage of Crustacea has been noticed in March and April.

Estimation of the total Crustacea of Khetri lake shows 2 distinct peaks of abundance in March 1963 and March-April, 1964. (Fig.222) The peak of 1964 is much greater than that of 1963. During the period of observation the Crustacea showed 3 peaks of abundance in Pilani tank (Fig.226); they were in April, 1963, July, 1963 and April, 1964. The maximum number of Crustacea has been observed in April, 1963. Although the total Crustacea showed an increase in April, 1964, the total number was much less than that of the previous year during the same period. Minimum number has been seen during winter months from October, 1963 to March, 1964.

The percentage composition of the major groups of Crustacea of the College pond is shown in Fig. 206. It is worth noting that the Calanoida was completely lacking from all the samples and the Copepoda was represented only by Cyclopoida. The Ostracoda was common in the samples collected during the summer months of 1963 and 1964. Among Crustacea the cyclopoids and nauplii dominated throughout the period. The percentage of Cyclopoida was very high during June to August, 1963 and April to June, 1964. The minimum percentage of cyclopoid has been observed in October, 1962 and January, 1963.

In Pilani tank the plankton Crustacea was mainly composed of crustacean larvae and Cladocera. (Fig.224.) During January, 1963, September, 1963 and September, 1964, the adult copepods

dominated the crustacean plankton. During January, 1963, nearly 82% of the Crustacea was constituted by copepods of which 71% (of the total Crustacea) formed the calanoids. The calanoids were completely lacking from the samples of May to July, 1963. The percentage of Crustacean larvae was generally higher during the winter months. The maximum percentage has been observed in February,1964, when it reached more than 77% and it was very low during May to July, 1963, and June to August, 1964. The Cladocera dominated the crustacean plankton during April to July of 1963 and 1964.

In Khetri lake the Cladocera or Calanoida always dominated over the other groups of Crustacea. (Fig.220.) In September,1963 85% of the Crustacea was constituted by calanoids while in October 77% was composed of Cladocera. The cyclopoids were comparatively less. The maximum percentage of Cyclopoida (34.5%) has been observed in December, 1963. Although the crustacean larvae were present throughout the period of collection, its percentage was considerably low.

A comparative estimation of the Cladocera and the adult copepods of Khetri Lake is shown in Fig.222. The copepods and Cladocerans show a somewhat identical pattern of seasonal variation. Generally the Cladocera are more in number than the copepods. In May, 1963 the crustacean plankton was mainly composed of these 2 groups in which 2/3 constituted Cladocera. In March, 1964, the Cladocera was only a little more than the copepods. In April, 1964, the copepods showed a sudden fall in their number while the cladocerans showed a further rise in their number and attained

dominated the crustacean plankton. During January, 1963, nearly 82% of the Crustacea was constituted by copepods of which 71% (of the total Crustacea) formed the calanoids. The calanoids were completely lacking from the samples of May to July, 1963. The percentage of Crustacean larvae was generally higher during the winter months. The maximum percentage has been observed in February,1964, when it reached more than 77% and it was very low during May to July, 1963, and June to August, 1964. The Cladocera dominated the crustacean plankton during April to July of 1963 and 1964.

In Khetri lake the Cladocera or Calanoida always dominated over the other groups of Crustacea. (Fig.220.) In September,1963 85% of the Crustacea was constituted by calanoids while in October 77% was composed of Cladocera. The cyclopoids were comparatively less. The maximum percentage of Cyclopoida (34.5%) has been observed in December, 1963. Although the crustacean larvae were present throughout the period of collection, its percentage was considerably low.

A comparative estimation of the Cladocera and the adult copepods of Khetri Lake is shown in Fig.222. The copepods and Cladocerans show a somewhat identical pattern of seasonal variation. Generally the Cladocera are more in number than the copepods. In May, 1963 the crustacean plankton was mainly composed of these 2 groups in which 2/3 constituted Cladocera. In March, 1964, the Cladocera was only a little more than the copepods. In April, 1964, the copepods showed a sudden fall in their number while the cladocerans showed a further rise in their number and attained

their maximum during the period of collection. During May, 1964, there was a sudden decrease in the Cladocera population.

In the Pilani tank the population of Copepoda and Cladocera follow almost the same pattern of variation (Fig.216). During October, 1963 to February, 1964, the total number of both copepods and Cladocera was much less.

The relative abundance of Cladocera and Copepoda of the College pond for the years 1962-63 and 1963-64 has been presented in Fig.205. The copepods were present throughout the year generally dominating over the Cladocera. In both the years during January there was a sharp fall in the number of copepods. The Cladocera show marked seasonal occurrence. The Cladocera was completely lacking from the samples of January-February, 1963, and February-March, 1964. During both the years the maximum number of Cladecera has been noticed in May.

52 Species Composition of Cladocera:

The common species of Cladocera observed in the periodical samples from Khetri lake are : Ceriodaphnia cornuta, Moina brachiata Diaphanosoma excisum, Daphnia similis, and Daphnia cucullata. Other forms which occasionally appeared were Pleuroxus spp, Chydorus sp and Simocephalus vetulus. The 2 species of Daphnia occurred during February to April, 1963, were completely lacking from the samples for the rest of the period. The Cladocera recorded from the Pilani tank include Ceriodaphnia cornuta, Moina brachiata, Diaphanosoma excisum, Daphnia similis, D.cucullata, Daphnia sp., Leydigia ciliata

etc. Ceriodaphnia cornuta and Moina brachiata are the only 2 species of Cladocera observed in the Collection from the College pond.

53 Ceriodaphnia cornuta:

This is the most common species found in all the three ponds. Its seasonal variation in the College pond is shown in Fig.205. During the first year of collection (October, 1962 to September, 1963), it disappeared from the samples of January to June and during the second year (October, 1963 to September, 1964) they were absent from the samples of February and March. During the second year this was the sole species of Cladocera collected from the College pond.

Ceriodaphnia cornuta was a dominant plankton in the Pilani tank throughout the period of observation except for a short period in November, 1963 and September, 1964. In the samples from Khetri Lake C.cornuta was present in varying numbers in all the samples. During 1963, it showed a small maxima in March. The second ~~wa~~ peak of abundance was shown in March, 1964, which was greater than that of the previous year (Fig.221). It occasionally occurred in the samples collected during April, 1963 to February, 1964.

54 Moina brachiata:

In the College pond M.brachiata occurred only for a short period of 2 months from May, 1963. The maximum number has been observed in the sample of 24 May 1963. (Fig.218). It was completely absent from the samples collected during the rest of the period. In

the Pilani tank a swarm of M.brachiata first noticed in April,1963 and were common in the samples up to December, 1963 (Fig.215). They were absent during January to March, 1964, and reappeared by the middle of April, 1964, and occurred in all the samples for the rest of the period.

Seasonal variation in the population of M.brachiata of Khetri lake is shown in Fig.221. There was a sporadic appearance of M.brachiata in May, 1963, when it constituted 65% of the total zooplankton. It almost disappeared in June and noticed only occasionally till November, 1963. They were absent in the samples collected during December, 1963 to March, 1964. There was again a swarm of this species in April, 1964 and during that period it attained its maximum number. The sample of May, 1964, showed a fall in their population. The number of M.brachiata in April, 1964, was twice more than that of May, 1963.

It is noteworthy that Ceriodaphnia cornuta was almost absent in May, 1963, when M.brachiata first appeared. When Ceriodaphnia was maximum in March, 1963 and March, 1964, Moina was completely lacking from the samples. In April, 1964, when Moina was abundant Ceriodaphnia showed sharp fall in their number.

55 Diaphanosoma excisum:

This species has been observed only in Pilani tank and Khetri lake. They were common in Khetri lake during April, 1963, August, 1963, November, 1963, and April-May, 1964. Compared with the other two species of Cladocera this species was very much less in number. The maximum number has been noticed in August, 1963.

Seasonal variation in the population of D.excisum collected from Pilani tank is shown in Fig.215. During the first year of collection it appeared toward the end of September, 1963 and disappeared by the middle of December. During 1964, it again appeared in May and continued for the rest of the period.

56 ROTIFERA:

The rotifers were present in all the samples collected from all the ponds, but with definite peak periods. The plankton counts of Rotifera of the College pond obtained during the two years are plotted in Fig.204. The rotifers were present throughout the year in appreciably large numbers. During the period from June, 1963 to August, 1963, the plankton contained comparatively less number of rotifers. The pattern of seasonal distribution of rotifers has been different in both the years. During the first year of collection (1962-63) the maximum number of rotifers has been observed in April, 1963, and during the second year it was in July, 1964. During both the years the population maxima was largely due to the abundance of Brachionus angularis.

In Pilani tank the rotifers occurred in all the samples collected throughout, with definite peak periods in February, 1963 and February, 1964 (Fig.226). The total number of rotifers in February, 1964, was much less than that of February, 1963 and in both the cases it was mainly contributed by Keratella tropica. Although the rotifers were present in all the samples collected from Khetri Lake, they constituted only a small percentage of the total zooplankton. The maximum percentage (48%) of rotifers has been

observed in July, 1963, which was mainly due to Brachionus calyciflorus. The rotifers showed the peak of abundance in July, 1963 and April, 1964.

Species Composition of Rotifera

57 Brachionus calyciflorus:

This is one of the most common rotifers found in the samples. The seasonal variation of B.calyciflorus and its relation to the physico-chemical factors of water is discussed under cyclomorphosis (Nayar 1965b). This species was present in the samples of College pond only for a short period from 9th November, 1962 to 25th Jan., 1963.

The numerical variation in the population of B.calyciflorus of Pilani tank and Khetri lake is shown in Fig.213, and Fig.227 respectively. The abundance in the population of rotifers observed in Khetri Lake in July, 1963 and April, 1964, was mainly due to the population of B.calyciflorus. In the Pilani tank it was common in the samples collected during April to September, 1963.

58 Brachionus caudatus:

This species has been obtained from the College pond and Pilani tank. In the College pond they occurred only in small numbers occasionally. The seasonal occurrence of B.caudatus in the Pilani tank is shown Fig. 213. It occurred in the samples of March-April, 1963 and January-June, 1964. During 1963 B.calyciflorus dominated among rotifers while during 1964 B.caudatus was more common.

59 Brachionus falcatus:

It has been collected from Khetri Lake; its seasonal occurrence is shown in Fig.227. They were common in the samples of May-July, 1963. It was completely lacking from the samples collected during December to March, 1964. This species is known to be present only in warm waters; in Europe it is summer form and it is widely distributed in tropics (Green 1960).

60 Brachionus angularis:

This species has been collected from the College pond and Pilani tank; its seasonal occurrence in the College pond for the period of 1962-63 and 1963-64 is shown in Fig.208. It was a very common form during the second year of collection except the months of January, February and March, 1964. They were abundant during April, 1963 and July, 1964.

61 Keratella tropica:

The seasonal occurrence of this species is shown in Figures 209, 223 and 227. In the College pond its first appearance has been noticed in December, 1962. During both the years of collection the maximum number has been noticed in February although the number was much less in the second year. In the Pilani tank and the Khetri lake also the maximum number has been noticed in February. It is of interest to note the absence of K.tropica during April in all the ponds except in the Pilani tank during April, 1964.

62 Keratella procurva:

The seasonal variation in the population of this species in the College pond for the years 1962 to 1964 and its relation to temperature and pH is shown in Figures 210 & 211. The appearance of this species in the plankton is associated with the fall of temperature. In both the years this form has been observed during October to March. It disappeared from the samples when the temperature was above 24°C. During the period of its presence the pH varied between 7.3 and 9.3.

63 Filinia longiseta:

This was one of the most common rotifers in the samples collected from Pilani tank; its seasonal occurrence is given in Fig.214. They were most common during February when it attained its peak of abundance. During the warmer months, May to July they were usually absent.

64 Filinia opoliensis:

The seasonal occurrence of this species in the Pilani tank is shown in Fig.214. They were most common during July to September, 1963.

65 Seasonal variation in the Number of species:

The variation in the number of species of Rotifera during different seasons has been given in the Table III,IV & V. This number includes only those forms which are obtained during the periodical collections. The total number of plankton rotifer

Seasonal Distribution of Rotifera by Species - College Pond.

	1962			1963												1964									Total
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	
B.calyciflorus	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
B.angularis	-	X	X	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	20
B.caudatus	-	-	X	-	-	-	-	-	-	-	-	X	-	-	-	X	X	-	-	-	-	X	-	-	5
K.tropica	-	-	X	X	X	X	-	X	X	X	X	X	X	X	X	X	X	X	-	X	X	X	X	X	20
K.procurva	X	X	X	X	X	X	-	-	-	-	-	-	X	X	X	X	X	X	-	-	-	-	-	X	13
F.longiseta	-	-	-	-	X	X	-	-	X	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	5
F.opoliensis	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	2
Hexarthra mira	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
L.nana	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	2
L.luna	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	3
A.fissa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	1
Trichocerca sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	1
Lepadella sp.	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Philodina sp.	-	-	-	-	-	-	-	-	X	X	-	-	X	X	X	-	-	-	-	-	-	-	-	-	5
Lepadella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	2
Total:	1	4	6	4	4	3	1	3	4	4	3	4	4	4	4	6	7	3	1	2	2	4	4	4	

Seasonal Distribution of Rotifera by Species - Pilani Tank.

	1963												1964									TOTAL
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	
B.calyciflorus	-	-	-	X	X	X	X	X	X	-	X	-	-	--	--	--	--	-	X	X	-	-	9
B.rubens	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	X	-	X	X	-	4
B.caudatus	-	-	X	X	-	-	X	-	X	-	-	X	X	X	X	X	X	X	X	-	-	-	11
K.tropica	X	X	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	20
K.procurva	-	-	-	-	-	-	-	-	-	-	X	X	X	X	-	-	-	-	-	-	-	-	4
K.edmondsoni	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	1
F.longiseta	X	X	X	-	-	-	-	X	-	X	-	-	X	X	-	X	-	-	-	X	X		10
F.opoliensis	-	-	-	-	-	X	X	X	X	X	-	X	-	-	-	X	-	-	X	-	-		8
F.terminalis	-	-	-	-	-	-	-	X	-	-	-	X	-	X	-	-	-	X	-	-	-		4
Hexarthra sp.	-	-	-	-	-	X	X	-	-	X	-	X	-	X	-	X	X	-	-	-	-		7
Lepadella sp.	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1
M.hamata	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-		1
Hexarthra sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X		1
A.fissa	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		2
Asplanchna sp.	-	X	X	-	X	-	-	-	-	X	-	-	-	-	X	-	X	-	-	-	-		6
Brachionus sp.	X	X	-	-	X	X	X	-	X	X	X	X	X	X	-	X	X	-	X	-	X		15
TOTAL:	4	5	5	2	4	5	6	5	6	6	4	7	6	8	3	6	6	4	5	3	4		

TABLE V

Seasonal Distribution of Rotifera by species - Khetri Lake

	1963											1964				Total
	F	M	A	M	J	J	A	S	O	N	D	F	M	A	M	
B. calyciflorus	-	-	-	-	X	X	X	X	X	X	-	-	-	X	X	8
B.falcatus	-	-	-	X	X	X	-	X	X	X	-	--	-	X	-	7
B.quadridentatus	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	1
K.Tropica	X	-	-	-	-	X	X	X	X	X	X	X	-	-	-	8
Euchlanis sp.	X	-	-	-	-	-	-	-	-	-	--	X	-	-	-	2
Asplanchna sp	-	-	-	-	-	-	-	X	X	-	-	X	-	-	-	3
Lacinularia flosculosa	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	1
F.longiseta	-	--	X	-	-	-	-	-	-	-	-	-	-	-	-	1
Total:	2	0	1	1	2	3	3	4	5	3	1	3	-	2	1	

observed from the samples of Khetri Lake is 8 while the samples from College pond and Pilani tank yielded 15 and 16 species respectively. A few species recorded were only found as single specimens.

The maximum number of species has been observed in February, 1964, in the College pond and Pilani tank. In Khetri lake the maximum was in October, 1963. Among all the rotifers Keratella tropica was the most common form occurred for the major part of the year in all the 3 ponds. It is remarkable enough that this form was generally lacking from the samples collected during April. Brachionus angularis was the other common rotifer recorded for 20 months from the College pond. These 2 species can be considered of constant occurrence throughout the year.

In the College pond, although the maximum number of rotifers has been noticed in April, 1963 and July, 1964, (Fig.204) the maximum number of species was in December, 1962 and February, 1964. The sample of April-May showed less number of species of rotifers compared with those of other months. Similarly in Khetri lake also there were only 2 species when the rotifers attained its maximum number (April, 1964). There were 5 species in October, 1963, when the total number was very low.

66 DISCUSSION:

The seasonal variation in the plankton population is a well-known phenomenon. In the temperate lakes the plankton production (including both nannoplankton and net plankton) often takes the form of a bimodal curve with a spring and autumn maxima (Welch 1952).

This variation is greatly influenced by the variation in the temperature along with many other factors. But the study of the seasonal variation in the net plankton, generally does not give any such periodicity. The present study based on seasonal observations does not show any well defined periodicity for the net plankton. Therefore, maninly this problem has been approached from the stand point of individual plankters.

Among the several hydrological features, temperature, hydrogen ion concentration, dissolved oxygen, salinity and other dissolved nutrients are known to control the production, composition, and distribution of plankton. The results of present study show that, generally, no correlation can be made between the seasonal abundance of these organisms and the estimation of pH, dissolved oxygen and other chemical factors. Ward (1940) observed negative correlations between the occurrence of Entomostraca and measurements of turbidity, oxygen, carbon dioxide and carbonates. Ricker (1937) also did not succeed in his attempt to find out the causes of plankton fluctuation in Cultus lake.

The role of dissolved oxygen on the population of Brachionus calyciflorus in the College pond is discussed under Cyclomorphosis. (Nayar 1965b). But similar observations could not be made in other ponds. Generally the fluctuation in the plankton organisms does not show any correlation with the variation in the oxygen content. Ward (1940) also found that the oxygen content is not usually a causal factor in quantitative or qualitative distribution of Entomostraca. But Green (1956) has shwon that the dissolved oxygen

is a factor in the complex controlling the growth and reproduction of Daphnia.

Hydrogen ion concentration appeared to have some importance as a limiting factor for many rotifers. It is well known that distribution of rotifers is greatly governed by the pH and there seems to be an optimum pH for the growth of a particular species (Green 1960). Ward (1940) suggests that pH may influence for the presence of species of Entomostraca but not for its number.

Apparently temperature is the most important single factor controlling the population of various plankton organisms. The temperature, both directly and indirectly plays a great role in the seasonal abundance of the plankton organisms. Birge (1898) suggested that the temperature determined the reproductive rhythm and was the major factor in determining the number of Entomostraca. The present study shows that the period from October to January can be considered poor in total plankton. The estimation of Crustacea clearly shows that the colder months of the year are poor in plankton Crustacea (Fig. 216). This is in accord with the findings of Birge (1898) in the Lake Mendota. He found a winter minimum from December to April and a midsummer maximum in July for the Entomostraca. Based on the present observations it can be generalised to some extent that the period from October to January is poor in plankton Crustacea while the period from March to May shows the maximum. It is noteworthy that the percentage of rotifers was generally higher during winter months. This has been clearly observed in the College pond and Pilani tank. At times the number

of rotifers increased during summer months due to the sporadic appearance of certain species of rotifer. This has been true especially of Brachionus angularis which constituted about 95% of the total zooplankton in July, 1964 (College pond).

Generally, the cladocera and the Copepoda followed identical pattern in their seasonal distribution. It is known that these two groups of crustacea have achieved equal success in a niche where rapid reproduction is necessary for survival (Odum 1963). It is interesting to note that the calanoids which dominated over the cyclopoids in Khetri lake, were relatively less in number in the Pilani tank. They were completely absent from the College pond throughout the period of collection. It is presumable, therefore, that the larger bodies of water are more favourable for the calanoid copepods while the cyclopoids prefer small bodies of water.

Shetty et al (1961) found out an inverse correlation between the number of Cladocera and temperature in the Hooghly-Maltah estuarine system. In the present study it has been clearly shown that in all the three ponds the cladocera was more in number during the summber months than in winter months. According to Kofoid (1908), based on his observations in the Illinois River, the cladocera are more common in warm waters. Dutt et al (1954) found that the maximum number of cladocera was obtained in Hooghly when the temperature ranged between 21.3°C and 21.7°C. They suggested that the temperature between 21°C and 22°C accompanied by low turbidity would be most favourable for the occurrence and reproduction of cladocera.

The following deductions could be made from the present observations:-

The cladocera are generally warm water forms and hence they are comparatively less in number during the colder months. A rise in temperature especially above 21°C stimulates the reproductions in them. Generally, the highest density of cladocera is noticed during the hottest months. Brown (1929) pointed out that temperature alone is sufficient to explain the geographic distribution of many of the cladocera. But there can be many other factors other than temperature controlling the abundance of cladocera. Green (1956) has shown that the dissolved oxygen content of the water is an important factor in the complex controlling the growth of Daphnia. He, while studying the cyclomorphosis of Scapholeberis mucronata, found that the rate of egg production is related to the amount of food available to them (Green 1963).

The quantitative analysis of Ceriodaphnia cornuta showed somewhat similar pattern of seasonal abundance in the successive years although it differed from pond to pond. This is contrary to the observations made by Michael(1962) who found dissimilar patterns in two successive years. In Khetri Lake the maximum density recorded for this species was during March, 1963 and March, 1964. During the rest of the period it was relatively poor in the samples. Michael (1962) also observed the maximum number of this species during March, 1962. The present observation agrees with his findings in showing only one pulse as far as Khetri Lake is concerned. The disappearance of C.cornuta during October, 1963 and September, 1964, from the

Pilani tank, and during February to March from College pond, show that the seasonal variation of this species does not follow the same pattern in different ponds. It is presumable that the nature of the pond might have some influence on the seasonal abundance of C.cornuta. Peterson (1926) found that temperature and water level conditions affect greatly the seasonal succession of organisms.

