STUDIES ON FRESHWATER CLADOCERA

Thesis Submitted to the University of Calicut
for the award of the Degree of

Doctor of Philosophy in Zoology

By

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May 2000

DECLARATION

This is to certify that the contents included in my thesis entitled "Studies on Freshwater Cladocera" is my original work and that it has not been formed the basis for the award of any degree/diploma.

Date: 03/05/2000.

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Certified that the thesis entitled "Studies on Freshwater Cladocera" submitted by Shri.K. K. Subhash Babu is an original piece of work based on studies by him under my supervision and guidance in the Department of Zoology of Christ College, Irinjalakuda.

I also certify that no parts of this thesis have been submitted to any other organisation for the award of any degree/diploma.

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I am forwarding herewith the thesis "Studies on freshwater Cladocera" for evaluation and award of the Degree of Doctor of Philosophy under the faculty of sciences of the University of Calicut. Sri. K.K. Subhash Babu has worked in the Dept. of Zoology, Christ College, Under the guidance of Dr. C.K. Gopinathan Nayar.

Date: 05.05.2000

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K.K. SUBHASH BABU.

CONTENTS

GENERAL INTRODUCTION

K. K. Subhash Babu “Studies on freshwater Cladocera ” Thesis. Department of Zoology, Christ college Irinjalakuda , University of Calicut, 2000

Chapter-1

GENERAL INTRODUCTION

GENERAL INTRODUCTION

Cladocerans, commonly known as 'water fleas' form an important microcrustacean group in freshwater habitats. They occur everywhere from Arctic to Antarctic, in temperate and tropical latitudes, in isolated ocean islands and in high mountain water bodies and in permanent and temporary waters. They are also reported from ground water (Dumont, 1987; Negrea *et al.* 1995), and even from tree trunks of extremely wet forest covered by moss (Frey, 1980). Usually cladocerans are more abundant in lentic environment than in lotic one. Majorty of species are inhabiting freshwater habitats but a few occur in brackish and marine waters. Most species are transparent or white; those found among weeds of littoral and benthic zones are darkly pigmented. Majorty of Cladocera are primarily filterfeeders whereas a few are predators.

Cladocerans are the favourite prey of many invertebrates and vertebrates. More over, they represent a very important group in the aquatic communities with regard to energy transfer along the food chain (Hutchinson, 1967). The significance of Cladocera as food for both fry and adult fishes was first investigated by Forbes (1893) and since then, the role has been investigated by many biologists.

The members of the group Cladocera generally show a size range of 0.2 to 4 mm in length. The body is laterally compressed and covered by bivalved carapace with a gap ventrally. The animal has a distinct head demarcated from the body by a cervical sinus. The most conspicuous structure on the head is the large single compound eye and ocellus. Head is often bent downward with a ventroposterior process-the rostrum. The head also bear a pair of small sensory antennules located ventrally near the rostrum. Originating from the posterior margin of the head is a pair of large biramous antenna that form the main swimming organ.

The body lies free with in the valves, divisible in to a thoracic region carrying 5 or 6 pairs of foliaceous appendages and suppressed postabdomen. However there is a prominent unsegmented postabdomen, which is bent forward and ends in two terminal

claws with lateral teeth or denticles. The postabdomen is used for cleaning debris from the appendages as well as to aid in locomotion especially in bottom living species.

The life cycle and reproduction of cladocerans are very interesting. During the greater period of the year most of the cladocerans reproduce parthenogenetically and population consists almost exclusively of females. The number of eggs / brood varies between 2 and 40 depending on the species and environmental conditions. Further development of the eggs takes place with in the brood chamber and the eggs hatch out into youngones similar to the adult. The juvenile passes through different instars by moulting before attaining maturity.

Under certain unfavorable environmental condition the parthenogenetic females resort to sexual cycle by producing eggs capable of being fertilized. Unlike parthenogenetic females these females need copulation with males. Males are generally smaller than females with large and modified antennules and postabdomen. The fertilized eggs pass into the brood chamber, the walls of which become thickened to form a special case called 'ephippium' around the egg and the female is called an ephippial female. The ephippium is shed along with the moulting of the animal and sinks to the bottom or float on the surface of water taking up an independent existence. The eggs in the ephippium are able to withstand extreme cold and dessication. In tropics, when the temporary water bodies dry up, the resting eggs remain dormant and hatch out into parthenogenetic females with the onset of favourable environmental conditions such as rain.

Studies on Cladocera being a vast subject, I have restricted my investigations to the studies on the systematics of the available species of cladocerans in the freshwater habitats of Kerala and to the biology of a few species. The State Kerala is rich with various types of freshwater bodies, ranging from rivers, lakes, reservoirs, ponds, irrigation canals, streams, wetlands (paddy fields), ditches and pools.

Relatively little is known about the species diversity, distribution and biology of freshwater Cladocera of Kerala State. Brehm, (1953) reported two marine species from Kerala waters based on collections obtained during the Yale-North India expedition. This was probably the first reported work from Kerala. Other significant work on freshwater Cladocera were Michael & Sharma, (1988) Raghunathan (1989) Thresiama *et al.*(1991) and Subhash Babu & C. K. G. Nayar (1993, 1997). The present study is dealt under two parts: Part-I Systematics & Faunistic study and Part-II Biology of 3 species namely *Moina micrura* Kurz; *Ceriodaphnia cornuta* Sars and *Simocephalus serrulatus* Koch, that are common in our locality.

PART-I
REVIEW OF LITERATURE

PART-I

SYSTEMATICS

Chapter-2

REVIEW OF LITERATURE

REVIEW OF LITERATURE ON INDIAN CLADOCERA

Our knowledge about Indian Cladocera starts with the work of Baird (1860) who described a new species *Daphnia newporty* Baird (= *Daphnia obtusa* Kurz) from a freshwater pool at Nagpur along with an anostracan *Streptocephalus dichotomus* Baird.

Gurney (1906) recorded 5 species of Cladocera from the collection of the Indian Museum. The collections were mainly from ponds and pools in Calcutta. The species described by him were

Daphnia fusca Gurney (= *Daphnia obtusa* Kurz)
Simosa elizabethae (King) (= *Simocephalus vetulus* O. F. Muller)
Ceriodaphnia rigaudi Richard (= *Ceriodaphnia cornuta* Sars)
Scapholeberis kingi Sars
Chydorus sphaericus (O. F. Muller)

In 1907 Gurney identified 18 species of Cladocera based on the collections from lower Bengal and Chota Nagpur. Of this, 14 species were new records to Indian lists. They were the following

Diaphanosoma sarsi Richard
Diaphanosoma sp.
Macrothrix triserialis Braday
Macrothrix ternicornis Braday
Macrothrix goeldi Richard
Ilyocryptus longiremis Sars (=*Ilyocryptus spinifer* Herrick)
Camptocercus australis Sars
Lynceus cambouei (De Guerne & Richard) (= *Alona cambouei* Guerne & Richard)
Lynceus guttata Sars (= *Alona guttata* Sars)
Leydigia australis Sars
Leydigia acanthocercoides Fischer
Alonella excisa (Fischer)
Chydorus globosus Baird
Dunhevedia crassa King

Daday (1911) reported one new species *Hyalodaphnia hypsicephala* from Bangalore, based on the collection sent by Dr. Annandale.

Arora (1931) reported 13 species of Cladocera including a new genus *Mediomoina* from sixty different ponds and pools at Lahore (now in Pakistan). The new genus *Mediomoina* had character of two genera viz. *Moina* Baird and *Moinodaphnia* Herrick. According to him new genus resembled *Moina daphnia* in having the body completely covered by the valve and in the presence of an abdominal process. However, the absence of ocellus, this genus agreed with *Moina* (Arora 1931, p. 72-73)

Sewell (1935) reported 11 species of Cladocera from Indian Museum tank, Calcutta during the period of 1929-1931.

Diaphanosoma excisum var. *longiremis* Ekman
Ceriodaphnia cornuta Sars
Simocephalus elizabethae (King) (= *Simocephalus vetulus* (O. F. Muller)
Moina dubia Guerney & Richard (= *Moina micrura* Kurz)
Ilyocryptus halyi Braday (= *Ilyocryptus spinifer* Herrick)
Dunhevedia crassa King
Alona protzi Hartwig
Allona guttata Sars
Kurzia longirostris (Daday)
Leydigia australis Sars.
Camptocercus macrourus Baird (= *Camptocercus lillijeborgi* Schoedler)

Brehm (1936) during the Yale-North India expedition reported 33 species of Cladocera from Punjab, Kashmir, Tibet, Nilgiri Hills and described 2 new species and one new variety. The new species described by him were *Alona ladacensis* Brehm and *Moina esau* Brehm (=*Moina macrocopa* (Straus) and new variety was *Daphnia crassa* var. *interrrupta*. He also reported one new genus *Drepanomacrothrix stsehelkanowzewi* (=*Macrothrix gronlandica* Lillijeborg) from Nilgiri Hills.

Brehm (1950) added 9 species of Cladocera to the Indian list from the collection of Indian Museum. They were

Diaphanosoma paucipinosum Brehm (=*Diaphanosoma exisum* Sars)

Daphnia carinata King

Daphnia lomholtzi Sars

Daphnia longispina O. F. Muller

Simocephalus vetulus O. F. Muller

Simocephalus vetuloides Sars

Ceriodaphnia rigaudi Richard (=*Ceriodaphnia cornuta* Sars)

Moina dubia Guerne & Richard (=*Moina micrura* Kurz)

Graptolebris testudinaria Fisher

Brehm (1952) described a new species *Diaphanosoma hydrocephalus* from Bombay.

Brehm (1953) reported 23 species of Cladocerans based on his wide spread collections from Nepal, Sikkim, W. Bengal, Maharashtra, Andrapradesh, Utter pradesh, Karnataka, Tamil Nadu, Kerala & Pondichery. He also enlisted 2 marine cladocerance viz. *Evadne tergestina* and *Penilia avirostris* from Cochin (Kerala) Malabar coast.

Gouder & Joseph (1961) recorded the presence of 4 species of Cladocera namely *Diaphanosoma* sp. *Daphnia longispina* O. F. Muller, *Ceriodaphnia rigaudi* Richard (=*Ceriodaphnia cornuta*) and *Moina rectirostris* Jurine (=*Moina micrura* Kurz) in the water bodies of Dharward (Karnataka-State).

Brehm (1963) reported *Bosminopsis deitersi* (Richard), *Moina ganapathi* Brehm (=*Moina macrocopa* (Straus) from Yamuna river, Delhi from the collection sent by Dr. S. V. Ganapathi.

Biswas (1964a) described one new species *Latona tiwari* from Rajasthan.

Biswas (1964b) reported 6 species belonged in to 3 genera based on the collection made by Swis Entomological Expedition in 1961 from NEFA. They were following

Daphnia carinata King

Daphnia pulex (De Geer)
Daphnia tibetana f. fusca Gurney
Daphnia obtusa kurz
Ceriodaphnia laticaudata P.E. Muller
Alona costata Sars

Biswas (1966) again reported one new species *Chydorus brehmi* Biswas (= *Chydorus ventricosus* Daday) from Rajasthan.

Petkovski (1966) reported the following 11 species of Cladocera, which included one new species *Indialona ganapathi* from Gujarat state based on the collections sent by Dr. S. V. Ganapathi.

Diaphanosoma sarsi Richard
Ceriodaphnia cornuta Sars
Dunhevedia crassa King
Chydorus barroisi (Richard) (= *Ephemeroporus barroisi* (Richard)
Chydorus ventricosus Daday
Alona rectangula Sars
Alona verrucosa Sars
Camptocercus rectirostris Sars
Leydigia acanthocercoide (Fischer)
Biapertura karua (King)
Indialona ganapathi (n.sp).

George (1966) during his studies on the comparative plankton ecology of fish tank in Delhi, enlisted the following 8 species of Cladocera
Simocephalus vetulus Schodler
Simocephalus serrulatus Koch
Ceriodaphnia rigaudi Richard (=*Ceriodaphnia cornuta* Sars)
Scapholeberis kingii Sars

Moina brachiata Jurine
Pleuroxus denticulatus Birge
Pleuroxus striatus Schodler
Chydorus sphaericus (O. F. Muller)

Michael (1968) reported the presence of 4 species of Cladocera during his studies on the zooplankton from a fishpond in Calcutta. They were
Diaphanosoma brachyurum (Lieven)
Ceriodaphnia cornuta Sars
Scapholeberis kingii Sars
Moina brachiata (Jurine)

Biswas (1971) reported 41 species, belonged in to 17 genera of Cladocera from Rajastan State. They were:
Latonopsis australis Sars
Latonopsis occidentalis Birge (= *Latonopsis australis* Sars)
Latona tiwari Biswas
Diaphanosoma sarsi Richard
Diaphanosoma excisum Sars
Diaphanosoma excisum var. *stingelini* Jenkin (= *Diaphanosoma excisum* Sars)
Diaphanosoma excisum var. *longiremis* Ekman (= *Diaphanosoma excisum* Sars)
Daphnia lumholtzi Sars
Daphnia hyaline Leydig (= *Daphnia carinata* King)
Ceriodaphnia reticulata var. *kurzi* Stingelin
Ceriodaphnia reticulata var. *serrata* Sars
Scapholeberis kingi (Sars)
Simocephalus vetulus (O.F.Muller)
Simocephalus elizabethae (King) (= *Simocephalus vetulus* (O.F.Muller)
Simocephalus australiensis Dana (= *Simocephalus exspinosus* (Koch)
Simocephalus latirostris Stingelin
Moina brachiata (Jurine)

Moina rectirostris (Leydig) (= *Moina micrura* Kurz)

Moina macrocopa (Straus)

Moina banyffi Daday (= *Moina macrocopa* (Straus)

Moina dubia Guerne & Richard (= *Moina micrura* Kurz)

Macrothrix triserialis Brady

Macrothrix chevreuxi Guerne & Richard (= *Macrothrix triserialis* Brady)

Macrothrix spinosa King

Gurneyella odiosa (Gurney) (= *Macrothrix odiosa* (Gurney)

Streblocerus serricaudatus (Fischer)

Ilyocryptus hayli Brady (= *Ilyocryptus spinifer* Herrick)

Pleuroxus aduncus (Jurine)

Dunhevedia crassa King

Chydorus reticulatus Daday

Chydorus brehmi Biswas (= *Chydorus ventricosus* Daday)

Chydorus robustus Stingelin (= *Chydorus parvus* (Daday)

Chydorus ventricosus Daday

Chydorus denticulatus Henry (= *Chydorus eurynotus* Sars)

Alolna rectangula Sars

Alona bukobensis Welter

Alona cambouei Guerne & Richard

Alona glabra Sars

Alona intermedia var. *minor* Stingelin

Leydigia acanthocercoides (Fischer)

Leydigia laevis Gurney.

Nayar (1971) also reported a total 17 species of Caldocera, which included one new species *Leydigia hardingi* sp. nov from Rajastan State.

Diaphanosoma excisum Sars

Daphnia lumholtzi Sars

Daphnia similis Claus

Ceriodaphnia reticulata (Jurine)

Ceriodaphnia cornuta Sars
Simocephalus vetulus Schodler
Moina brachiata (Jurine)
Macrothrix goeldi Richard
Alona pulchella King
Alona verrucosa Sars (= *Biapertura vrrucosa* Sars)
Alona rectangula Sars
Chydorus eurynotus Baird
Chydorus globosus Baird (= *Pseudochydorus globosus* (Baird)
Pleuroxus trigonellus (O.F. Muller)
Pleuroxus aduncus (Jurine)
Leydigia acanthocercoides (Fischer)
Leydigia hardingi sp. nov

Moitra and Mukherjee (1972) reported the following species of Cladocera in the plankton collections from a fishpond in Kalyani, W. Bengal
Macrothrix laticornis (jurine)
Bosmina longirostris (O. F. Muller)
Bosmina coregoni Baird
Alonella diaphana (king)
Chydorus sphaericus (O. F. Muller)
Ophryoxus gracilis Sars
Leptodora kindtii (Focke)

Michael (1973) recorded *Daphnia carinata* King; *Daphnia carinata* var *cephalata* King; *Daphnia lumholtzi* Sars and the presence of the genera *Diaphanosoma*; *Macrothrix*; *Ceriodaphnia*; *Moina;* S*imocephalus* and *Leydigia* from Madurai (Tamil Nadu).

Patil (1976) recorded 17 species of Cladocera included 13 genera from Meghalaya and Manipur. They were:
Diaphanosoma sarsi Richard
Ceriodaphnia cornuta Sars

Scapholeberis kingi (Sars)

Simocephalus exspinosus (Koch) -

Moina brachiata (Jurine)

Bosmina longirostris (O. F. Muller)

Macrothrix spinosa King

Streblocerus serricaudatus (Ficher)

Ilyocryptus hayli Brady (= *Ilyocryptus spinifer* Herrick)

Chydorus globosus Baird (= *Pseudochydorus globosus* (Baird)

Chydorus sphaericus (O. F. Muller)

Chydorus denticulatus Henry (= *Chydorus eurynotus* Sars)

Alona rectangula Sars

Alona costata Sars

Acroperus harpae (Baird)

Camptocercus rectirostris Schoedler

Biapertura affinis (Leydig)

Shirgur & Naik (1977) recorded one new species *Alona taraporevalae* from Bombay.

Nasar (1977) reported 11 species of Cladocera belonged in to 5 genera from Bhagalpur (Bihar).

Diaphanosoma sarsi Richard

Diaphanosoma excisum Sars

Diaphanosoma excisum var. *longiremis* Ekman

Daphnia lumholtzi Sars

Daphnia pulex (De Geer)

Daphnia carinata King

Simocephalus vetulus (O. F. Muller)

Simocephalus elizabethae (King)

Ceriodaphnia rigaudi Sars (= *C. cornuta* Sars)

Ceriodaphnia reticulata (jurine)

Moina dubia Guerne & Richard (= *Moina micrura* Kurz)

Yousuf & Qadri (1977) reported 7 species of Cladocera from Malpur Sar (Kashmir) They were following

Bosmina longirostris (O. F. Muller)

Pleuroxus similis Vavra

Alonella exigua (Lillijeborg)

Chydorus spaericus (O. F. Muller)

Alona rectangula Sars

Acroperous harpae (Baird)

Camptocercus australis Sars

Quadri & Yousuf (1978) reported 4 species belonged in to 4 genera from Beehama spring (Kashmir). They were:

Simocephalus elizabethae King (= *Simocephalus vetulus* (O. F. Muller)

Pleuroxus similis Vavra

Alonella exigua (Lillijeborg)

Chydorus sphaericus (O. F. Muller)

Sharma (1978) enlisted 34 species of Cladocera under 23 genera from W. Bengal region.

Diaphanosoma sarsi Richard

Diaphanosoma excisum Sars

Daphnia carinata King

Daphnia lumholtzi Sars

Ceriodaphnia cornuta Sars

Scapholeberis kingi (Sars)

Simocephalus vetulus (O. F. Muller)

Simocephalus exspinosus (Koch)

Moina micrura dubia Guerne & Richard

Moinodaphnia macleayi (King)

Bosmina longirostris (O. F. Muller)

Macrothrix goeldi Richard

Echinisca triserialis (Brady) (= *Macrothrix triserialis* Brady)

Ilyocryptus spinifer Herrick

Pleuroxus similis Vavra (= *Picripleuroxus similis* (Vavra)

Dunhevedia crassa King

Chydorus sphaericus (O. F. Muller)

Chydorus barroisi (Richard) (= *Ephemeroporus barroisi* (Richard)

Chydorus eurynotus Sars

Alona rectangula rectangula Sars

Alona rectangula richardi (Stingelin)

Alona davidi davidi Richard

Alona davidi punctata Daday

Alona pulchella Sars

Acroperus harpae (Baird)

Camptocercus rectirostris Scholder

Leydigia acathocercoides (Fischer)

Biapertura affinis (Leydig)

Biapertura karua (King)

Oxyurella singalensis (Sars)

Oxyurella tenuicaudis (Sars)

Kurzia longirostris (Daday)

Euryalona orientalis (Daday)

Indialona globulosa (Daday) (= *Notoalona globulosa* Daday)

Michael & Hann (1979) reported two species of Cladocera *Chydorus reticulatus* Daday and *Chydorus ventricosus* Daday from Trivandrum based on the collection made by Dr. D. G. Frey.

Battish (1981) reported 12 species of Cladocera belonged to the families Chydoridae and Macrothrixidae from Punjab. His lists included 3 new species

Alona dhilloni sp. nov

Comptocercus kapuri sp. nov

Ilyocryptus bhardwaj sp. nov

Venkataraman & Krishnaswamy (1984) reported *Diaphanosoma senegalensis* Gauthier from a pond at Madurai, Ramanad district. In the same year they reported several females and males of *Leydigia ciliata* Gauthier from a pond at Panjamali Hill near the Madurai Kamaraj University, Tamil Nadu.

Fernando & Kanduru (1984) enlisted 130 species of Cladocera from Indian subcontinent, which extending from 6° N to 37° N, based on their own collections from India and other published data from various authors. The work aimed to prove the hypothesis that the limnetic species less diverse in equatorial than temperate region.

Rane (1985a) reported a new species *Camptocercus latikae* from Madhya Pradesh. In the same year (1985b) he again reported another new species *Simocephalus surekhae* from Deotal, (M. P).

Igor Hudec (1987) reported one new *species Moina oryzae* from Tamil Nadu (S. India).

Sharma & Michael (1987) listed 93 species of freshwater Cladocera from India along with remarks on their biogeography.

Michael & Sharma (1988) recorded 90 species of cladocerans as a part of their monograph on Indian freshwater Cladocera. They reported 20 species from Kerala, on the basis of collections sent by Dr. C. K. G. Nayar & Dr. D. G. Frey. The following species were recorded from Kerala.

Pseudosida bidentata Herrick
Diaphanosoma exisum Sars
Ceriodaphnia cornuta Sars
Moina micrura Kurz
Moinodaphnia macleayi (King)
Bosminopsis deitersi Richard

Macrothrix laticornis (Jurine)

Echinisca triserialis (Braday) (=*Macrothrix triserialis* Braday)

Ilyocryptus spinifer Herrick

Alonella excisa (Fischer)

Chydorus parvus (Daday)

Chydorus cf. *herrmanni* Brehm

Chydorus barroisi Richard (=*Ephimeroporous barroisi* (Richard)

Chydorus ventricosus Daday

Chydorus reticulatus Daday

Dunhevedia crassa crassa King

Dadaya macrops (Daday)

Biapertura verrucosa (Sars)

Oxyurella singalensis (Daday)

Indialona globulosa (Daday) (= *Notolona globulosa* (Daday)

Patil & Gouder (1988) while making a detailed study of the cladoceran fauna reported 40 species from Dharward (Karnataka State), which included a new record *Graptolebris raphalis* Richard from India.

Raghunathan (1989) recorded occurrence of 11 species of Cladocera from Wynadu district, Kerala State. They were:

Diaphanosoma exicisum Sars

Diaphanosoma sarsi Richard

Ceriodaphnia cornuta Sars

Simocephalus acutirostratus King

Simocephalus vetulus (Müller)

Moina micrura Kurz

Macrothrix triserialis Brady

Chydorus ventricosus Daday

Chydorus reticulatus Daday

Alona costata Sars
Alona rectangula Sars

Rane & Jafri (1990) during the study of cladoceran fauna of Madhya Pradesh they repported the occurrence of a new species *Daphnia madhuriae* sp. nov

Battish (1992) reported 38 species of Cladocera belonging to 17 genera and 5 families, in his book entitled 'Freshwater Zooplankton of India'. Majorty of species was recorded from Punjab region.

Rane (1992) reported the occurrence of *Indialona ganapathi* Petkovski from Ujani wetland, Maharashtra and described the male and reproductive female.

Venkataraman (1992a) recorded 39 species of Cladocera from Keoladeo National Park and its environs, Bhartpur, of which, 25 species were recorded first time from Rajasthan.

Venkataraman (1992b) Recorded two more cladocerans viz. *Camptocercus* cf. *australis* Sars and *Indialona globulosa* (Daday) from Keoladeo National Park, Rajasthan.

Venkataraman (1993) recorded 5 species of Cladocera belonging to the family Sididae from Tamil Nadu and described the males of *Latonopsis australis* Sars and *Diaphanosoma excisum* Sars. The recorded female species of family Sididae were:
Latonopsis australis Sars
Pseudosida bidentata Herrick
Diaphanosoma excisum Sars
Diaphanosoma sarsi Richard
Diaphanosoma senegalensis (Gauthier)

Venkataraman (1994a) during the survey of the wet-land of Hughly district of W. Bengal, recorded a palaeartic cladoceran *Diaphanosoma brachyurum* (Lieven)

Venkataraman (1994b) during the study of zooplankton fauna of Tripura State, he repotred several females of *Echinisca capensis monodi* (Gauthier) from the littoral region of Gumti reservoir and several females of *Disparalona rostrata* (Koch) from a weedy pond of Somamura. These species were recorded first time from India.