The appearance of Moina brachiata during April-May in all the three ponds and its absence during the coldest months of the year suggest that it is a warm water species. Its absence from the College pond, except for a short period of May-June, 1963, is perhaps due to the absence of sufficient phytoplankton in the water. Because, this form is known to live in warm water ponds which are rich in phytoplankton (Ward 1940). The College pond is relatively poor in phytoplankton. The presence of M.brachiata during August and September, 1964, in the Pilani tank when the pH was below 7 is noteworthy. This is in contrast to the observations made by Pacaud (1939) and Ward (1940) who reported these forms from alkaline waters only. Therefore, the appearance and seasonal distribution of M.brachiata is more likely to be influenced by temperature and food than pH.

Although there was a reduction in the total number of plankton during the winter months, the relative percentage of rotifers was high. Besides, the number of rotifer species was also more during winter months than in summer. Green (1960) also observed an increase in the number of species inspite of a great decrease in the total number of specimens in the River Sokoto.

Brachionus calyciflorus is known to be a cosmopolitan species, more common in warm waters. They had been absent from the samples collected during December to March in Pilani tank and Khetri lake. The presence of the same species in the College pond when the temperature was as low as 7°C shows that this species can withstand a wide range of temperature. B.angularis can be considered a tropical form because of its absence during the winter months. Moreover, its maximum density of population has been noticed in summer months.

The occurrence of Keratella procurva during October to March in the College pond and its absence during the rest of the period suggests that the temperature can be an important factor in the appearance of this species. (Figures 210 & 211). Although this is a tropical form distributed in Africa, Asia and Australia it is presumable that it cannot withstand a high temperature. Keratella tropica is of constant occurrence throughout the year reaching its maximum number during spring. Its distribution may be controlled by some factors other than temperature. It is known that the hydrogen ion concentration of a habitat is not a limiting factor in the distribution of the species of Keratella (Ahlstrom 1943). Filinia opoliensis is widely distributed in tropics while it is a summer form in Europe.

It has been observed by many workers that the variation in the climate greatly influences the fluctuations in the abundance of many plankters. But the effect of various factors on a particular species has to be shown experimentally.

In addition to the physicochemical factors, the estimation of predators and the quantity of food available is important in determining the success of a community. Similarly observations made on the rate of reproduction of various species in natural populations will greatly help in explaining the seasonal fluctuations in plankton populations. Edmondson (1960) has made a detailed study of the reproductive rate of a few rotifers. The ratio eggs:female in a population is proportional to the rate of egg production. This birth rate can be calculated if the duration of the development of the eggs is known. By employing this egg ratio method one can estimate the actual growth of a population and can know how much it should have grown in an interval of time. From this one can also assess the effect of mortality in a population. Edmondson et al (1962) estimated the rate of egg laying by female copepods in nature. They found that the increase in the rate of reproduction is accompanied by an increase in the phytoplankton density. Edmondson (1965), further, found that the reproductive rate of rotifers varied in relation to the abundance of food organisms with temperature. Thus it is evident that the seasonal variation in the plankton population is influenced by the changes in the food available which in turn is probably effected by the changes in the physicochemical factors. Studies in that line may greatly help in explaining the seasonal variation in the plankton populations.

...

P A R T III

Cyclomorphosis and Morphometric study

CHAPTER VI

1. Morphometric studies on the rotifer Brachionus calyciflorus Pallas
2. Cyclomorphosis of Brachionus calyciflorus Pallas.

RPHOMETRIC STUDIES ON THE ROTIFER *BRACHIONUS CALYCIFLORUS* PALLAS

BY

C. K. G. NAYAR

Reprinted from "Curr. Sci.", August 5, 1964, 33, *No.* 15, 469-470

eprinted from "Curr. Sci.", August 5, 1964, 33, No. 15, 469-470

MORPHOMETRIC STUDIES ON THE ROTIFER *BRACHIONUS CALYCIFLORUS* PALLAS

COLLECTED a number of rotifers from different ocalities of Rajasthan during 1961-63. Appa-ently *Brachionus calyciflorus* Pallas has been ound to be an extremely variable species. Mor-hometric study of *B. calyciflorus* has earlier een done mainly in connection with its cyclo-norphosis.[1-3] An attempt is made here to study he nature and extent of variation of the rotifer ollected from different localities.

Collections have been made from six places n Rajasthan, *viz.*, Pilani, Amer (Jaipur), Nakki ake (Mount Abu), Ajit sagar (Khetri), Gajner Bikaner) and Swarup sagar (Udaipur). In 'ilani they were collected from a small pond 'hile other samples were collected from lakes. 'ow net made of nylon cloth has been used for ne collection. Hundred specimens were mea-ured from the sample from Pilani and 25 from ach of the other samples. Measurements were ot made for the specimens from Udaipur owing o inadequate number of specimens obtained n the sample.

It has been found that the specimens from Khetri have got the maximum length of the orica (Table I). Their length varied from 317 o 362 μ and 60% of the individuals were having mean length of 347 μ. The specimens from Bikaner showed a variation from 182 to 277 μ, hat of Jaipur and Mt. Abu from 167 to 242 μ nd that of Pilani from 154 to 226 μ. Out of all he five samples the specimens from Khetri howed the minimum range of variability.

TABLE I

Variation in the dimensions of B. calyciflorus

Locality	Mean length	Mean width	Left post spine	Rt. post spine
Khetri ..	340 μ	247·4 μ	34·72 μ	19 μ
Bikaner ..	228	190	52	47·2
Jaipur ..	213·2	186·7	0	0
Mt. Abu ..	210	160	18·1	12·8
Pilani ..	181·2	147·7	10·4	3·8

Maximum width has been shown by the specimens from Khetri with a range of variation from 210 to 277 μ. The smallest width has been shown by the specimens from Pilani with a range of variation from 120 to 164 μ. The speci-mens from Jaipur and Mt. Abu showed a range of variation from 170 to 203 μ and 130 to 185 μ respectively. In the sample from Mt. Abu 64% of the individuals was having a width of 164 μ.

In addition to the variation in the size of the lorica the specimens showed marked variation in the presence of the posterolateral spines as well as in their length. There were no specimens with posterolateral spines in the sample from Jaipur. The specimens from Bikaner showed a mean length of 52 μ for the left posterolateral spine and 47·2 μ for the right spine. In the specimens from Pilani the posterior spines were comparatively smaller than that of the speci-mens of other samples. The maximum mean length for the posterolateral spines was shown by the specimens from Bikaner. In specimens of Khetri as well as Pilani the right posterolateral spine was much smaller than the left while in other samples they were of nearly equal size. There were only a few specimens with equally developed posterolateral spines in the samples.

Ahlstrom[1] suggests that 'forms lacking posterior spines are commonly larger in size than forms possessing posterolateral spines'. The present observation does not reveal such correlation between the size of the lorica and the posterolateral spines. The specimens from Jaipur which are devoid of posterolateral spines are much smaller than the specimens from Khetri and Bikaner which have got postero-lateral spines. Buchner *et al.*[2] suggests that poor feeding enhances the spine growth in *B. calyci-florus*. Nayar[3] suggested that the increase in the number of individuals as well as the produc-tion of additional structures depend upon the quantity of food available. It is assumable that variation in the size of the lorica and the postero-lateral spines should be due to the difference in the nature and quantity of food available in the different localities.

Thanks are due to Prof. A. K. Datta Gupta and Mr. P. K. B. Menon for their valuable sug-gestions and criticism.

Department of Zoology, C. K. G. NAYAR.
Birla College,
Pilani (Rajasthan), *April* 8, 1964.

1. Ahlstrom, E. H., *Bull. Amer. Mus. nat. Hist.*, 1940, **77**, 143.
2. Buchner, H., Mulzer, F. and Rauh, F., *Biol. Zentralb.*, 1957, **76**, 289.
3. Nayar, C. K. G., *Hydrobiologia* (in Press).

PLATE I Figures 1 to 21

1. Brachionus rubens Dorsal view (Shivpur)
2. Brachionus rubens Dorsal view (Ganganagar)
3. Brachionus rubens Ventral view (Pilani)
4. Brachionus plicatilis D.V. (Pilani)
5. Brachionus rubens D.V. (Pilani)
6. Brachionus plicatilis V.V. (Pilani)
7. Brachionus caudatus f.apsteini D.V. (Pilani)
8. Brachionus caudatus var. aculeatus D.V. (Pilani)
9. Brachionus caudatus var.aculeatus Lateral view (Pilani Tank)
10. Brachionus caudatus f. majusculus D.V. (Jaipur)
11. Brachionus caudatus D.V. (Alwar)
12. Brachionus falcatus D.V. (Mt.Abu)
13. Brachionus angularis D.V. (Pilani)
14. Brachionus angularis D.V. (Pilani)
15. Brachionus angularis D.V. (Churu)
16. Brachionus angularis D.V. (Pilani)
17. Brachionus angularis D.V. (Pilani)
18. Brachionus dimidiatus D.V. (Pilani)
19. Brachionus diversicornis D.V. (Pilani)
20. Brachionus diversicornis Foot and toe (Alwar)
21. Brachionus forficula V.V. (Mt.Abu)

All figures except Figures 11, 12, 13, and 19 are drawn to the same scale. Scale in mm.

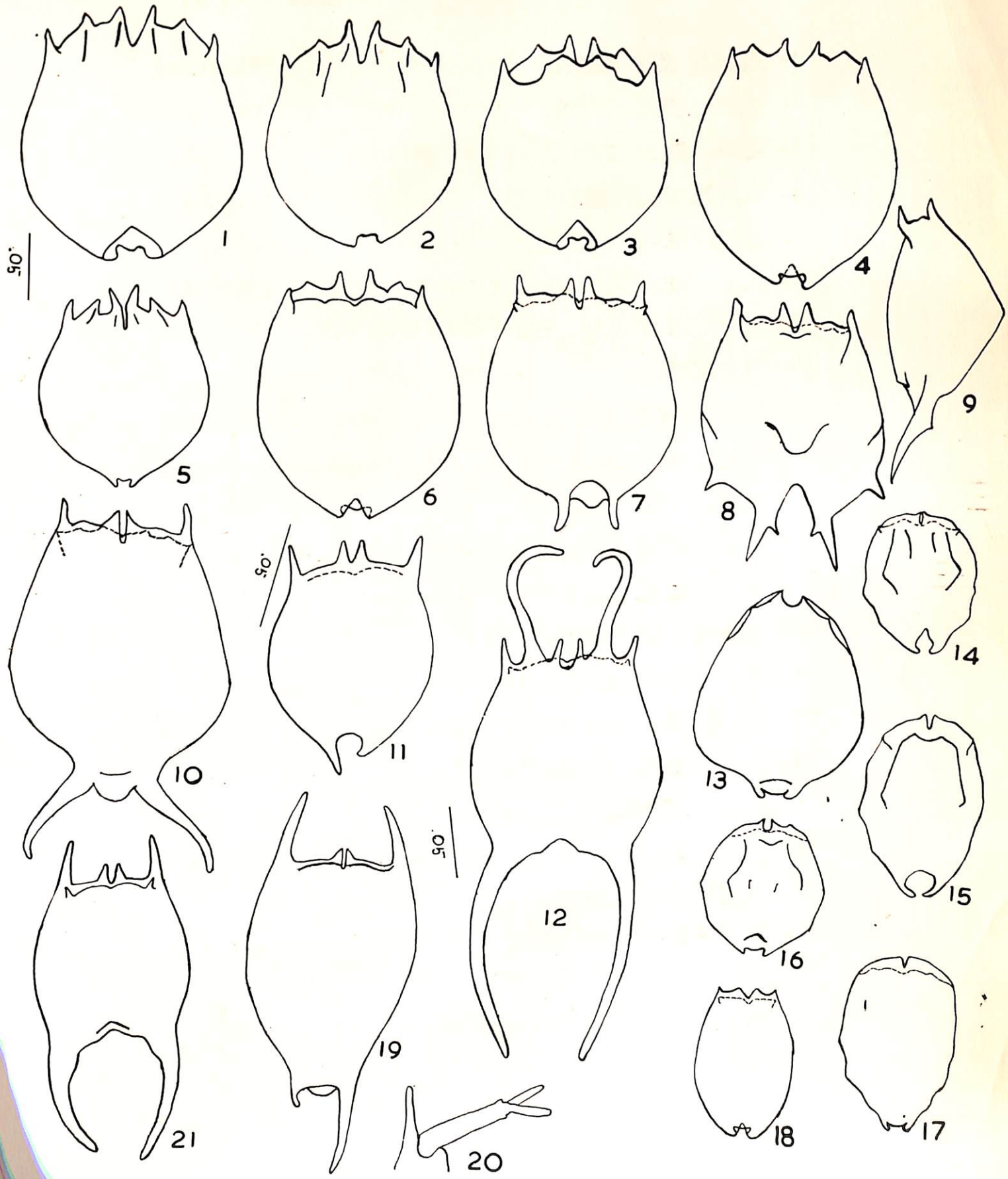

.05
1
2
3
4
5
6
7
8
9
.05
10
11
12
.05
13
14
15
16
17
18
19
20
21

PLATE II Figures 22 to 39

22. Brachionus calyciflorus D.V. (College Pond)
23. Brachionus calyciflorus D.V. (College Pond)
24. Brachionus calyciflorus D.V. (College Pond)
25. Keratella edmondsoni D.V. (Chirawa)
26. Anterior margin of Brachionus calyciflorus V.V. (Khetri)
27. Brachionus quadridentatus V.V. (Khetri)
28. Keratella tropica D.V. (Pilani)
29. Posterior margin of Keratella tropica (Pilani)
30. Keratella procurva D.V. (Pilani)
31. Keratella procurva Lateral view (Pilani)
32. Keratella procurva D.V. (Pilani)
33. Lepadella patella (Pilani)
34. Lepadella sp. (Pilani)
35. Macrochaetus collinsii (Pilani)
36. Anuraeopsis fissa D.V. (Pilani)
37. Mytilina ventralis Laterla view (Pilani)
38. Hexarthra mira (Pilani)
39. Polyarthra multiappendiculata (Alwar)

Figures 22, 23, 24, 26 drawn to the same scale. Figures 27, 36, drawn to the same scale, and the rest to the same scale. Scale

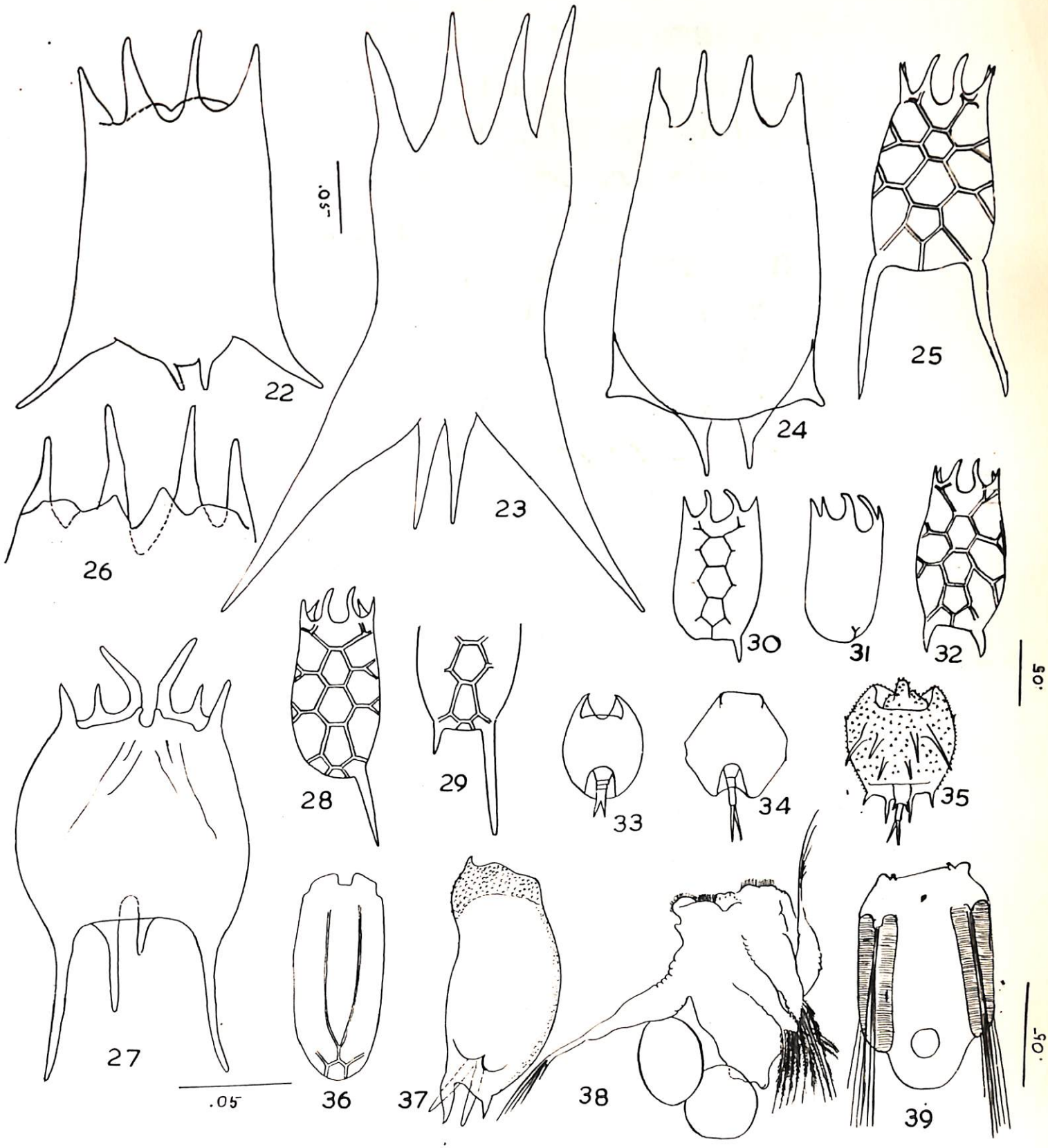

22
.05
23
24
25
26
30
31
32
.05
27
28
29
33
34
35
.05
36
37
38
39
.05

PLATE III Figures 40 to 66

40. Lecane luna V.V. (Pilani)
41. Lecane luna D.V. (Pilani)
42. Lecane papuana V.V. (Pilani)
43. Lecane papuana D.V. (Pilani)
44. Lecane nana D.V. (Pilani)
45. Lecane nana V.V. (Pilani)
46. Lecane tryphema V.V. (Pilani)
47. Lecane tryphema D.V. (Pilani)
48. Monostyla punctata V.V. (Pilani)
49. Monostyla punctata D.V. (Pilani)
50. Monostyla hamata D.V. (Pilani)
51. Monostyla hamata V.V. (Pilani)
52. Monostyla quadridentata V.V. (Pilani)
53. Monostyla quadridentata D.V. (Pilani) (Different specimens)
54. Monostyla sp. D.V. (Pilani)
55. Monostyla sp. V.V. (Pilani)
56. Monostyla bulla D.V. (Pilani)
57. Monostyla bulla V.V. (Pilani)
58. Lecane ploenensis D.V. (Pilani)
59. Lecane ploenensis V.V. (Pilani)
60. Monostyla closterocerca D.V. (Pilani)
61. Monostyla closterocerca V.V. (Pilani)
62. Trichocerca sp. (Alwar)
63. Trichocerca sp. (Jaipur)
64. Trichocerca stylata (Alwar)
65. Trichocerca similis (Alwar)
66. Trichocerca similis D.V. (Anterior margin) (Alwar)

Figures 40-43, 52-59 drawn to same scale.
Figures 44-51, 60,61 drawn to same scale. Scale in mm.

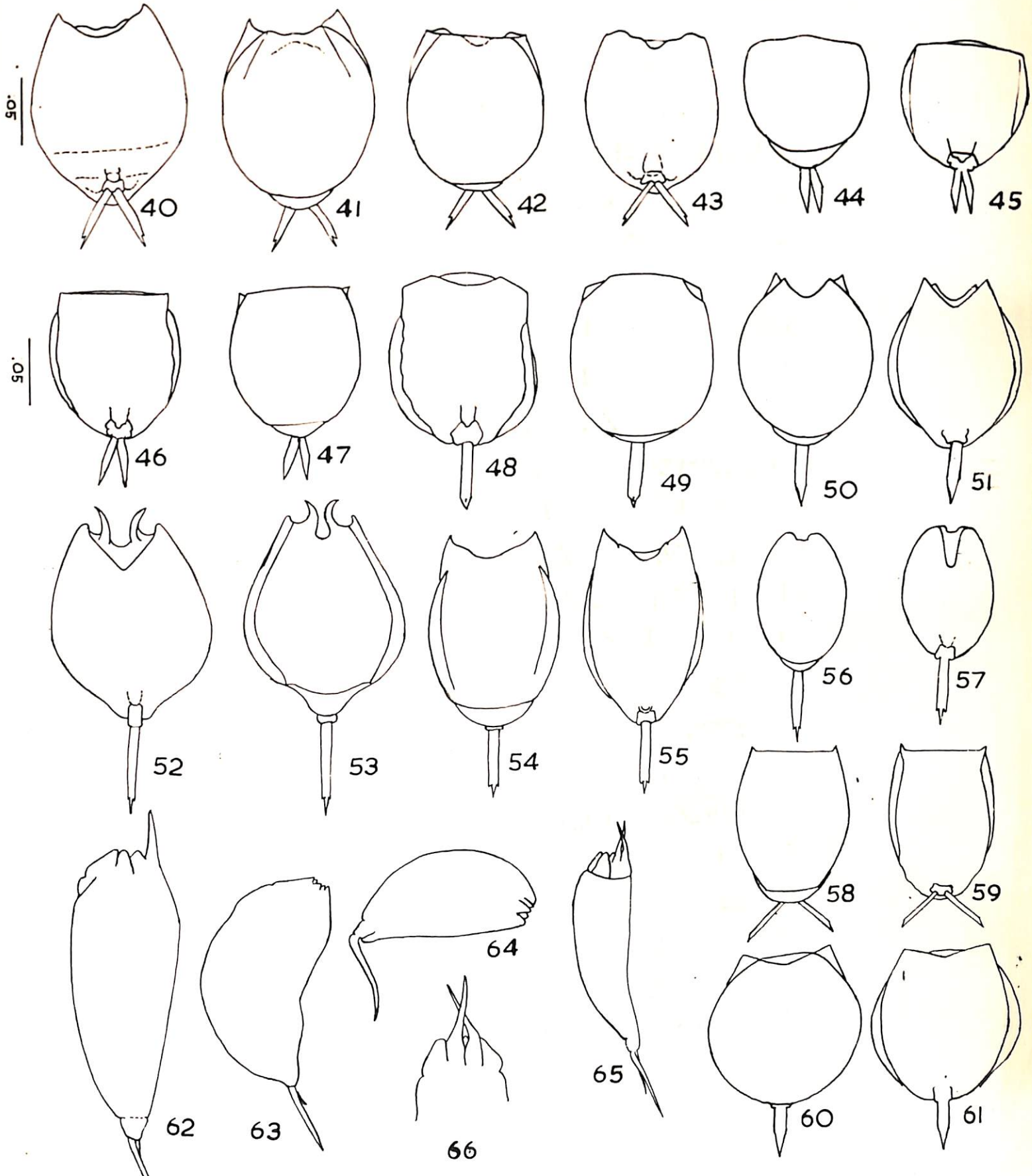

.05
40
41
42
43
44
45
.05
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66

PLATE IV Figures 67 to 76

67. Filinia longiseta (Pilani)

68. Filinia terminalis (Pilani)

69. Filinia opoliensis (Mt.Abu)

70. Lacinularia flosculosa (Khetri)

71. Streptocephalus simplex arabicus (Male antenna)

72. Streptocephalus dichotomus Male (Pilani)

73. Streptocephalus dichotomus Head of female (Pilani)

74. Branchinella sp. Female (Khetri)

75. Branchinella sp. End of the abdomen.

76. Branchinella sp. Male Head (Khetri)

Figures 67-76 are drawn to the same scale.
Scale in mm.

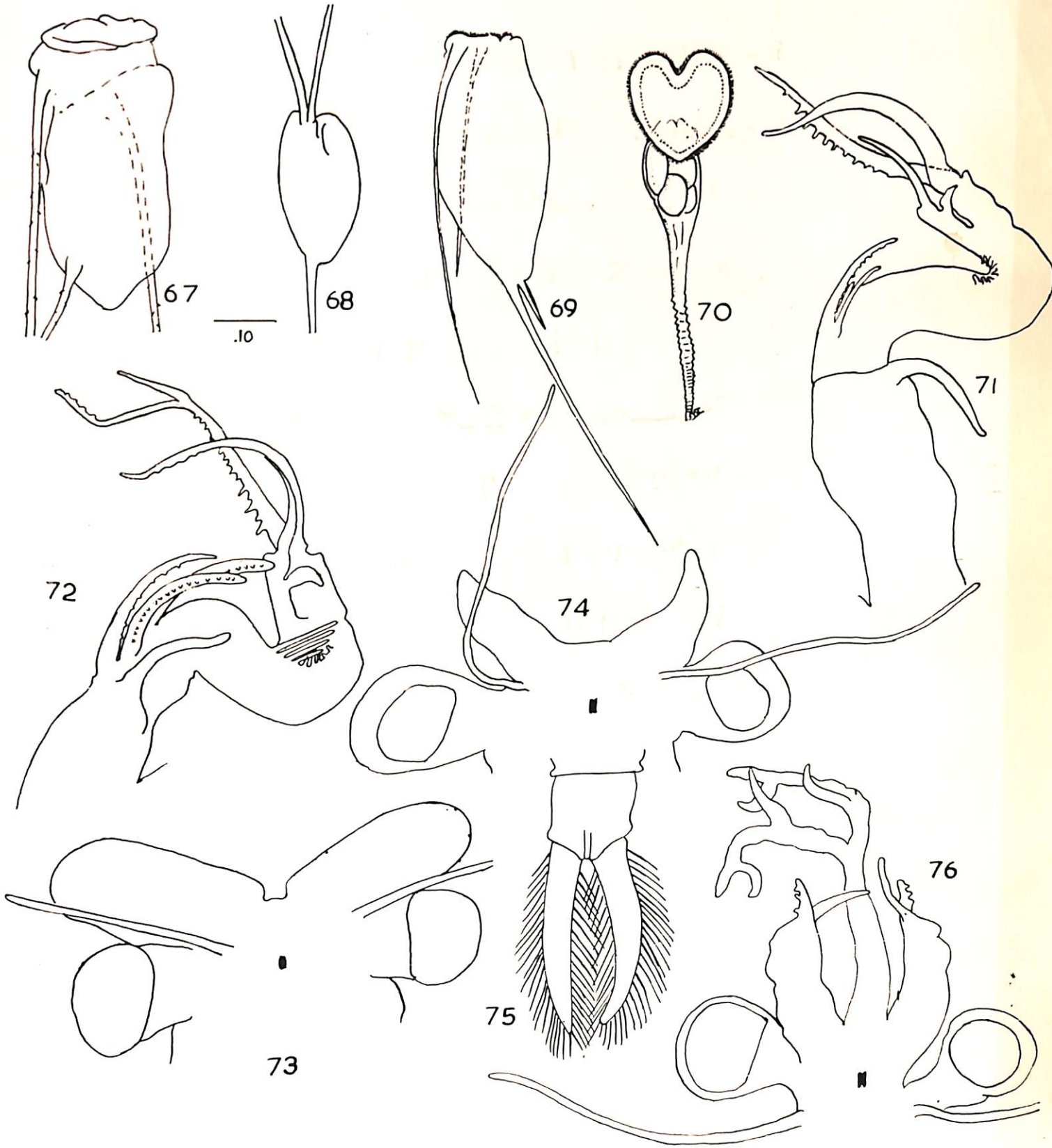

67
68
.10
69
70
71
72
74
73
75
76

PLATE V Figures 77 to 91

77. Branchinella kugenumaensis Male Head (Khetri)

78. Branchinella kugenumaensis Female Head (Khetri)

79. Branchinella kugenumaensis Male ventral view of the abdomen.

80. Apus cancriformis Telson

81. Leptestheria longispinosa Shell Male

82. Leptestheria longispinosa Shell Female

83. Leptestheria longispinosa Telson Female

84. Leptestheria longispinosa Female spines on the dorsal margi of the telson.

85. Leptestheria longispinosa Female spines on the claw.

86. Leptestheria longispinosa Head Male

87. Leptestheria longispinosa Head Female

88. Leptestheria longispinosa First peraeopod Female

89. Leptestheria longispinosa First peraeopod Male

90. Leptestheria longispinosa Tenth peraeopod Female

91. Leptestheria longispinosa Telson Male

Figures 83, 86-91 drawn to same scale.

Scale in mm.

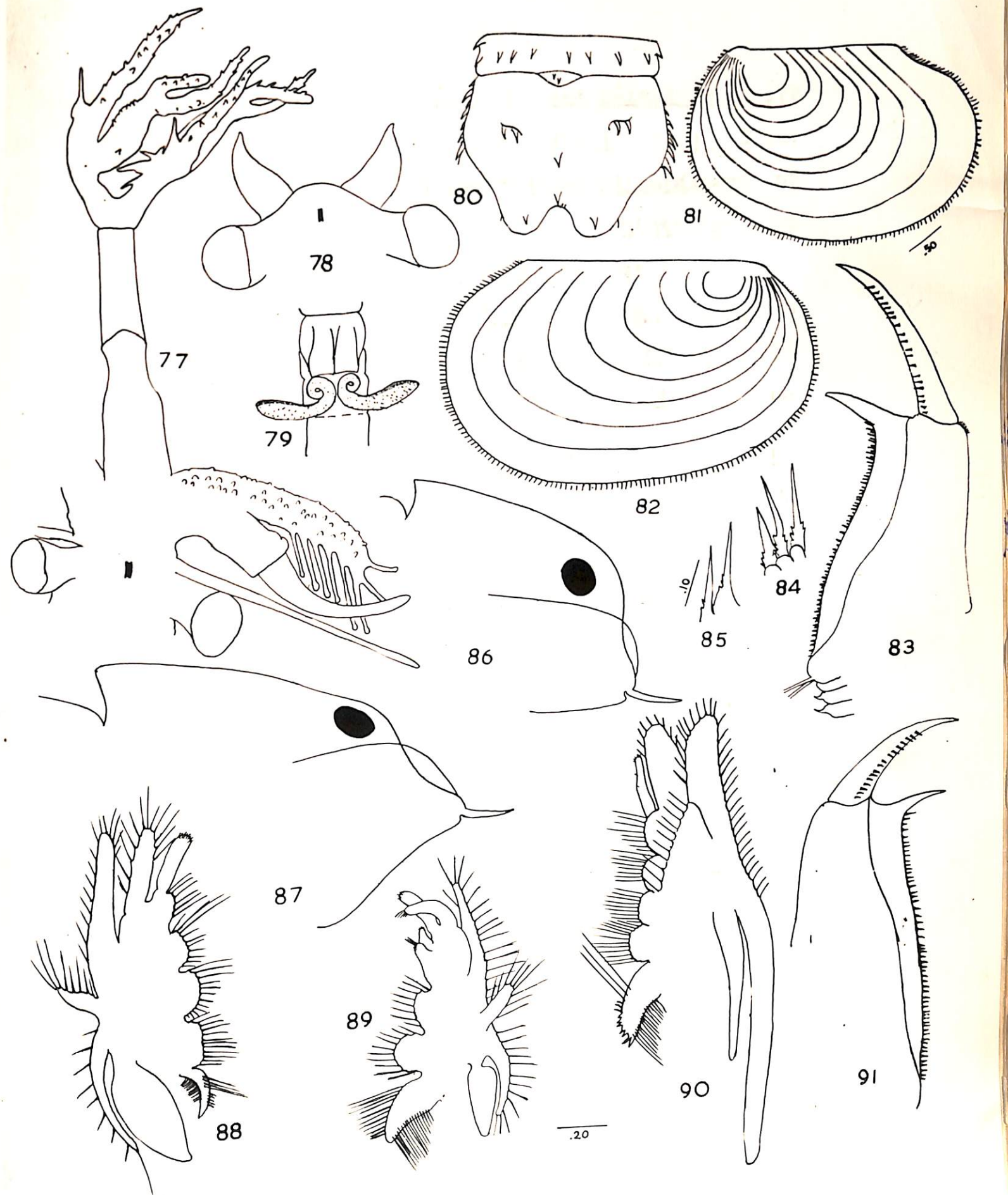

77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
.10
.50
.20

PLATE VI Figures 92-111

92. Leptestheria longispinosa Second peraeopod Male
93. Leptestheria longispinosa 'Hand' of second peraeopod Male
94. Eocyzicus acuta Shell Male
95. Eocyzicus acuta Head Female
96. Eocyzicus acuta Telson Female
97. Eocyzicus acuta First peraeopod Female
98. Eulimnadia ovata Shell Female
99. Eulimnadia ovata Head Female
100. Eulimnadia ovata First peraeopod Female
101. Eulimnadia ovata Part of 9th peraeopod Female
102. Eulimnadia ovata Telson Female
103. Ceriodaphnia cornuta Female (Pilani)
104. Ceriodaphnia cornuta Female (Pilani)
105. Ceriodaphnia cornuta Post abdomen Female
106. Ceriodaphnia cornuta Female (Mt.Abu)
107. Ceriodaphnia cornuta Female (Mt.Abu)
108. Ceriodaphnia cornuta Antenna (Mt.Abu)
109. Ceriodaphnia reticulata Postabdomen (Pilani)
110. Ceriodaphnia reticulata Head (Pilani)
111. Ceriodaphnia reticulata Female (Pilani)

Figures 93, 105-107,110 drawn to same scale.
Figures 92, 97 - same scale. Figures 103,104,111 - same scale
Figures 94, 99-101 - same scale.
Figures 95, 102 - same scale.
Scale in mm.

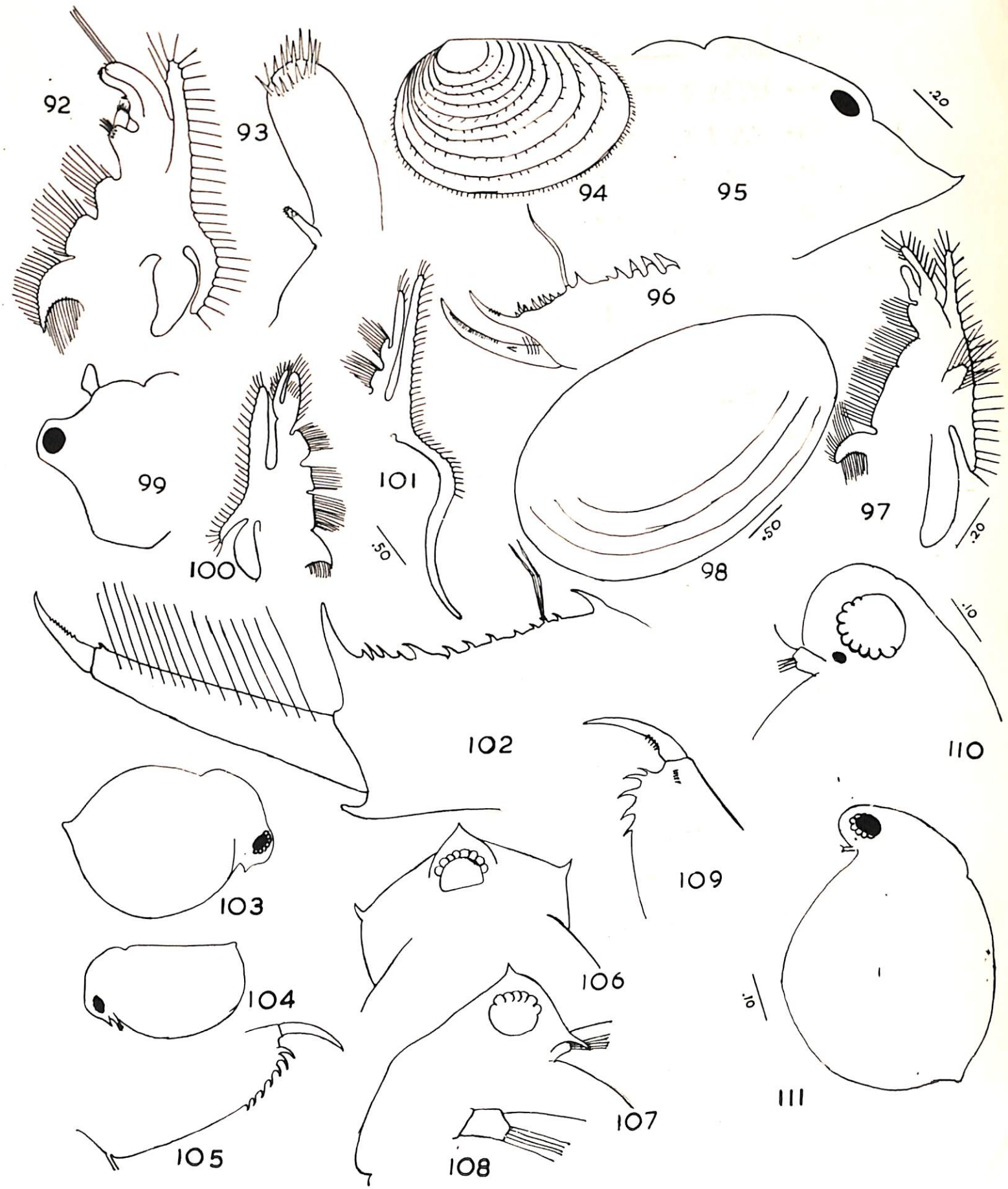

92
93
94
95
.20
96
99
101
97
.20
100
.50
98
.50
102
110
.10
103
109
104
106
111
.10
105
107
108

PLATE VII Fitures 112 to 128

112. Daphnia similis Female
113. Daphnia similis Female Rostral region
114. Daphnia similis Female Postabdomen
115. Daphnia similis Female Claw
116. Daphnia similis Female Carapace margin-left valve
117. Daphnia similis Male Postabdomen
118. Daphnia similis Male
119. Daphnia similis Male Antennule
120. Daphnia magna Female (Ganganagar)
121. Daphnia magna Female Rostral region
122. Daphnis magna Female Claw
123. Daphnia magna Female Postabdomen
124. Daphnia magna Female Postabdomen
125. Daphnia magna Male
126. Daphnia magna Male Postabdomen
127. Daphnia magna Male Postabdomen
128. Daphnia magna Male Antennule

Figures 112, 118, 120 drawn to same scale.
Figures 113, 115, 117, 119 same scale.
Figures 114, 122, 124, 126 - same scale.
Figures 121, 123 - same scale.
Scale in mm.

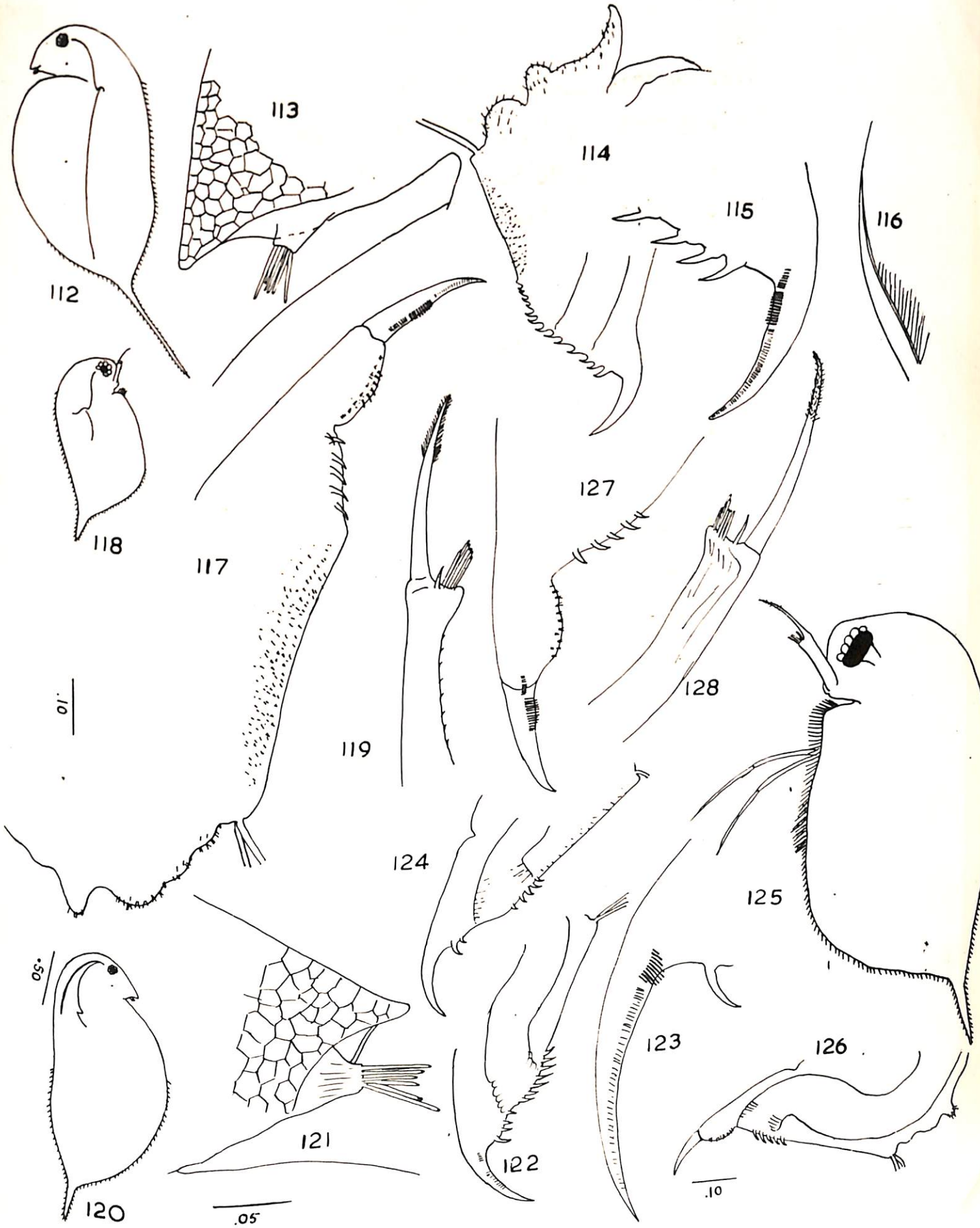

112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
.10
.50
.05
.10

PLATE VIII Figures 129 to 145

129.	Daphnia lumholtzi	Female	(Mt.Abu)
130.	Daphnia lumholtzi	Female	(Rostral region)
131.	Daphnia lumholtzi	Female	Postabdomen
132.	Daphnia lumholtzi	Female	(Udaipur)
133.	Daphnia lumholtzi	Female	(Udaipur)
134.	Daphnia lumholtzi	Female	(Udaipur) Rostral
135.	Daphnia lumholtzi	Female	(Udaipur) Postabdo
136.	Daphnia lumholtzi	Male	(Udaipur)
137.	Daphnia lumholtzi	Male	Antennule
138.	Daphnia lumholtzi	Male	Postabdomen
139.	Daphnia cucullata	Female	(Pilani)
140.	Daphnia cucullata	Female	Rostral region
141.	Daphnia cucullata	Female	Postabdomen
142.	Daphnia cucullata	Male	(Pilani)
143.	Daphnia cucullata	Male	Head
144.	Daphnia cucullata	Male	Antennule
145.	Daphnia cucullata	Male	Postabdomen

Figures 129, 132, 133, 136, 139 drawn to same scale.
Figures 130, 131, 134, 135, 137, 138, 140, 141 - same scale.
Figures 143 and 145 - same scale.
Scale in mm.