Venkataraman & Das (1995) reported two species Cladocera viz. *Sida crystallina* (O. F. Müller) and *Acroperus harpae* (Baird) from the wetlands of Tripura.

Venkataraman (1995) described 16 species of male cladocerans from different parts of India and Andaman Nicobar Islands.

Murugan *et al.* (1998). They published a monograph entitled Cladocera. In which they described the taxonomy, biology and ecology of Indian freshwater Cladocera. Further more, added an identification key for all relevant species.

Venkataraman (1998) reported 3 species of Cladocera viz. *Alona cannellata Brehm*; *Alona pseudonodonta anodonta* Daday; *Alona holdeni* Green. The first two species were reported from Tamil Nadu and third from Keoladeo National Park, Rajasthan. All these three species were reported first time from India.

Venkataraman & Das (1998) reported *Chydorus faviformis* Birge from Kashipur Hoogla Jhill, Howrah district, W. Bengal.

PART-I
FAUNESTIC AND SYSTEMATIC STUDY

K. K. Subhash Babu “Studies on freshwater Cladocera ” Thesis. Department of Zoology, Christ college Irinjalakuda , University of Calicut, 2000

Chapter-3

FAUNESTIC AND SYSTEMATIC STUDY

INTRODUCTION

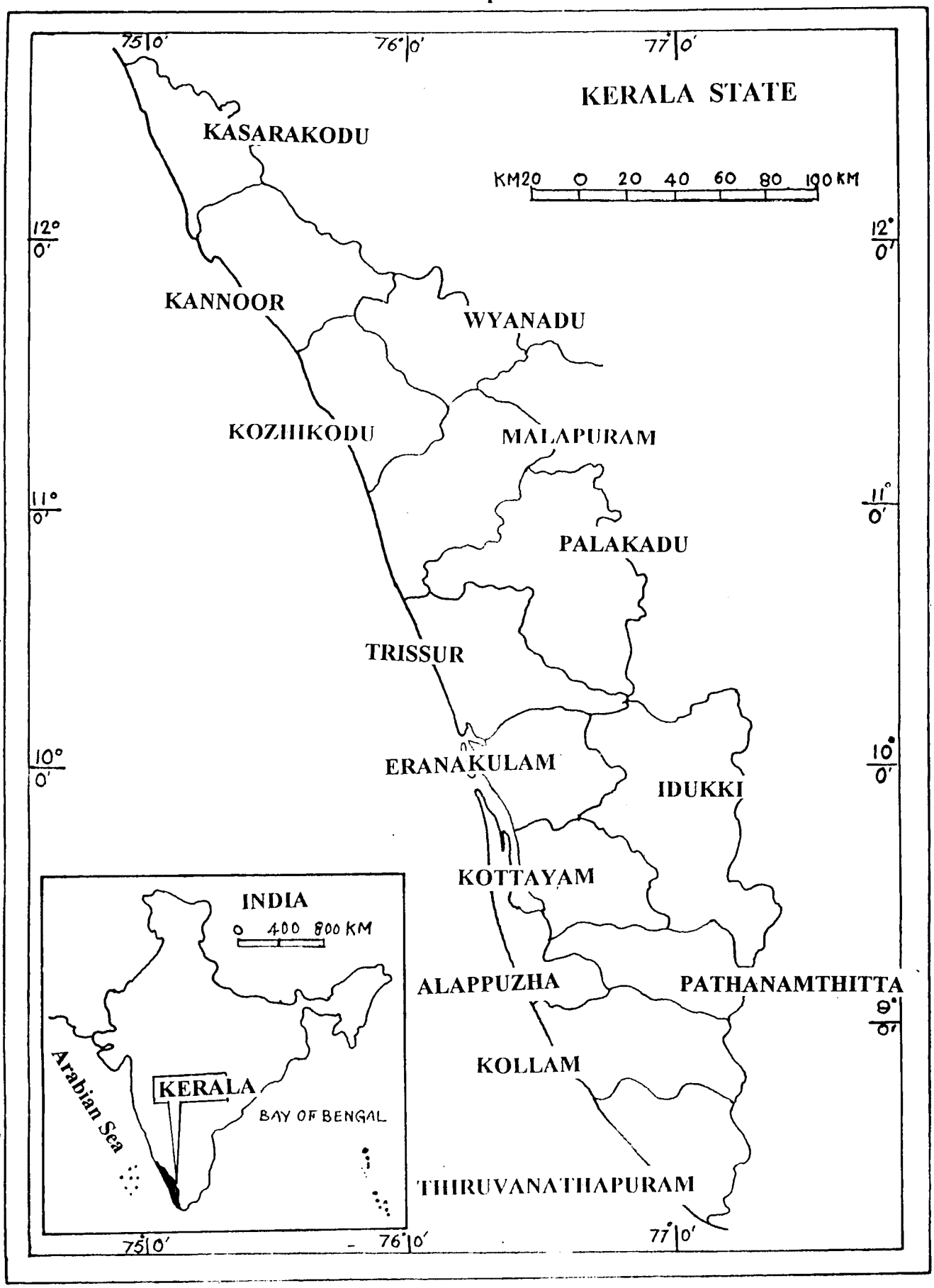
The organisms commonly called Cladocera are an artifical group of microcrustaceans. The group today is divided in to 4 orders, 11 families, about 80 genera and roughly 450 species (Dodson & Frey, 1991). Majorty of genera inhabiting freshwater while few genera like *Podon, Penilia & Evadne* are inhabiting marine habitat. In India normally the studies about freshwater Cladocera are related to pure limnological investigations, where as some of the studies were conducted only on state-wise level. Recentaly Michael & Sharma (1988) published a comprehensive systematic study on Indian Cladocera and reported 90 species including 20 species of Cladocera from Kerala. Furthermore, Brehm (1953) reported two marine species from Kerala State and Raghunathan (1989) reported 11 species from Wyanadu District-Kerala State. These are the main works so far recorded from Kerala region.

Due to lack of good literature on cladoceran taxonomy from Indian context, our limnologists often use Europen or N. American monographs for their identification of Indian fauna. Correct species identification usually is the first and important pre requisite for all biological studies. As a part of present inverstigation here I described 54 species that belonged to 29 genera and 7 families along with notes on their distribution in India.

MATERIAL AND METHODS

The specimens for the present study were collected from different localities all over Kerala during the last 5 years. Collections were made with the help of tow net made of bolting silk with mesh size of 50 μ and 70 μ. A scoop net of mesh size of 50 μ with a handle and 20 cm mouth diameter was used for collection from the littoral area of the lakes and ponds by scooping it through the marginal weeds. A large numbers of epiphytic forms could be collected by this method. Another tow net with a mesh size of 70 μ and 28 cm mouth tied to a long rope was used for collection from limnetic region. The net was dragged through the sub surface water column from bank or from a moving boat with uniform speed. Active swimming limnetic species could be collected by this

Map -1


KERALA STATE
KASARAKODU
KANNOOR
WYANADU
KOZHIKODU
MALAPURAM
PALAKADU
TRISSUR
ERANAKULAM
IDUKKI
KOTTAYAM
ALAPPUZHA
PATHANAMTHITTA
KOLLAM
THIRUVANATHAPURAM
KM 20 0 20 40 60 80 100 KM
75° 0′
76° 0′
77° 0′
12° 0′
11° 0′
10° 0′
9° 0′
INDIA
0 400 800 KM
KERALA
Arabian Sea
BAY OF BENGAL

method. Specimens were also collected by washing the aquatic weeds and roots of floating weeds in a bucket of water to obtain the epiphytic species clinging on these plants; the water was then filtered through the scoop net to obtain the specimens.

Immediately after collection the concentrated samples were preserved in 4 % formalin and brought to the laboratory for further study. Specimens were brought alive to the laboratory from neighbouring localities so that they could be observed in the living condition. The cladocerans were sorted out under a low power stereoscopic microscope. Anatomical features of taxonomic importance were studied by dissecting the specimens using fine tungston needles and mounting them on glass slide in glycerine-jelly medium. The cover slips were sealed with nail polish or D P X for further study of the material under high magnification using oil immersion. Drawings were made with the help of camera lucida and measurements were taken with calibrated micrometers. The temperatures of water were measured by an ordinary mercury thermometer and pH of the water by a portable pH meter in the field. Taxonomic status of the specimens were determined mainly by using monographic works of Smirnov (1992, 1974 & 1996); Golden (1968); B A G Idris (1983); Michael & Sharma (1988); Dodson & Frey (1991) and Korovchinsky (1992).

STUDY AREA

Kerala State is one of the smallest states in peninsular India, lying between 8° 18′ and 12°48′ N latitude and 74° 52′ and 77° 22 ′ E longitude (See Map-1). In the present study samples were collected from 40 localities. Details of sampled localities are given below.

1, Angamaly paddy fields (Eranakulam district)

A paddy field near to N H 47 near Angamaly town. The collections were made during monsoon. The water was slightly yellowish in colour at the time of collection due to decaying hey.

No: of samples collected: 2. Date of collection: 19 / 7 / 92.

pH: 7.8. Temperature: 28° C.

2, Appukuttan pond (Thrissur district)

A small circular pond, nearly 8 meteres in diametere filled with slightly greenish water due to abundent growth of algae mainly *Chlorella sp.* Water lettuce *Pistia sp*: was also present.

Date of collection: 4 / 11 / 92.

3, Arimboor paddy field (Thrissur district)

A vast inundated paddy field. Water was clear and weeds like *Eichornia* sp: & *Salvinia* sp: were present

No: of collection: 3. Date of collection: 6 / 1 / 92

4, Athirappilly lower stream (Thrissur district)

Upper stream of Chalakkudy River and the collections were made through the rocky bank. Water was very clear.

Date of collection: 19 / 3 / 92.

5, Bharathapuzha river (Thrissur district)

The collections were made from some water pockets among sand dunes of the riverbank near Kuttypuram Bridge. Water was clear and no algal growth was noticed.

Date of collection: 17 / 3 / 92

pH: 6.4. Temp: 32° C.

6, Boothathankettu reservoir (Idukki district)

The reservoir situated in Idukki district with latitude: 76° 40 - 76° 42 N and longitude: 10° 7 - 11° 0 E. The reservoir is the part of Thattaekadu bird sanctuary. Maximum depth of the reservoir is 15 meters.

No. of samples 4; Date of collection: 8/12/ 1994.

7, Christ College tank (Thrissur district)

This is a small concrete tank of 0.5 x 0.5 x 0.5 metere size, situated in the college garden. Water was slightly dark in colour due to organic matters. The surface of the water was partialy covered by duck weeds (*Lemna* sp.)

No: of collection: 2. Date of collections: 16 / 5 / 93

pH: 7.6. Temp: 29° C.

8, Chalakudy paddy field (Thrissur district)

Paddy field near Chalakkudy railway station. Collections were made from a small irrigation canal within the paddy field. Water was rich with filamentus algae.

No. of collection: 1. Date of collection: 13 / 6 / 92.

9, Chakrapani rocky pool (Thrissur district)

A small quarry with rainwater situated within the Vettilappara Teak-wood plantation. Water was dark brown in colour due to organic nutrients. No weeds were observed.

No: of collection: 1. Date of collection: 20 / 5 / 93.

pH: 8. Temp: 33° C.

10, Devikulam upper lake (Idukki district)

A small lake of about 4.6 hecters situated in Western ghat region at a latitude: 10° 6′ N and longitude: 77° 9′ E with altitude of 2025 meters. Collections were made through aquatic weeds mostly of *Sirpus sp*: and *Utricularia* sp:

No: of collection: 2. Date of collection: 10 / 12 / 94.

pH: 7.2. Temp: 14° C.

11, Ditch near Nellayi Railway station (Thrissur district)

A small monsoon ditch situated close to Nellayi railway station.

No: of collection: 1, Date of collection: 10 / 8 / 93

12, Eloor paddy field (Ernakulam district)

A small paddy fields near Eloor Industrial area (Udyogamandal), no agricultural operation at the time of collection. Samples were collected from a small ditch near one irrigation canal. Water was slightly turbid and no algal growth was observed.

Date of collection: 4 / 2 / 92

pH: 6. 2. Temp: 28° C

13, Farook pond (Kozhikodu district)

A large pond situated near Farook town, 22.3 x 12.6 meters size with an average depth of 2 meters. The pond was more or less covered with weeds like *Salveenia* sp: and *Echiornia* sp: at the time of collection.

No: of collection: 2. Date of collection: 6 / 3 / 92

14, Kalpetta paddy field (Wynadu district)

Small paddy field near Kalpetta town. The collections were made from a ditch in the paddy field.

No: of collection: 1. Date of collection: 7 / 3 / 92.

15, Kannankuzhi stream (Thrissur district)

This is one of the tributaries of Chalakudy River. Collection was made near the bank having marginal aquatic weeds.

Date of collection: 19 / 3 / 92

16, Kollenkodu pond (Palakadu district)

A small circular pond with approximate diameter of 12 meters and average depth of 2 meters, situated in a paddy field. Surface was covered with weeds.

No: of collection: 3. Date of collection: 3 / 11 / 92

pH: 6.2. Temp: 28° C.

17, Kokkara wayal ditch (Idukki district)

A small ditch situated inside the Periyar tiger reserve. The approximate size is 6x5

meters and average depth 2 meters. Pond is used as a drinking water source by wild animals. Aquatic weeds like *Nymphae* sp; *Utricularia* sp:, *Najas* spp: were present. Date of collection: 8 / 3 / 92.

18, Kunnu bigg pond (Thrissur district)

Large pond with approximate area of 0.5 acre and the water surface was covered with mainly water hyacinth *(Eichornia* sp.)

No: of collections: 2. Date of collection: 12 / 12 / 92

19, Monastry pond (Thrissur district)

A small pond near Christ college monastry, the surface of water was heavily covered with the weed *Salvinia Sp.*

No: of collection: 2. Date of collections: 10 / 7 / 92 and 26 / 1 / 94.

20, Mavoor paddy field (Kozhikodu district)

A paddy field near Mavoor Rayons factory not used for agriculture. Collections were made from a ditch inside the field. Water was little turbid, bottom full of mud. No weeds and algal growth were observed.

Date of collection: 9 / 3 / 92.

pH: 6.5. Temp: 31° C.

21, Mavoor irrigation canal (Kozhikodu district)

A small canal near Mavoor Rayons factory. Water was clear and no weeds.

Date of collection: 9 / 3 / 92.

pH: 6. Temp: 32° C.

22, Munnar small canal (Idukki district)

A small canal near Munnar town. Water was slightly turbid with monsoon rainwater. No weeds.

Date of collection: 14 / 1 / 96

23, Muriyad kayal (Thrissur district)

An inundated paddy field where water was slightly brownish in colour due to decaying hey and other organic matters.

No: of collection: 2. Date of collection: 2 / 2 / 96.

24, Muvattupuzha rocky pool (Ernakulam district)

A small rocky pool near Nirmala College Muvattupuzha. Water was slightly greenish having no weeds. Date of collection: 18 / 8 / 92

pH: 8. 7. Temp: 32° C.

25, Navarikulam pond (Thrissur district)

A pond with an area of 0.25 acres, protected by cement walls, with an outlet. Water surface was covered with aquatic weeds.

No: of collection: 2. Date of collection: 12 / 2 / 92 & 8 / 10 / 94 respectively.

pH: 6.6. Temp: 32° C (First collection)

pH: 7.8. Temp: 29° C (Second collection)

26, Nellayi paddy field (Thrissur district)

A paddy field near Kurumaly River. The collections were made from a newly prepaered paddy nursery, which contained slightly turbid water.

No: of collection: 2. Date of collection: 2 / 2 / 92

pH: 8.2. Temp: 32° C.

27, Nandikara bricks-yard (Thrissur district)

An abandoned bricks-yard situated near the church, Nandikara. Collections were made from small ditches in yard. Water was very clear and no algal growth observed.

No: of collection: 2. Date of collection: 2 / 2 / 92

pH: 7.5. Temp: 32° C.

28, Parappukara paddy field (Thrissur district)

Inundated paddy field. Collections were made during the monsoon period.

Date of collection: 8 / 7 / 96

pH:7.5. Temp: 28.

29, Peechi reservoir (Thrissur district)

A reservoir for irrigation and drinking water supply, situated in Trichur district with latitude 76° 23 E and longitude 10° 32 N.

No: of collections: 3. Date of collections: 28/ 6/ 93

30, Periyar Lake, Thekkady (Idukki district)

This is a man made lake situated inside the Periyar tiger reserve, Thekkady. Latitude: 9° 18′ and 9° 40′ N, Longitude: 76° 55′ and 77° 25′ E.

No: of collection: 3. Date of collection: 2 / 2 / 94 (pH: 6.7, Temp: 26° C)

No: of collection: 2. Date of collection: 18 / 12 / 96 (pH: 7.5, Temp: 24° C

31, Ponkothra paddy field (Thrissur district)

Inundated paddy field with monsoon rainwater. Collections were made during early monsoon period.

No: of collection: 3. Date of collection: 18 / 6 / 96.

32, Pookodu lake (Wynadu district)

Pookodu lake is a water body of about 7.5 ha surrounded by a chain of hills rising to the order of 800 meters above m.s.l (lati: 11° 34′ - 11° 32′ N, longi: 76° 24′ - 76° 34′ E) situated in Vythiri taluk of Wynadu district

No. of samples:4; Date of collection: 14/ 8/ 95

33, Pullur pond (Thrissur district)

A pond near Pullur mission hospital contains with lot of weeds.

No. of collection: 1. Date of collection: 28 / 3 / 92

34, Puthanpally pond (Thrissur district)

A protected pond situated near Puthanpally church. Water was slightly greenish in colour due to growth of algae. No other aquatic weeds.

No: of collection: 1. Date of collection: 14 / 8 / 92

35, Rappal bricks-yard (Thrissur district)

Collections were made from a small ditch inside the yard. Water was slightly turbid.

Date of collection: 24 / 4 / 94

36, R. E. C Pond (Kozhikodu district)

A small pond situated inside the Regional Engineering college campus at Calicut.

No: of collection: 1. Date of collection: 12 / 8 / 95

37, Sasthankotta lake (Kollam district)

A freshwater lake situated in kollam district. Longitude:10° 32′ N, Latitude: 76° 23′E. No: of collection: 1. Date of collection: 20/ 4/ 92.

38, S.N.Pond (Thrissur district)

Protected pond with size of 38 x 26.5 meters and average depth of 3.2 meters and situated in Irinjalakuda muncipality area. Pond has one outlet. Normally using for bathing and washing clothes.

Date of collection: 29 / 2 / 92

pH: 7.5, Temp: 32° C.

39, Swarnakulam (Thrissur district)

A Pond with size of 35 x 22 meters and 3.2 meters depth. *Eichornia* sp. was the common weed. Several samples were collected during 1992 – '93

Date of collection 20 / 1 / 92, pH: 6.5, Temp: 31° C. (Water was clear)

Date of collection 30 / 3 / 92, pH: 7, Temp: 34° C. (Water was slightly greenish with algae *Microcystis* sp.)

Date of collection 15 / 2 / 92, pH: 5.5, Temp: 31° C. (Clear water)

Date of collection 15 / 7 / 93, pH: 5, Temp: 29° C. (Very clear water)

Date of collection 30 / 10 / 93, pH: 6, Temp: 32° C. (Very clear water)

40, Vazhachal waterfalls (Thrissur district)

Waterfall situated in the Chalakudy River. Collections were made near the riverbank.

No: of collection: 2. Date of collection; 7 / 4 / 94

pH: 7.8, Temp: 24° C.

SYSTEMATIC ACCOUNT

Cladocerans are generally considered an artificial group comprising representatives of rather different phylogenetic origin. Frćyer (1987) classified the "group" Cladocera in to 4 orders viz. Ctenopoda, Anomopoda, Onychopoda and Haplopoda.

CLASS: CRUSTACEA
SUB- CLASS: BRANCHIOPODA
ORDER: CTENOPODA

Family: Sididae Baird, 1850

1, *Pseudosida bidentata* Herrick, 1884

(Plate: 1, Figs: a-e)

Female: Size: Length: 0. 80 mm, Height: 0. 32 mm.

Body large and elongated (P. 1, fig. a). Valve thick and transparent with out any special ornamentation on surface. Head small and distinct. Eye large situated near antero ventral margin of the head. Ocellus small and situated near the base of the antennule. Vertex not evenly rounded but slightly flattened, cervical sinus, fornix absent. Antennule long, flexible and flagellum type with a tuft of sensory hairs in the middle. on the ventral side (P. 1, fig. b). Swimming antennae strong and large with two segmented dorsal ramus and 3 segmented ventral ramus (P. 1, fig. c). Dorsal side of the carapace arched with distinct posteroventral corner. Posterior margin highly arched poseroventral corner rounded with row of un-grouped spinules ventral margin of the valve slightly inflexed. Shell gland present on the anterior portion of the valve (P. 1, fig. d). Postabdomen wedge shaped with ten clusters of spinules (P. 1, fig. e). Claw stout, curved and setulated on ventral and dorsal margins. Two large and one small basal spine at the base of the claw dorsally. Three small spinules also present on the base of the ventral side of the claw.

Male: Not observed

Distribution: Burnihat, Nandalur & Karikal (Brehm, 1953); Karnataka (Patil & Gouder, 1988) Rajastan (Biswas, 1971, Venkataraman, 1992a) Tamil Nadu, Kerala (Michael & Sharma, 1988); Tamil Nadu (Venkataraman, 1993)

Remarks: *P. bidentata* has already been reported from Kerala by Michael & sharma (1988) based on the collection from Dr. C.K.G.Nayar. This is a common species in weedy ponds with clear water, absent in turbid and temporary waters. The protuberance on the ventral base of the claw is absent in the present specimens as described by Birge (1910).

2, *Latonopsis australis* Sars, 1888

(Plate: 1, figs: f-i)

Female: Size: Length: 1.06 mm; Height: 0.61 mm.

Body thick elongated (P.1, fig.f), head small and indistictinctly separated from body. Eye small and situated more close to the anterior margin of the head. Ocells small and situated near to the base of the labrum. Antennule long , segmented with numerous small hairs on its distal portion (P. 1, fig. i). Ventral side of the valve slightly convex with numerous long setae.The characteristic branched shell gland present on the anterior portion of the valve (P. 1, fig. G), posterior branch longer than anterior one. Posteroventral corner of the valve rounded with series of longe setae which decrease in size dorsally. Postabdomen short and fleshy with 9 lateral spinules (P. 1, fig. h). Claw curved, setulated on concave margin, with two long basal spines.

Male: Not observed.

Occurrence: Angamali paddy field, Appukuttankulam, Boothathankettu reservoir, Farook pond, Kalpetta paddy fields, Mavoor paddy fields and Nellayi paddy fields.

Distributions: Rajastan (Biswas, 1971; Michal & sharma, 1988; Venkataraman, 1992a)

Madurai (Michael & Sharma, 1988), Dharward (Patil & Gouder, 1988), Tamil Nadu (Venkataraman, 1993).

Remarks: *L. australis* can be easily distinguished by its massive pale yellow body and long segmented flagellum-type antennule. The present specimens agree with the description given by Brooks (1959), Idris (1983) Michael & Sharma (1988) and Pennak (1991). Harding & Petkovki (1963) treated *L. occidentalis* Birge as a synonym of *L. australis* Sars. The segmentations on the antennule is not clearly visible under low power optical microscope while clearly visible under high power.

3, ***Diaphanosoma sarsi*** **Richard, 1894**
(Plate: 2, figs: e-k)

Female: Size: Length: 0. 86 mm, Height: 0. 44 mm.

Head small, more or less rectangular with a slope on dorsal margin (P. 2, fig. e). Ventral margin of the head slightly concave. Eye large and situated closer to the ventral margin than to dorsal margin of the head. Ocellus absent. Antennule small and cigarette (cigar) shaped. The swimming antennae short, weak, and not reaching the hind end of the valve when it reflexed. Carapace oblong, posterodorsal corner ending in an angle under than right angle. Posteroventral corner rounded with 20 small denticles, which decrease in size towards the dorsal side (P. 2, fig. f). Ventral margin of the shell inflexed forming a broad flap (duplicature) at inner side. Postabdomen comparatively small, narrow and with out any lateral spine (P. 2, fig. g). Claw large and curved with 3 basal spines. Ephippial female with two eggs, a true ephippial case absent, button like protuberances present on surface of the ephippial egg (P. 2, fig. h).