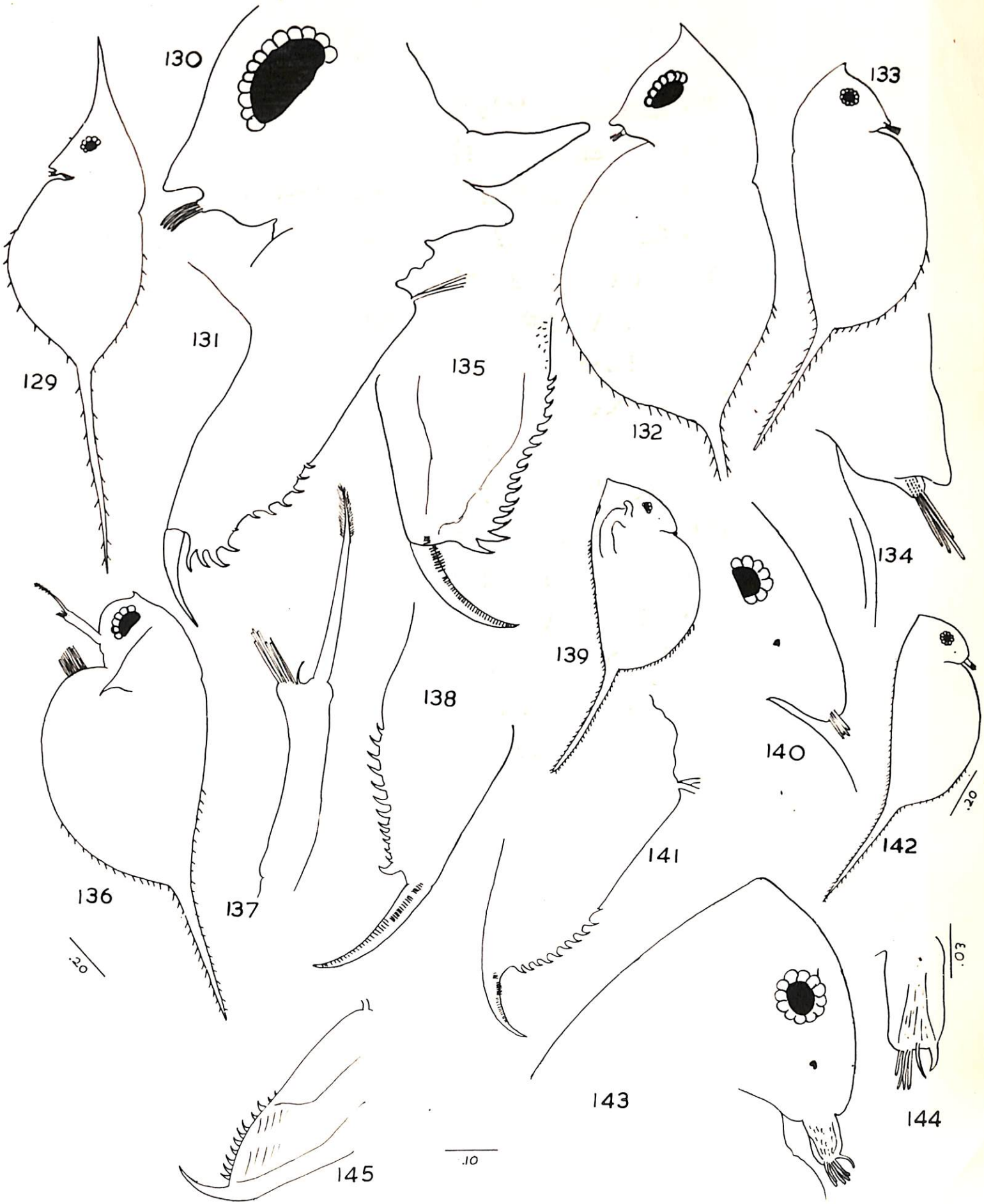

129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
.20
.10
.03

PLATE IX Figures 146 to 162.

146. Daphnia sp. Female (Pilani)
147. Daphnia sp. Female Head
148. Daphnia sp. Female Postabdomen
149. Daphnia sp. Female Claw
150. Daphnia sp. Male
151. Daphnia sp. Male Head
152. Daphnia sp. Male Antennule
153. Daphnia sp. Male Claw
154. Simocephalus vetulus Female (Khetri)
155. Simocephalus vetulus Female
156. Simocephalus vetulus Head
157. Simocephalus vetulus Postabdomen
158. Diaphanosoma excisum Female (Khetri)
159. Diaphanosoma excisum Female Postabdomen
160. Diaphanosoma excisum Female Antennule
161. Diaphanosoma excisum Male Head
162. Diaphanosoma excisum Male Antennule

Figures 146, 150, drawn to same scale.
Figures 147, 148, 151, 156, 157, 161 - same scale.
Figures 149, 152, 153 - same scale.
Figures 154, 155, 158 - same scale.
Figures 159, 160, 162 - same scale.
Scale in mm.

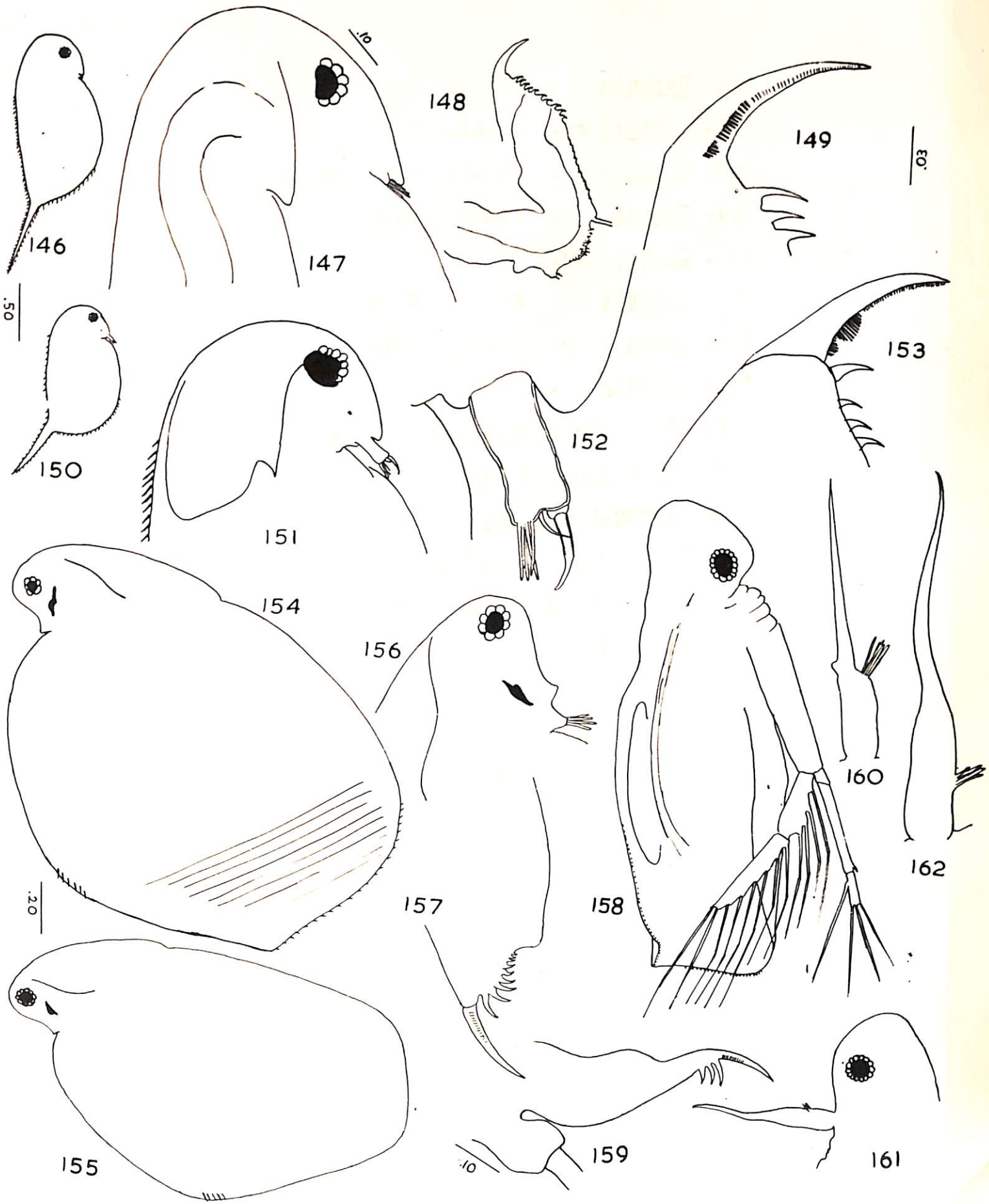

146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
.10
.03
.50
.20
.10

PLATE X Figures 163 to 176

163. Moina brachiata Female (Pilani)

164. Moina brachiata Female Postabdomen

165. Moina brachiata Male

166. Moina brachiata Male Antennule

167. Moina brachiata Female Antennule

168. Macrothrix goeldii Female (Khetri)

169. Macrothrix goeldii Head

170. Macrothrix goeldii Postabdomen

171. Macrothrix goeldii Part of the ventral margin of carapace.

172. Alona pulchella (Churu)

173. Alona pulchella Head

174. Alona pulchella Postabdomen

175. Alona verrucosa (Churu)

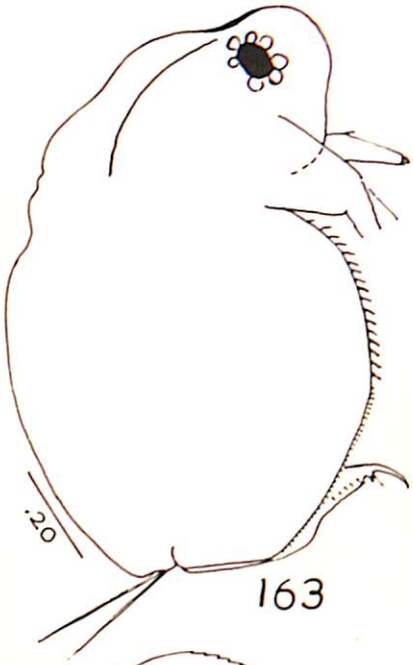
176. Alona verrucosa Postabdomen

Figures 163, 165, are drawn to same scale.

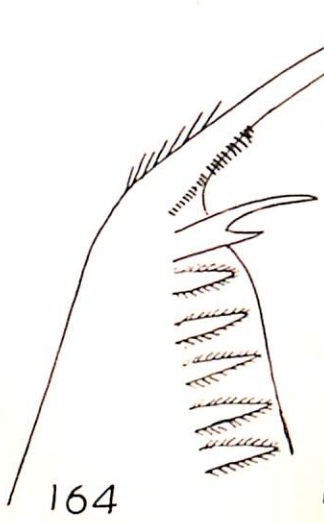
Figures 164, 174, 176 - same scale.

Figures 166, 167, 175 - same scale.

Scale in mm.



163

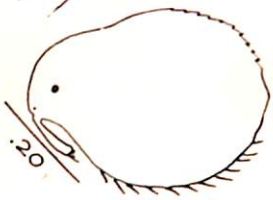


164

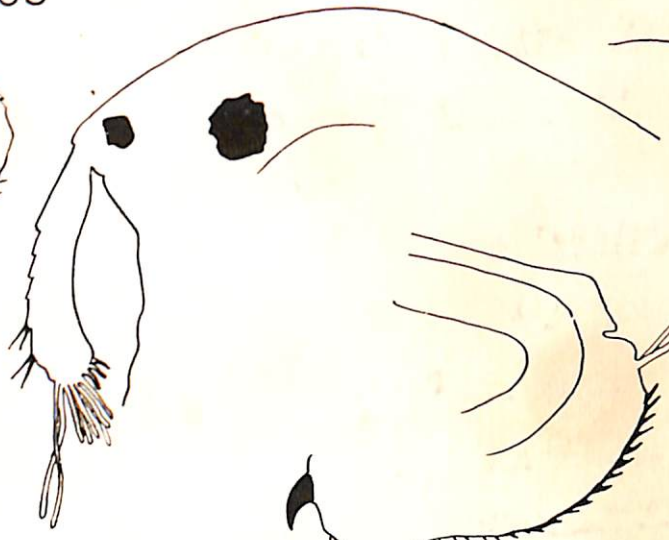
165

166

167

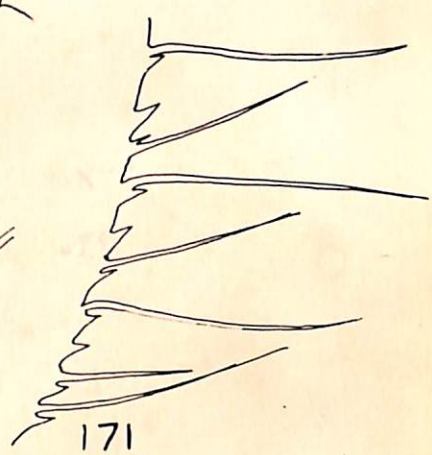


168

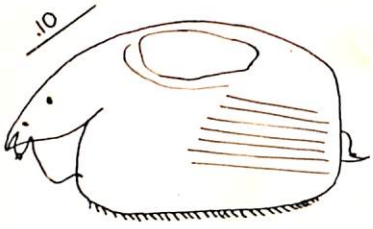


169

170



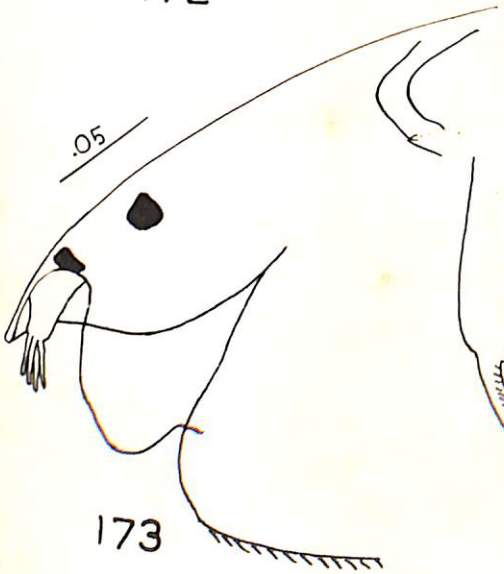
171



172

176

174



173

175

PLATE XI Figures 177 to 191.

177. Alona rectangula (Khetri)

178. Alona rectangula Postabdomen

179. Alona rectangula Head

180. Chydorus eurynotus (Khetri)

181. Chydorus eurynotus Head

182. Chydorus eurynotus Postabdomen

183. Chydorus eurynotus (Khetri)

184. Chydorus eurynotus Head

185. Chydorus sp. (Khetri)

186. Chydorus sp. Postabdomen

187. Chydorus sp. Head

188. Pleuroxus trigonellus (Khetri)

189. Pleuroxus trigonellus Head

190. Pleuroxus trigonellus Infra-posteal angle of carapace.

191. Pleuroxus trigonellus Postabdomen.

Figures 177, 180, 183, 185, 188 are drawn to same scale.

Figures 178, 182, 190 - same scale.

Figures 179, 181, 184, 186, 189, 191 - same scale.

Scale in mm.

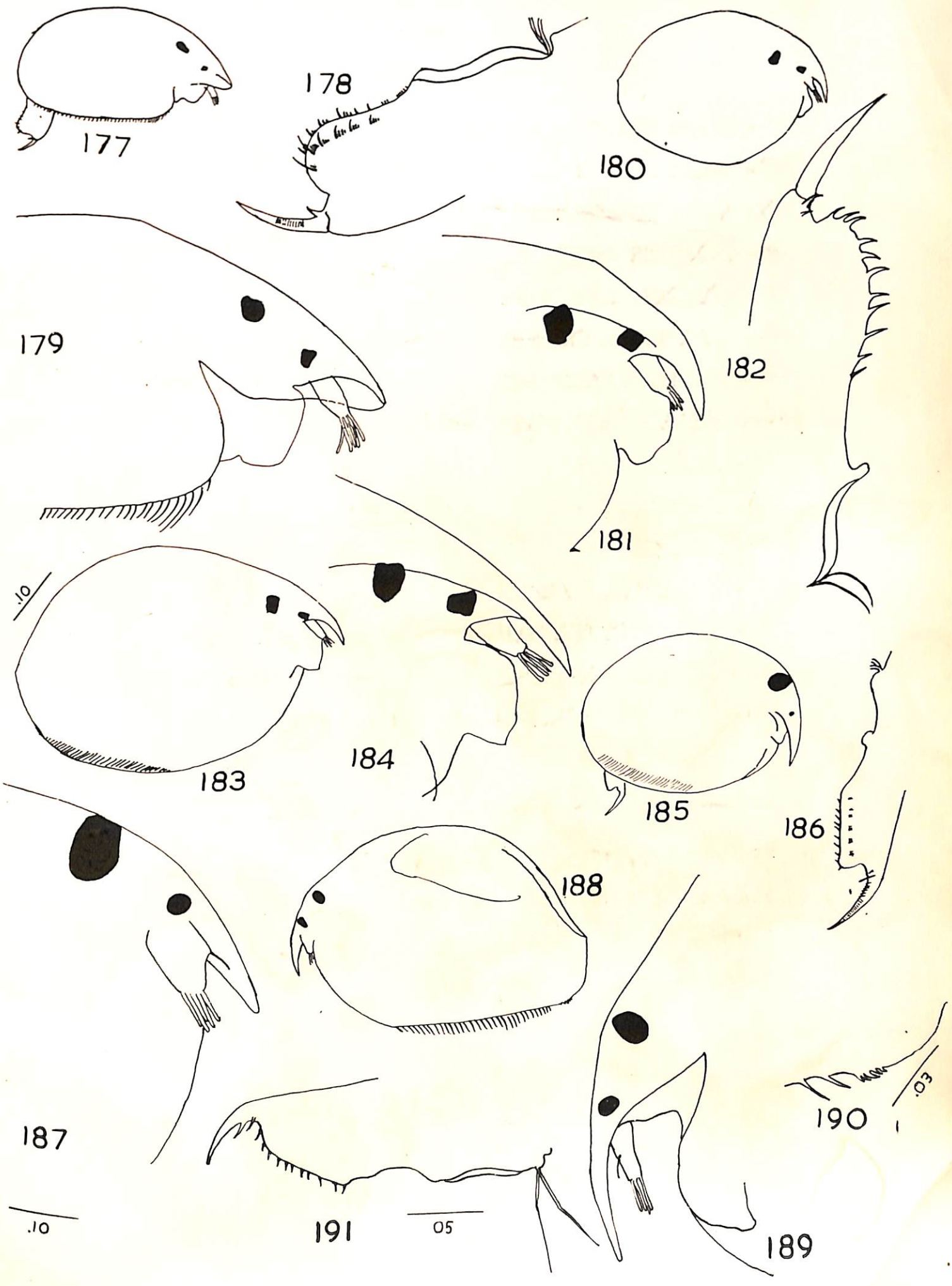

177
178
180
179
182
181
.10
183
184
185
186
188
187
190
.03
.10
191
.05
189

PLATE XII Figures 192 to 202.

192. Pleuroxus sp. (Pilani)

193. Pleuroxus sp. (Pilani)

194. Pleuroxus sp. Head of Fig. 192.

195. Pleuroxus sp. Head

196. Pleuroxus sp. Postabdomen } of same individual.

197. Leydigia acanthoceroides (Pilani)

198. Leydigia acanthoceroides Postabdomen

199. Leydigia acanthoceroides Head

200. Leydigia ciliata (Khetri)

201. Leydigia ciliata Head

202. Leydigia ciliata Postabdomen.

Figures 192, 193 are drawn to same scale.

Figures 194, 198, 199, 201, 202 - same scale.

Figures 197, 200 - same scale.

Figures 195, 196 - same scale.

Scale in mm.

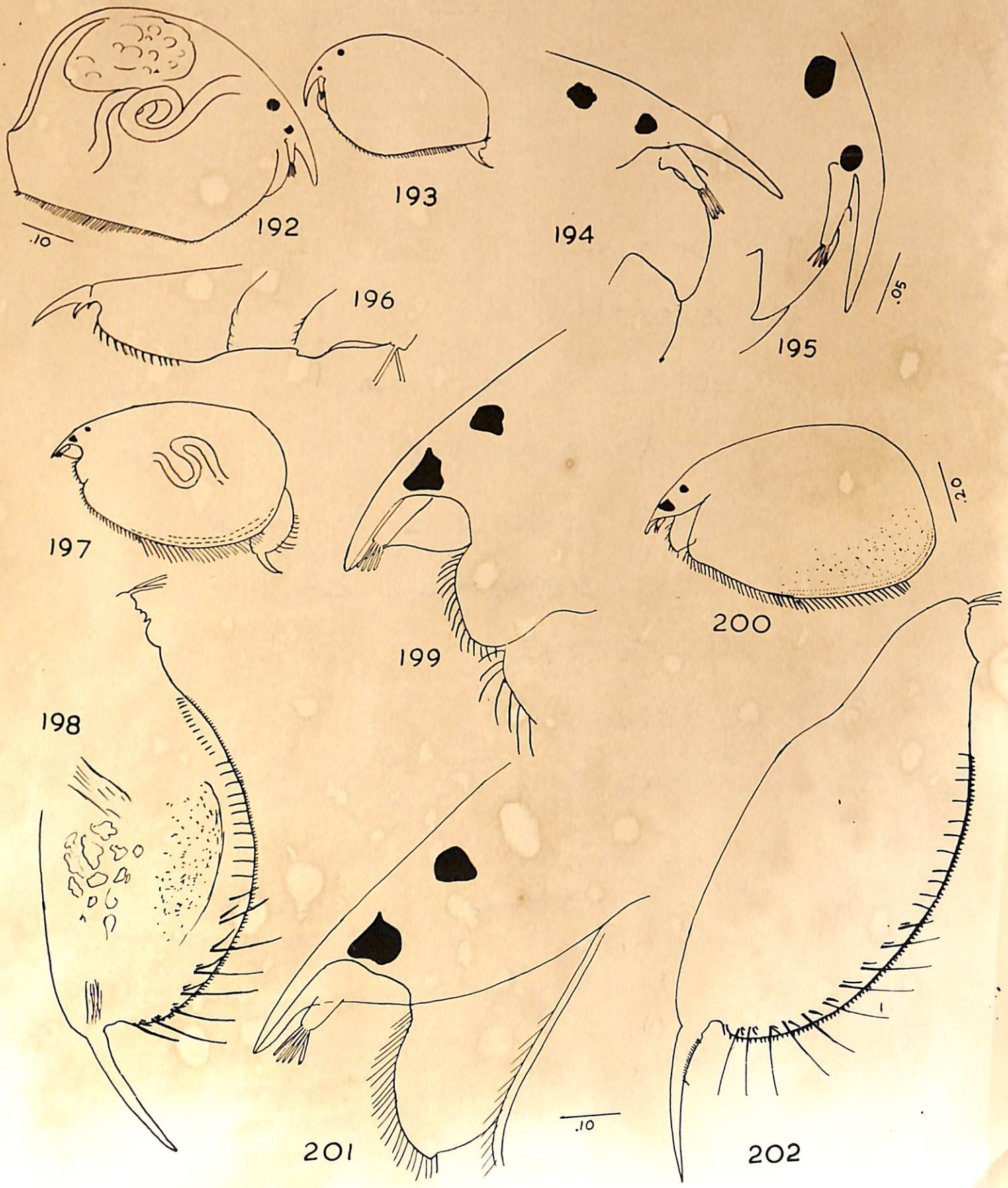

192
193
194
195
196
197
198
199
200
201
202
.10
.05
.20
.10

PLATE XIII Figures 203 & 204.