Occurrence: Arimboor paddy field, Chalakudy paddyfield and Rappal brickyard.

Male: Size: Length: 0. 70 mm, Height: 0. 32 mm.

Male smaller than female with a pair of elongated whip-like antennules (P. 2, fig. I). Head somewhat rectangular, eye very large. Basipod of the swimming antennae with a sharp distal spine. Postabdomen more narrow and elongated than that of female and with a pair of copulatory appendages (P. 2, fig. k). The first thoracic leg longer than the rest and its endopodite modified as sickle shaped hook (P. 2, fig. j).

Occurrence: R.E.C. Pond Kozhikod and Periyar Lake.

Distribution: Bihar (Gurney, 1907), Rajastan (Biswas, 1971; Venkataraman, 1992a) Meghalaya (Patil, 1976), West bengal (Sharma, 1978), Madurai, New Delhi, Agra (Michael & Sharma, 1988), Kerala, (Raghunathan, 1989), Punjab.(Battish, 1992), Tamil Nadu (Venkataraman, 1992)

Remarks: This is a widely distributed species in India. In the present study this species is found to be abundant in the paddy fields and bricks yards. The specimens agreed well with the descriptions given by Michael & Sharma (1988), Korovechensky (1992) and Idris (1983). The number of denticles on the posteroventral corner of the right and left valves of the some individuals is found to vary in many specimens. Smilar observations have also been made by earlier workers (Korovchensky 1992; Battish, 1992).

4, ***Diaphanosoma excisum*** **Sars, 1885**
(Plate: 2, figs: a-d)

Female: Size: Length = 0.86 mm; Height = 0. 38 mm.

Body oblong (P. 2, fig. a). Head large with a depression on the anterior region. Eye large and situated close to anteroventral side of the head. Ocellus absent. Antennule cigarette-shaped with a longe sensory papilla. Swimming antennae large but do not reach the posterior margin of the valve. The basipodite of the swimming antennae large and extend beyond the middle of the valve. Posterodorsal corner of valves almost ending with right angle. Posteroventral corner rounded with variable number of denticles followed by

ungrouped small spinules (P. 2, fig. c). Number of denticles on the posteroventral corner of the valve may vary from right to left valve. The duplicature on the ventral shell margin join nearly at right angle (P. 2, fig. b). No specific ornamentation on the valve. Postabdomen small, narrow with fine setules on the dorsal margin (P. 2, fig. d), claw large having 3 large basal spins which decreasing in size proximally. The concave surface of the claw setulated, a true pecten not present.

Male: Not observed.

Occurrence: Muriyard kayal, Peechi reservoir, Swarnakulam and Sasthankotta Lake.

Distribution: West Bengal (Sewell, 1935, Sharma, 1978), Rajastan (Biswas, 1971; Nayar, 1971; Michael & Sharma, 1988; Venkataraman, 1992a), Bihar (Nassar, 1977), Kerala (Michael & Sharma, 1988; Ragunathan, 1989), Karnataka (Patil & Gouder, 1988), Assam, Collariu lake (Michael & Sharma, 1988) and Tamil Nadu (Venkataraman, 1993).

Remarks: D. excisum is a one of the common species in temporary clear water with out weeds. The species already reported from Kerala state by Michal & Sharma (1988) based on the collections sent by Dr. C. K. G. Nayar and also reported by Ragunathan (1989) from Wynadu district.

ORDER - ANOMOPODA

Family: Daphiniidae Straus, 1820

5, ***Ceriodaphnia laticaudata*** **P.E. Muller, 1867**

(Plate: 3, figs: a-c)

Female: Size: Length = 0. 74 mm; Height = 0.51 mm.

Body rounded ventrally (P. 3, fig. a). Head evenly rounded ventrally and not produced in to a spine or beak anteriorly. Eye moderately large and situated in middle of the anterior

portion of the head. Ocellus small, situated near the base of the antennule. Antennule small with one large lateral sensory hair near its tip (P. 3, fig. b) Valve reticulated with polygonal markings; ventral rim of the shell smooth; posterodorsal angle slightly elevated from the dorsal margin. Head clearly separated from the rest of the body by cervical sinus. Postabdomen large flattened and dilated (P. 3, fig. c). Claw short, slightly curved, setulated with out basal spine.

Male: Not observed.

Occurrence: Vazhachal waterfalls.

Distribution: Pune, (Brehm, 1953), Simla hills (Biswas, 1964b), Rajastan (Biswas, 1971) Kashmir, U.P, Tamil Nadu (Michael & Sharma, 1988) and Karnataka (Patil & Gouder, 1988).

Remarks: *C. laticaudata* can be easily distinguished by its characteristic rounded shape, absence of beak-like rostrum and the dilated postabdomen. The present specimens agree with the discriptions given Michael & Sharma (1988) and Patil & Gouder (1988).

6, ***Ceriodaphnia cornuta*** **Sars, 1885**
(Plate: 3, figs: d-h)

Female: Size: Length = 0. 55 mm; Height = 0. 40 mm.

Body rounded in outline (P. 3, fig. d). Anterior portion of the head rounded. Ventral margin of the head produced in to a short, pointed beak like rostrum. Antennule short and broad with one lateral sensory seta and a group of sensory papillaeat its apex. Eye large situated at the middle of the head. Ocellus small and punctiform. Valve sub-quadrate ending with a spine-like protuberance posteriorly. Valve reticulated with polygonal markings. Postabdomen broad and flat with 5 anal spines (P. 3, fig. e). Claw short and stout without basal spine and pecten.

Occurrence: Muriyard kayal, Navarikulam, Peechi reservoir, Pulloor pond, Rappal bricks yard, Swarnakulam and Periyar Lake.

Male: Size: Length = 0. 38 mm; Height = 0. 23 mm.

Smaller than female and quadrangular in shape (P.3, fig. f). Dorsal margin more or less straight ending on a spine-like process posteriorly. Ventral margin slightly convex. Eye large, ocellus very small and punctiform. Rostrum beak-like as in female. Antennule somewhat longer than that of female and with two lateral sensory hairs, proximal one smaller than the distal one (P.3, fig. h). First thoracic leg with a long flagellum, terminally forming a hook like structure and extend out (P. 3, fig. g). Postabdomen with 6 anal spins. Claw short without basal spine and pecten.

Occurrence: Periyar Lake.

Distribution: In India it is reported from West Bengal (Gurney, 1906, 1907; Sewell, 1935; Sharma, 1978; Michael & Sharma, 1988), Bihar (Brehm, 1950; Nasar 1977) Rajasthan (Biswas, 1971; Nayar, 1971; Venkataraman, 1992a), Kerala (Brehm, 1953; Michael & Sharma, 1988; Raghunathan, 1989), Meghalya (Patil, 1976), Karnataka (Patil & Gouder, 1988), Tamil Nadu, M.P, Punjab, Haryana and Himachal pradesh (Michael & Sharma, 1988).

Rremarks: This widely distributed species known from different parts of our country. Michael & Sharma (1988) reported this species from Kerala based on a collection sent by Dr. C.K.G.Nayar from Irinjalakuda. In the present study the males were collected from marginal area of lake along with enormous number of femals.

7, ***Simocephalus serrulatus*** **(Koch, 1841)**
(Plate: 3-4, figs: i-l)

Female: Size: Length = 0. 90 mm; Height = 0. 48 mm.

Body oval in shape, slightly widened posteriorly (P. 3, fig. i). Dorsal margin evenly arched, vertex serrated with small spines (P. 3, fig. j). Eye comparatively large, ocellus small and rhomboidal in shape. Rostrum small and the antennules extend beyond the tip of the rostrum, lateral sensory seta of the antennule situated near its base. Fornix rounded and smooth, posterodorsal corner as well as the posteroventral corner rounded, posteroventral corner armed with 3 spines. Posterior margin of the carapace end with a blunt spine-like protuberance. Small denticles present on posterodorsal side as well as posteroventral side of the valves. Valve ornamented with interconnected striations. Postabdomen broad and large with a prominent pre-anal corner. Anal denticles 8 in number, claw somewhat straight and pectinated (P. 3, fig. k).

Occurrence: Arimboor paddy field, Boothathankettu reservoir, Devikulam Lake, Monastry pond, Munnar small canal and Parappukara paddy field.

Male: Size: Length = 0. 62 mm; Height = 0. 33 mm.

Male smaller than female with rounded head having serrated margin (P. 3, fig. L). Males can be distinguished from the female by the presence of two lateral sensory setae on antennule of which one is long and thin whereas the other is thick and short (P.4, fig. a) Sensory papillae longer than that of parthenogenetic female. Eye large occupying the anterior region of the head. Valve with interconnected striations. Postabdomen somewhat similar to that of female with 3 anal denticles, claw straight and pectinated (P. 4, fig. b)

Occurrence: Parappukara paddy field

Distribution: Tamil Nadu, Meghalaya (Michael & Sharma, 1988)

Remarks: *S. serrulatus* has been found to be numerically less abundant than the other species of *Simocephalus*. S. serrulatus can be easily distingushed from the others by the characteristic angulated and serrated vertex. The posterior blunt process along the median axis of the animal has been found to vary with the age of animals. In younger specimens

the process was more dorsal in position where as in older specimens it occupied in median position.

8, ***Simocephalus latirostris*** **Stingelin, 1906**

(Plate: 4, figs: c-e)

Female: Size: length = 0.96 mm; Height = 0.64 mm.

Body oval in shape with its maximum height just behind the middle of the body (P. 4, fig. c). Head small and depressed. Vertex rounded with out any serrations. Anterior portion of the head ventrally directed. Eye moderately large and situated closer to the dorsal margin of the head than to the ventral margin. Ocellus elongated and slightly rhomboidal in shape, situated obliqually near the base of the rostrum. Ventral margin of the head concave with long and laterally broadened rostrum (P. 4, fig. d). Antennule slightly longer than rostrum, lateral sensory setae situated near base. Fornix evenly rounded, swimming antennae small and it reaches about half of the carapace when extened. Shell ornamented with interconnected oblique straiations, forming a meash work. Dorsal margin of the shell arched and ventral margin slightly invaginated. Head separated from the body by a deep cevical sinus. A blunt spine-like protuberance on the median axis of the body. Posterior margin armed with spinules. Postabdomen broad, large with a prominent pre-anal angle and 6 anal denticles increasing in size distally (P. 4, fig. e). Claw long, curved and pectinate.

Male: Not observed

Occurrence: Boothathankettu reservoir, Farook pond and S. N. Pond, Periyar Lake.

Distribution: Rajastan (Biswas, 1971), Madurai (Michael & Sharma, 1988)

Remarks: Although *S. latirostris* resembles with *S. vetulus* the former can be distinguished from the latter in having less number (5- 6) of anal denticles and more

pointed protuberance on the median axis of the shell. *S. latirostris* is found to be a common species of perennial ponds with clear water having aquatic weeds such as waterhyacinth. Aged specimens exhibit brown patches due to pigmentation on the valve.

9, ***Simocephalus exspinosus*** **(Koch, 1841)**
(Plate: 4, figs: f-g)

Female: Size: Length = 1. 35 mm; Height = 0. 86 mm.

Body oval in out line, posterior half broader than anterior half (P. 4, fig. f). Head small, distinctly separated from body. Eye relatively small, situated near the anterodorsal margin of head. Ocellus small and rhomboidal in shape, rostrum small and wedge shaped. Antennule small and situated just below the rostrum. Dorsal margin slightly arched forming a blunt protuberance at the posterior margin. Cervical sinus present, posterior part of the dorsal margin denticulated. Valve ornamented with oblique striations, which are interconnected. Postabdomen broad, large and slightly tapering towards apex with one rudimentary abdominal process (P. 4, fig. g) and nine ciliated anal denticles. Pre anal angle acute and projecting. Claw slightly curved and pectinated.

Male: Not observed

Occurrence: Kokkara wayal ditch, Navarikulam, Swarnakulam, and Periyar Lake.

Distribution: Meghalaya (Patil, 1976), W. Bengal (Sharma, 1978) Shillong, Rajastan, & W. Bengal, (Michael & Sharma, 1988).

Remarks: *S. exspinosus* can be distinguished from other related species by its small rostrum, small rhomboidal ocellus and 12-14 anal denticles on postabdomen present specimens agree with the descriptions given Brooks (1959) and Michael & Sharma, (1988).

10, ***Simocephalus vetulus*** **(O.F.Muller, 1776)**

(Plate: 4, figs: h-i)

Female: Size: length = 1. 08; Height = 0. 67 mm.

Body oval in outline, head small clearly separated from body by cervical sinus (P. 4, fig. h). Anterior portion of the head rounded and smooth. Eye of moderate size situated close to the anterodorsal margin of the head. Dorsal margin of the valve arched and a blunt angle present on the median axis. Ocellus large and elongated. Rostrum short and pointed. Antennule small and extend beyond the tip of the rostrum, lateral sensory hair situated close to the base of the antennule. Swimming antennae weak and short. Fornix smooth and rounded. Valve ornamented with inter-connected striations. Posteroventral corner of the valve with 4 spines. Ventral margin of the valve slightly arched. Posterior part of dorsal margin as well as ventral margin with distinct denticles. Postabdomen large and broad with 9 ciliated anal denticles increasing in size distally (P. 4, fig. i), pre anal angle prominent. Claw large and slightly curved and pectinate.

Male: Not observed

Occurrence: Kollenkodu pond.

Distribution: Punjab, Kashmir & Mysore (Brehm, 1936), Kumanon, W. Himalaya (Brehm, 1950), Rajastan, (Biswas, 1971; Nayar, 1971; Michael & Sharma, 1988), W. Bengal, (Sharma, 1978; Michael & Sharma, 1988), Madras, Ninital (U.P) Collairu lake, Tibet (Michael & Sharma, 1988) and Kerala (Raghunathan, 1989), Bihar (Nasar, 1977) Kashmir (Quadri & Yousuf, 1978)

Remarks: Good number of parthenogenetic females of this species were collected from Kollenkodu pond along with other species of Cladocera. However, there were no males or ephippial females of S. vetulus in the collections. *Simocephalus elizabethae* (King) reported by Biswas (1971), Nasar (1977) and Quadri & Yousuf (1978) are considered synonymous with *S. vetulus* considering the similarity of present specimens with the

descriptions given by Michael & Sharma (1988). Dumont & Van de Velde (1977) however, regards *S. elizabethae* as a sub- species of *S. vetulus.*

11, ***Scapholeberis kingi*** **Sars, 1903 b**
(Plate: 5, figs: a-c)

Female: Size: Length = 0. 65mm; Height = 0. 45 mm.

Body arched dorsally, maximum height behind the middle (P. 5, fig. a). Head small depressed. Rostrum rounded infront, projecting ventrally. Eyes large occupying a major portion of the head. Ocellus small, punctiform and situated at the base of the rostrum. Antennule short and stumpy with one long sensory seta (P. 5, fig. b). Posteroventral corner of each valve produced in to a sharply pointed spine directing backward. Valve ornamented with transverse striations. Ventral margin of the valve ciliated and with a slightly concave anterior portion. Head separated from rest of the body by well marked cervical sinus. Postabdomen short and broad, distal margin rounded with 5 spines (P. 5, fig. c). Dorsal margin of the postabdomen hard and clearly striated. Claw slightly curved, without basal spine but with a series of small spinules on its concave margin.

Male: Not observed.

Occurrence: Angamaly paddy field, Bharadapuza River, Monastry pond, Nandikara brickyard, Parappukara paddy field and Peechi reservoir.

Distribution: West Bengal (Gurney, 1906,1907; Michael & Sharma, 1988; Sharma, 1978) Kashmir & Nilgiri hills (Brehm, 1936) Rajastan, (Biswas, 1971, Michael & Sharma, 1988; Venkataraman, 1992a) Megalaya & Assam, (Patil, 1976) Madras & Shillong, (Michael & Sharma, 1988).

Remarks: In the present study this species has been found to be common in the collections made after monsoon rain from paddy fields and bricks yards. *S. kingi*

appeared in swam in the collections from brick-yard at Nandikara where the water was highly turbid. Taxonomic features of the present specimens agree well with the descriptions given by Brooks (1959); Idris (1983) and Michael & Sharma (1988).

Family: Moinidae Goulden, 1968

12, ***Moina micrura*** **Kurz 1874**
(Plate: 5, figs: d-k)

Female: Size: Length = 0. 75 mm; Height = 0. 44 mm

Body thick and heavy (P. 5, fig. d). Head large rounded anteriorly and with a well developed supraocular depression and a distinct cervical sinus. Eye large situated near the anterior margin of head. Ocellus absent; antennule long movable, with rings of small setae (P. 5,fig. e). Lateral sensory seta situated on the middle of the antennule. Valves rhomboid in shape and obscurely striated. Dorsal margin of the body rounded, ventral margin also rounded with a row of 22 spines followed by groups of spinules distally. No hairs on head or valve. Terminal segment of the antenna reach up to middle of the valve when extended. Ephippial female with only one egg (P. 5, fig. g). Ephippium hard, darkly pigmented and saddle shaped. Postabdomen with 6 small feathered teeth (P.5, fig. f). Claw long with setulated ventral margin and bident basal spine.

Occurrence: Christ college cement tank, Kollenkodu pond, Kunnu bigg pond, Mavoor paddy field, Muriyard kayal, Parappukara paddy field, Peechi reservoir, Ponkothra paddy field, Rappal bricks yard.

Male: Size: Length = 0. 56 mm; Height = 0. 33 mm.

Male smaller than female with oblong outline in lateral view (P.5, fig. h). Supraoccular depression well developed, anterior part of the head rounded. Eye large. Antennule much longer than that of female and it is bent at a point 1/ 3 of the distance from the head (P. 5,

fig. i). Two sensory setae of unequal length. Terminal portion of the antennule carries four recurved hooks. First thoracic leg modified into a curved hook (P. 5, fig. j). Shape of the postabdomen similar to that of female, distal part of the postabdonen conical with 6 featherd teeth (P. 5, fig. k) and a bident basal spine. Sperm ducts open on the ventral side of the postabdomen.

Occurrence: Christ college cement tank and Parappukara paddy field.

Distribution: *M. micrura* is a widely distributed species reported from Bihar (Brehm, 1950), W. Bengal (Sewel, 1935; Sharma, 1978) Nilgiri hills (Brehm, 1936), Bijapur (Brehm, 1953), Rajastan (Biswas, 1971; Venkataraman, 1992a), Karnataka (Patil & Gouder, 1988), Kerala (Michael & Sharma, 1988; Ragunathan, 1989), Madurai, Kalyani, Sambar lake, Gudha talao, julgh lake, W. Bengal, Punjab, Haryana (Michael & Sharma, 1988).

Remarks: This species is found to be more common in paddy fields, ditches, ponds and rocky pools. One of the interesting observations in the present study is the presence of epizoic rotifers particularly of *Brachionus* sp: on the valves of *M. micrura*. This is a common phenomenon among *M. micrura* especially during summer months.
The species *M. micrura* easily can be distinguished from other related species by its comparatively smaller size and complete absence of hairs on the body. The present species agree with the descriptions given by Brooks (1959), Idris (1983), Michael & Sharma (1988) and Pennak (1991).

13, ***Moina brachiata* (Jurine, 1820)**
(Plate: 6, figs: a-f)

Female: Size: Length =0. 98 mm; Height = 0. 26 mm.

Head large and broad with distinct supraocular depression (P. 6, fig. a). Eye moderately large and situated near the anterior margin of head. Ocellus absent. Head and body

separated by cervical sinus; hairs absent on head and carapace, small tuft of hairs on lower ventral margin of head. Antennule thin and long with circlets of setae. Lateral sensory seta of the antennule situated 1/ 3 of its distance from head (P.6, fig. b); valve granulated and reticulated. Anterior 2/ 3 of ventral shell margin armed with 32 short setae followed by twenty two groups of small setae, with intermittent long setae (P. 6, fig. c). Anterior setae on the ultimate and penultimate segment of first thoracic leg feathered (P. 6, fig. d). Postabdomen large and long with 8 lateral feathered teeth, basal spine long and bident. Claw pectinate with 12 spinules (P. 6, fig. e-f). Dorsal margin of postabdomen with patches of small hairs.

Male: Not observed

Occurrence: Arimboor paddy field.

Distribution: Lahore (Arora, 1931), Kashmir (Brehm, 1936), Rajastan (Biswas, 1971; Nayar, 1971), NorthEast India (Patil, 1976), Punjab (Battish & Kumari, 1986) and Karnataka (Patil & Gounder, 1988).

Remarks: Several females were collected from innundated paddy fields and found to occur along with *M. brachiata*, rotifer *Brachionus calyciflorus* Pallas. *M. brachiata* can be distinguished from other species of the same genus by its large sized body with no hairs, distinct supraocular depression and distinct pecten with 12 teeth. The shape of the animal varies depending on the presence and the number of embryos in the brood. Specimens with large number of embryos appear spherical and more arched than those with less number of embryos. Patil & Gouder (1988) reported *M. bachiata* from Dharward, Karnataka State with greenish yellow colouration but no such colouration was observed in the present specimens. Their specimens had lateral sensory hair in the middle region of the antennule where as in the present specimens the lateral sensory hair is situated nearer to head. Golden (1968) described *M. brachiata* with moderate sized eye situated near the dorsal margin of head. In the present specimens however, the eye was

more or less centrally placed. The body form and other structural details of the present specimens agree well with the descriptions given by Golden (1968).

14, ***Moina macrocopa*** **(Straus, 1820)**

(Plates: 6-7, figs: g-k)

Female: Size: Female = 1. 06 mm; Height = 0. 65 mm.

Head relatively small, without distinct supraocular depression (P. 6, fig. 7). Vertex rounded. Eye somewhat in the middle of the head. Ocellus absent. Head and body covered with dense hairs; hairs more prominent on dorsal areas. Shell granulated with faint reticulations formed by interconnected longitudinal lines. Antennule large, robust, armed with hairs and setules (P. 6, fig. h) and situated on the ventral side of the head just behind the eye; lateral sensory hair centrally situated; second antennae stout and hairy. Ventral margin of the shell armed with 86 small setae followed by ungrouped setules (P. 6, fig. i). The first thoracic leg of female very distinct; anterior setae on the penultimate segment bear teeth on their ventral margin (P. 6, fig. j). Postabdomen large, broad with 9 long lateral feathered spines on its ventral margin with rows of fine hairs which slant towards the margin(P. 6, fig. k). Claw pectinate with one bident basal spine, besides two spines on the ventral base of the claw. Ephippial female generally smaller than parthenogenetic female and carries two sexual eggs in its ephippium (P. 7, fig. a). Hairs absent on the head and shell surface. Ephippium more or less saddle-shaped and ornamented with polygonal cells (P. 7, fig. b).

Male: Size: Length = 0. 65 mm; Height = 0. 36 mm.

Male smaller than female; head region distinctly separated from the body by cervical sinus (P. 7, fig. c). Head and body densely covered with hairs. Eye fills the anterior portion of the head; supraocular depression absent. Antennule very long bent at the middle with two lateral sensory hairs of unequal size. Antennule situated at the anteroventral side of the head and carry 5 terminal hooks (P. 7, fig. d). Ventral margin of

the shell armed with 36 setae. First thoracic leg distinct with very large thick recurved hook on its penultimate segment. Exopod terminate with very long setae reaching the posterior margin of the shell (P. 7, fig. e). Postabdomen similar to that of female (P. 7, fig.f).

Occurrence: Periyar Lake (Elephant foot depressions in catchment area).

Distribution: Nilgiri hills (Brehm, 1936), Yamuna River, Delhi (Brehm, 1963), Rajastan (Biswas, 1971), Bombay (Michael & Sharma, 1988).

Remarks: *M. macrocopa* can be distinguished by its rounded head without supraocular depression and hairy nature of head and body. Further, the first leg of female also has taxonomic significance in *M. macrocopa* Goulden (1968). *Moina esau* described from Nilgiri Hills (Brerhm, 1936) and *Moina ganapathi* from Delhi (Brehm, 1963) are considered here synonyms of *M. macrocopa* as proposed by Goulden (1968). Golden (1968) described *M. macrocopa* with 55-65 setae on ventral shell margin where as in the present specimens female carries more than 86 setae on ventral shell margin. In all other characters the present specimens agree with the descriptions given by Goulden (1968). In sexual females, normally the eggs are placed along its long axis parallel to each other.

15, ***Moina sp.***
(Plates: 7-8, figs: g-h)

Female: Length = 0. 93 mm; Height = 0. 53 mm.

Head large and rounded with out any indication of supraocular depression (P. 7, fig. g). Eye situated near the dorsal margin of head. Ocellus absent. Antennule robust with a bend at the middle, covered with small setules throughout its length (P. 7, fig. h); lateral sensory hair situated at the middle of the antennule. Swimming antennae very stout and hairy. Body oblong in lateral view. The ventral surface of head, especially the portion just behind the antennule, as well as the anteroventral area of the body covered with hairs.

Hairs absent on lateral and dorsal side of the carapace. Shell with reticulations and striations; striations interconnected only here and there. The anteroventral margin of the valve armed with 22 setae followed by the posterior ventral margin having grouped setules (P. 8, fig. b) First leg of the female similar to that of other moinids, anterior setae of the penultimate segment finely setulated and not teethed (P. 8, fig. a). Postabdomen long and broad with 10 lateral feathered spines on the distal conical portion and a bident tooth (P. 7, fig. i). The claw pectinate with fine teeth. The dorsal margin of the postabdomen with long hairs. Ephippial female smaller than parthenogenetic female, having no hairs on body and head. Ephippium contains only one egg, slightly brownish in colour and ornamented with polygonal markings.

Male: Size: Length: 0. 68 mm; Height: 0. 36 mm.

Male similar to female with long prehensile antennule (P. 8, fig. c). Antennule bent at 1/4 distance from the head with 4 recurved hooks at the tip, ventral portion of the antennule serrated with spinules. Like parthenogenetic female the supraocular depression absent. Head and body covered with hairs, hairs more prominent on ventral side of the head and body. Anteroventral shell rim armed with 18 small setae followed by grouped setules. First leg poorly developed with a curved hook (P. 8, fig. d). Postabdomen similar to female with 7 feathered lateral teeth and single bident basal spine (P.8, fig.e).

Occurrence: Ditch near Nellayi railway station.

Remarks: 16 parthenogenetic females, 3 males and 1 ephippial females were collected from a small ditch filled with turbid water. The present species might be confused with *Moina wessmani Ishikava* and *Moina affinis* due to the presence of hairs on the head and body and due to the presence of single sexual egg in ephippium. On comparing the present specimens with the figures and descriptions given by Golden (1968) the following differences become apparent, absence of supraocular depression, presence of long hairs on the dorsal side of the postabdomen and absence of pecten on the claw. In M. affinis the bend on the male antennule is not clearly demarcated but in the present

specimen it is very evident and located about ¼th distance from its base. Besides, the present specimen has few serrations on the lover side of the antennule. Although the present specimens appear to be a related species to *M. affinis* and *M. weismani*, the differences cited above indicate the possibility of this being a new species.

16, ***Moinodaphnia macleayi*** **(King, 1853)**
(Plates: 8-9, figs: f-j)

Female: Size: Length = 0.8 mm; Height = 0.55mm.

Head triangular in shape. Eye large, ocellus small, situated above the point of origin of antennule (P. 8; fig. f). Antennule long and movable lake that of *Moina* spp. lateral sensory hair situated nearer to the base of the antennule than to the tip. Antennule with a few serration on its ventral and dorsal margin (P. 8, fig. g). Labral keel with setules on ventral margin (P. 8, fig. j), second antennae thin and long with endopod of 3 segments and exopod of 4 segments. Valve broad, round and laterally compressed, ornamented with faint reticulations and striations; oblique striations visible even in preserved specimens. Ventral shell margin completely armed with small setae, setules absent on dorsal margin of shell. Postabdomen elongated with 8 marginal feathery teeth and a distal bident (P. 8, fig. h). Claw long curved and non-pectinate but small setules present on the ventral base of the claw. Ephippial female smaller than parthenogenetic female with single rounded sexual egg. Ephippium rounded and highly reticulated with polygonal markings (P. 8, fig. i).

Male: Size: Length = 0. 65 mm; Height 0. 30 mm.

Male smaller than female with long antennule (P.9, fig. a). Head somewhat triangular and elongated. Eye large, ocellus small and sometime obscure in preserved specimens. Antennule long and curved inward with one lateral sensory hair situated a little before the middle (P. 9, fig. b), two separate patches of sensory papillae at the tip of the antennule.

First leg almost similar to that of the male *M. micrura*. Postabdomen similar to that of female with feathered lateral spines. Claw nonpectinate with single bident basal spine.

Occurrence: Arimboor paddy field, Chalakudy paddy field, Kollenkodu paddy field and Rappal bricks-yard.

Distribution: S. India (Brehm, 1953), Karnataka (Patil&Gouder, 1988), W. Bengal, Kerala (Michael & Sharma, 1988), Rajasthan (Venkataraman, 1992a), Port Blair, Andaman and Nicobar islands (Venkataraman, 1995).

Remarks: Michael & Sharma (1988) reported the occurrence of this species in the collections made by Dr D. G. Frey from Jagady pond, Trivandrum. This species has been found to be common in weedy pond and inundated paddy fields but rare in turbid waters.

Family: Bosminidae Sars, 1865

17, ***Bosmina longirostris* (O. F. Muller 1776)**
(Plate: 9, figs: c-e)

Female: Size: Length = 0. 41 mm; Height = 0. 29 mm.

Body transparent, oval; a spine-like long protuberance on posteroventral corner of carapace (P.9, fig. c). Head large, dorsal margin arched. Eye large, situated close to the dorsal margin of head. Cervical sinus absents. Antennule long and delicate parallel to each other (P. 9, fig. d). Sensory seta situated more or less at the mid point of antennule. Swimming antennae small and weak with 3 and 4 segmented rami. Head pore situated very near to the base of antenna. Valve transparent without any ornamentation; posteroventral corner of each valve with a spine or mucro the size of which varies from animal to animal. Postabdomen quadrate in shape with 3 dorsal spines. Claw curved with two sets of pecten, proximal with 4 spines and distal pecten with 9 sinules (P. 9, fig. e).

Male: Not observed.

Occurrence: Boothathankettu reservoir, Nandikara bricks-yard, Pookodu Lake, Swarnakulam and Periyar Lake.

Remarks: *B. longirostris* can be distinguished by its small size, transparent body with two long proboscis-like antennule and quadrate postabdomen, This is known to be a common limnetic species found in perennial pond and totally absent in turbid water and newly formed water bodies. Variations in the length of the posteroventral protuberance of mature specimens may be due to cyclomorphosis as has been observed in *Scapholeberis spp.* by Green (1963). The present specimens agree with descriptions given by Brooks (1959), Pennak (1991) and Michael & Sharma (1988).

18, ***Bosminopsis deitersi* Richared, 1895**

(Plate: 9, fig: f-h)

Female: Size: Length = 0. 28 mm; Height = 0. 20 mm.

Body transparent oval; maximum height nears the posterior end of the body (P. 9, fig. f). Head small with long; rostrum divided in to two lateral branches at apex. Eye large and situated close to anterior margin of head. Ocellus absent. Antennules long, united with each other at their base; about 6 sensory setae on the ventral side near its apex (P. 9, fig. g). Cervical sinus not prominent in the present specimen. Valve ornamented with faint polygonal reticulations. Ventral margin slightly arched, serrated and with a long, sharply pointed marginal spine on the posteroventral corner. Postabdomen relatively small and tapering distally; 7 anal spines on post anal margin. Claw large, curved and nonpectinated with one large basal spine (P. 9, fig. h).

Male: Not observed

Occurrence: Boothathankettu reservoir, Sasthankotta Lake, Swarnakulam and Periyar Lake.

Distribution: Yamuna River, Delhi (Brehm, 1963), Keoladeo National park, Rajastan (Venkataraman, 1992a), Darwad, Karnataka (Patil & Gouder, 1988), Irinjalakuda, Kerala, (Michael & Sharma, 1988).

Remarks: *B. deitersi* is already reported from Kerala by Michael & Sharma (1988) based on the collections sent by Dr. C.K G. Nayar. The species can be identified by its small size with long rostrum and distally divided antennule. The present specimens exhibit variations in the number of spines on the posteroventral corner of the valve. Specimens collected from Boothathankettu reservior had only one long spine on the posteroventral corner while the specimens from Sasthankotta Lake showed one more small spins on that region. Patil & Gouder (1988) also observed the same phenomenon in Dharwad fauna. *B. deitersi* was totally absent in newly formed ditches which contained turbid water.

Family: Macrothricidae Norman & Brady, 1867

19, ***Macrothrix spinosa*** King 1853
(Plates: 9-10, figs: i -l)

Female: Size: Length = 0. 36 mm; Height = 0. 25 mm.

Body oval in outline, dorsal margin arched and serrated, serrations more prominent on head region (P. 9, fig. i). Head large and its ventral side slightly concave. Eye large situated close to the dorsal margin of head. Ocellus small and situated closer to the base of antennule than to eye. Antennule situated at tip of the rostrum and dilated at its apex (P. 9, fig. j). Dorsal margin of the antennule serrated with spines-like incisions. The lateral sensory setae situated near to the base of the antennule; 4 un-equal long spine like sensory papillae were present at dilated tip along with clusters of small setules. Antenna small and weak with 0-0-1-3 / 1-1-3 setations. Setae on first endopodite segment was long and reaching over posterior margin of valve without any spines on seta. Valve distinctly reticulated with scale like pattern, reticulations were more prominent at posterior region of the valve. Ventral margin of shell with two rows of stout finely

setulated spine (P. 9, fig. k). Posterior margin of the valve with a clear protuberance about in line of axis of the body. Postabdomen small, bi-lobed and dorsal margin armed with numerous backwardly directed spinules. The dorsal distal corner of postabdomen rounded with group of sharply pointed denticles (P. 9, fig. l). Claw short, curved and non-pectinated.

Occurrence: Arimboor paddy field, Boothathankettu reservoir, Mavoor paddy field, and Periyar Lake & Pullor pond.

Male: Size: Length = 0. 26 mm; Height = 0. 17 mm.

Male smaller than female and oval in shape (P. 10, fig. a). Head large, ventral margin concave. Eye large, situated close to dorsal margin of head. Ocellus small, situated closer to tip of the rostrum than to eye. Antennule longer than that of female with a long sensory hair near the base and a series of spinules on the entire surface (P10. fig. b); group of sensory papillae also present on tip of the antennule. Valve reticulated like female but no clear protuberance on posterior margin. The first thoracic leg armed with a hook for clasping female. Postabdomen bilobed, small and broadly rounded with numerous backwardly directed spinules on dorsal margin, opening of vasdeferance not visible on postabdomen. Claw short without basal spines.

Occurrence: Nandikara paddy field, Pullor pond.

Distribution: Rajastan (Biswas, 1971; Venkataraman, 1992a), Manipur (Patil, 1976) Madras (Michael & Sharma, 1988).

Remarks: *M. spinosa* may be confused with *M. laticornis* Jurine due to their small size and serrated dorsal margin. However, in *M. spinosa* the serrations are seen both on the dorsal side of head as well as on valve. In *M. laticornis* serrations are confined the dorsal margin of the valve only. Dumont & Van de velde (1977) during their studies on Nepalees Cladocera fauna, they suggested that the distinctions between *M. spinosa* and

M. goeldii is untenable and only *M. spinosa* is the valid name. Michael & Sharma (1988) treated *M. spinosa* and *M. goeldii* as separate species due to their differences in size, structure of antennule and the shape of postabdomen, present specimen agree with descriptions given by Michael & Sharma (1988), Smirnov (1992) and Idris (1983).

20, ***Macrothrix triserialis*** **(Brady, 1886)**

(Plate: 10, figs: d-h)

Female: Size: Length = 0. 56 mm; Height = 0. 34 mm.

Body oval in shape; dorsal and ventral margin arched (P. 10, fig. d). Head large with conspicuous ridge on its anterior side and separates it from rest of the body by means of a cervical depression. Rostrum pointed, labrum straight posteriorly. Eye large situated in the middle of head. Ocellus small, situated closer to base of the antennule than to eye. Antennule long, armed with series of small spinules on entire length; distal part with 3 long unequal sensory setae. Lateral sensory hair situated very near the base of antennule (P. 10, fig. e). Antenna short with 3 spines in the middle of the long setae. Valve reticulated and sharply pointed posteriorly; ventral margin serrated and moderately long setae. Postabdomen bi-lobed with numerous backwardly curved spines on dorsal margin increasing in size proximally. Claw short, curved without basal spine (P. 10, fig. f).

Occurrence: Angamali paddy field, Mavoor factory canal, Monastry pond and Periyar Lake.

Distribution: W. Bengal (Gurney, 1907; Sharma, 1978), Rajastan (Biswas, 1971; Michael & Sharma, 1988; Venkataraman, 1992a) Culcutta (Michael & Sharma, 1988), Kerala (Michael & Sharma, 1988) and Karnataka (Patil & Gauder, 1988).

Male: Size: Length =0.50 mm; Height =0.29 mm.

Smaller than female (P. 10, fig. g). Antennule longer than that of female and bend

outwards. Second half of the antennule with groups of setules while the rest without setules and plane. Three long and 5-6 short sensory papillae on tip of the antennule. A hook present on first thoracic leg. Postabdomen with a rounded fleshy terminal portion that often protrudes through the ventral side of the valve and with two claw-like structures (P. 10, fig. h). Opening of vasdeferentia on tip of the postabdomen.

Occurrence: Monastry pond.

Remarks: The present specimens agree with the descriptions given by Smirnov (1992); Idris (1983) and Michael & Sharma (1988). It is a species commonly found among marginal weeds of water bodies; *M. triserialis* have already been reported from Kerala state by Michael & Sharma, (1988) but the male has reported first time from India. Fernando & Kandru (1984) reported *Echinisca rosea* (=*Macrothrix rosea*) and *Echinisca triserialis* (=*Macrothrix triserialis*) from Indian sub-continent. Idris (1983) while studying the Malaysian cladoceran fauna did not notice any significant differences between the species *E. triserialis* and *E. rosea*. However, Smirnov (1992) consider these are two distinct species.

21, ***Macrothtix odiosa*** **(Gurney, 1907)**
(Plate: 10; figs: i-k)

Female: Size: Length = 0. 76 mm; Height = 0. 53 mm.

Body oval and no spine or protuberance on posterior margin of the valve (P. 10, fig. i). Head large with a ridge above the eye; a cervical depression separates the head from the rest of body. Labrum concave with a rounded protuberance in the middle. Eye large situated close to dorsal margin of head. Ocellus small situated near the tip of rostrum. Antennule long, cylindrical with 3 spines situated more or less in the middle of antennule in equal distance (P. 10, fig. j). Lateral sensory setae situated near the base; 7 sensory papillae present on tip of antennule. Antenna short and weak with 0-0-1-3 / 1-1-3 setation. Three-segmented endopodite with one long, stout seta on first segment, reaching beyond the posterior margin of shell. Valve without any particular ornamentation; postero

dorsal corner distinct without any spine. Ventral nargin of the valve heavily spinulated along the whole length. Postabdomen rectangular in shape and bilobed; dorsal distal margin rounded with 3 spines (P. 10, fig. k). Claw short and curved with fine serrations on concave margin.

Male: Not observed.

Occurrence: Boothathankettu reservoir, Pulloor pond and Periyar Lake.

Distribution: Bihar (Gurney, 1907), Rajastan (Biswas, 1971; Michael & Sharma, 1988) Karnataka (Patil & Gouder, 1988) and Tripura (Venkataraman, 1994).

Remarks: A single mature female was collected from Pulloor pond, Irinjalakuda. Later 3 mature parthenogenetic female and two youngones were obtained from the littoral area of Periyar lake, Thekkady. *E. odiosa* can distinguished from other species of the same genus by its rounded, oval large body with typical antenna. The labrum is also typical of the species.

M. odiosa was originally found in India by Gurney (1907) and named *Macrothrix tenuicornis*, The specimens collected by him from Sri Lanka was named *Macrothrix odiosa* Gurney (1916). Later the same species was reported from different countries by various workers with different names as *Macrothrix madagascariensi* (Brehm, 1933); *Gurnella sumatrensis* Brehm (1933); *Guerneylla monodi* Bening (1941); *Echinisca odiosa* Smirnov (1976). The present specimens from Kerala agree with descriptions given by Smirnov (1976); Michael & Sharma (1988); Dumont & Van de Velde (1977) and Idris (1983).

22, ***Grimaldina brazzai*** **Richard, 1892**

(Plate: 10, figs: l-m)

Female: Size: Length = 0. 63 mm; Height = 0. 46 mm.

Body quadrangular in lateral view (P. 10, fig. l). Head small, eye large and situated near dorsal margin of head. Ocellus small and rounded situated closer to the base of the

antennule than to eye. Plate of labrum concave and pointed posteriorly. Antennule long, slender and the sensory hair situated very close to base (P. 10, fig. m). The antennule seems to be serrated in appearance; second antenna weak, approximately reaching half of the body length. Valve quadrangular in shape, dorsal margin more or less straight with the depression of cervical sinus. Ventral margin of the valve slightly arched with long setae increasing their size posteriorly. Postabdomen large and bilobed with broadly rounded pre anal margin (P. 10, fig. n). Pre anal corner armed with one long spine. Post-anal margin armed with two sets of long, sharp spines; each set of 4 spines. Claw long and pectinated with one basal spine.

Male: Not observed.

Occurrence: Rappal bricks yard.

Disrtibution: Keoladeo National park, Rajastan (Venkataraman, 1992a)

Remarks: Only a single female specimen of this species was obtained from a inundated brick-yard. *G. brazzai* was the only species reported so far from the genus *Grimaldina*. The present species was first reported from S. India by Fernando & Kandru (1984) during their survey on latitudinal distribution of Cladocera on Indian sub-continent. They did not disclose the exact location of collection but only revealed the latitude as below 12° N from where the samples were collected. *G. brazzai* can easily be distinguished by its quadrangular shape, long antennule and large bilobed postabdomen. Freyer (1974), Idris (1983) and Venkataraman (1992) reported this species having two large long spines on pre anal corner of the postabdomen while in the present specimen only one long spine was observed. Except this variation in all other details the present specimen agrees with descriptions given by Fryer (1974), Idris (1983), Smirnov (1992) and Venkataraman (1992).

Family: Ilyocriptidae Smirnov, 1992

23, ***Ilyocryptus spinifer*** **Herrick, 1882**

(Plate: 11; figs: a-d)

Female: Size: Length = 0. 67 mm; Height = 0. 53 mm.

Body ovate in shape (P. 11, fig. a). Head small with pointed vertex; dorsal margin of head rounded and ventral margin more or less straight. Eye large, situated near the ventral margin of head. Ocellus small, situated near the base of the antennule. Antennule thin, long and two-segmented; basal segment with one dorsal finger-like projection; distal segment with apical cluster of sensory papillae (P. 11, fig. b). Antennae short, weak with swimming setae ratio 0-0-0-3 / 1-1-3. Valve faintly reticulated and thick due to number of growth lines. Ventral and posterior margin of valve rounded with numerous plumose branched setae (P. 11, fig. c). Postabdomen large and elongated with a prominent depression in the middle (P. 11, fig. d); distal dorsal margin of postabdomen rounded with 6 long post anal spines followed by numerous small pre anal spines. Claw large and slightly curved with two unequal basal spines.

Male: Not observed.

Occurrence: Boothathankettu reservoir, Kalpetta paddy field, Kunnu bigg pond, Nandikara brickyard, Mavoor paddy field, Periyar Lake.

Distribution: W.Bengal (Gurney, 1907; Sharma, 1978), Karnataka (Patil & Gouder, 1988), Meghalaya (Patil, 1976), Rajastan (Biswas, 1971; Venkataraman, 1992a) and Kerala (Michael & Sharma, 1988).

Remarks: *I. Spinifer* is considered a benthic species, found in all type of habitat. It can be distinguished from other species by its characteristic flat postabdomen having a fairly deep notch on its middle. The anus opens more or less in the center of postabdomen. A finger-like protuberance on the basal segment of the antennule is also unique character of the present specimen. Sometimes, specimens were found covered with dense algal growth on the surface of the valve. The present specimen agrees with descriptions given by Smirnov (1992), Korinek (1984), Idris (1983) and Michael & Sharma (1988).

Family: Chydoridae Stebbing, 1902

Sub- Family: Chydorinae Stebbing, 1902

24, ***Picripleuroxus similis*** **(Vavra, 1900)** (= *Pleuroxus similis* Vavra, 1900)

(Plate: 11, figs: e-h)

Female: Size: Length = 0. 44 mm; Height = 0. 30 mm.

Body oval with a distinct posterodorsal angle (P. 11, fig. e) and with two spines on posteroventral angle. Dorsal margin highly arched; ventral margin slightly convex with maximum height just before the middle. Rostrum very long, pointed and curved posteriorly. Ocellus smaller than eye and situated closer to eye than to tip of the rostrum. Plate of labrum convex anteriorly with rounded posterior margin (P. 11, fig. f). Antennule small and without a peg at its base. Head shield with rounded posterior margin and long pointed anterior margin (P. 11, fig. g); two main head pores situated on the median line and other two minor pores lie in between. Valve without any ornamentation; ventral margin with a row of feathered setae. Postabdomen elongated tapering slightly to distal end with distinct pre anal and post anal angles (P. 11, fig. h). Anal spines 12 their size increase gradually to distal end. Claw large and setulated on concave margin with two unequal basal spines.

Male: Not observed

Occurrence: Kokkara wayal ditch, Pookodu Lake.

Disribution: Kashmir (Quadri & Yousuf, 1978; Yousuf & Quadri, 1977), Shillong (Michael & Sharma, 1988), W. Bengal (Sharma, 1978), Rajastan (Venkataraman, 1992a).

Remarks: The present material agree with the descriptions given by Smirnov (1974) and Michael & Sharma, 1988). Posterior corner of the valve is beset with 1-2 spines. In younger specimens usually only one spine is observed. Further, the number of denticles on the posteroventral corner of the valve is vary on left and right valve of same animal. Michael & sharma (1988) also made the same observation. *P. similis* can be confused with *Pleuroxus trigonellus* because of highly arched dorsal margin and distinct poderodorsal angle. But it differs from *P. trigonellus* in the following characters such as

presence of non-reticulated valve, rounded posterior margin of head shield and rounded apex of the labrum.

25, ***Picripleuroxus laevis*** **(Sars, 1862)** (= *Pleuroxus laevis* Sars, 1862)

(Plate: 11, figs: i-m)

Female: Size: Length = 0. 45 mm; Height =0. 28 mm.

Body oval in shape, dorsal margin arched with distinct posterodorsal corner (P. 11, fig. i). Ventral margin slightly arched with plumose setae and maximum height before the middle. Ocellus smaller than eye, situated closer to eye than to apex of rostrum; rostrum long and pointed. Antennule small without peg at its base and reaching only 1 / 3 length of rostrum. The ratio of antennal setae is 0-0-3 / 1-1-3. Labrum convex anteriorly with blunt apex (P. 11. fig. j). Head shield pointed anteriorly and rounded posteriorly with characteristic head pores (P. 11, fig. k). Valve faintly striated with more or less straight posterior margin. Posteroventral margin armed with a single spine and a row of small spinules along the line of posterior margin (P. 11, fig. l). Postabdomen long tapering distally with distinct pre and post anal corners (P. 11, fig. m). The dorsal margin of postabdomen slightly concave with 15 anal denticles and fine setules on anal region. Claw long, curved with fine setules on concave margin; basal spine two, proximal one short.

Male: Not observed.

Occurrence: Kalpetta paddy field.

Distribution: Kashmir (Michael & Sharma, 1988).

Remarks: Only six parthenogenetic females were present in the samples collected from the weedy littoral margin of Boothathankettu reservoir, near Thattakadu birds sanctuary. *P. laevis* can be distinguished from other related species by its single spine on posteroventral corner of the valve, row of spinules on entire length of posterior margin and blunt apex of labrum. *P. laevis* first reported from India by Michael & Sharma, (1988) based on the collection sent by Dr Khan from Kashmir. Fernando & Kanduru

(1984) reported *P. laevis* from locality above 20° N (He did not disclose the exact locality). Present material agrees with description given by Smirnov (1996), Idris (1983) and Michael & Sharma (1988). Present report forms the first report of this species from south India.

26, ***Picripleroxus denticulatus*** **(Birge, 1879)** (= *Pleuroxus denticulatus* Birge, 1879)

(Plate: 12, figs: a-b)

Female: Size: Length = 0. 50 mm; Height = 0. 31 mm.