204. Monthly variation in the total number of rotifers of College Pond.

203. Monthly variation in the temperature and total zooplankton of College Pond.

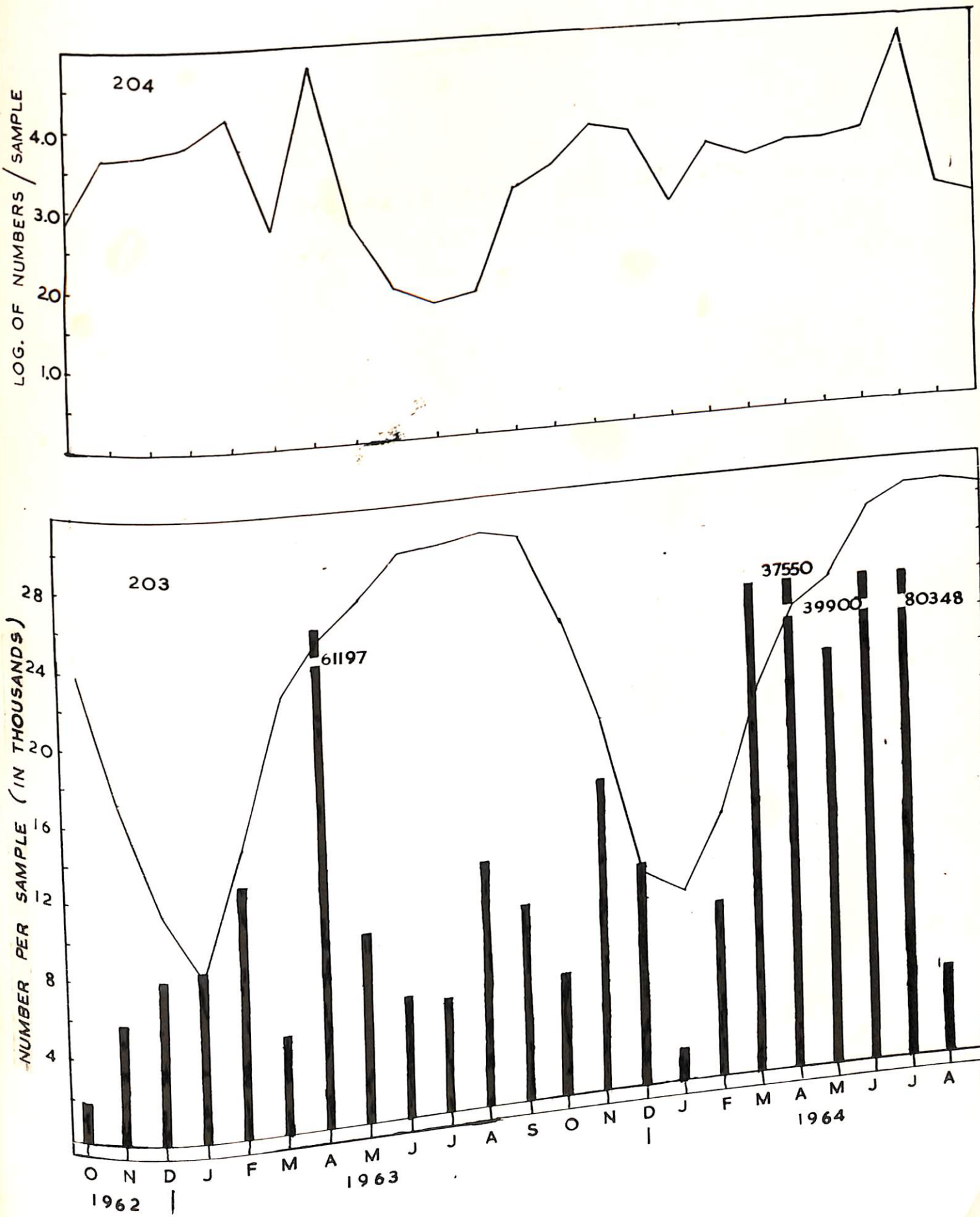

204
LOG. OF NUMBERS / SAMPLE
4.0
3.0
2.0
1.0
203
NUMBER PER SAMPLE (IN THOUSANDS)
28
24
20
16
12
8
4
61197
37550
39900
80348
TEMPERATURE °C
30
26
22
18
14
10
6
O N D J F M A M J J A S O N D J F M A M J J A S
1962
1963
1964

PLATE XIV Figures 205 to 207

205. Monthly variation in the total number of Copepoda and Cladocera of College Pond.

206. Percentage composition of Crustacean Zooplankton of College Pond; each group is plotted as a percentage of the total number of Crustacea.

207. Seasonal variation in the percentage of Crustacea (of the total zooplankton) of College Pond.

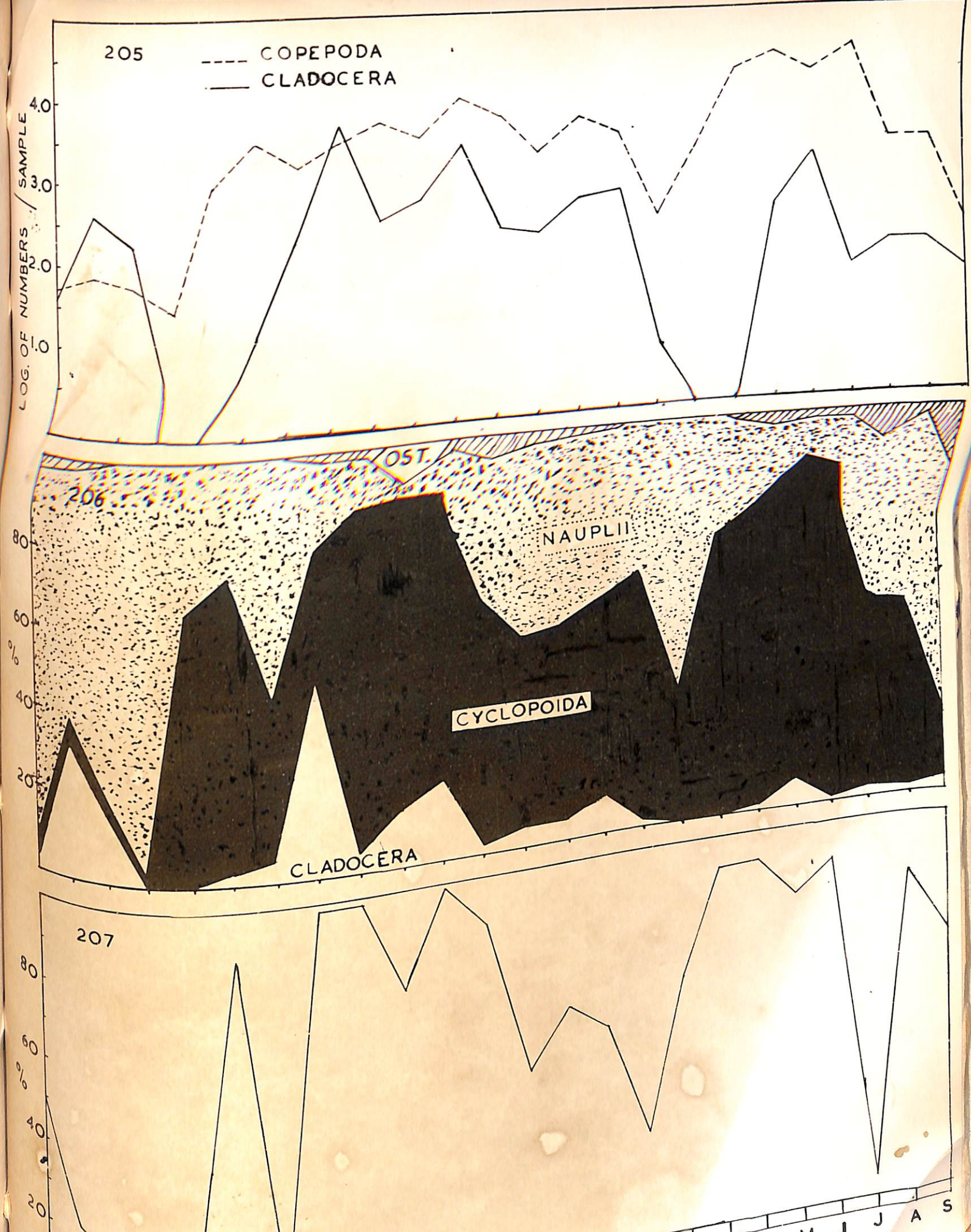

205
COPEPODA
CLADOCERA
LOG. OF NUMBERS / SAMPLE
4.0
3.0
2.0
1.0
206
OST.
NAUPLII
CYCLOPOIDA
CLADOCERA
80
60
40
20
%
207
80
60
40
20
%
J
A
S

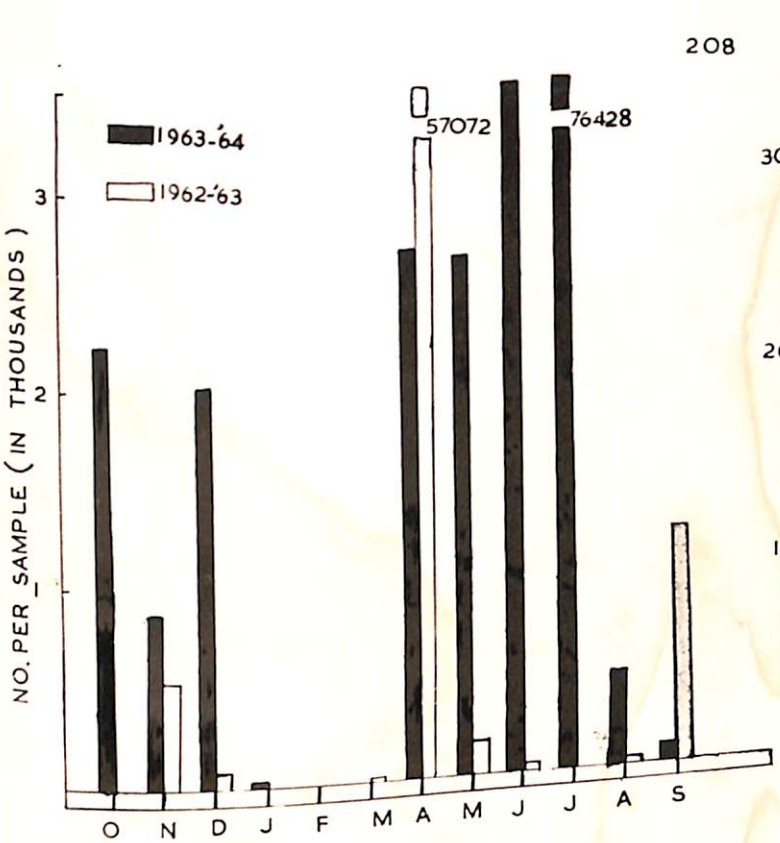
PLATE XV Figures 208 to 211

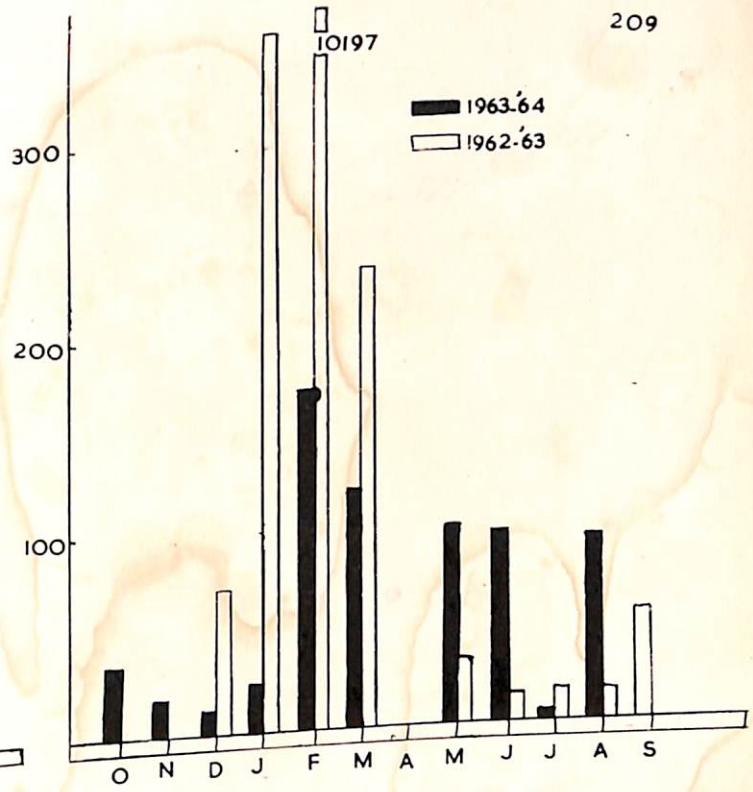
208. Seasonal occurrence of Brachionus angularis for the years 1962-63 and 1963-64 in College Pond.

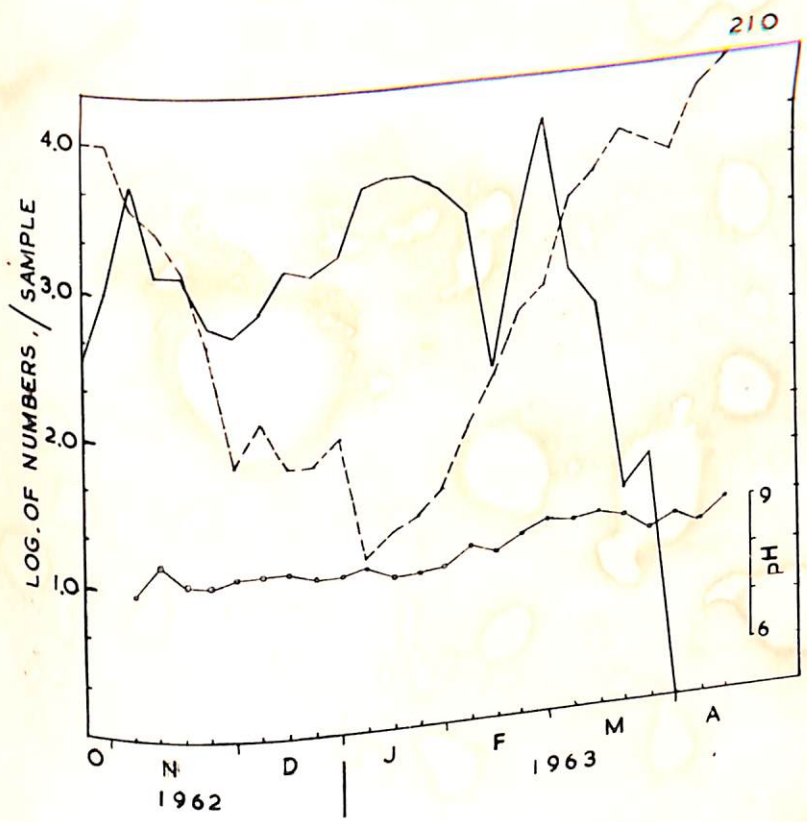
209. Seasonal occurrence of Keratella tropica for the years 1962-63 and 1963-64 in College Pond.

210. Weekly variation in the temperature, pH and number of Keratella procurva for the year 1962-63 in College Pond.

211. Weekly variation in the temperature, pH and number of Keratella procurva for the year 1963-64 in College Pond.


208
1963-'64
1962-'63
57072
76428
NO. PER SAMPLE (IN THOUSANDS)
3
2
O N D J F M A M J J A S


209
10197
1963-'64
1962-'63
300
200
100
O N D J F M A M J J A S


210
LOG. OF NUMBERS / SAMPLE
4.0
3.0
2.0
1.0
pH
9
6
O N D J F M A
1962
1963

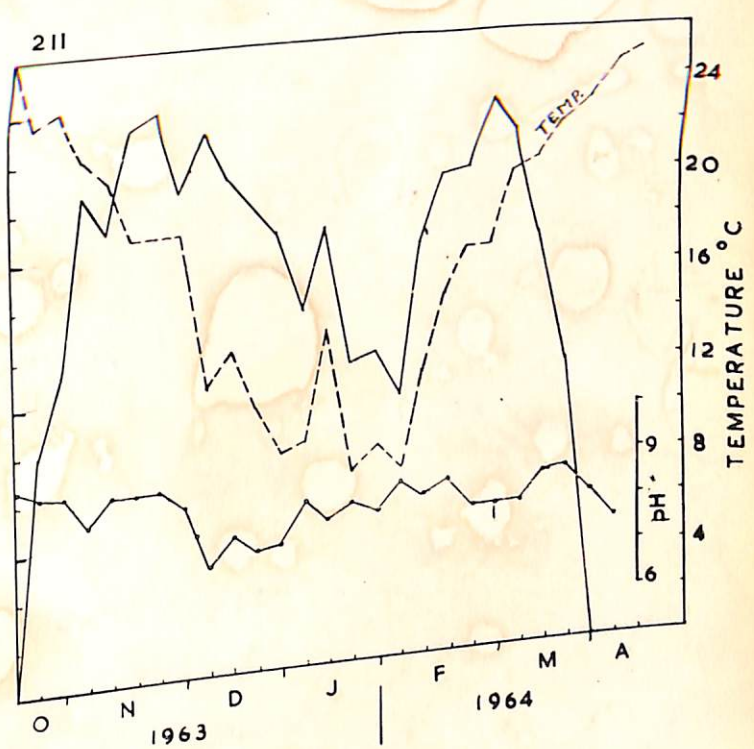
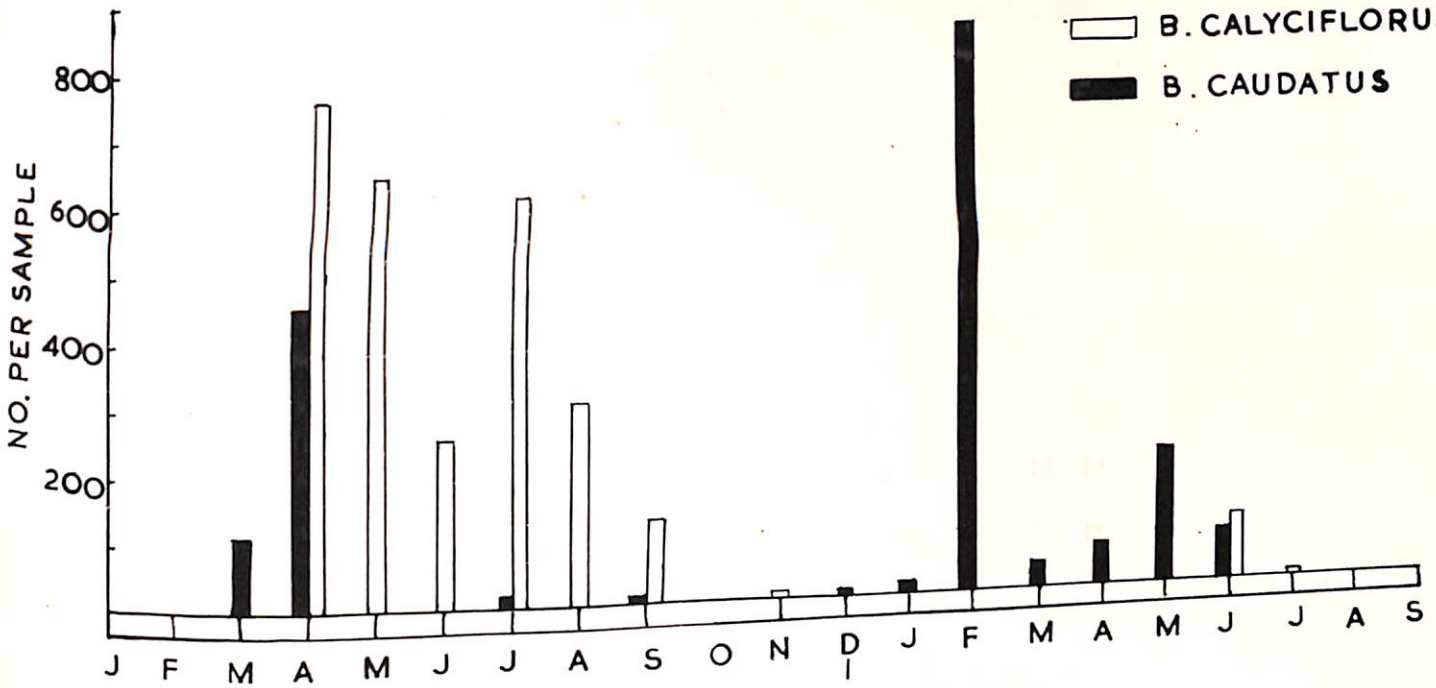