Body oval in outline (P. 12, fig. a). Rostrum elongated, pointed and directed downwards. Ocellus smaller than eye and situated closer to eye than to apex of rostrum. Antennule ending before the middle of rostrum and does not have peg at the base. Antenna not reaching apex of rostrum and its setae ratio: 0-0-3/ 1-1-3. Plate of labrum broad with pointed apex. Valve faintly striated and its posteroventral margin denticulated with 3 spines. Postabdomen wide, tapering distally with truncated apex. The dorsal angle of postabdomen not so elongated and have larger teeth (P. 12, fig. b) and 10 groups of lateral setae. Postanal angle of postabdomen more prominent than preanal angle. Claw large with two basal spines, distal one is longer than proximal one.

Male: Not observed.

Occurrence: Parappukara paddy field.

Distribution: W. Bengal (Sharma, 1978)

Remarks: In the specimens obtained in the present collection show a bulging on the ventral margin of the valve while the descriptions given by Michael and Sharma (1988) the specimens from W. Bengal do not show such a structure; instead the ventral margin was straight.

27, ***Alonella clathratula*** **Sars1896,**

(Plate: 12; figs: c-g)

Female: Size: Length = 0. 32 mm; Height = 0. 22 mm.

Body oval in outline with distinct posterodorsal and posteroventral corners (P. 12, fig. c) Posterior margin of valve straight with a blunt protuberance on postero-ventral corner. Dorsal margin of animal highly arched; ventral margin slightly convex with plumose setae on entire length. Ocellus smaller than eye and situated little closer to eye than to apex of rostrum. Rostrum long, pointed and backwardly curved. Head shield with rounded posterior margin and pointed anterior margin (P. 12, fig. d). Two large head pores situated on the median line and another two small pores close together in between the main head pores. Antennule small not reaching apex of the rostrum. Antennal seta ratio 0-0-3 / 1-1-3. Plate of labrum with convex anterior margin and a blunt apex with a notch (P. 12, fig. e). Valve obliquely striated and reticulated with doted polygons (P. 12, fig. f). Postabdomen short with blunted pre anal corner and distinct post anal corner. Anal denticles groups of setules present on anal margin. Claw moderately large with two unequal basal spines, proximal being short (P. 12, fig. g).

Male: Not observed.

Occurrence: Arimboor paddy field, Boothathankettu reservoir and Kokkara wayal ditch.

Distribution: First report from India.

Remarks: *A. clathratula* can be confused with the related species Alonella excisa (Fischer) in identification. However, the former has more elongated body than *A. excisa* and the length-height ratio is 1: 8. Further more, the valve ornamentation was doted polygons with longitudinal striations and posterior margin of postabdomen almost straight. Taxonomical details of present specimen agree with the descriptions given by Smirnov (1996) p. 92.

28, ***Chydorus pubescens*** **Sars, 1901**

(Plate: 12, figs: h-i)

Female: Size: Length = 0. 38 mm; Height = 0. 30 mm.

Body oval in outline; surface of the valve covered with small setules (P. 12, fig. h). Posterodorsal margin as well as posteroventral margin rounded. Ocellus slightly smaller than eye and situated closer to eye than to tip of the rostrum. Rostrum pointed and directed slightly backward. Antennule small reaching up to the middle of rostrum. Labrum broad apex blunt, with a small nipple like process. Ventral margin of valve moderately bulged and maximum height slightly before the middle. Postabdomen small with 12 anal spines and 8-9 groups of lateral spinules (P. 12, fig. i). Claw pectinated with two unequal basal spines; the distal one is longer than proximal.

Male: Not observed.

Occurrence: Kannankuzhy stream.

Distribution: Assam (Michael & Sharma, 1988).

Remarks: Only two mature female were collected. On comparing the present specimens with the text and figures of *C. pubescens* as described by Michael & Sharma (1988) and Smirnov (1974) the following differences become apparent: ocellus is slightly smaller than eye, valve not reticulated, apex of labral plate has one nipple-like process. However, in other details like setulated body surface, structural details of rostral tip and postabdomen the present specimens are similar to *C. pubescens*.

29, ***Chydorus sphaericus*** **(O. F. Muller, 1776)**

(Plate: 12, figs: j-m)

Female: Size: Length = 0.36 mm; Height =0.34 mm.

Body sub-globular in outline; length of body slightly more than width; maximum height at middle (P. 12, fig. j). Ocellus smaller than eye, situated near to eye than to apex of rostrum. Rostrum pointed at apex and curved posteriorly. Antennule small lateral sensory hair situated more or less at the center. Labrum pointed at apex, without serrations on anterior margin (P. 12, fig. k). Dorsal margin of valve highly arched and posterodorsal corner distinct. Posteroventral corner rounded without denticles. Valve reticulated with polygonal cells. Setae on antennae: 0-0-3 / 0-1-3. Posterior margin of head shield

rounded (P. 12. fig. l). Postabdomen short with 7 anal denticles (P. 12, fig. m); pre anal corner projecting and narrowed distally. Lateral surface with regular pattern of very fine setules. Claw short and curved with two unequal basal spines; proximal one much smaller than distal one. Small setules also present on concave margin of claw.

Male: Not observed.

Occurrence: Angamaly paddy field, Kollenkodu pond and Muriyard kayal.

Distribution: W. Bengal (Gurney, 1906; Sharma 1978; Michael & Sharma, 1988) Bihar (Gurney, 1907), Kashmir, Ladakh, & Nilgiri hills (Brehm, 1936), Meghalaya (Patil, 1976), Shillong, Ninital (Michael & Sharma, 1988).

Remarks: *C. sphaericus* is known to be a widely distributed species occurring in weedy margin of ponds and also in paddy fields after inundation. Most of the earlier workers believed that all small globular Chydorus cladocerans were sphaericus Birge (1918) echoing opinions of his predecessors that " this species is commonest of all Cladocera found all over the world". Later Smirnov (1974) revealed the 'sphaericus complex' and recorded 8 sub-species in *Chydorus sphaericus*. The present specimen agrees with the descriptions given by Smirnov (1974) and Michael & Sharma (1988). Due to the absence of males in the collection the sub-species status could not be ascertained.

30, ***Chydorus parvus*** **(Daday, 1898)**

(Plate: 13, figs: a-e)

Female: Size: Length = 0. 30 mm; Height = 0. 27 mm.

Body almost globular in outline with distinct posterodorsal corner (P. 13, fig. a). Posteroventral corner rounded without denticles. Ocellus small, situated half way between eye and tip of the rostrum; rostrum pointed and backwardly curved. Head shield with rounded posterior margin and slightly pointed anterior margin (P. 13, fig. b). Head pore typical for the genus. Antennule small, not reaching apex of rostrum; plate of labrum with blunt apex (P. 13, fig. c). Valve smmoth without prominent reticulations; dorsal margin of valve highly arched and ventral margin convex with two large tubercles on

inner side of the anterior margin (P. 13, fig. d). Postabdomen short with distinct preanal corners; postanal angle slightly distinct (P. 13, fig. e). Dorsal margin armed with 9 anal denticles followed by a row of spinules along the margin up to the preanal corner. Lateral surface of postabdomen also armed with small spinules arranged in groups. Claw curved and setulated on concave margin; two unequal basal spines observed on base of the claw.

Male: Not observed.

Occurrence: Parappukara paddy field and S. N. Pond.

Distribution: Punjab (Battish, 1981), Kerala, Madras (Michael & Sharma, 1988) Rajastan (Venkataraman, 1992a).

Remarks: *C. parvus* have already been recorded by Michael & Sharma (1988) from Kerala based on the collection sent by Dr. C. K. G. Nayar. Several specimens were collected from different environs. No ephippial females and males were observed. The present species can be distinguished from all other known species under the same genus by the presence of tubercles on inner margin of the valve at anterior portion. Fryer (1957) reported that the number of tubercles and arrangement of tubercles can vary among animals in the same species. Smirnov (1974) reported two sub-species in *C. parvus*. The present specimens more similar to *C. parvus parvus* due to narrow antennule. Michael & Sharma (1988) reported the species with prominent reticulations on ventral margin of valve but reticulation were not so prominent in the present materials.

31, ***Chydorus faviformis*** **Birge, 1893**

(Plate: 13, figs: f-g)

Female: Size: Length = 0. 29 mm; Height = 0. 22 mm.

Body rounded in outline; head and body completely covered with deep polygonal depressions.(P. 13, fig. f). Rostrum short with pointed apex. Ocellus smaller than eye situated closer to eye than to apex of rostrum. Antennule short, and not reaching apex of rostrum. Plate of labrum with blunt apex. Head shield with rounded posterior margin and pointed anterior margin; head pore typical for the genus. Head shield cover half of the

dorsal portion of the body. Dorsal margin of valve irregularly arched, ventral margin arched without plumose setae. Postabdomen short; preanal corner projecting; postanal angle distinct (P. 13, fig. g). Dorsal margin of postabdomen armed with 8 anal spines followed by spinules up to the preanal corner. Lateral groups of setules also present. Claw long and pectinated; basal spines two of unequal length.

Male: Not observed.

Occurrence: pookodu Lake.

Distribution: Kashmir (Khan *et al*, 1978; Michael & Sharma, 1988), Karnataka (Patil & Gouder, 1988), Shillong (Michael & Sharma, 1988) and W. Bengal (Venkataraman, 1998).

Remarks: Only three parthenogenetic females of this species were obtained in a collection made from the lake margin. This species can be distinguished by its deep polygonal reticulations on valve and head. Present material agrees with the descriptions given by Smirnov (1974), Idris (1983) and Michael & Sharma, (1988).

32, ***Ephemeroporus barroisi*** **(Richard, 1894)**

(Plate: 13, figs: h-j)

Female: Size: Length = 0. 27 mm; Height = 0. 19 mm.

Body oval in shape with maximum height at center (P. 13, fig. h); ocellus smaller than eye and situated half way between eye and rostrum; rostrum short and pointed. Antennule not reaching apex of rostrum; plate of labrum bulged and serrated with 5 teeth (P. 13, fig. i). Head shield with rounded posterior margin and bluntly pointed anterior margin; head pore not visible. Valve slightly reticulated with polygons; dorsal margin and ventral margin highly arched with a obtuse angle at about middle of the ventral margin. Posterodorsal corner of valve distinct and posterior margin straight. The posteroventral corner distinct with a sharp spine on both left and right valves. Postabdomen short, tapering distally with very distinct pre anal corner (P. 13, fig. j). Dorsal margin armed with total 8 unequal anal spines. Anal grove with 3 groups of spinules followed by

another group of spinules on post-anal region. Claw slightly curved and setulated on concave margin with two unequal basal spines.

Male: Not observed.

Occurrence: Arimboor paddy field, Boothathankettu reservoir, Kollenkodu pond, Kunnu bigg pond and Mavoor factory canal.

Distribution: Gujarat (Petkovski, 1966), W. Bengal (Sharma, 1978; Michael & Sharma, 1988), Tamil Nadu and Kerala (Michael & Sharma, 1988).

Remarks: The present species has already been recorded from Kerala by Michael & Sharma (1988) based on the collections from Jagady pond, Trivandrum by Dr. D. G. Frey. *E. barroisi* can be distinguished by its peculiar characters like bulged and serrated labrum; presnce of posteroventral spine on the valve and characteristic unequal anal spines on the postabdomen. Richard (1894) described the species as *Pleuroxus barroisi* Later Sars (1895) changed the genus name into *Chydorus*. Due to the presence of some variable morphological characters Brehm (1933) recommended that, the *barroisi* group would certainly has to be removed either to *Alonella* or completely to a new genus. Because of the presence of some typical character and absence of head pore in head shield. Frey (1982) relocated the *Chydorus barroisi* and related species in to a new genus *Ephemeropores*. The present specimens agree with the descriptions of *E. barroisi* given by Frey (1982) (p. 234-237)

33, ***Chydorus ventricosus* Daday, 1898**

(Plate: 14, figs: a-d)

Female: Size: Length = 0. 50 mm; Height = 0. 43 mm.

Body oval in outline; posterodorsal corner and posteroventral corner rounded without denticles (P. 14, fig. a). Rostrum long and pointed at apex. Ocellus smaller than eye situated closer to eye than to apex of rostrum. Antennule reaching about half length of the rostrum. Labral plate broad and slightly pointed at anterior portion (P. fig. b). Valve ornamented with faint polygonal cells and dots. Ventral margin of valve strongly bulged

at centre; dorsal margin highly arched. Maximum height a little before the middle. Head shield rounded at posterior margin and pointed at anterior margin with a notch (P. 14, fig. c). Head pores typical for the genus. Postabdomen elongated and slightly tapering distally (P. 14, fig. d). Pre anal angle projecting and post anal corner also distinct. Dorsal margin of postabdomen armed with 9 anal spines and 5 groups of spinules on lateral side. Claw curved and setulated on concave margin.

Male: Not observed.

Occurrence: Boothathankettu reservoir, Kollenkodu pond, Periyar Lake.

Distribution: Nilgiri hills (Brehm, 1936; Michael & Sharma, 1988), Gujarat (Petkovski, 1966), Rajastan (Biswas, 1971; Michael & Sharma, 1988; Venkataraman, 1992a), Kerala (Michael & Sharma, 1988; Raghunathan, 1989).

Remarks: This common species found among weeds. *C. ventricosus* has already been recorded from Kerala by Michael & Sharma (1988) based on the collections sent by Dr. D. G. Frey and Dr. C. K. G. Nayar. Raghunathan (1989) also reported the same species from Wynadu district, Kerala. Daday (1898) and Smirnov (1974) noticed 3 spinules between the base of the claw and the beginning of rows of anal denticles. But in the present study these spinules were absent. Idris (1983) also did not observe the same in his Malaysian specimens. *C. ventricosus* can be distinguished by its long pointed rostrum, elongated postabdomen and its large sized body.

34, ***Chydorus eurynotus*** **Sars, 1901**

(Plate: 14, figs: e-g)

Female: Size: Length = 0. 36 mm; Height = 0. 32 mm.

Body more or less rounded in outline with distinct posterodorsal corner (P. 14, fig. e). Posteroventral corner rounded without denticles Ocellus smaller than eye and situated closer to eye than to apex of rostrum. Rostrum long with pointed apex. Head shield rounded at posterior margin, anterior margin pointed without notch (P. 14, fig. f). Head shield protects 1/ 3 of the dorsal side of the animal; head pore typical of the genus.

Antennule small, reaching half way to the apex of rostrum. Plate of labrum curved anteriorly and slightly pointed at apex with a nipple like structure. Valve without any reticulation and markings. Dorsal margin highly arched ventral margin also slightly convex. Postabdomen elongated with distinct preanal corner; post anal corner not so prominant (P. 14, fig. g). Dorsal margin armed with 9 anal denticles. Lateral surface of postabdomen occupied by 7 groups of spinules. Claw curved and setulated on concave margin with two unequal basal spines.

Male: Not observed.

Occurrence: Devikulam upper Lake, Muriyard kayal and Periyar Lake.

Distribution: Rajastan (Nayar, 1971; Venkataraman, 1992a), Punjab (Battish, 1981).

Remarks: Several parthenogenetic females were collected from the above mentioned localities *C. eurynotus* can easily be distinguished from other species umder the same genus by its structure and shape of the postabdomen, number of anal denticles on postabdomen and shape of lateral plate. Smirnov (1974) reported 4 sub- species in *C. eurynotus*. The present specimens agree with the details of *C. eurynotus brehmi* because of its non-reticulated valve and a papiliform process on ventral portion of the labral plate. Sars (1901) and Paggi (1972) observed a double contour line on posteroventral corner of the valve, but no such contour lines were observed in the present specimens.

35, ***Pseudochydorus globosus*** **(Baird, 1843)**

(Plate: 14; figs: h-i)

Female: Size: length = 0. 51 mm; Height = 0. 47 mm.

Body globular in shape with distinct posterodorsal corner in aged specimens; length slightly longer than height (P. 14, fig. h). Ocellus smaller than eye situated closer to eye than to tip of rostrum. Rostrum pointed and ventrally directed. Head shield with rounded posterior margin and pointed anterior margin. Head pores typical of the sub family. Labrum without a true plate. Antennule not reaching apex of rostrum; one long lateral sensory hair situated more or less center of the antennule. Antennal setation: 0-0-3 / 1-1-

3. Valve pitted and reticulated with hexagonal and polygonal cells. Posteroventral corner of valve rounded without denticles. Ventral margin of valve smooth and the marginal setae situated on inner side. Postabdomen narow and elongated with uniform width. Dorsal margin armed with 26 anal spines, which decrease its size proximally. Claw long and curved with two unequal basal spines; setules present on concave margin of claw. Further, groups of setules also present on lateral side of postabdomen (P. 14. fig. i).

Male: Not observed.

Occurrence: Pulloor pond.

Distribution: Bengal (Gurney, 1907), Meghalaya (Patil, 1976; Michael & Sharma, 1988) Tamil Nadu (Michael & Sharma, 1988).

Remarks: Only four parthenogenetic females were collected. Posterodorsal corner not distinct in immature specimens where as the corner fully distinct in aged specimen. Present material agree with descriptions given by Smirnov (1974).

36, ***Dunhevedia crassa*** **King, 1853**

(Plate: 15; figs: a-c)

Female: Size: Length = 0. 36 mm; Height = 0. 27 mm.

Body oval in shape with maximum height a little before middle (P. 15, fig. a). Ocellus smaller than eye, situated half way between eye and the tip of rostrum. Plate of labrum not serrated at anterior end. Antennule not reaching apex of rostrum. Valve faintly striated and not reticulated. Posterior margin of valve arched; posterodorsal corner distinct. Posteroventral corner also distinct with two spines. Posterior margin almost straight. Ventral margin of valve covex with sub marginal long setules. Head shield with rounded posterior and anterior margin with two main pores in median line and small pores in between them (P. 15, fig. b). Antennal setae: 0-0-3 / 0-1-3. Postabdomen oval, short and without distinct preanal corner (P. 15, fig. c). Dorsal surface armed with 16 anal spines and lateral surface also armed with clusters of spinules. Claw setulated on concave margin with single basal spine.

Male: Not observed.

Occurrence: Boothathankettu reservoir near Thattekadu bird sanctuary.

Distribution: Kerala (Micheal&Sharma, 1988), Rajasthan (Biswas, 1971; Venkataraman, 1992a; Michael&Sharma, 1988), Tamil Nadu (Michael&Sharma, 1988).

Remarks: *D. crassa* has already been reported from Kerala by Michael & Sharma (1988) based on the collection made by Dr. D. G. Frey from Trivandrum. Only three parthenogenetic females were collected along with a lot of ostracods. Present animals agree with descriptions given by Smirnov (1974) Michael & Sharma (1988) and Battish, (1992).

37, ***Duhevedia serrata*** **Daday, 1898**

(Plate: 15; figs: d-g)

Female: Size: Length = 0. 49 mm; Height = 0. 30 mm.

Body oval posteroventral corner of valve and postabdomen very similar to that of *D. crassa King* (P. 15, fig. d). Dorsal margin as well as ventral margin of the valve convex; valve ornamented with longitudinal striations; two denticles on posteroventral corner (P. 15. fig. e). Antennule not reaching apex of rostrum. Ocellus smaller than eye situated half way between eye and tip of the rostrum. Plate of labrum serrated (P. 15, fig. f). Head shield with rounded anterior and posterior margin. Head pores typical for the genus *Dunhevedia.* Postabdomen oval with 18 anal denticles and numerous groups of spinules on lateral side (P. 15, fig. g). Claw short and slightly curved with single basal spine; setules present on concave margin of claw.

Male: Not observed.

Occurrence: Parappukara paddy field.

Distribution: Madras (Michael & Sharma, 1988), Karnataka (Patil & Gouder, 1988).

Remarks: Only two parthenogenetic females were obtained along with good number of *Moina micrura* kurz, Copepods (*Calanoids*) and Ostracods. Present materials agree with descriptions given by Smirnov (1974) and Michael & Sharma, (1988).

38, ***Dadaya macrops*** **(Daday, 1898)**

(Plate: 15; figs: h-i)

Female: Size: Length = 0. 32 mm; Height = 0. 29 mm.

Body oval in shape with distinct posterodorsal corner (P. 15, fig. h). Ocellus and eye very large; ocellus larger than eye situated nearer to apex of rostrum than to eye. Rostrum short and pointed. Antennule projecting beyond the rostrum. Antennal setae: 0-0-3/ 0-1-3 Labral plate with rounded anterior margin. Valve ornamented with polygons and lines. Dorsal margin of valve highly arched; ventral margin slightly convex with long setae. Posteroventral corner of valve rounded without denticles; posterior margin slightly convex. Head shield with rounded posterior margin pointed anterior margin; head pore single situated on the median line to centre. Postabdomen with distinct preanal and postanal corners; groups of spinules present on lateral side. Dorsal margin armed with 14 spinules. Claw curved and setulated on concave margin with a single basal spine (P. 15, fig. i).

Male: Not observed.

Occurrence: Boothathankettu reservoir, Pookodu Lake, Swarnakulam.

Distribution: S. India (locality not clear) (Brehm 1953) Kerala, Tamil Nadu (Michael & Sharma, 1988) Rajastan (Venkataraman, 1992a).

Remarks: More than 10 parthenogenetic females were obtained from littoral area of Swarnakulam pond along with large number of *Ceriodaphnia cornuta* Sars, *Bosminopsis deitersi* Richard and *Copepods* (*calanoids*). *D. macrops* can be distinguished from other cladocerans by its oval shaped body, large eye and ocellus and projecting antennule. Daday (1910) described the same species with a denticle on posteroventral corner of valve, whereas, Smirnov (1974) described *D. macrops* with and without denticle. In the

present material no such denticle was observed while in other characters they agree with the descriptions given by Smirnov (1974), Idris (1983) and Michael & Sharma,(1988).

Sub - family: Aloninae Frey, 1967

39, ***Alona monacantha tridentata*** **(Stingelin, 1904)**

(Plate: 15; figs: j-m)

Female: Size: Length = 0. 29 mm; Height = 0. 16 mm.

Body almost oval in outline with 3 denticles on posteroventral corner of valve (P. 15, fig. j). Dorsal margin of body highly arched and ventral margin slightly convex. Ocellus smaller than eye situated half way between eye and tip of the rostrum. Antennule short not reaching apex of rostrum . Rostrum longs and blunt. Plate of labrum rounded with a small denticle on anterior margin (P. 15, fig. l). Valve striated with longitudinal lines. Posteroventral corner of valve with 2-3 spins (P. 15, fig. k). Head shield with rounded posterior margin and blunted anterior margin. Postabdomen with distinct preanal corner and rounded distal end (P. 15, fig. m). Dorsal margin armed with 12 anal denticles and 6 groups of spinules on lareral side. Claw long and curved, with a long basal spine.

Male: Not observed.

Occurrence: Nandikara bricks yard, Pookodu Lake, Rappal bricks yard and Swarnakulam.

Distribution: Madurai - Tamil Nadu (Michael & Sharma, 1988).

Remarks: Six animals were collected from two localities 4 animals from Farook pond and 2 animals from Peechi reservoir. Number of denticles on the posteroventral corner of valve varies from 2 to 3. In younger specimens the denticles on the labral plate was not so distinct. In the present material the ocellus is situated exactly half way between eye and tip of the rostrum, where as Michael & Sharma (1988) described the same species with ocellus near to the eye. My material agrees with descriptions given by Smirnov (1974).

40, ***Alona davidi punctata*** **(Daday, 1898)**

(Plate: 16, figs: a-d)

Female: Size: Length = 0. 40 mm; Height = 0. 29 mm.

Body almost oval in outline with maximum height in the middle (P.16, fig.a). Dorsal margin highly arched with a distinct posterodorsal corner. Ventral margin projecting at middle with series of setules on the margin. Ocellus smaller than eye situated half way between eye and tip of rostrum. Antennule short not reaching the apex of rostrum. Rostrum blunt. Plate of labrum evenly rounded at anterior and posterior margin (P.16, fig.b). Head shield blunt anterior at end and rounded at posterior; margin with 3 connected pores (P.16, fig.c). Valve not reticulated and striated but punctuated. Postabdomen long and tapering distally with maximum width at middle. (P.16, fig.d). Preanal angle not distinct and postanal angle rounded. Dorsal margin armed with 11 groups of denticles and 10 groups of spinules on lateral side. Claw long and curved with one short basal spine. Claw and basal spine setulated.

Male: Not observed.

Occurrence: Boothathankettu reservoir, Devikulam Upper Lake, Parappukara paddy field and Pookodu Lake.

Distribution: W. Bengal (Sharma, 1978; Michael & Sharma, 1988), Tamil Nadu (Michael & Sharma, 1988), Rajastan (Venkataraman, 1992a).

Remarks: 8 parthenogenetic females were collected from the Parappukara paddy field, Devikulam upper lake and 2 males from Pookodu Lake. The punctuations and lines on the valve were more prominent on the posterior half. In specimens from both the localities, the preanal angle of the postabdoman was not so distinct. Present material agrees with descriptions given by Smirnov (1974).

41, ***Alona pulchella*** **King, 1853**

(Plate: 16, figs: e-h)

Female: Size: Length = 0. 45 mm; Height = 0. 27 mm.

Body oval in shape with distinct posterodorsal corner (P.16, fig.e). Ocellus smaller than eye and situated half way between eye and tip of the rostrum. Rostrum blunt. Plate of labrum with rounded anterior margin and slightly pointed apex (P.16, fig.f). Antennule short and not reaching apex of the rostrum. Head shield narrowly rounded anteriorly and broadly rounded posteriorly; three median pores situated close to the posterior margin of shield; two lateral pores situated about one inner pore distance from the anterior pore (P.16, fig.g). Valve punctuate without striations and reticulations. Postabdomen long with distinct preanal angle (P.16, fig.h). Postanal angle not so distinct. Dorsal margin armed with 10 sub- marginal denticles; lateral surface armed with 7 groups of spinules. Anal groove slightly concave occupied by fine cluster of setules. Claw long and slightly curved with one basal spine and setules on concave margin of the claw.

Male: Not observed.

Occurrence: Kollenkodu pond, Muvattupuza rocky pool and Navarikulam pond.

Distribution: Gujarat (Petkovski, 1966), W. Bengal (Sharma, 1978; Michael & Sharma, 1988), Tamil Nadu (Michael & Sharma, 1988), Punjab (Battish, 1992).

Remarks: Sars (1888) re-described *A. pulchella* King having faint longitudinal striations on the valve; postabdomen with parallel dorsal and ventral margin. Present material agree with the postabdominal shape but the ornamentation of the valve not so matched with description given by Sars.

42, ***Alona*** *sp.*

(Plate: 16, figs: i-k)

Female: Size: Length = 0.24 mm; Height = 0.14 mm.

Body oval in outline without distinct posterodorsal corner (P.16, fig.i). Ocellus smaller than eye and situated nearer to eye than to the tip of the rostrum. Rostrum blunt; antennule not reaching apex of rostrum. Plate of labrum rounded. (P.16, fig.j). Valve

plain with no reticulations or striations. Dorsal margin highly arched; ventral almost straight with series of setae. Posteroventral corner rounded without denticles. Head shield with rounded posterior margin and narrowly rounded anterior margin. Head pore typical for the genus. Postabdomen short with distinct preanal corner; distal corner rounded and slightly projecting beyond the base of the claw (P.16, fig.k). Dorsal margin armed with 10-12 denticles increasing in size distally. Claw short, curved and setulated on concave margin with one short basal spine.

Male: Not observed.

Occurrence: Kollenkod pond.

Remarks: Three specimens belonging to this unidentified species where present in a collection made from pond at Kollekodu, Palakkad Dt. Although the present specimen resemble *Alona kerelica* Stenros (1897) they differ in the following characters: shape of the labrum, size and shape of postabdomen and the position of ocellus. In *A. kerelica* valve reticulated and the antennule reaches the apex of rostrum. Moreover, the present specimens are much smaller than *A. keralica* which is about 0.51 mm in length (Smirnov, 1974)

43, ***Alona guttata*** **Sars, 1862 a**

(Plate.17; figs.a-d)

Female: Size: Length = 0. 36 mm; Height = 0. 22 mm.

Body oval in shape with rounded posterodorsal and posteroventral corners (P.17, fig.a). Valve punctuated without any reticulation and striations. Ocellus slightly smaller than eye and situated little closer to eye than tip of the rostrum. Antennule not reaching apex of rostrum. Rostrum blunted. Plate of labrum rounded both anterior and ventral margin (P.17, fig.b). Head shield with rounded and wavey posterior margin (P.17, fig.c). Dorsal margin of body highly arched and ventral margin almost straight with series of setae. Postabdomen long with pointed distal preanal corner (P.17, fig.d). Dorsal margin of the postabdomen armed with 9 anal spines and groups of lateral setules also present. Distal

dorsal end of postabdomen projecting beyond the base of claw. Claw long with a single basal spine.

Male: Not observed.

Occurrence: R. E. C. pond.

Distribution: Ladakh, Nilgiri hills (Brehm, 1936); Kashmir (Michael & Sharma, 1988).

Rremarks: The specimens obtained from the R.E.C. pond at Calicut differ from the earlier descriptions of this species by Sars (1862a) in the absences of reticulations, longitudinal striations or tubercles on the valve. However, in other major details such as shape of the body, structure of labrum, number of denticles and shape of postabdomen, the present specimens agree with the species description of *A. guttata.*

44, ***Camptocercus uncinatus*** **Smirnov, 1971**

(Plate.17; figs.e-h)

Female: Size: Length = 0. 74 mm; Height = 0. 49 mm.

Body almost oval in outline; dorsal margin arched and ventral margin slightly concave with setae (P.17; fig.e). Posterior margin of valve rounded without any denticles (P.17;fig.f). Maximum height of the animal slightly before the middle. Valve ornamented with number of longitudinal lines; 9 lines visible on posterior region of the valve. Ocellus small and situated closer to the eye than to apex of rostrum. Rostrum blunt and antennule reaching tip of the rostrum. Setae on antennae: 0-0-3 / 0-1-3. Plate of labrum with bluntly ponted ventral margine (P.17; fig.g). Head shield with 3 main head pores and pores situated closer to posterior margin of shield. Postabdomen very long, tapering distally (P.17; fig.h). Claw long with one large basal spine, concave surface of the claw with setae in 2 groups, those in proximal group consist of spine-like setae increasing in size distally and ending in a longer spine. Distal setae short and fine, ending some distance before the tip.

Male: Not observed.

Occurrence: Kokkara wayal ditch, Nandikara paddy field, Nellayi paddy field, Ponkothara paddy field and Periyar Lake.

Distribution: First report from India.

Remarks: Quite a good number of specimens belonging to this species were present in the samples collected mostly from paddyfields of Thrissur district in addition to a few from Periyar Lake, Thekkady. Present report forms the first record of this species from India. Specimans are characterised by rounded posterodosal and posteroventral corners having no denticles. The antennule is large enough to reach the tip of rostrum. Although this species resembles *Comptocercus australis* the above mentioned characters unique to *C. uncinatus*

45, ***Graptoleberis testudinaria*** (Fischer, 1851)

(Plate: 17,figs:i-m)

Female: Size: Length = 0. 47 mm; Height = 0. 27 mm.

Dorsal margin arched; ventral margin almost straight; maximum height at middle (P.17, fig.i). Rostrum semicircular at apex covering the antennule. Ocellus small and situated nearer to eye than to apex of rostrum. Antennae setae: 0-0-3 / 0-1-3. Labrum rounded at apex (P.17, fig.j). Valve reticulated with longitudinal and transverse lines. Ventral margin of valve with series of long and feathered setae decreasing in size posteriorly. Posteroventral corner of valve armed with two denticles (P.17, fig.k). Head shield with broadly rounded anterior margin and narrow posterior margin. Three connected head pores situated on the median line about ½ inter pore distance from the posterior end (P. 17, fig. l). Postabdomen tapering distally with a sharp pre-anal corner. Dorsal margin armed with 8 small spines and 9 groups of spinules on the lateral surface of postabdomen. Claw short and setulated on concave margin with one small basal spine (P. 17, fig.m).

Male: Not observed.

Occurrence: Pulloor pond.

Distribution: Kashmir (Brehm, 1936; Michael & Sharma, 1988), Kumaon, western Himalaya (Brehm, 1950), Collairu lake, Tamil Nadu (Michael & Sharma, 1988).

Remarks: Rare. Only 2 mature female were collected from marginal zone of the pond along with lot of duckweeds. The associated cladoceran species were *Chydorus barroisi* Richard, *Ceriodaphnia cornuta* Sars and *Macrothrix spinosa* King.

46, ***Leydigia acanthocercoides*** **(Fischer, 1854)**

(Plate: 18, figs: a-e)

Female: Size: Length = 0. 39 mm; Height = 0. 26 mm.

Body almost oblong; dorsal margin evenly curved (P.18, fig.a). Ventral margin of the valve slightly convex with series of long setae; posterior margin of valve also convex. Valve ornamented with longitudinal lines and dots. Ocellus larger than eye; situated closer to eye than to apex of rostrum. Plate of labrum with hairs on anterior margin (P.18, fig.b). Rostrum short, blunt and directed ventrally. Antennule not reaching apex of rostrum. Head shield with narrow rounded anterior and posterior margin (P.18, fig.c). Three connected head pores situated on median line of shield and two small lateral pores situated closer to the middle pore. Postabdomen large and broadly rounded with concave anal margin (P.18, fig.d). Dorsal margin armed with 20 groups of small denticles each group consisting 2- 3 denticles with distalmost denticles being the longest in each group. Lateral side also armed with 20 groups of long spines, which decrease in size proximally. Claw without basal spine and setulated on concave margin (P.18, fig.e).

Male: Not observed.

Occurrence: Marginal area of Vazhachal water falls.

Distributions: Calcutta (Gurney, 1907), Rajastan (Biswas, 1971; Nayar, 1971; Michael & Sharma, 1988; Venkataraman, 1992a), Gujarat (Petkovski, 1966), Kashmir (Michael & Sharma, 1988), Punjab (Battish, 1992).

Remarks: *L. acanthocercoides*, only two immature females were collected from among decaying leaves. Although Fisher (1854) described the presence of longitudinal lines on the valves in the present specimens the lines were represented by only lines of dots. In the absence of mature specimens detailed studied could not be made.

47, ***Biapertura affinis*** **(Leydig, 1860)**

(Plate: 18, figs: f-j)

Female: Size: Length = 0. 62 mm; Height = 0. 34 mm.

Body oblong; dorsal margin arched; ventral margin angular at middle (P.18, fig.f). Maximum height little before the middle. Posterodorsal corner and posteroventral corner rounded. Ventral margin of the valve with series of setae followed by a row of short setules along the posteroventral margin which continue dorsally as a row of spinules on the inner side of the posterior margin (P.18, fig.g). Ocellus smaller than eye situated closer to eye than to apex of rostrum. Plate of labrum with convex anterior margin (P.18, fig.h). Rostrum blunts; antennule not reaching apex of rostrum. Setae on antenna: 0-0-3/ 1-1-3. Head shield with rounded anterior margin and pointed posterior margin with fine striations on the surface (P.18, fig.i). Two connected median head pores situated near posterior margin and two lateral pores situated on both sides of the anterior pore. Valve ornamented with longitudinal lines. Postabdomen uniformly wide, pre and post anal corners distinct. Dorsal margin armed with 15 ciliated anal denticles. Lateral side of the postabdomen also armed with 10 groups of setules. Claw long, curved with one long basal spine. Series of setules at the base of the claw and along the proximal surface of basal spine (P.18, fig.j).

Male: Not observed.

Occurrence: Boothathankettu reservoir, Kokkara wayal ditch, Kollenkodu pond and Ponkothara paddy field.

Distributions: Kashmir (Brehm, 1936), Gujarat (Petkovski, 1966), W. Bengal (Sharma, 1978; Michael & Sharma, 1988), Meghalaya (Michael & Sharma, 1988), Punjab (Battish, 1992).

Remarks: Common among weeds. More than 15 parthenogenrtic females were collected from a ditch near to Kokkara wayal and 3 females from marginal weedy zone of Boothathankettu reservoir near Thattakadu birds sanctuary. The present specimens agree with descriptions given by Smirnov (1974), Michael & Sharma, (1988) and Battish (1992).

48. ***Biapertura karua*** **(King, 1853)**

(Plate: 19, figs: a-d)

Female: Size: Length = 0. 36 mm; Height = 0. 23 mm.

Body oval in outline with distinct posterodorsal corner (P.19, fig.a). Maximum height slightly before the middle. Ocellus smaller than eye; situated closer to the eye. Rostrum blunt; antennule not reaching apex of rostrum. Plate of labrum rounded anteriorly, slightly pointed ventrally with a notch on the apex (P.19, fig.b). Head shield with narrowly rounded anterior margin and broadly rounded posterior margin (P.19, fig.c). Two connected head pores situated near the posterior margin. Valve ornamented with distinct lines and polygons. Ventral margin with series of setae. Posteroventral corner rounded with 5 denticles. Postabdomen moderately large with distinct preanal and postanal corners (P.19, fig.d), distal corner rounded. Dorsal margin armed with 10 denticles sub-marginally. Lateral margin occupied with 11 groups of setules. Claw long with very small basal spine. Claw and basal spine setulated on concave margin.

Male: Not observed.

Occurrence: Boothathankettu reservoir, Chalakudy paddy field, Navarikulam and Periyar Lake.

Distribution: Meghalaya (Patil, 1979), Karnataka (Patil&Gouder, 1988), W. Bengal (Sharma, 1978; Michael & Sharma, 1988), Madras- Tamil Nadu (Michael & Sharma, 1988), Rajasthan (Venkataraman, 1992a), Punjab (Battish, 1992).

Remarks: Common species, King (1853) first described the species as *Alona karua*. The present species can be distinguished by its two connected head pores on head shield and 4-5 denticles on posteroventral corner of valve. The number of denticles on posteroventral coner of valve varies from animal to animal even in the same population. Idris (1983) described this species from Malaysia with 2-4 denticles on posteroventral corner of valve and two sets of setules on concave margin of postabdominal claw. The two sets of setules on claw were not observed in the present material.

49, ***Biapertura verrucosa*** **(Sars, 1901)**

(Plate: 19, figs: e-g)

Female: Size: Length = 0. 32 mm; Height = 0. 23 mm.

Body oval in out line with rounded posterodorsal and posteroventral corners (P.19, fig.e). Ocellus smaller than eye situated closer to eye than to apex of rostrum. Rostrum blunt and antennule not reaching apex of rostrum. Plate of labrum with an incision in the middle of the anterior margin (P.19, fig.f). Setae on antennae: 0-0-3/ 0-1-3. Valve ornamented with tubercles (verrucae); tubercles clearly visible only on anterodorsal area of body. Ventral margin of valve with a series of setae followed by a row of setules along the posteroventral corner and inside the posterior margin. Head shield with narrowly rounded anterior margin. Two connected median pores situated one interpore distance from posterior margin and two large lateral pores on either side of the anterior pore. Postabdomen with distinct preanal and postanal corners (P.19, fig.g). Dorsal margin armed with 10 anal denticles; 9 groups of lateral setules on postabdomen. Distal corner of postabdomen rounded. Claw with small basal spine and two types of setules on concave margin.

Male: Not observed.

Occurrence: Kollenkodu pond, Peechi reservoir and Periyar Lake.

Distribution: Gujarat (Petkovski, 1966), Rajastan (Nayar, 1971; Venkataraman, 1992a) Kerala, Madras, Madurai, Nainital (Michael & Sharma, 1988).

Remarks: Common species among weedy margins of water bodies. Present species already been recorded from Kerala by Michael & Sharma (1988) based on the collection sent by Dr. D. G. Frey from Jagady pond. The '*verruca*' in the present specimens visible only on anterodorsal margin of valve, even in aged specimens. In young specimens the *verrucae* (tubercles) were not so prominent.

50, ***Biapertura intermedia* Sars, 1862**

(Plate: 19, figs: h-j)

Female: Size: Female = 0. 38 mm; Height = 0. 25 mm.

Body almost sub-quadrate in shape with rounded posterodorsal corner (P.19, fig.h). Dorsal margin of valve arched; ventral margin with series of setae, followed by groups of setules on posteroventral corner which continue with series of setules inside the posterior margin (P.19, fig.i). Valve ornamented with longitudinal lines. Ocellus smaller than eye and situated half way between eye and tip of the rostrum. Rostrum blunt, antennule not reaching apex of rostrum. Plate of labrum rounded anteriorly and slightly conical ventraly. Head shield with narrowly rounded anterior margin and slightly pointed posterior margin. Head pores typical for the genus. Postabdomen long and slightly expanded distally with rounded distal corner (P.19, fig.j). Preanal corner distinct; post anal corner not so distinct. Dorsal margin armed with 8 denticles lateral side armed with 12 groups of setules; distalmost setules projecting beyond the dorsal margin of the postabdomen. Claw long and slightly curved with single basal spine. Claw and basal spine setulated on concave margin.

Male: Not observed

Occurrence: Periyar Lake.

Distribution: First report from India.

Remarks: Seven parthenogenetic females were present in a sample collected from the Periyar Lake near the boathouse. In general, the present specimens agree with the descriptions given by Smirnov (1974) but differ in having ocellus smaller than eye and antennule note reaching the apex of rostrum. The specimens obtained by Idris (1983) from Malaysia also had smaller ocellus and antennule note reaching the apex of rostrum like the Periyar specimens.

51, ***Oxyurella singalensis*** **(Daday, 1898)**

(Plate: 20, figs: a-e)

Female: Size: Length = 0.47 mm; Height = 0. 28 mm.

Body oval in outline with rounded posterodorsal corner (P.20, fig.a); maximum height in the middle; ventral margin of the valve almost straight with setae followed by series of spinules continuing dorsally (P.20, fig.b). Ocellus smaller than eye and situated closer to eye than apex of rostrum. Rostrum blunt, antennule not reaching apex of rostrum. Plate of labrum rounded at anterior margin (P.20, fig.c). Head shield with narrow rounded anterior margin and broadly rounded posterior margin (P.20, fig.d). Two separate main head pores situated behind each other in median line of head shield. Two other small head pores also present in between the main head pores. Valve not reticulated but ornamented with dots. Postabdomen narrowing distally with 12 spines on dorsal margin which decreasing in size proximally; distalmost spine short (P.20, fig.e). Lateral side occupied by 4 groups of spinules. Claw long and slightly curved with one large and an additional small basal spine.

Male: Not observed.

Occurrence: Boothathankettu reservoir, Kollenkodu pond, Muvatupuzha rocky pool, Parappukara paddy field, Parambikulam earth dam.

Distribution: W. Bengal (Sharma, 1978; Michael & Sharma, 1988), Punjab (Battish, 1981), Kerala (Michael & Sharma, 1988), Rajasthan (Venkataraman, 1992a).

Remarks: Quite a good numbers of specimens of this species were collected from different localities Smirnov (1974) described this species from White Nile.Those specimens were characterized by a labral plate with pointed apex and a postabdominal claw with 3-4 Basel spines. In the specimens from present localities the labrum somewhat rounded without a point and the claw has only two basal spines that are unequal.

52, ***Kurzia longirostris*** **(Daday, 1898)**

(Plate: 20, figs: f-h)

Female: Size: Length = 0. 52 mm; Height = 0. 38 mm.

Body oval in outline with posterodorsal and posteroventral corners rounded (P.20, fig.f). Dorsal margin of valve rounded; ventral margin convex anteriorly and concave posteriorly. Posterior margin convex and setulated along the margin. Rostrum very long and ventrally directed. Ocellus small and situated nearer to eye than to apex of rostrum. Valve ornamented with longitudinal lines and fine dots. Antennule reaching just beyond the middle of rostrum. Head shield with rounded posterior margin and pointed anterior margin; three connected head pores (P.20, fig.g). Plate of labrum with pointed apex. Postabdomen long and tapering distally with rounded distal corner projecting beyond the base of claw (P.20, fig.h). Pre and post anal angle distinct with 13 spines on dorsal margin of postabdomen. 11 groups of spinules also present on lateral side. Claw setulated on concave margin with fine setules.

Male: Not observed.

Occurrence: Boothathankettu reservoir, Muriyard kayal and Ponkothara paddy field.

Distribution: W. Bengal (Sewell, 1935; Sharma, 1978; Michael & Sharma, 1988) Madurai (Michael & Sharma, 1988) Rajasthan (Venkataraman, 1992a).

Remarks: Occurred in weedy marginal zone of water bodies. Venkataraman (1992) did not notice the longitudinal lines on the valve of *K. longirostris* obtained from Keoladeo National park, Rajastan but in the present specimen the longitudinal striations are very

clear and prominent. Present specimens agree with the descriptions given by Smirnov (1974), Michael & Sharma, (1988).

53, ***Euryalona orientalis*** **(Daday, 1898)**

(Plate: 20, figs: i-j)

Female: Size: Length = 0. 72 mm; Height = 0. 54 mm.

Body almost quadrangular in outline (P.20, fig.i). Posterodorsdal and posteroventral corners of valve rounded. Dorsal margin evenly rounded; posterior margin convex. Ocellus smaller than eye and situated half way between eye and apex of rostrum. Plate of labrum with convex anterior margin. Setae on antennae: 0-1-3/ 0-0-3. Valve ornamented with lines of dots, ventral margin of valve with several concentric rows of weak dots and blunt process also present before middle. Rostrum blunt and antennule reaching the apex of rostrum. Head shield broad with rounded anterior and posterior margin. Postabdomen long and tapering distally with rounded distal end (P.20, fig.j). Preanal and postanal corners not so distinct, postanal margin slightly concave. Dorsal margin armed with 26 denticles, decreasing in size proximally. Claw with two sets of setules, those in proximal group slightly longer and ending in stouter setae, distal setules shorter and ending some distance before tip.

Male: Not observed.

Occurrence: Boothathankettu reservoir, Kollenkodu pond, Navarikulam, Nandikara paddy field and Swarnakulam pond.

Distribution: W. Bengal (Sharma, 1978; Maichael & Sharma, 1988), Tamilnadu (Michael & Sharma, 1988), Rajasthan (Venkataraman, 1992a).

Remarks: Several females of this common species were collected. This is the only species of *Euryalona* reported so far from India.

54, ***Notolona globulosa*** **(Daday, 1898)** (= *Indialona globulosa* (Daday, 1898)

(Plate: 21, figs: a-c)

Female: Size: Length = 0. 33 mm; Height = 0. 22 mm.

Body almost oval in outline with distinct posterodorsal corner (P.21, fig.a). Posteroventral corner rounded without denticles. Dorsal margin evenly arched; maximum height before middle. Ocellus small and situated half way between eye and tip of rostrum. Rostrum blunt and antennule not reaching apex of rostrum. Valve ornamented with longitudinal striations; ventral margin turned inward at the anterior and posterior part of valve. Head shield with blunt anterior margin and pointed posterior margin (P.21, fig.b). Plate of the labrum with bluntly denticulated anterior margin (P.21, fig.c). Head shield with two large semicircular holes. Postabdomen long and tapering distally with distinct pre and post anal angle (P.21, fig.d). Dorsal margin armed with 12 small denticles and 10 groups of lateral spinules. Claw long, setulated on concave margin and with short single basal spine.

Male: Not observed.

Occurrence: Kunnu bigg pond, Parappukara paddy field.

Distribution: W. Bengal (Sharma, 1978; Michael & Sharma, 1988), Madurai, (Michael & Sharma, 1988), Kerala, (Michael & Sharma, 1988), Rajasthan (Venkataraman, 1992b).

Remarks: *Notalona globulosa* have already been reported from Kerala state by Michael & Sharma (1988) based on the collection taken by Dr. D. G. Frey from Jagady pond, Trivandrum. Michael & Sharma (1988) reported the species with bluntly denticulated pointed apex of labrum where as in the present materials labrum show some degree of variations in denticulation. Same specimens donot have much denticulation on their labral plates (P.21, fig.c).

PART-I
DISCUSSION

K. K. Subhash Babu “Studies on freshwater Cladocera ” Thesis. Department of Zoology, Christ college Irinjalakuda , University of Calicut, 2000

Chapter-4

DISCUSSION

DISCUSSION

Among the freshwater zooplankton, cladocerans constitute a highly diversified group represented by nearly 450 species all over the world. The present study has revealed the occurrence of 54 species of Cladocera belonging to 29 genera under 7 families. Since the data is based on random collections from different localities, more extensive sample collections during different seasons of the year may reveal the presence of larger number of species from this state. As per the earlier literature (Brehm, 1953, Michael & Sharma, 1988 and Raghunathan, 1989) only 25 species are so far known from Kerala. Different types of freshwater habitats comprising large water bodies and perennial ponds, monsoon ditches and pools and inundated paddy fields existing in Kerala provide ideal habitats for the survival and growth of cladoceran species. Welch (1952) and Hutchinson (1967) have already indicated the suitability of lentic habitats for better survival of these micro crustaceans. The fact that only 5 species were obtained from lotic habitats in the present study support the earlier observation

One of the interesting observations in the present study is the species richness observed in inundated paddy fields. Among the 54 species 27 species were found abundantly present in paddy fields inundated after rain. The decaying hay and other organic matter might have provided an ideal environment for growth and propagation of the cladocerans. Among the cladocerans moinids often appeared in swarms in early phase of cultivation. Margratitora *et al.*(1987) also observed the abundance *Moina affinis* along with other moinids in a experimental rice field in Italy. Presence of 15 species of Cladocera in a temporary pond (Kollemkodu pond) in the district of Palakkad is noteworthy. Presence of *Moina macrocopa* a hairy form of moinid in the highly turbid water collected from an elephant foot depression at Thekkady was another interesting observation.