211
TEMP.
24
20
16
12
8
4
°C
TEMPERATURE
pH
9
6
O N D J F M A
1963
1964

PLATE XVI Figures 212 & 213

213. Seasonal occurrence of Brachionus calyciflorus and Brachionus caudatus in Pilani Tank.

212. Monthly variation in the temperature and number of total zooplankton of Pilani Tank.

213


B. CALYCIFLORUS
B. CAUDATUS
NO. PER SAMPLE
800
600
400
200
J F M A M J J A S O N D J F M A M J J A S

212

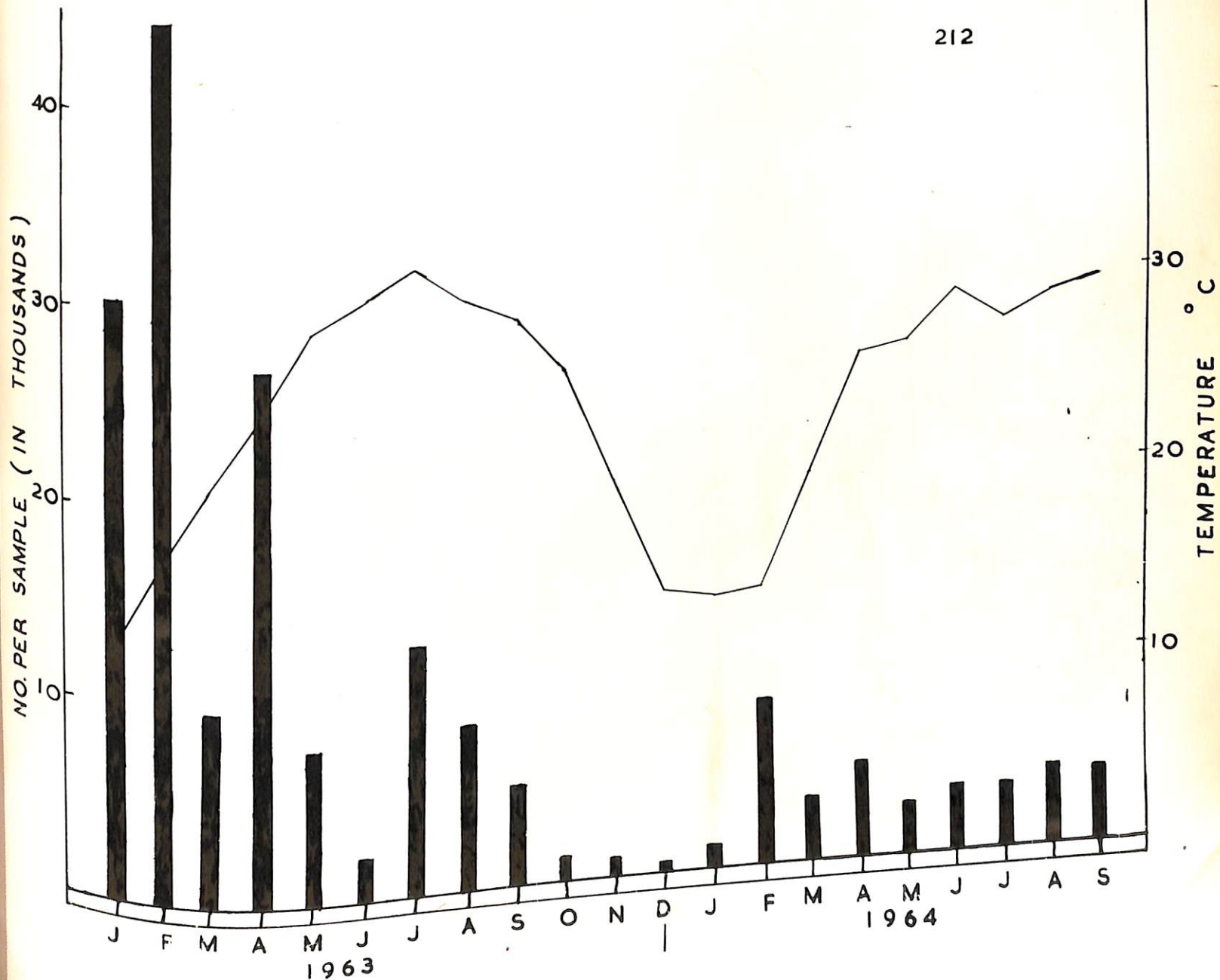
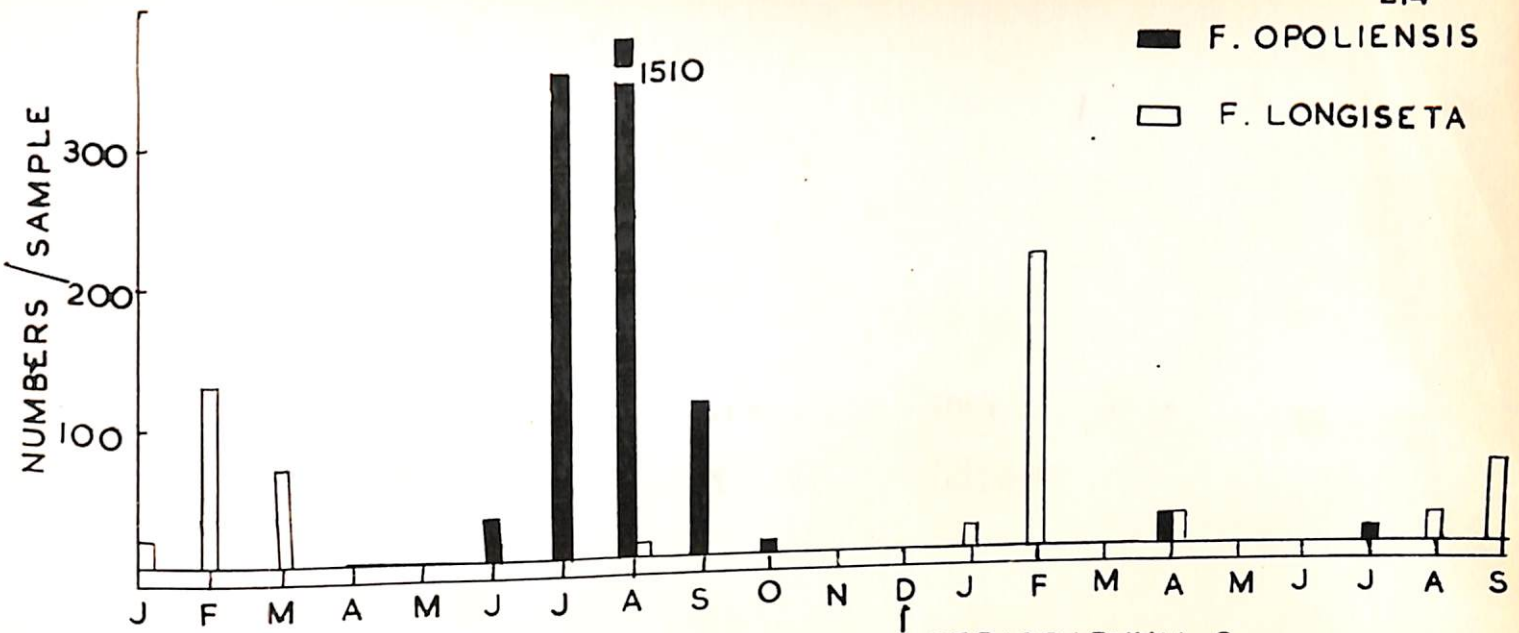

NO. PER SAMPLE (IN THOUSANDS)
40
30
20
10
0
TEMPERATURE °C
30
20
10
J F M A M J J A S O N D J F M A M J J A S
1963
1964

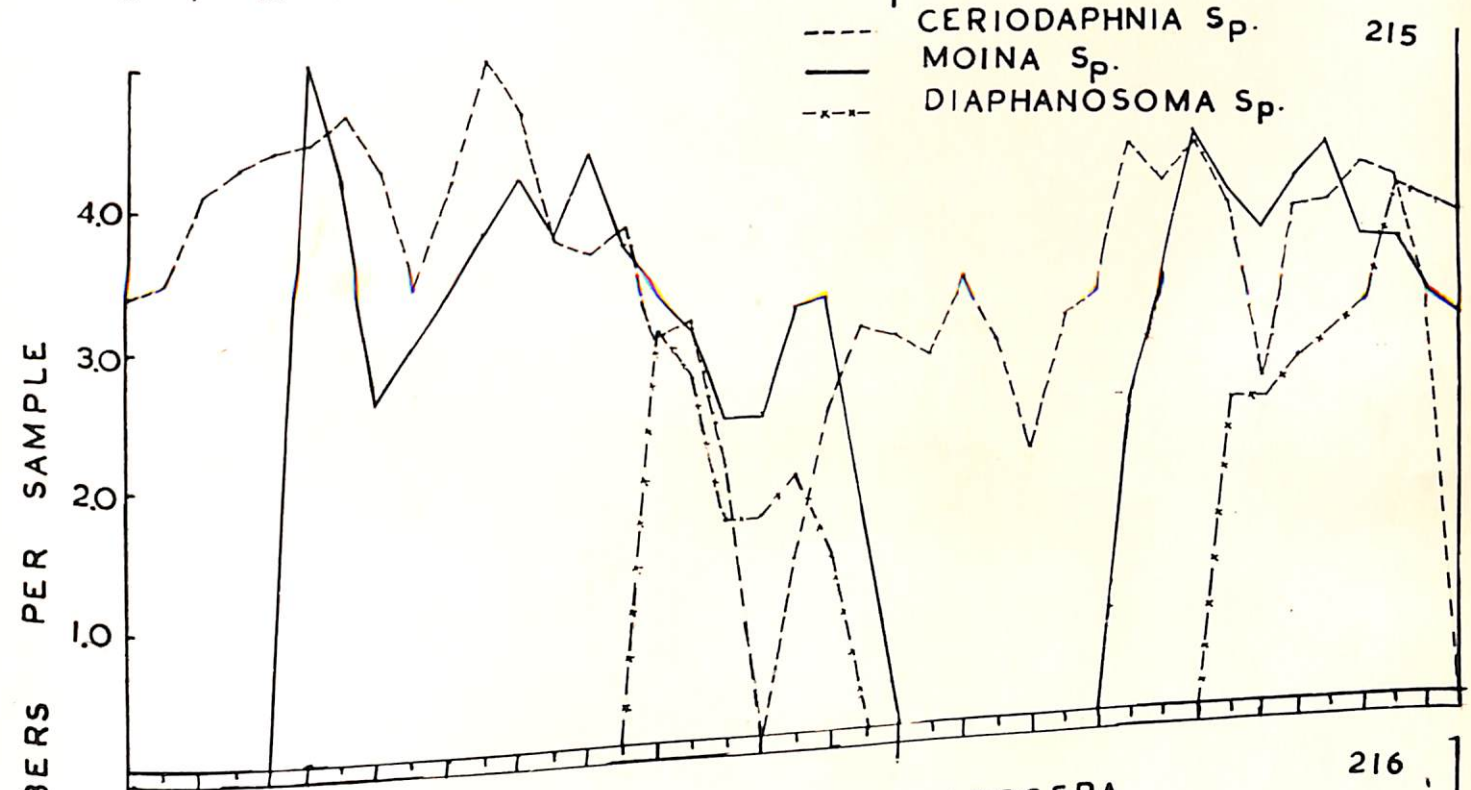
PLATE XVII Figures 214 to 216

214. Seasonal occurrence of Filinia opoliensis and F.longiseta in Pilani Tank.

215. Seasonal occurrence of Ceriodaphnia cornuta, Moina brachiata and Diaphanosoma excisum in Pilani Tank.

216. Fortnightly variation in the number of Copepoda and Cladocera. (Pilani Tank.)


F. OPOLIENSIS
F. LONGISETA
1510
NUMBERS / SAMPLE
300
200
100
J F M A M J J A S O N D J F M A M J J A S


CERIODAPHNIA Sp.
MOINA Sp.
DIAPHANOSOMA Sp.
NUMBERS PER SAMPLE
4.0
3.0
2.0
1.0

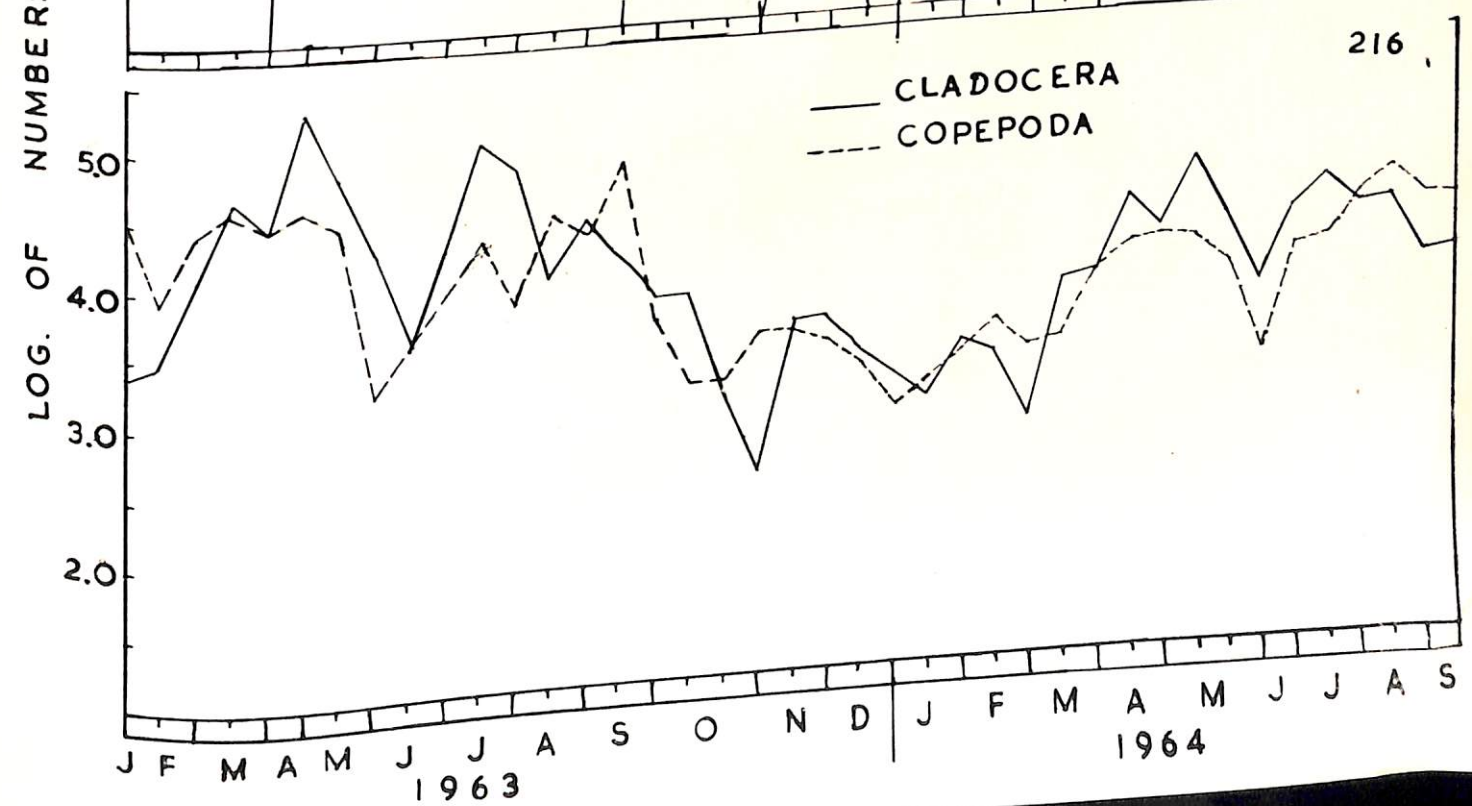

CLADOCERA
COPEPODA
LOG. OF NUMBERS
5.0
4.0
3.0
2.0
J F M A M J J A S O N D J F M A M J J A S
1963
1964

PLATE XVIII Figures 217 to 222

217. Monthly variation in the percentage of Crustacea (of the total zooplankton) of Khetri Lake.

218. Seasonal occurrence of Moina brachiata. (College Pond)

219. Monthly variation in the temperature and total zooplankton of Khetri Lake.

220. Percentage composition of Crustacean zooplankton of Khetri Lake; each group is plotted as a percentage of total zooplankton.

221. Seasonal occurrence of Moina brachiata and Ceriodaphnia cornuta. (Khetri Lake.)

222. Seasonal variation in the Copepoda and Cladocera population. (Khetri Lake.)

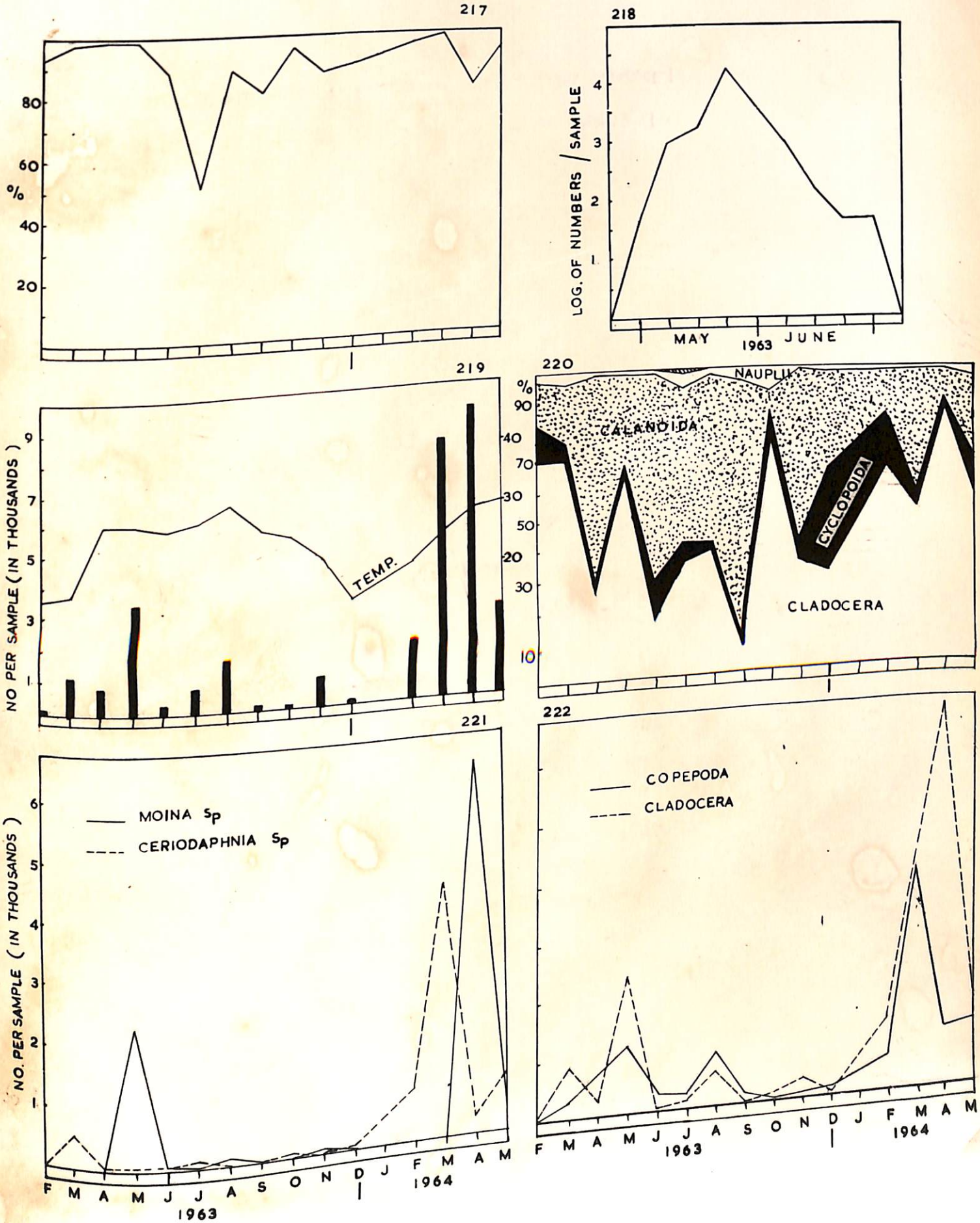

217
80
60
%
40
20
218
LOG. OF NUMBERS / SAMPLE
4
3
2
1
MAY
1963
JUNE
219
NO PER SAMPLE (IN THOUSANDS)
9
7
5
3
1
TEMP.
220
%
90
70
50
30
10
40
30
20
NAUPLII
CALANOIDA
CYCLOPOIDA
CLADOCERA
221
NO. PER SAMPLE (IN THOUSANDS)
6
5
4
3
2
1
MOINA Sp
CERIODAPHNIA Sp
F M A M J J A S O N D J F M A M
1963
1964
222
COPEPODA
CLADOCERA
F M A M J J A S O N D J F M A M
1963
1964

PLATE XIX Figures 223 to 225.

223. Seasonal occurrence of Keratella tropica (Pilani Tank).

224. Percentage composition of Crustacean zooplankton of Pilani tank; each group is plotted as a percentage of total zooplankton.

225. Monthly variation in the percentage of Crustacea (of the total zooplankton) of Pilani Tank.

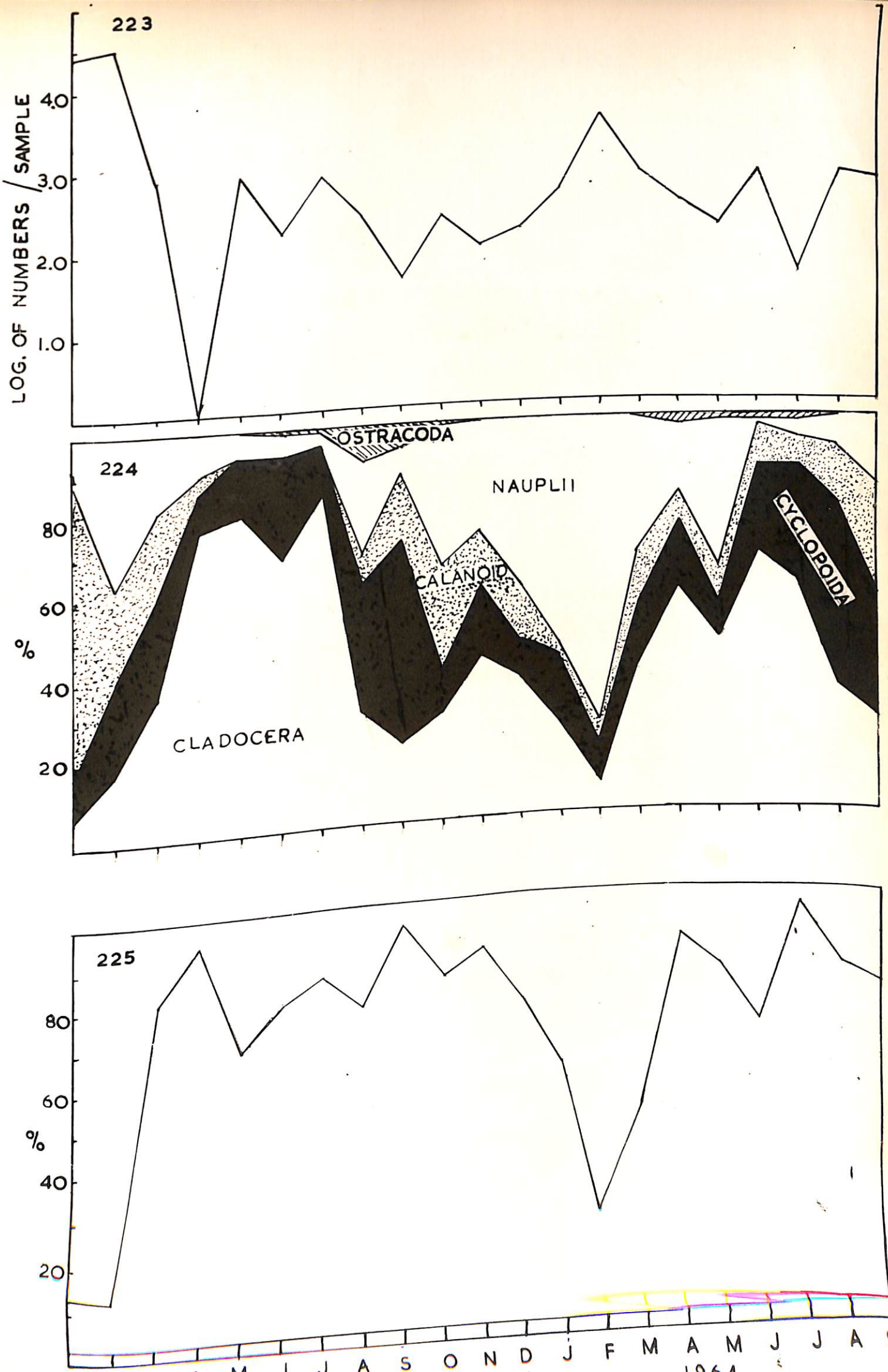
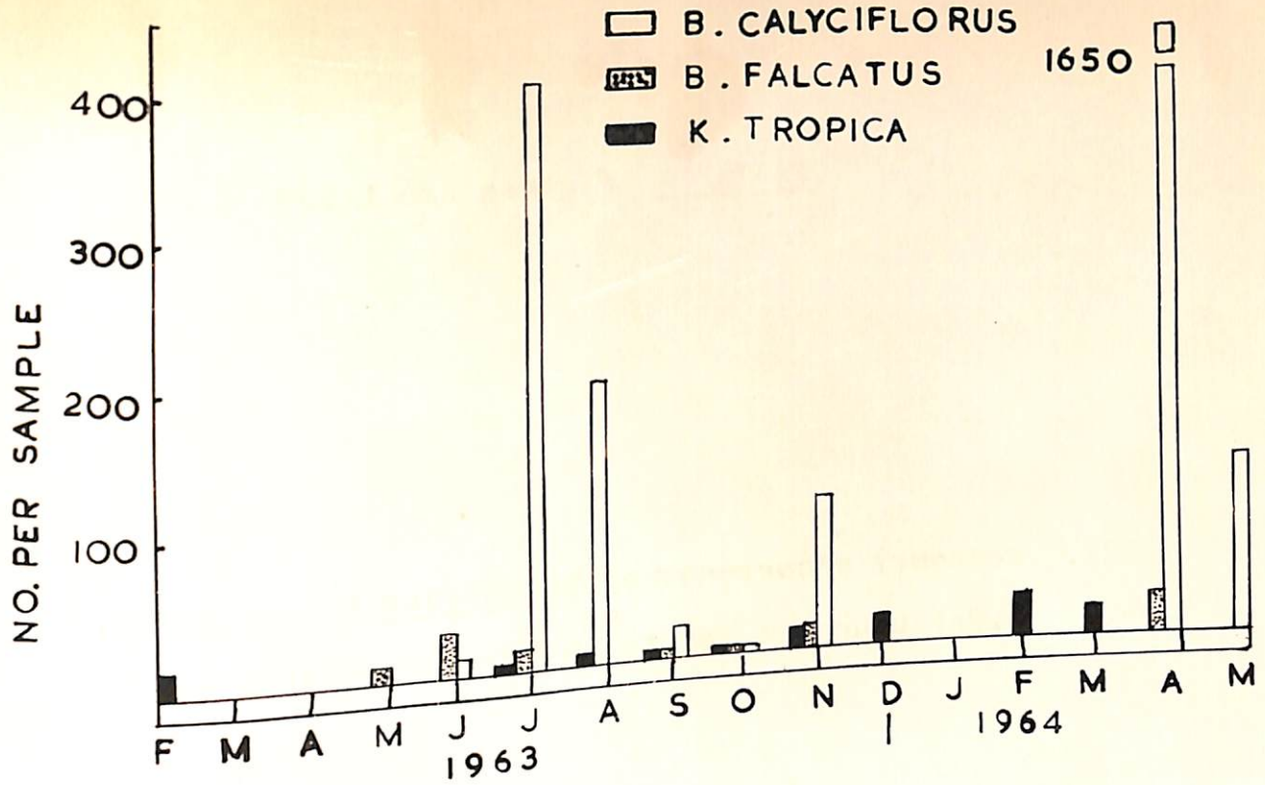
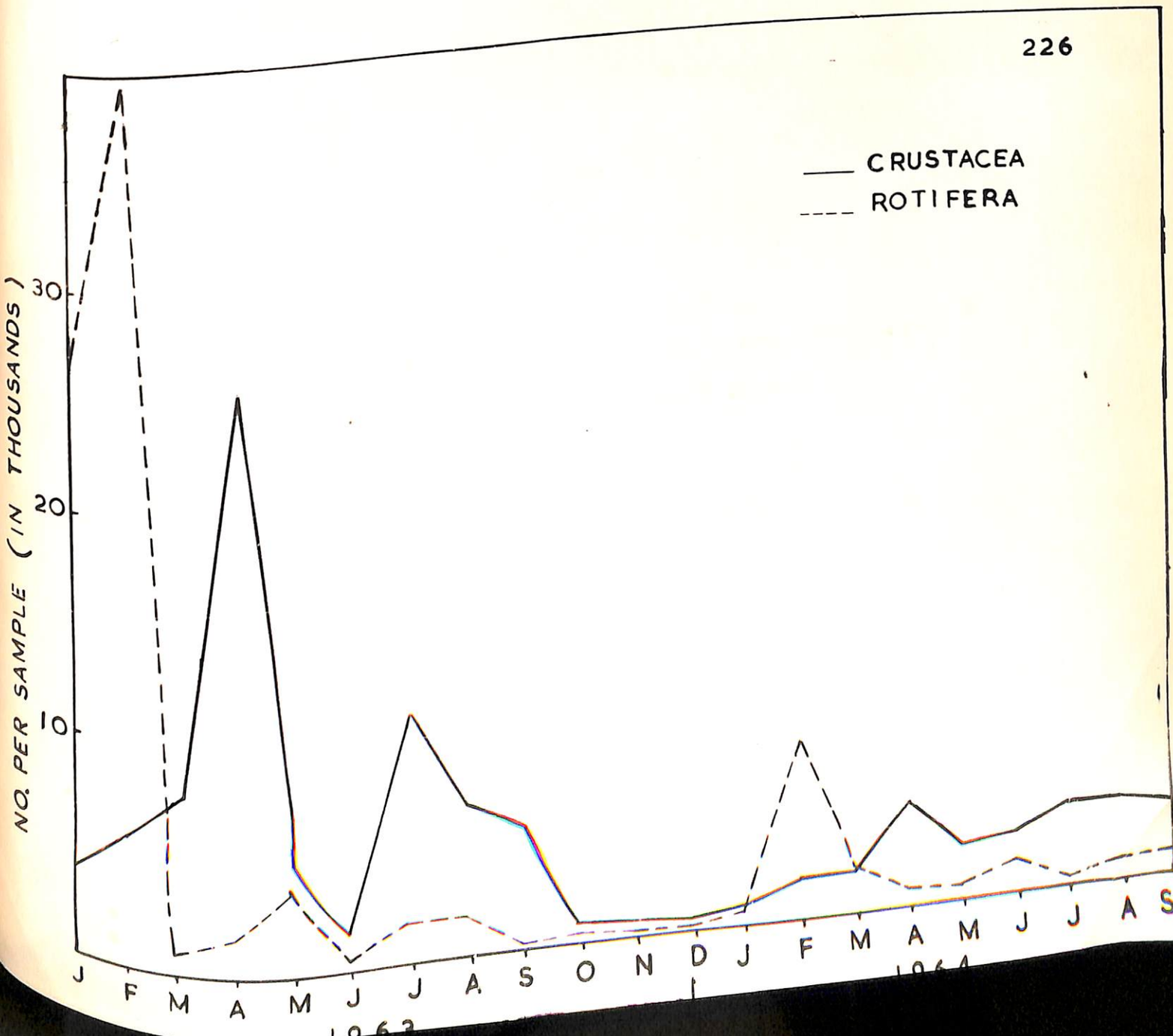

223
LOG. OF NUMBERS / SAMPLE
4.0
3.0
2.0
1.0
224
OSTRACODA
NAUPLII
CALANOID
CYCLOPOIDA
CLADOCERA
%
80
60
40
20
225
%
80
60
40
20
J F M A M J J A S O N D J F M A M J J A S
1964

PLATE XX Figures 226 & 227

227. Seasonal occurrence of Brachionus calyciflorus, B.falcutus and Keratella tropica (Khetri Lake).

226. Relative abundance of Crustacea and Rotifera of Pilani Tank.


B. CALYCIFLORUS
B. FALCATUS
K. TROPICA
1650
NO. PER SAMPLE
400
300
200
100
F M A M J J A S O N D J F M A M
1963
1964


CRUSTACEA
ROTIFERA
NO. PER SAMPLE (IN THOUSANDS)
30
20
10
J F M A M J J A S O N D J F M A M J J A S
1963
1964

BAIRD, W. 1860b Description of a new species of Estheria from Nagpur, Central India. Proc.zool.Soc.London LXXI p.188.

BERZINS, BRUNO. 1953 Zur kenntnis der Rotatorien aus West-Australien. Lunds Univ. Arsskrift No.4 : 1-12.

_____ 1954a Zur Rotatorienfauna Siziliens. Hydrobiologia Vol.VI (3-4) : 309-320.

_____ 1954b Nomenkclatorische Bemerkungen an einingen planktischen Rotatorien Arten aus der Gattung Keratella. Hydrobiologia VI (3-4) : 321-327.

_____ 1955 Taxonomie und Verbreitung von Keratella und verwendten Formen. Ark. Zoöl. VIII (8) : 549-559.

_____ 1957 Beitrag zur Rotatorienfauna Gambiens. Acta Tropica XIV (3) : 230-235.

_____ 1960 Neue Rotatorien aus Madagasker Mem. de L'Institut Scientfique de Madagaskar serrie A-Tome XIV : 1-6.

_____ 1961a Rotatoria - Contribution a b'etude de la fauna d'Afghanistan. 23. K.Fysiogr.Sallskapets i Lund Forhandl 31 : 5-16.

_____ 1961b New Rotatoria (Rotifera) from Victoria, Australia. Proc.Roy.Soc.Victoria vol.74 Pt.1:83-86.

_____ 1961 Revision der Gattung Anuraeopsis Lauterborn (Rotatoria). Kungl. Fysiogr. Sallskapets i Lund Forhandl 32 (5) : 33-47.

_____ 1963 Two new Keratella, Rotatoria from Australia. Hydrobiologia 21 (3/4) : 380-383.

*BIRGE, E.A. 1898 Plankton studies on Lake Mendota II. Crustacea of plankton from July 1894 to Dec.1896. Trans. Wis. Acad. 11 : 274-448.

BISWAS, S 1964 A new species of the cladocaran genus Latona Straus 1820 from Rajasthan, India. Proc. zool. Soc. Calcutta 17: 149-152.

BOND, B. 1934 Report on Phyllopod Crustacea (Anostraca, Notostraca and Conchostraca) including a revision of the Anostraca of the Indian Empire. Mem.Conn.Acad.Arts.Sci. 10 : 29-62.

BOSE, B. 1956 Observations on the hydrology of the Hooghly estuary. Ind.J.Fish. 3 : 101-118.

BREHM, V. 1950 Contribution to the freshwater fauna of India. Rec.Ind.Mus.XLVIII (1) : 9-28.

BROOKS, J.L. 1959 Cladocera: in Ward & Whipple, Fresh-Water Biology, pp.587-656.

*BROWN, L.A. 1929 Natural History of Cladocerans in relation to temperature. I. Distribution and temperature limits for vital activities. Amer.Natur. 63 (686) : 248-264.

CALMAN, W.T. 1909 Crustacea. Third Fascicle Part VII in: Lankester, Treatise of Zoology. A. and C. Black, London.

CHACKO, P.I. 1950 Occurrence of the fairy shrimp. Apus in a temple tank in Tirunelveli District, Madras. J.Bombay Nat.Hist.Soc. vol.49(3/4):571.

CHAKRABARTY, R.D., P. ROY, and S.B. SINGH 1960 A quantitative study of the plankton and the physicochemical conditions of the River Jamuna at Allahabad in 1954-55 Ind. J. Fish. 6(1) : 186-203.

DADAY DE DEES 1908 Entomostraca et Hydrachnidae E Tibet Rec.Ind.Mus. vol.II Pt.4 : 323-341.

DAS, S.M., and SRIVASTAVA, V.K. 1956a Quantitative studies on freshwater plankton I.Plankton of a fish tank in Lucknow, India. Proc.Natl.Acad.Sci.India (B) 26(2):85-92.

——— 1956b Some new observations on the plankton from freshwater ponds and tanks of Lucknow. Sci. and Culture. 21 (8) : 466-467.

DAVIS, CHARLES C 1955 The marine and freshwater plankton XI 562 Michigan State Univ.Press.

DEVASUNDARAM, M.P. and J.C. ROY 1954 A preliminary study of the plankton of the Chilka Lake for the years 1950 and 1951. Indo-Pacific Fish.Counc.Proc.Sect.II (5) : 48-54.

DUTTA, N., MALHOTRA, J.C. and BOSE, B.B. 1954 Hydrology and seasonal fluctuations of the plankton in the Hooghly estuary. Indo=Pacific Fish.Counc.Proc.II(5):35-47.

EDMONDSON, W.T. 1959 (edited by) Fresh Water Biology (second edition) by Ward, H.B. and Whipple, G.C. XX 1248
John Wiley and Sons; Inc. New York.

_____ 1960 Reproductive rates of rotifers in natural populations.
Mem.Inst.Ital.Idrobiol., 12 : 21-77.

_____ 1965 Reproductive rate of planktonic rotifers as related to food and temperature in nature.
Ecol.Monograph. 35 : 61-111.

Edmondson, W.T., COMITA, G.W., and ANDERSON, G.C. 1962 Reproductive rate of Copepods in nature and its relation to phytoplankton population.
Ecol. 43 (4) : 625-634.

EDMONDSON, W.T. and HUTCHINSON, G.L. 1934 Yale North India Expedition. Article IX Report on Rotatoria.
Mem.Conn.Acad.Arts.Sci.10 : 153-186.

GALLAGHER, JOHN J. 1957 Generic classification of the Rotifera
Proc.Pennsylvania Acad.Sci. 31 : 182-187.

_____ 1957b Cyclomorphosis in the rotifer Keratella cochlearis (Gosse)
Trans. Amer.micro.Soc. 76 : 197-203.

* GAUTHIER, H 1939 Contribution a l'etude La Faune Dulcaquicole de la Region du Tcd
Bull Inst Fraca Afr noire 1, 110-244.

GEORGE, M.G. 1961a Observations on the rotifers from shallow ponds in Delhi.
Curr.Sci. 30 : 268-269.

_____ 1961b Diurnal variations in Two shallow ponds in Delhi, India.
Hydrobiologia XVIII (3) : 265-273.

GEORGE MICHAEL R. 1962 Seasonal events in a natural population of the cladoceran Ceriodaphnia cornuta Sars and observations on its life cycle.
J.zool.Soc.India 14 : 211-218.

GEORGE, M.J. 1958 Observations on the plankton of the Cochin backwaters.
Indian J. Fish. V (2) : 375- 401.

GREEN, J. 1954 Size and reproduction of Daphnia magna (Crustacea : Cladocera)
Proc. Zool. Soc. London 124 : 535-545.

_____ 1956 Growth size and reproduction in Daphnia (Crustacea : Cladocera)
Proc.zool.Soc.London 126 : 173-204.

GREEN, J. 1960 Zooplankton of the River Sokoto. The Rotifera. Proc.zool.soc.London 135 : 491-523.

_____ 1962 Zooplankton of the River Sokoto. The Crustacea. Proc.zool.Soc.London 138 : 415-453.

_____ 1963 Seasonal polymorphism in Scapholeberis mucronata (O.F.Muller) (Crustacea: Cladocera). J.Anim.Ecol. 32 : 425-439.

_____ 1965 Zooplankton of Lake Mutanda, Bunyonye and Mulehe. Proc.zool.Soc.London.144 (3): 383-402.

GURNEY, R. 1906 On some freshwater entomostraca in the collection of the Indian Museum. Jour.Proc.Asiatic Soc.Bengal 11(7):273-281.

_____ 1907 Further notes on Indian freshwater entomostraca. Rec.Ind.Mus. I (1) : 21-33.

_____ 1920 List of entomostraca collected in Seistan and the Baluch Desert. Rec.Ind. Mus. XVIII (3) : 145-146.

_____ 1921 Freshwater Crustacea collected by Dr. P.A. Duxton in Mesopotamia and Persia. J.Bombay Nat.Hist.Soc. 27(4) : 835-843.

_____ 1925 Apus asiaticus Gurney Rec.Ind.Mus. XXVII : 440.

HAMMERTON, D. 1964 Hydrobiological research in the Sudan 12th annual symposium Sudan. Philosophical Society, 181-204.

HARDING, J.P. 1941 A key to the British freshwater Cladocera with notes on their ecology. Freshwat.Biol.Ass.of Brit.Emp.Scient. Publ. No.5 pp.1-50.

_____ 1955 The Percy Sladen Trust Expedition to Lake Titicaca in 1937 XIX Crustacea:Cladocera Trans.Linn.Soc.Lond. (3) 1 : 331-354.

_____ 1957a The South African cladoceran Euryalona coletti (Sars) and another African species. Ann. S. Afr. Mus. 43 : 245-247.

_____ 1957b Crustacea : Cladocera. Res.Sci.Explor.Hydrobiol.Lac Tanganika 3 : 55-89.

*HARDING, H.K. 1913 Synopsis of the Rotatoria. Bull.U.S.Natl.Museum, 81 : 1-226.

HARDING, H.K. and MYERS, F.J. 1922 The Rotifer fauna of Wisconsin I Trans.Wis.Acad.Sci.Arts.Let. 20:553-662.

_____ 1924 The Rotifer fauna of Wisconsin II Ibid. 21:415-549.

_____ 1926 The Rotifer fauna of Wisconsin III Ibid. 22 : 315-423.

_____ 1928 The Rotifer fauna of Wisconsin IV Ibid. 23 : 667-803.

HAUER, J. 1963 Zur kenntnis der Radertiere (Rotatoria) von Agypten. Arch.Hydrobiol. 59(2) : 162-195.

HENRY, M. 1922 A monograph of the freshwater Entomostraca of new South Wales. I. Cladocera. Proc.Linn.Soc.N.S.W. 47 : 26-52.

HOLSINGER,E.C.T. 1955 The distribution and periodicity of the phytoplankton of three Ceylon lakes. Hydrobiologia 7(1-2) : 25-35.

*HUDSON, C.T. and GOSSE, P.H. 1886 The Rotifera, or Wheel-animalcules, both British and foreign, 2 Vols. Longmans, Green, London.

HYMAN, L.H. 1951 The Invertebrates III pp.59-151 McGraw-Hill Book Company, Inc.

JENNINGS, H.S. 1900 Rotatoria of the United States, with special reference to those of the Great Lakes. Bull.U.S. Fish.Comm.Wash. 19 : 67-104.

JOHNSON, D.S. 1952a The British species of the genus Daphnia (Crustacea:Cladocera) Proc.zool.Soc.London 122:435-462.

_____ 1952b A thermal race of Daphnia atkinsoni Baird and its distributional significance. J.Anim.Ecol. 21 (1) : 118-119.

_____ 'Water fleas' pp.1-19.

_____ 1954 Systematic and ecological notes on the Cladocera of Lake Toba and the surrounding country, North Sumatra. Linn.Soc.Jour.Zool. XLIII (289) : 72-91.

KARANDE, A.A. and N.B. INAMDAR 1959 Observations on the taxonomic characters of Triops orientalis (Tiwari) with a note on its Biology. J.Bombay Nat.Hist.Soc. 56(1) : 215-225.