In the natural habitat the cladoceran population is almost completely formed of parthenogenetic female and the males appearing very rarely. Appearance of males in generally found associated with the onset of drying of the pond, increased density of population leading to crowding effect and probably deterioration of the environment (Pennak, 1991; Dodson & Frey, 1992). Appearance of males in the

population is known to induce the production of ephippial females, which enable the species to tide over the unfavorable environmental conditions.

Although *Daphnia* is known to be widely distributed genera, its absence from Kerala waters deserves more attention. Michael and Sharma (1988) reported 3 species of *Daphnia* from the neighboring state TamilNadu. While Fernando (1974) reported the same from SreLanka. Herbaček (1958) demonstrate the importance of fish in the regulation of the size and composition of Zooplankton. Further investigations are necessary to verify the absence of the genus from Kerala so as to ascertain whether it is due to some ecological factors or not.

As reported by many workers the chydorids are the very successful group among cladocerans. Presence of 31 species of chydorids in the present collections also indicates the high survival value of the group. This may be due to their miniature size and comparatively hard carapace that enabled them to escape from the predatory pressure existing in the environment.

Fernando and Kanduru (1984) not recorded *Pleuroxus laevis* (=*Picripleuroxus laevis*) below 22° N but in the present study same species recorded from below 12° N. Further more, the present study added two more *Pleuroxus* species viz., *Pleuroxus similes*; *Pleuroxus denticulatus* to Kerala list. Occurrence of northern cladocerans in Kerala waters may be introduced by birds. Thiememann (1950) suggested the role of the birds in the distribution of Zooplankton of the freshwater environment. Birds, especially those with migratory habit are likely to carry the resting stages such as cysts, eggs and ephippia on their legs and other body parts while they visiting from one water body to another. Presence of large number of cladoceran species in the paddy fields of Kerala can be attributed to the seasonal visit of migratory birds. Further studies in the fresh water micro crustacean fauna of their habitat that are frequently visited by migratory birds will help us greatly in providing valuable information regarding the distributions of several species.

PART-II
REVIEW OF LITERATURE

PART-II

BIOLOGY AND LIFE CYCLE

Chapter-5

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Although, more than 93 taxa of cladocerans have already been reported from India our knowledge about the biology of Indian Cladocera is restricted to only a few species.

Michael (1962). Studies made by Michael on the biology and reproduction dynamics of *Ceriodaphnia cornuta* Sars is probably the first in this direction. The study was made based on a natural population of this species from a pond at Barackpore, W. Bengal. During this study he observed 1-2 preadult instars and 9 adult instars and the maximum number of eggs produced were found to be 42 in a life span of 12 days.

Navaneethakrishnan & Michael (1971). They studied the life cycle of *Daphnia carinata* King and observed that the animal under gone 5 preadult instars and 8 adult instars during a life span of 24 days and produced an average of 42.4 eggs at 29 - 31° C. They also pointed out that the egg numbers in *D. carinata* gradually increased from the first to the last instar.

Murugan & Venkataraman (1975). Detailed observations were made on the embryonic development of *Daphina carinata* King. They observed that the basic pattern of development was similar to that of other daphnids. Whereas duration of the total period of development as well as the individual stages in *D. carinata* differed from those of other tropical and temperate forms. The total embryonic development time observed was found to be 28-30 hours.

Murugan (1975a). The laboratory studies of *Moina micrura* Kurz revealed that the animal produced 61.8 eggs during the life span of 13 days. He also observed 2 preadult and 11 adult instars at temperature of 28-30° C and instar duration was found to be 24 hours for all. The embryonic stages of *M. micrura* exhibited a close relationship with other cladoceran species.

Murugan & Sivaramakrishnan (1976). Under laboratory conditions *Scapholeberis kingi* (sars) produced 239 eggs during a life span of 20.56 days at 18-30° C and the animal had two preadult and seventeen adult instars. The duration of preadult and adult instars was compared with that of other tropical Cladocera. Egg production was found to be uniformly high with minor fluctuations. The general pattern of embryonic development of *S. kingi* showed close similarities to that of allied tropical and temperate species.

Murugan (1977). Development of the parthenogenetic egg of *Simocephalus acutirostratus* Sars was studied in different artificial media. The hatchability was found to be 100% in 0.001 to 0.01 M of sodium chloride. Hundred percent hatchability was also noticed in concentration ranging from 0.001M to 0.05 M of calcium chloride. High percentage of hatchability was noticed when solution of sodium and calcium chloride were mixed. Apart from this, the hatchability of the different stages of the embryo was studied in artificial media, which contained varied proportions of sodium chloride, potassium chloride and calcium chloride. All these results were discussed and compared with temperate species of *Simocephalus vetulus*(O.F. Muller).

Sharma *et al.* (1981). Laboratory studies on a cladoceran male *Daphnia lumholtzi* Sars indicated that the animal had under gone total 13 instars and with average life span of 30.3 days at 12 - 18° C temperature.

Venkatarman (1981). The life history and seasonal variation in egg production of *Daphinia carinata* King were studied under laboratory conditions. Laboratory studies revealed that the animal had undergone 3 pre adult and 15 adult instars at a temperature of 29 ± 1°C and animal produced 57.8 eggs in the life span of 26 days.

Murugan & Jobe (1982).The biology of *Ledigia acanthocercoides* (Fischer) has been studied with reference tolongevity, instar duration, growth, fecundity and embryonic development at temperature range of 28-30° C. The animals had

undergone 3 pre adult and 13 adult instars during a period of 23 days and produced 20 eggs. The general pattern of embryonic development of *L. acanthocercoides* was also studied.

Kanaujia (1982). The life cycle of *Ceriodaphnia cornuta* Sars comprising instar duration, average number of eggs / brood, total number of eggs produced and life span at 16°C-25°C were studied under laboratory conditions. Based on these studies he concluded that the instar duration, number of instar, egg production and longevity of *C. cornuta* exihibit direct relationship with temperature.

Kanaujia (1984). while studying the life cycle of *Daphnia lumholtzi* Sars observed 3-4 pre- adult instars and 20 adult instars. This species produced 301 eggs during the life span of 54 days at water temperature 18-26° C. He also observed the appearance ephippial eggs when the population became crowded in. Moreover, instar duration, number of eggs/ brood, egg production and longevity of animal were also found to be influenced by seasonal water temperature. Seasonal variations also induced the formation of helmet in female *D. lumholtzi.*

Kanaujia (1987). In his laboratory studies, *Simocephalus vetulus* (O.F. Muller) passed through 3-4 pre adult instars and 20 adult instars during the life span of 41 days and produced 496.7 eggs at water temperature of 28-31° C. He also observed the pond water having organic detritus and nanoplankters were ideal for Cladocera. The duration of last few instars was very long and the increase in the size of the individual at each instar was rapid during pre-adult phase. He observed that the light coupled with particular range of temperature and food were main factors in the development of ephippia in *Simocephalus vetulus.*

Kanaujia (1988). The observation on the annual life cycle of *Simocephlus vetulus* (O.F. Muller) disclosed that an individual produced maximum 66 eggs / brood and total 627 eggs during the life span of 67 days in winter (16-27° C) where as the same species under laboratory condition produced average 26 eggs / brood and total

361 eggs in a life span of 31 days in summer (33-35° C) He also observed that the food and temperature have great influence on the life cycle of *S. vetulus*.

Murugan & Moorthy (1988). Laboratory studies on the life span, growth, fecundity and embryonic development of *Daphnia cephalata* King revealed that 15 of the 22 individuals became primiparous at 4^{th} instar and the remaining at 5^{th} instar. During the life span of 52 days the animals produced about 200 eggs at 27 ± 2° C. Various stages of embryonic development were also noticed during this study. In general, the developmental stages were same in all cladocerans but it differed only in period within the brood chamber.

Sharma & Sharma (1989). During the life span of 41.16 days at 20 ± 2 °C *Simocephalus exspinosus* (Koch) passed through 4 pre adult and 14 adult instars and produced 265.1 eggs. The adult instar duration was longer than pre adult instar duration. The mean clutch size ranged between 6.03 and 38.02 eggs / brood and the fecundity followed a uni-modal pattern.

Malhotra & Langer (1990). Biological aspects of *Moina macrocopa* (Straus) in relation to temperature variations. The life cycle of *M. macrocopa* were studied under different temperature ranges (7 -10° C, 13 -16 °C, 25 -28° C, & 30 -32° C). It produced maximum 300 eggs at low temperature (13 -15° C) during the mean life span of 53 days whereas at higher temperature (25 - 28° C) it produced higher number of eggs (255 nos.) during comparatively shorter period of 22 days. They also noticed the duration of embryonic development. The development was completed in 168 hours at 7-10° C and in 210 hours at 30-32° C.

Chandini (1991). Laboratory investigations were made on the effects of food and cadmium stress on the reproductive value and residual reproduction value of the two cladoceran, *Echinisca triserialis* (Brady) and *Daphnia carinata* King. Attempts were also made to test the cost of reproduction hypothesis on weather, the energy invested by organisms at particular time in reproduction could effects their future survival and reproduction.

Singh & Datta-Munshi (1991). Their studies on the biology of *Ceriodaphnia rigaudi* Richard and *Daphnia lumholtzi* Sars under laboratory condition revealed that a temperature of 28°C. *C. rigaudi* produced 46 eggs during the life span of 32 days where as the same animal produced 144 eggs at 32 ± 1° C in average life span of 14 days. In another instance *D.lumholtzi* produced only 14 eggs in a life span of 16 days at temperature 21.5 ± 1 °C. They collected these species from river Ganga and compared their results with similar studies on other Indian cladocerans.

Subhash Babu & Nayar (1993). During the laboratory investigations on the life cycle of *Ceriodaphnia cornuta* Sars they observed that the animal had undergone 2 pre adult instars and 12 adult instars and produced 67.3 eggs with in a life span of 16-17 days. Parthenogenetic egg production started at the 3rd instar and reached its maximum at the 8th instar and then declined till their death.

Subhash Babu & Nayar (1997). Laboratory observations on the life cycle of *Simocephalus serrulatus* Koch indicated that the neonates produced from the same brood pouch may be all females , all males or both male and female. The female neonates under gone 3 pre adult and 18 adults instars, producing 384.5 eggs during a life span of 35.8 days at 27 ± 2°C whereas males have only 2 pre adult phase. Maximum number of eggs are produced during the 10th-12th instars and declined subsequently till their death. Single sexual egg was observed in ephippial female, protected by two different coverings

PART-II
LIFE CYCLE OF MOINA MICRURA KURZ

K. K. Subhash Babu “Studies on freshwater Cladocera ” Thesis. Department of Zoology, Christ college Irinjalakuda , University of Calicut, 2000

Chapter-6

LIFE CYCLE OF *MOINA MICRURA* KURZ

Life cycle of *Moina micrura* Kurz

INTRODUCTION

Cladocera constitute an integral link in the aquatic food chain of freshwater ecosystem as they are able to produce large population within short time intervals. Study of the life cycle of the individual species of Cladocera are therefore valuable source of information in secondary productivity of aquatic ecosystems (Edmondson, 1971). More over, cladocerans are considered an ideal food in nursery pond and fish hatcheries of all cultivable fishes (Alikunhi *et al.* 1955; Parabrahmam *et al.* 1967). Therefore, knowledge about the life cycle and biology of Cladocera is a prerequisite for successful culture of these micro-crustaceans. In India investigations have already started in this direction by a few workers. One of the early reports on the life cycle of Indian Cladocera is that of Michael (1962) who made some observations on the life cycle of *Ceriodaphnia cornuta* Sars while studying the seasonal variations in its natural populations at Barackpure, Bengal. The other related studies under Indian context are those of Navaneethakrishnan & Michael (1971) on *Daphnia carinata* King; Murugan & Sivaramakrishnan (1976) on *Scapholeberis kingi* Sars; Murugan (1975b) on *Ceriodaphnia cornuta* Sars ; Murugan & Venkataraman (1977) on *Daphnia carinata*; Sharma *et al.* on male *Daphnia lumholtze* Sars; Murugan & Jobe (1982) on *Leydigia acanthocercoides*; Kanaujia (1982) on *Ceriodaphnia conuta* Sars ; Kanaujia (1984) on *Daphnia lumholtzi* sars; Kanaujia (1987) in *Simocephalus vetulus*. All these studies were mostly restricted to females while Sharma *et al.* (1981) studied the biology of male *Daphnia lumholtzi* Sars. This is probably the only investigation regarding the male reported from India.

The study of Thresiama *et al.* (1991) on production and population density of *Moina micrura* Kurz; Subhash Babu & Nayar (1993) on biology and life cycle of *Ceriodaphnia cornuta;* Subhash Babu and Nayar (1997) on laboratory studies on the life cycle of *Simocephalus serrulatus* Koch are similar studies made from Kerala. The above studies although gives good accounts on the life cycle of parthenogenetic

females they do not give much information about the life cycle of male. The present study is a detailed investigation on life cycle of *Moina micrura* Kurz, a common species in Kerala.

MATERIAL and METHODS

The specimens for the present study were collected from a concrete tank located in Christ College campus, Irinjalakuda and brought live to the laboratory. Ten healthy ovigerous females were sorted out under stereomicroscope and were transferred in to an earthen pot of 5-litter capacity containing culture medium. This was maintained as a stock culture and kept outside the laboratory. The culture medium was prepared by green pond water and filtered through a net made up of No: 50 bolting silk. The medium contained mainly unicellular algae (*Chlorella.* sp) with a density of about 10 x 10^4 cells / litre. Further, 500 mg / litre finely powered groundnut cake was also added for supplementary food for animals and growing algal cells.

One ovigerous healthy female isolated from stock culture with the help of a pipette was inoculated into a glass beaker containing 250 ml of the culture medium. The female was kept under constant observation so as to isolate the newly hatched young ones. Young ones (neonates) were individually reared in 10 different petridishes containing the culture medium and kept in laboratory under fluorescent light (40 watts). The time of hatching, moulting, number of neonates hatched in each brood and the life span of all the individuals were regularly recorded until their death. Newly released young ones from experimental animal were subjected to careful observation under low power microscope to check whether their sex and they were carefully transferred to another sets of petridish containing culture medium. All observations were made at room temperature 28 ± 2° C .The medium was changed every 24 hours in order to prevent any possible starvation and accumulation of faecal matters

Ephippial females were also collected from the stock culture and isolated under the microscope. Free ephippia found in large numbers floating on the surface of the culture medium as well as sticking on to the sides of the container were easily collected with the help of brush or pipette. Another set of 5 individuals was simultaneously reared in the same medium for dissections. Dissections were made using micro-tungsten needle and measurements were made with calibrated micrometers.

OBSERVATIONS

In mature females, the ovaries were seen as a pair of elongated sacs on each side of the alimentary canal. The content of the ovary was discharged through a small opening at the posterior end into the brood pouch. The discharged mass later become spherical and formed the eggs. The relation ship between mean size and the number of eggs produced from each brood and instar duration are given in Table - I.

The morphological features of the embryonic stages of *M. micrura* Kurz are given below, following the terminology of Green, 1965.

1. Eggs spherical, slightly greenish with transparent edge, encased by a thin egg membrane
   (Fig.1a).
2. Slightly elongated embryo with granulated central region surrounded by dividing cells. (Fig.1b).
3. Elongated embryo without distinct head lobe but the rudiments of antennae. Some fat globules present in the central portion of the developing embryo. (Fig. 1c).
4. Embryo with distinct head lobe and rudiments of antennae and antennule. The egg membrane cast off with the appearance of two pinkish eyespots (Fig. 1d).
5. Two pink eyespots changed in to large dark eyespots and moved closer to each other. The segmented endopodite and exopodite of the antennae clearly visible and with two rudiments of antennule (Fig. 1e).

6. Two dark eyespots fused and formed a large single median eye. Towards the end of this stage all appendages were well developed and the young ones started exhibiting movements (Fig. 1f).

The neonates hatched out from brood chamber resembled the adults in their morphological features (Fig. 1g).

The young ones were released from brood pouch by jerking movement of the postabdomen. Female neonates had a mean length of 0.49 mm and width of 0.24 mm. Individuals pass through a single pre adult instar and eleven adult instars in a life span of 12.6 days with an average instar duration of 25.1 ± 3.2 hours (n=10).

Maximum length of 1.2 mm and width of 0.84 mm were attained on its 10^{th} instar and maximum growth rate at its pre adult instar. In the first adult instar the animals produced 6 eggs and maximum number of eggs 18.4 ± 2.2 were observed at 7^{th} instar. After 7^{th} instar there was a decline in egg production and no eggs were observed at its 12^{th} instar. In total 122.8 ±11.06 eggs were produced during a life span of 12.5 days (Table-III). The number of eggs in individual brood was found to be less variable in early instars where as variations were more pronounced at their later instars (7^{th}-11^{th}) (Fig: 2). Moulting occurred at any time immediately after the release of the young ones from the brood pouch. Another sets of eggs were discharged in to the brood-pouch immediately after moulting and the parthenogenetic cycle is repeated.

EPHIPPIAL FEMALE (SEXUAL FEMALE)

Numerous ephippial females were observed in the stock culture. Ephippial female could be distinguished from parthenogenetic female by its somewhat smaller size and the presence of dark ephippium on its dorsal side of the carapace (Fig. 1i). Ephippium is a modified form of brood pouch with its outer surface ornamented with honeycomb-like pattern. It is somewhat saddle shaped with mean size 0.38m.m. Ephippium contain only single resting egg, which requires fertilisation by male.

MALE

Male was more oblong than female with a pair of long prehensile antennule (fig. h). Newly released male measured 0.49 mm in length and 0.24 mm height and the antennule measured 0.15 mm. One pair of long testes was clearly visible on both sides of the alimentry canal after its 1st instar. Six instars were observed during the life span of 417 hours (Table - II) and attained an average size of 0.89 mm in length and 0.39 mm width at their last instar. After 6th instar the animals stopped its moulting and maintained their size until death. In the present study nearly 20 % of animals were survived till the end of the experiment. Spermatozoa were spherical in shape with many radiating axons and measured 25μm, free movement of spermatozoa was observed in the testis after it's 3 rd instar. Testis opens on the dorsal side of the postabdomen by a pair of sperm ducts. The relationship between mean length, width, and instar numbers is shown in Fig. 3.

DISCUSSION

Cladocerans mainly reproduce parthenogenetically (Shan, 1969; Herbert, 1987a) and sexual reproduction can be either obligate or facultative. Life cycle of tropical Cladocera *Moina micrura* Kurz has already been studied by Murugan (1975a). He observed 2 pre adult instar and 11 adult instar during the life span of 13 days and he indicated that the duration of pre adult and adult instars were same (24 hours). However, in the present study the *M. micrura* Kurz has under gone only single preadult instar and eleven adult instars during the life span of 12.6 days (Table- I). Further, the preadult instar duration was shorter than average adult instar duration. In the present observation the adult instar duration varied from 22.2-28.4 hours. Similar observations on the variation of adult instar duration was also noticed by other workers in different tropical cladocerans (Venkataraman, 1981); (Kanaujia, 1987); (Subhash Babu & Nayar, 1993).

In the present observations, the average number of eggs produced by each female during their life span was 122.8±11.06 while Murugan (1975 a) observed only

61.8 eggs. The number of eggs / brood and duration of instar are directly influenced by many factors such as amount of food available to the animal (Anderson & Jenkins, 1943), temperature of the culture medium (Kanaujia, 1988) and genetic constitution of the specific species (Banta & Wood, 1939). Recent studies on the life history of Cladocera revealed that the instar duration, number of instars for primiparous stage,time to primiparous stage, and clutch size are all influenced not only by temperature and food but also by chemical signals produced by predators (Han, 1984; Schwatz, 1984; Havel & Dodson, 1987; Dodson, 1989). However, it needs further study for confirmation.

Increase in the size of the individual at each instar was found to be more rapid during the period of pre adult phase (Table- I). Green (1965) also observed the maximum growth rate in the pre adult instar of many daphnids.

In the present study number of eggs in first primiparous instar was 6 and maximum number of eggs were observed in it's 7^{th} instar, after which there was a decline and no eggs were observed at its last instar (Table-I), similar observation was also noticed by Green (1956); Murugan (1975a) and Venkataraman (1981). However, Navaneethakrishnan & Michael (1971) observed in *Daphnia carinata* King that the eggs/brood gradually increased from the first instar to last instar, while Murugan & Job (1982) observed only two eggs in all adult instars of *Ledigia acanthocercoids* (Fischer) with out any increase or decrease in the egg rate.

The embryonic stages in *M. micrura* revealed a close similarity with the general pattern of development and only the duration of embryonic period was different. Hutchinson (1967) pointed that the duration of embryonic development depends on the length of the instar.

Cladocerans also reproduce sexually (Shan, 1969; Herbert, 1978) but sexual reproduction is not obligatory. In the present study males were hatched out from parthenogenetic eggs. But according to Dodson & Frey (1991) males of *Moina* and *Daphniopsis* produced from sexually derived resting eggs. Asexual formation of males in other cladocerans is induced by some deterioration of the environment, such

as changes in food concentration, crowding, and decreasing photo - periods (Dodson & Frey, 1991).

Sharma *et al.* (1981) and Subhash Babu & Nayar (1997) reported the life span of male shorter than that of female in *D. lumholtzi* Sars and *Simocephalus serrulatus* Koch respectively. Further, no adult instar was observed in *S. serrulatus*. In the present study the life span of male was found longer than that of female (Table- II) and moulting occurred in the adult phase also. In chydorids, males mature in the 3rd instar and there is no further moulting. However, in the genus *Scapholeberis* and *Daphnia* males continue to moult even after maturity (Dodson & Frey, 1991). In the present observation the spermatozoa were spherical with radiating axons. Spherical spermatozoa with radiating axons is probably a generic character, since Goulden (1968) also observed similar features in *M. micrura*.

Male has an important role in production of ephippial female which enable the animals to tide over unfavourable environmental conditions. In nature, males appear in the population before the appearance of ephippial females (Shan, 1969). In the present study large numbers of ephippial females appeared in the stock culture when the population attained its peak which indicating the probable influence of crowding in the production of ephippial females. Similar observations were also made by Pennak (1991), Michael (1962) and Hutchinson (1967). It can be concluded, therefore, over crowding is a determinant factor induces male production and subsequent appearance of ephippial female.

Fig.1. Life cycle of *Moina micrura* Kurz

a. Female with spherical parthenogenetic eggs (0.9 mm)

b. Slightly elongated embryo with granulated central region (0.14 mm)

c. Elongated embryo with out distinct head lobe (0.23 mm)

d. Embryo with distinct head lobe (0.25 mm)

e. Embryo with two pink eye spots and well developed antennae and antennule(0.32mm)

f. Fully developed young one with single eye (0.37 mm)

g. Newly hatched young one (0.44 mm)

h. Male (0.70 mm)

i. Ephippial female with sexual egg (0.80 mm).