_____ 1960 A new species of the genus Leptestheriell from India. Ann.Mag.Nat.Hist. 2(17) : 305-308.

_____ 1961 Some observations on the biology of the conchostracan branchiopod (Crustacea) Leptestheriella gigas Karande & Inamdar. J.Bombay Nat.Hist.Soc. 58(1) : 92-99.

KLIMOWICZ, H. 1964 Rotifers of "astatic waters". Part I. The littoral of Lake Kisajno. Polskie Archiwum Hydrobiologii,Tom.XII(XX Nr.2 : 279-305.

*KOFOID, C.A. 1908 Planktonstudies V. The plankton of the Illinois River 1894-1899 Part II. Constituent Organisms&their seasonal distribution. Bull.III. State Lab.Nat.Hist.8(1):1-361.

KOMAROVSKY, B. 1959 The plankton of Lake Tiberias. Bull.No.25 Sea Fisheries Research Station, Division of Fisheries, Ministry of Agricu Israel State.

KRISHNA, DAYA and INDER CHAND BAID 1958 Studies on the population of Artemia salin of the Sambhar Lake, Rajasthan. Proc.Natl.Acad.Sci.India.Sect.B 28(6):416-

KRISHNAMOORTHY,K.P. 1965 Survival of a daphnid (Moina dubia Gurney and Richard) in different oxygen content levels. Proc.Ind.Acad.Sci. LXI (2) : 90-97.

MATHUR,S.N. and SIDHU, N.S. 1957 Occurrence of Apus (Crustacea:Notostraca) in Pilani, Rajasthan. J.Bombay Nat.Hist.Soc. 54 : 961-962.

MURRAY, J. 1906 Some Rotifera of the Sikkim Himalaya. J.R.Micr.Soc.London (Ser.2) 9 : 259.

MYERS, F.J. 1930 The Rotifer fauna of Wisconsin V Trans.Wis.Acad.Sci. Arts Let.25:353-413.

NAYAR, C.K.G. 1964 Morphometric studies on the Rotifer Brachionus calyciflorus Pallas. Curr.Sci. 33 (15) : 469-470.

NAYAR,C.K.G. 1965a Three new species of Conchostraca (Branchiopoda:Crustacea) from Rajasthan. Bull.Syst.Zool. 1 (1) : 18-23.

NAYAR, C.K.G. 1965b Cyclomorphosis of Brachionus calyciflorus Pallas.
Hydrobiologia XXV (3-4) : 538-544.

_____ 1965c Taxonomic notes on the Indian species of Keratella (Rotifera)
Hydrobiologia (In press).

ODUM, E.P. 1959 Fundamentals of ecology. XVII 546.
W.B.Saunders U.S. (Revised 1963).

*PACAUD, A. 1939 Contribution a 1'Ecologie des Cladoceres.
Supplement XXV.
Bull.Biol.de France et de Belgique 1-260.

PASHA, S.M.K. 1961 On a collection of freshwater retifers from Madras.
J.zool.Soc.India. XIII (1) : 50-55.

PEJLER, BIRGER 1957a Taxonomical and ecological studies on planktonic Rotatoria from Northern Swedish Lapland.
K.Svenska Ventenskapsakad.Handl.6(5):1-68.

_____ 1957b Taxonomic and ecological studies on planktonic Rotatoria from Central Sweden.
K.Svenska Vetenkapsakad.Handl.6(7):1-52.

_____ 1957c On variation and evolution in planktonic Rotatoria.
Zool.Bidrag.Uppsala. 32 : 2-66.

_____ 1962a On the taxonomy and ecology of benthic and Periphytic Rotatoria.
Zoologiska Bidrag. Fran Uppsala, Band 33 p.307-319.

_____ 1962b Taxonomic notes on some planktic freshwater rotifers.
Zoologiska Bidrag Fran Uppsala, Band 35 pp.307-319.

_____ 1965 Regional-ecological studies of Swedish freshwater zooplankton.
Zoologiska Bidrag Fran Uppsala, Band 36:4 pp.407-515.

*PETERSON, W. 1926 Seasonal succession of animals in a Chara cattail pond.
Ecology 7 : 371-377.

PRATT, H.S. 1935 A manual of the common Invertebrate animals.
Blackiston's Son & Co;,Inc. XVII - 852.

RAY, H. 1955 Plankton ecology of the River Hooghly W.Bengal.
Ecology. 36(2) : 169-175.

*REMANE, A. 1929 Rotatoria
In:Die Tierwelt der Nord-und Ostsee.
Viie : 1-156.

RICKER, W.E. 1937 Seasonal and annual variations in quantity of pelagic net plankton, Cultus Lake, British Columbia.
Jour.Fish Res. Bd. Can. 4 : 33-47.

ROUSSELET, C. 1906 Contributions to our knowledge of the Rotifera of South Africa.
Jour.Royal.Micro.Soc.1906, pp.393-414.

RUSSELL, C.R. 1944 A new rotifer from New Zealand.
Jour. Roy.Micro.Soc. LXIV : 121-133.

——— 1947 Additions to the Rotatoria of New Zealand Part I
Trans.Roy.Soc. New Zealand 76(3):403-408.

——— 1949 Additions to the Rotatoria of New Zealand Part II.
Trans.Roy.Soc.New Zealand 77(3):351-354.

——— 1951 The Rotatoria of the Upper Still water Swamp.
Rec.Cant. Mus. V(5) : 245-251.

——— 1952 Additions to the Rotatoria of New Zealand Part IV.
Trans.Roy.Soc. New Zealand 80(1):59-62.

——— 1954 Additions to the Rotatoria of New Zealand Part VI.
ibid. 82 (2) : 461-463.

——— 1956 Some Rotifers from the Gold Coast.
Jour. West. African Sci. Assoc.2(2):139-144.

——— 1956 Some additions to the Rotatoria of the Chatham islands.
Rec. Cant. Mus. VII (1) : 51-53.

——— 1956 Some rotifers from the Fiorland District.
Ibid. VII (1) : 55-59.

——— 1957 Some rotifers from the South Pacific islands and Northern Australia.
Trans. Roy. Soc. New Zealand 84 (4) : 897-902.

RUSSELL, C.R. 1957 Additions to the Rotatoria of New Zealand Part VII.
Ibid. 84 (4) : 939-940.

——— 1958 Some rotifers from Malaya.
Ibid. 85 (3) : 433-437.

——— 1958 Some rotifers from Campbell Island.
Rec. Dominion Mus. 3(2) : 137-140.

——— 1959 Additions to the Rotatoria of New Zealand Part VIII.
Trans.Roy.Soc.New Zealand.87(1&2):69-73.

——— 1959 Rotifera - B.A.N.Z. Antaractic Research Expedition 1929-1931.
Vol.8 Pt.3 pp.83-87.

——— 1961 The Rotatoria of Quuensland, Australia.
Trans. Roy. Soc. New Zealand.
Vol. I No.17 pp.235-239.

——— 1962 Additions to the rotatoria of new Zealand Part IX.
Vol.I No.26 pp.337-341.

RZOSKA, JULIAN 1956 On the variability and status of the cladocera Ceriodaphnia cornuta and C.rigaudi.
Ann.and Mag. Nat.Hist.9(103) : 505-510.

——— 1961a Observations on tropical rainpools and general remarks on temporary waters.
Hydrobiologia XVII (4) : 265-286.

——— 1961b Some aspects of the hydrobiology of the River Nile.
Verh.Internat. Verein.Limnol. XIV: 505-507.

SAHA, K.C., SEN, D.P. and SENGUPTA 1959 Note on the biochemical stratification in pond fisheries and their productivity.
Sci. and Culture. 25 (3) : 216-218.

SARS, G.O. 1916 The freshwater Entomostraca of Cape Province. Part I Cladocera.
Ann. S. Afr. Mus. 15 : 303-351.

SCOURFIELD, D.J. and HARDING, J.P. 1941 A key to the British species of freshwater cladocera with notes on their ecology.
Freshwater Biol.Ass.Sci. Publ.5 1-50.

SHETTY, H.P.C. SAHA, S.B. and GHOSH, B.B. 1963 Observations on the distribution and fluctuations of plankton in the Hooghly-Maltah estuarine system;with notes on their relation to commercial fish landings.
Ind.J.Fish. VIII (2) : 326-363.

SIDHU, N.S. 1959 Identification of certain crustaceans collected from rain water pools near Pilani, Rajasthan. Jour.B.N.H.Soc. 1959 p.159.

SREENIVASAN, A.R R. SUNDER RAJ and KUMARI FELICY ANTONY 1964 Limnological studies of tropical impoundment II. Hydrological features and Plankton of Bhavanisagar Reservoir (Madras State) for 1961-63. Proc.Ind.Acad.Sci. LIX B(2) : 53-71.

TIWARI, K.K. 1951 Indian species of the genus Apus (Crustacea:Brachiopoda) with description of two new species. Rec.Ind.Mus. XLIX (2) : 197-206.

_____ 1959 Diagonosis of a new species of the genus Brachinella Sayce (Crustacea:Brachiopoda): Anostraca) from Sambhar Lake, Rajasthan. J.Bombay Nat.Hist.Soc. 55(3) : 585-588.

J

_____ 1962 New species of Conchostraca (Crustacea: Phyllopoda) from Rajasthan. Proc.1st All India Congr.Zool.Pt.2:180-190.

UPADHYAYA, M.P. 1963 Hydrobiological survey of Gujaratal, Jaunpur, India. LABDEW J.S.T. 1 : 1-6.

WARD, E.B. 1940 A seasonal population study of pond entomostraca in the Cincinnati region. Am.Midl.Nat. 23 : 635-691.

WELCH, P.S. 1935 Limnology (New edition 1952) McGraw Hill Book Co. Inc. New York and London.

---

* Papers not referred in original.

APPENDIX I

TABLE I — Khetri Lake

Physicochemical Qualities

Date	Time	Temp.	pH	Diss.02	Alkalinities		
					Total	Carbonate	Bicarbonate
5-2-63	11.30	18	8.05	11.6	187.5	50	137.5 ppm.
3-3-63	11.30	19	7.5	3.0	200	0	200
13-4-63	11.30	30	8.05	10.4	156.25	25	131.25
25-5-63	11.30	30	7.4	9.2	175	0	175
23-6-63	11.30	29	8.4	12.0	200	37.5	162.5
27-7-63	11.30	30	7.5	11.4	206.25	0	206.25
18-8-63	11.30	32.5	8.4	19.2	175	50	125
27-9-63	11.30	28	9.0	29.2	175	25	150
26-10-63	11.30	26.5	9.9	-	150	50	100
30-11-63	11.30	22.5	8.55	5.2	187.5	0	187.5
31-12-63	11.30	16	8.3	7.7	225	0	225
22-2-64	11.30	21	8.0	8.5	175	0	175
21-3-64	11.30	25	7.8	5.2	225	0	225
30-4-64	11.30	29	7.0	10.2	250	25	225
20-5-64	11.30	30	7.5	6.7	250	0	250

Temperature in degree Centigrade; Dissolved oxygen content and alkalinities in ppm.

TABLE II

Pilani Tank

Physicochemical qualities

Date	Time	Temp.	pH	Diss.02.	Alkalinities Total	Carbonate	Bicarbonate
22-1-63	11.15	12.5	8.05	6.8	162.5	0	162.5
62-2-63	11.00	16	7.5	10.0	162.5	0	162.5
19-2-63	10.00	18	8.35	9.8	162.5	25	137.5
5-3-63	10.20	20	8.3	8.8	162.5	12.5	150
19-3-63	10.15	22	8.35	8.8	162.5	12.5	150
2-4-63	10.15	24	8.15	9	187.5	37	150.5
16-4-63	9.15	25.5	7.85	6.4	175	0	175
14-5-63	9.30	28.5	8.9	13.6	175	75	100
29-5-63	9.00	29	7.7	10.2	200	75	125
12-6-63	9.10	28	8.5	8.4	-	-	-
27-6-63	9.30	32.5	9.6	14.4	187.5	50	137.5
9-7-63	10.15	32.5	9.5	15.2	200	75	125
23-7-63	9.30	31	8.8	16	187.5	37.5	150
8-8-63	9.30	29.5	7.2	3.2	150	0	150
20-8-63	9.45	30.5	7.9	10.0	100	0	100
6-9-63	10.15	29	7.3	5.6	87.5	0	87.5
18-9-63	10.15	29	7.75	14.4	100	0	100
2-10-63	9.30	27.5	8.9	15.2	125	0	125
14-10-63	9.30	26	8.2	14.4	137.5	0	137.5
30-10-63	9.45	23.5	7.9	-	150	0	150
	9.45	21.5	8.5	2.6	137.5	0	137.5

(Contd..)

TABLE II (Contd...)

Date	Time	Temp.	pH	Diss.02.	Alkalinities		
					Total	Carbonate	Bicarbonate
26-11-63	9.45	19	8.7	2.8	187.5	0	187.5
11-12-63	9.45	16	8.2	2.1	150	0	150
24-12-63	10.00	13	8.1	3.7	162.5	0	162.5
8-1-64	9.45	14	8.95	5.2	162.5	25	137.5
21-1-64	9.45	14	9.3	5	175	0	175
4-2-64	10.00	11	8.3	5.24	162.5	0	162.5
19-2-64	10.10	17.5	7.8	6.8	175	0	175
3-3-64	9.30	18	7.3	4.5	187.5	0	187.5
17-3-64	9.15	22.5	8.8	5.2	212.5	0	212.5
1-4-64	9.00	23.5	3.9	3.9	237.5	0	237.5
14-4-64	9.15	27	7	4.7	225	0	225
29-4-64	9.30	28	7.1	3.2	225	0	225
13-5-64	9.15	26	6.9	7.4	262.5	25	237.5
26-5-64	9.15	27	7.5	16.3	187.5	125	62.5
10-6-64	9.45	29	7.5	16	218.75	87.5	131.25
15-7-64	9.15	28	6.5	6	50	0	50
30-7-64	9.15	27	6.5	7.4	87.5	0	87.5
13-8-64	9.00	28.5	6	5.8	62.5	0	62.5
27-8-64	9.45	29	6.5	1.6	87.5	0	87.5
10-9-64	9.30	29.5	6.2	4.8	100	0	100

Temperature in degree Centigrade; Dissolved oxygen content and alkalinities in ppm.

TABLE III College Pond

Physicochemical Qualities

Date	Time	Temp.	pH	Diss.O2.	Alkalinities		
					Total	Carbonate	Bicarbonate
19-10-62	10.40	24	-	8.4	-	-	-
26-10-62	10.00	24	-	8.0	-	-	-
2-11-62	9.45	21.5	7.9	6.8	890	290	600
9-11-62	10.15	20.5	8.5	5.6	875	575	300
16-11-62	10.00	19	8.1	7.6	875	350	525
23-11-62	10.15	16	8.1	8.0	850	300	550
30-11-62	10.30	11	8.25	10.0	906	350	556
7-12-62	10.00	12.8	8.3	10.8	912.5	450	462.5
14-12-62	10.15	11	8.3	10.4	925	300	625
21-12-62	10.15	11	8.2	9.2	925	475	450
28-12-62	10.45	12	8.2	10.6	925	325	600
4-1-63	10.15	7	8.3	10.6	950	300	650
11-1-63	10.15	8	8.05	8.0	962.5	337.5	625
18-1-63	10.30	8.5	8.1	10.6	950	250	700
25-1-63	10.20	9.5	8.2	11.2	975	175	800
1-2-63	10.15	12	8.6	8	1006.2	250	756.2
8-2-63	10.10	14	8.4	7.4	1050	400	650
15-2-63	9.50	16.5	8.7	10.4	1075	525	550
22-2-63	10.45	17.5	8.95	6.2	1112.5	400	712.5
1-3-63	10.30	21	8.9	8.6	1106.25	662.5	443.75
8-3-63	10.15	22	8.95	10.6	1137.5	950.5	186.5

(Contd...)

TABLE III (Contd...)

Date	Time	Temp.	pH	Diss.O2.	Alkalinities Total	Carbonate	Bicarbonate
16-3-63	10.35	23.5	8.85	10.8	1175	650	525
22-3-63	9.35	23	8.5	12.6	1125	525	600
29-3-63	9.45	22.5	8.75	15.8	1168.7	550	618.7
5-4-63	10.15	25	8.6	12.6	1100	450	650
12-4-63	9.30	26	9.0	15.2	1062.5	375	687.5
19-4-63	10.15	25	9.6	7.2	-	-	-
26-4-63	10.00	25	9.15	8.2	-	-	-
3-5-63	9.30	27	10.5	13.6	-	-	-
10-5-63	9.30	25	8.7	7.2	-	-	-
17-5-63	9.10	27.5	9.15	2.4	1287.5	675	612.5
24-5-63	10.15	28	8.55	8.0	1375	950	425
31-5-63	9.00	28	9.0	9.0	1387.5	1050	337.5
7-6-63	8.30	30	8.75	14.8	-	-	-
14-6-63	8.30	29	9.5	8.8	1575	1325	250
21-6-63	8.30	27.5	9.35	-	1587.5	775	812.5
29-6-63	9.45	31	9.45	12.0	1500	825	675
5-7-63	9.30	30	10.0	11.2	1337.5	525	812.5
12-7-63	9.30	30	9.5	14.0	1262.5	600	662.5
19-7-63	9.30	29	8.3	12.6	1125	300	825
26-7-63	9.45	30	8.6	9.5	1212.5	775	437.5
2-8-63	9.20	29.5	9.25	12.4	1150	600	550
10-8-63	10.00	29.5	8.7	17.2	962	250	712
17-8-63	9.30	30.5	8.4	9.6	937.5	350	587.5

(Contd...)

TABLE III (Contd...)

Date	Time	Temp.	pH	Diss.O2.	Total Alkalinities	Carbonate	Bicarbonate
24-8-63	9.30	30.5	7.4	12.0	862.5	375	487.5
30-8-63	9.30	30.5	8.0	8.8	962.5	225	737.5
7-9-63	9.30	29.5	8.3	12.2	875	325	550
13-9-63	9.45	31.5	8.9	-	912.5	225	687.5
21-9-63	10.00	30.5	8.75	-	937.5	300	637.5
26-9-63	9 .20	27.5	9.45	-	950	400	550
5-10-63	9.45	27.5	10.9	-	975	200	775
11-10-63	9.30	26	9.8	-	987.5	300	687.5
10-10-63	9.00	23.5	9.1	-	975	300	675
25-10-63	9.30	24	9.1	-	975	350	625
2-11-63	9.30	22	8.4	7.34	975	300	675
7-11-63	9.30	21	9.0	5	1000	375	625
16-11-63	10.00	18.5	8.95	4.45	1012.5	400	612.5
22-11-63	9.30	18.5	9.0	2.88	1062.5	275	787.5
29-11-63	9.30	18.5	8.65	2.1	1062.5	125	937.5
6-12-63	9.45	12	7.3	2.34	1037.5	200	837.5
14-12-63	9.45	13.5	7.9	3.41	1050	125	925
21-12-63	9.45	11	7.55	5.5	962.5	50	912.5
27-12-63	10.00	9	7.6	6.29	1012.5	75	937.5
4-1-64	9.30	9.5	8.5	5.5	1012.5	75	937.5
10-1-64	9.00	14	8.05	6.03	975	100	875
18-1-64	9.45	8	8.35	6.8	950	250	700
24-1-64	9.30	9	8.1	6.8	950	175	775

(Contd...)

TABLE III (Contd...)

Date	Time	Temp.	pH	Diss.02	Total Alkalinities.	Carbonate	Bicarbonate
1-2-64	9.45	8	8.7	8.65	925	100	825
8-2-64	9.30	12	8.4	7.86	962.5	225	737.5
15-2-64	9.30	15	8.6	7.04	925	150	775
21-2-64	9.15	17	8.0	7.07	950	150	800
29-2-64	9.15	17	8.0	9.17	1000	250	750
6-3-64	9.30	20	8.0	7.07	987.5	250	737.5
13-3-64	9.20	20.5	8.6	3.41	1062.5	325	737.5
20-3-64	9.00	22	8.7	3.93	975	250	725
27-3-64	9.15	23	-	5.5	900	300	600
4-4-64	9.15	24.5	7.5	5.76	1212.5	325	887.5
11-4-64	9.30	25	8	5.5	1300	425	875
19-4-64	9.20	23	8	2.56	1412.5	400	1012.5
24-4-64	9.00	26	8.5	7.68	1287.5	525	762.5
1-5-64	9.10	25	8	1.28	1375	650	725
8-5-64	9.10	25	8.5	0.64	1450	700	750
16-5-64	9.15	27	9.0	2.24	1500	700	800
22-5-64	9.00	26	9.0	0.64	1550	600	950
29-5-64	9.00	27	9.0	1.60	1575	675	900
5-6-64	9.00	28.5	8.5	4.80	1650	800	850
13-6-64	9.00	29.5	9.0	15.68	1425	700	725
19-6-64	9.00	29.5	9.0	12.80	1462.5	750	712.5
27-6-64	9.15	31	8.5	7.36	1500	750	750
4-7-64	9.00	32	8.5	8	1500	800	700

(Contd...)

TABLE III (Contd...)

Date	Time	Temp.	pH	Diss.02	Alkalinities.		
					Total	Carbonate	Bicarbonate
10-7-64	9.00	30	7.5	4.48	1175	150	1025
17-7-64	9.15	30.5	7.5	16.0	812.5	225	587.5
25-7-64	9.30	30	7.5	4.16	937.5	250	687.5
31-7-64	10.00	31	7.5	13.76	837.5	225	612.5
6-8-64	9.00	32	7.75	9.6	912.5	250	662.5
14-8-64	10.00	31	7.3	5.76	925	375	550
28-8-64	10.15	29.5	8.5	-	800	425	375
5-9-64	10.30	31	7.5	-	950	400	550
11-9-64	9.20	29.5	7.0	-	962.5	375	587.5
19-9-64	10.00	31	8.0	-	987.5	275	712.5

Temperature in degree Centigrade; Dissolved oxygen content and alkalinities in ppm.