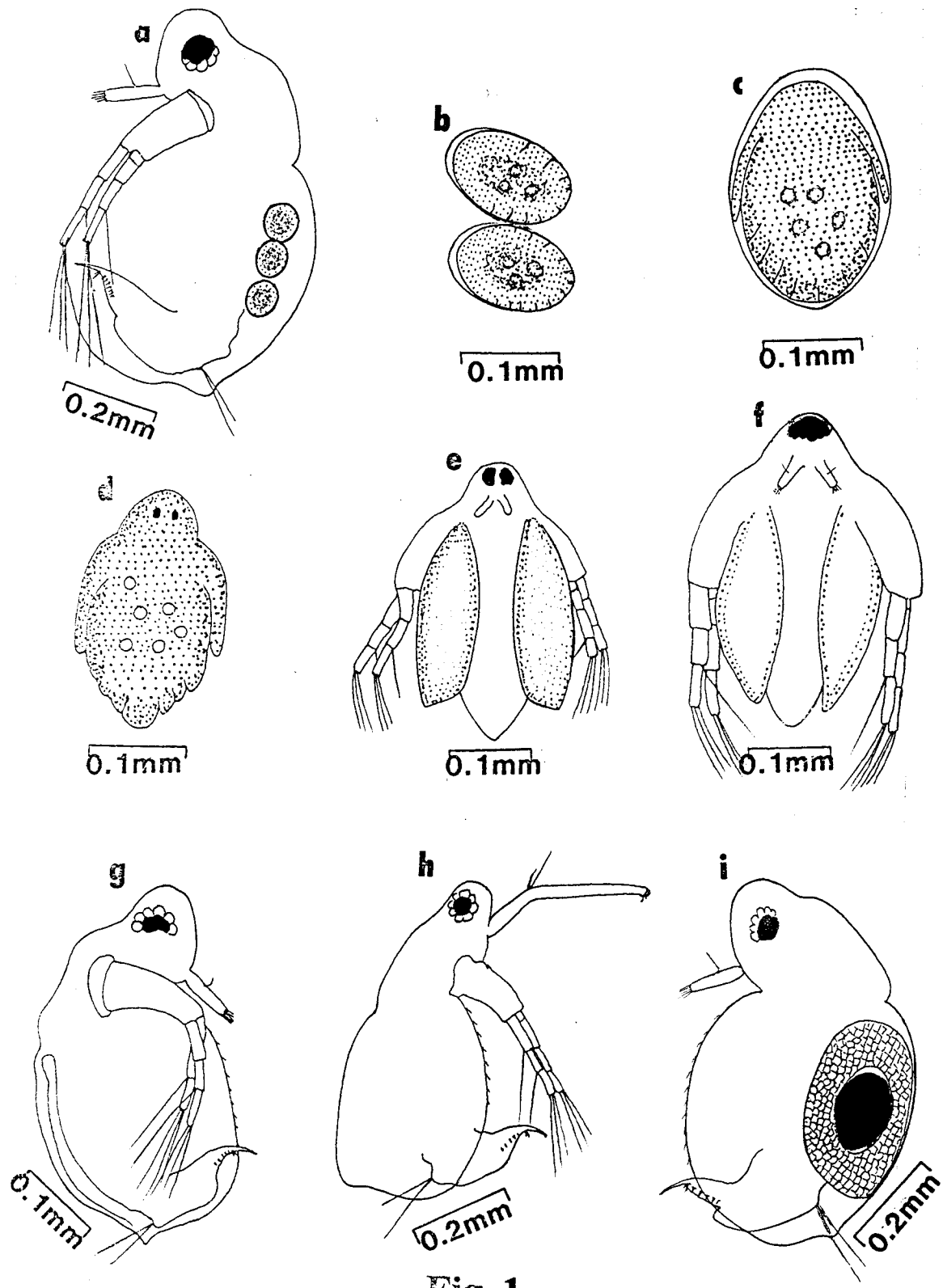


Fig. 1.

Table-1. Number of instars, size variation, number of eggs / brood and duration of instars in *Moina micrura* Kurz (female) at 28 ± 2° C (n = 10)

Instar No.	Mean Length (mm)	Mean Height (mm)	Eggs / Brood ($\bar{X}$ ± S. D.)	Instar Duration (in hours).	Cumulative Duration of instar (in hours).
1	0. 49	0. 24	0	20. 0	20.0
2	0.75	0.45	6 ± 0	22.2	42.2
3	0.87	0.54	16.3 ± 0.5	22.3	64.5
4	0.98	0.67	16.2 ± 0.6	24.1	88.6
5	1.03	0.71	16.8 ± 1.2	25.0	113.6
6	1.09	0.76	16.7 ± 1.2	28.4	142.0
7	1.12	0.80	18.4 ± 2.2	26.5	168.5
8	1.16	0.80	16.6 ± 1.6	28.2	196.7
9	1.18	0.82	11.3 ± 1.9	27.0	223.7
10	1.20	0.84	10.6 ± 2.3	28.1	251.8
11	1.20	0.84	7.5 ± 4.5	29.5	281.3
12	1.20	0.84	0	20.0	301.3

Table-II. Numbers of instars, duration of instars and size variations in *Moina micrura* Kurz (male) at 28 ± 2°C (n =10)

Instar No.	Mean length (mm)	Mean height (mm)	Duration of instars in hours	Cumulative duration of instars in hours
1	0.49	0.24	42.1	42.1
2	0.69	0.32	48.0	90.1
3	0.81	0.36	48.5	138.6
4	0.83	0.38	55.1	193.7
5	0.86	0.38	58.5	252.2
6	0.89	0.39	164.8	417.0

TABLE -III Eggs/brood in 10 animals (Ex_1-Ex_{10}) of *Moina micrura* Kurz at 28 ± 2°C

Instar No:	Ex_1	Ex_2	Ex_3	Ex_4	Ex_5	Ex_6	Ex_7	Ex_8	Ex_9	Ex_{10}	$\bar{X}$ ± SD
1	0	0	0	0	0	0	0	0	0	0	0
2	6	6	6	6	6	6	6	6	6	6	6 ± 0
3	17	16	16	16	17	17	16	16	16	16	16.3 ± 0.5
4	16	15	16	17	17	17	16	16	16	17	16.3 ±0.64
5	16	16	17	17	20	16	17	17	17	15	16.8 ±1.2
6	17	18	16	17	16	16	19	14	17	17	16.7 ±1.2
7	21	19	16	20	15	19	18	22	15	19	18.4 ±2.2
8	17	14	16	18	14	19	16	17	16	19	16.6 ±1.6
9	12	9	14	10	*	19	10	12	9	14	11.3 ±1.9
10	*	8	14	8	*	*	10	12	*	*	10.4 ±2.3
11	*	*	12	*	*	*	*	3	*	*	7.5 ±4.5
12	*	*	0	*	*	*	*	0	*	*	0
Total	**122**	**121**	**143**	**129**	**105**	**110**	**128**	**135**	**112**	**123**	**122.8±11.06**

0= No eggs * Animal died $\bar{X}$ = Mean SD = Standard deviation

Fig. 2. Relationship between number of instars, size variations, eggs/brood and duration of instars in *Moina micrura* Kurz (female) at 28± 2^{0}C (n=10)

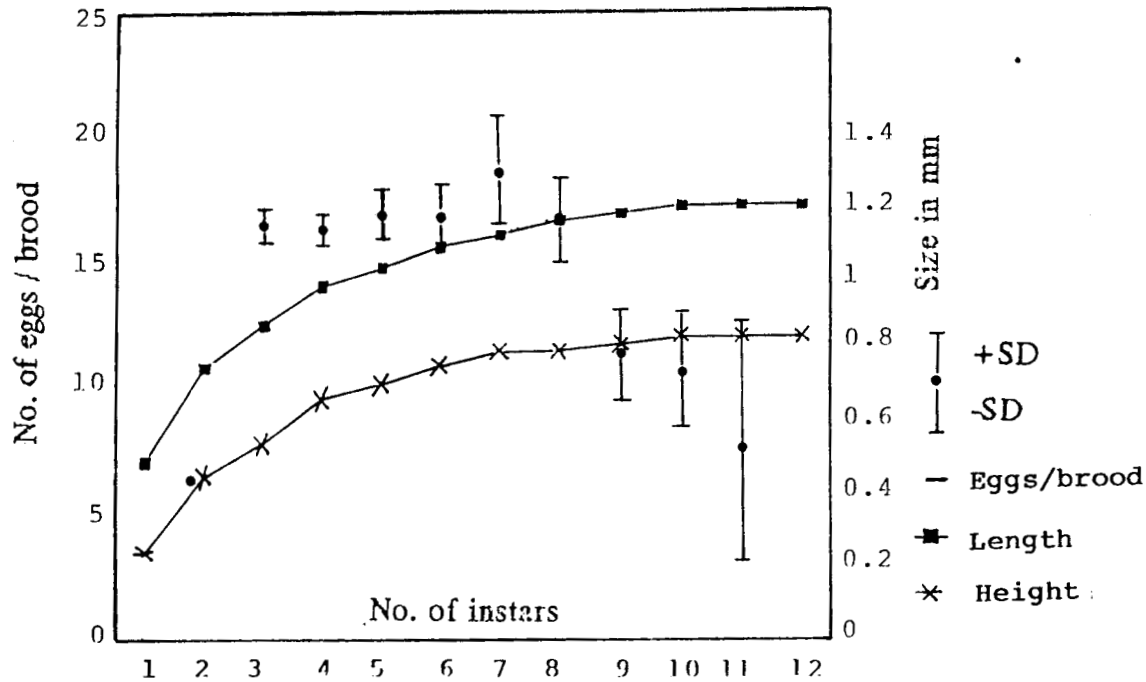
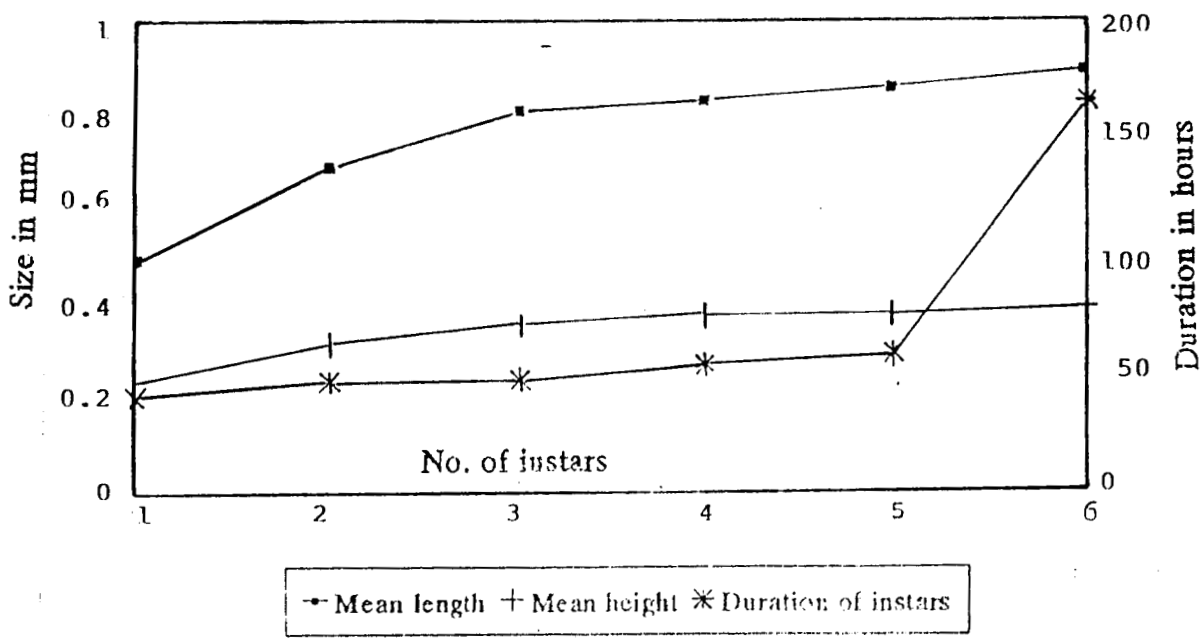


Fig. 3. Relationship between number of instars, duration of instars and size variation in *Moina micrura* Kurz (male) at 28± 2^{0}C (n=10)



PART-II
OBSERVATION ON THE LIFE CYCLE OF CERIODAPHNIA CORNUTA SARS

K. K. Subhash Babu “Studies on freshwater Cladocera ” Thesis. Department of Zoology, Christ college Irinjalakuda , University of Calicut, 2000

Chapter-7

OBSERVATION ON THE LIFE CYCLE OF *CERIODAPHNIA CORNUTA* SARS

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OBSERVATIONS ON THE LIFE CYCLE OF *CERIODAPHNIA CORNUTA* SARS

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ABSTRACT

Life cycle of *Ceriodaphnia cornuta* (Crustacea : Cladocera) has been studied in laboratory culture. No males or ephippial females appeared in the culture. Embryonic development was completed within 20-22 hours. *C. cornuta* showed two preadult instars and twelve adult instars with a life span of 16-17 days. Parthenogenetic egg production started with the 3rd instar, gradually increased to reach its maximum at the 8th instar, and then declined till their death.

Key Words : *Ceriodaphnia cornuta*, life cycle, culture.

INTRODUCTION

The success of fish culture operations greatly depends on the availability of suitable live food organisms in the fish pond. The importance of live feed in nursery ponds of carp culturre was pointed out by Alikunhi (1952) and Alikunhi *et al.* (1955). In freshwater environments Cladocera constitute an important group as they form a major food item of many species of fishes, particularly young ones. Culture of Cladocera, therefore, has assumed significance in freshwater fish culture, for which thorough knowledge about the biology and life cycle of different species is a prerequisite. Michael (1962) while studying the seasonal variations in the natural population of *Ceriodaphnia cornuta* collected from Barrackpore, Bengal, made some observations on its life cycle. Murugan (1975) made a detailed study of the biology of this species obtained from Madurai, Tamil Nadu. The only other report on the biology of this species from India is of Kanaujia (1988) based on collections from Cuttack, Orissa. In Kerala, no serious attempt has been made so far to study the systematics and biology of Cladocera of the the freshwater enviroment except that of Thressiamma *et al.* (1991), who studied the population density of another common species *Moina micrura* Kurz cultured in different media. Hence, the present work has been undertaken to study the life cycle of *Ceriodaphnia cornuta*, a common species found in the freshwater habitat.

MATERIALS AND METHODS

The specimens were collected from a concrete tank located on the Christ College campus, Irinjalakuda, Trichur district, Kerala, in October 1992 and brought to the laboratory in live condition. From this wild population, five healthy ovigerous females were selected under a stereoscopic microscope and transferred each of them to a 500 ml culture medium containing *Chlorella* sp. (10×10^3 cells/1 of water). The culture medium was prepared using organic manure (groundnut cake powder) at the rate of 2.5 gm/1 of water and maintained in the laboratory as stock culture under fluroscent light (40 watts).

The new individuals (neonates) released from each of the five females were transferred to separate petridishes containing the same culture medium. The medium was changed every 24 hours for proper maintenance of the culture. The time and mode of moulting, number of eggs/brood and life span of each individual were regularly monitored and recorded till their death. The experiments were repeated thrice and the mean values were taken. Observations were made under a stereomicroscope (12.5X x 4.0X) and measurements were taken by calibrated micrometers. Length of animals was measured from the

tip of the head to the tip of the posterior border of the carapace and width refers to the maximum width of the animal.

RESULTS AND DISCUSSION

The newly hatched young ones were all females and there were no males or ephippial females in the laboratory culture. Absence of males in the natural population of *C. cornuta* has also been observed by Michael (1962), Kanaujia (1988) and Byars (1960) indicating absence of sexual reproduction in this species. It is not unusual that certain species of Cladocera resort to only asexual reproduction (Edmondson, 1956) although ephippial females may appear in the natural population. Presence of ephippial females in the natural population and absence of males in *C. cornuta* suggest the possible parthenogenetic development of unfertilized resting eggs unlike many other Cladocera.

Development of the embryo within the brood pouch was completed in about 20-22 hours. Three embryonic stages were generally recognised : early, middle and later stages (Green, 1956). The early stage was represented by oval-shaped egg with a large middle area and a clear marginal area (Plate I-B). Later it became translucent with cleaved cells. During the middle stage the embryo became elongated anteroposteriorly and measured 0.183 mm. At this stage, rudiments of head lobe and antennary buds were formed, followed by the appearance of eye spots. During the later stage the antennae were segmented, eye became distinct and limb rudiments appeared on the ventral side of the embryo. After completing embryonic development, the young ones were released from the brood pouch by jerking movements of the postabdomen of mother. Moulting occurred as soon as the young ones were released and completed in a few minutes (Plate I-C). A slit appeared on the dorsal side of the cervical region and subsequently the carapace was discarded.

The newly hatched young ones liber-

TABLE I

Mean length, width, eggs/brood, total eggs produced, duration of each instar and cumulative frequency of eggs in each instar in *Ceriodaphnia cornuta*

No. of instar	Mean length (mm)	Mean width (mm)	Eggs/brood	Cumulative number of eggs	Instar duration in hours	Cumulative duration of Instar in hours
1.	0.240	0.150	—	—	23.3	23.3
2.	0.339	0.225	—	—	24.0	47.3
3.	0.464	0.312	1.3	1.3	26.6	73.9
4.	0.532	0.382	3.9	5.2	26.6	100.5
5.	0.552	0.405	4.7	9.9	27.3	127.8
6.	0.625	0.441	7.9	17.8	28.6	156.4
7.	0.669	0.461	9.8	27.6	30.0	186.4
8.	0.700	0.489	10.1	37.7	29.6	216.0
9.	0.721	0.504	7.25	44.9	27.3	243.3
10.	0.735	0.514	8.05	53.0	29.3	272.6
11.	0.738	0.519	6.4	59.4	33.6	306.2
12.	0.745	0.526	5.05	64.4	31.0	337.2
13.	0.752	0.530	1.45	65.9	35.3	372.5
14.	0.752	0.530	1.40	67.3	23.0	395.5

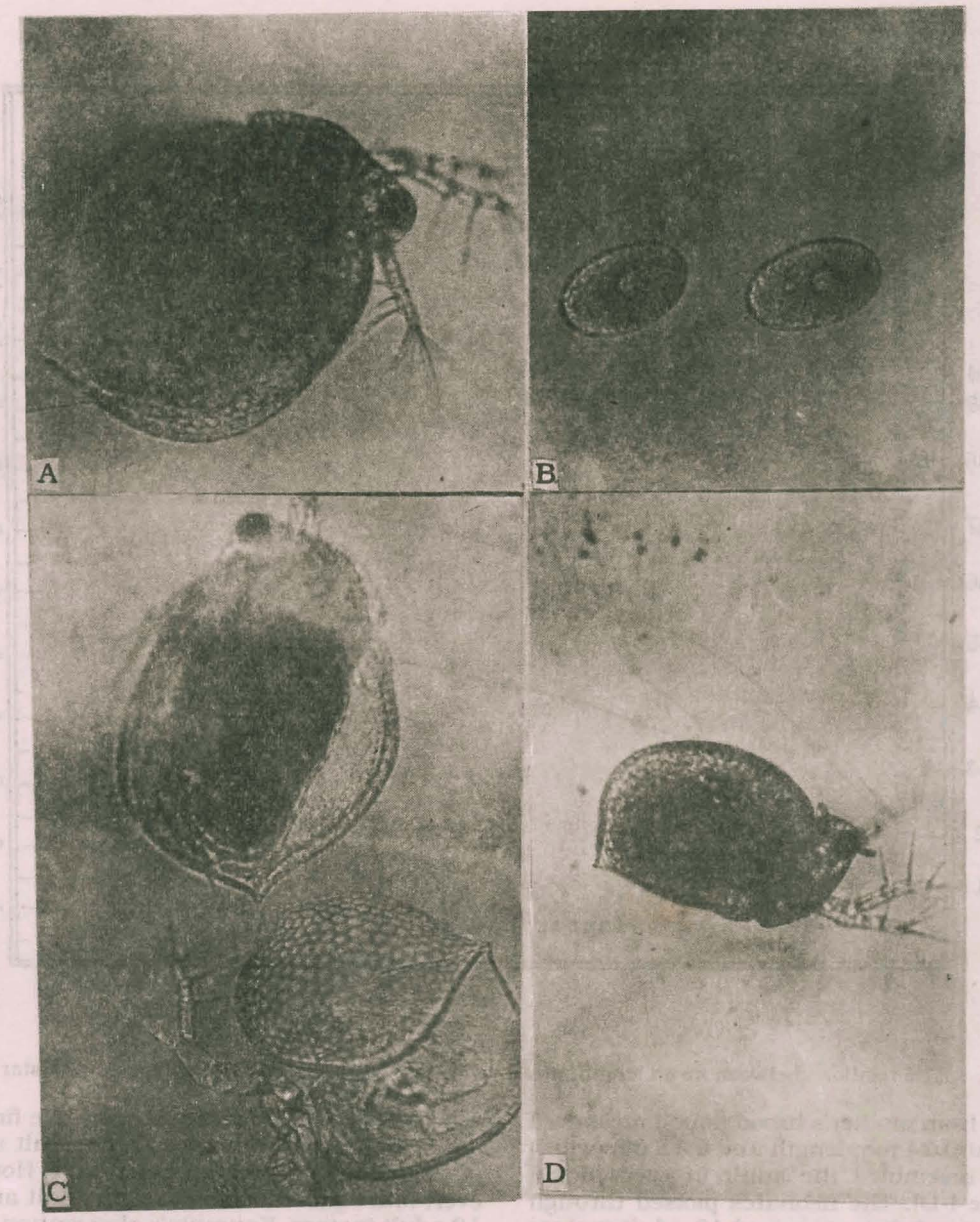

PLATE 1

A. Parthenogenetic female with eggs (0.480 mm) X 125
B. Parthenogenetic egg showing transparent outer margin and large granulated inner area (0.165mm) X 150
C. Parthenogenetic female just after moulting (0.465 mm) X 100
D. Newly released youngone (0.240 mm) X 200
(Numbers in parentheses indicate the actual size)

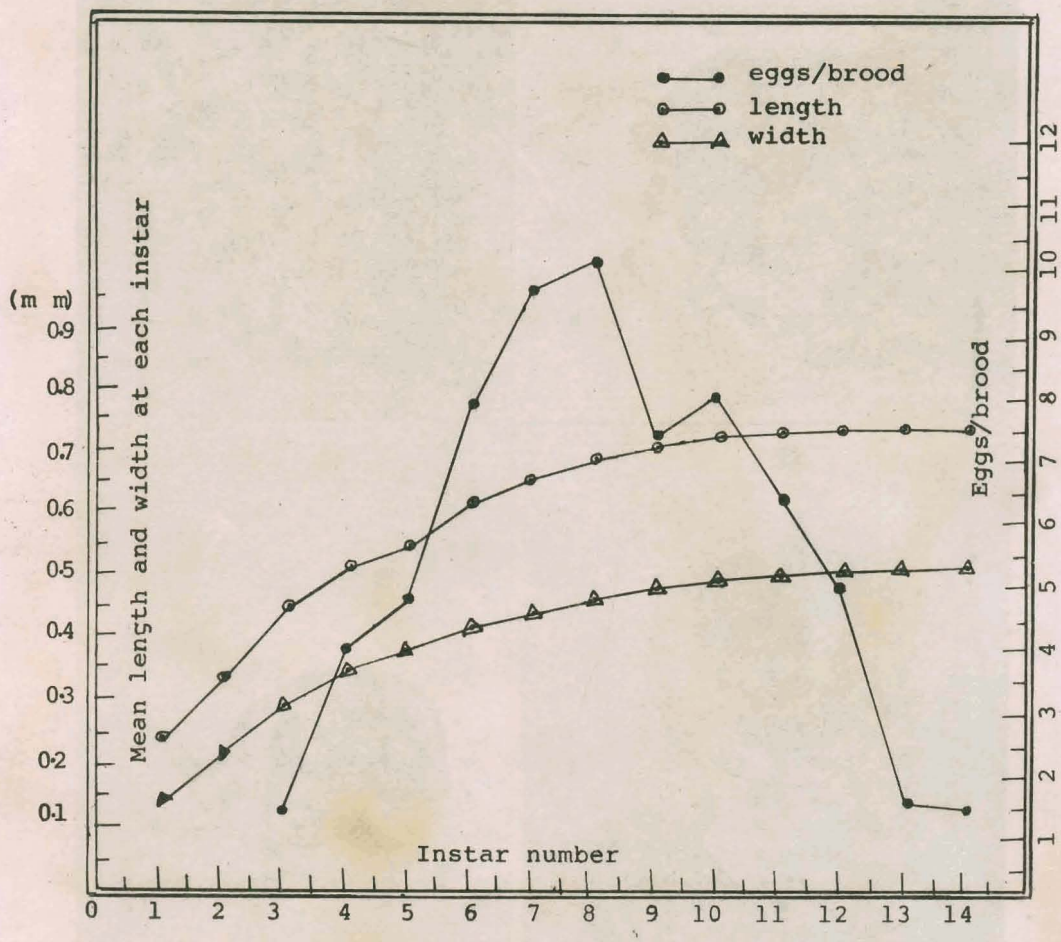

Fig. 1. The relations between mean length, mean width and eggs/brood of animals at each instar.

ated from mother's brood pouch measured about 0.24 mm length and 0.15 mm width and resembled the adult in every detail (Plate I-D). The neonates passed through two preadult instars and 12 adult instars by moulting during the life span of 16-17 days (Table I). Although the observations of Michael (1962), Murugan (1975) and Kanaujia (1988) agree with the present observation with regard to the number instars, there are differences in the number of adult instars. Michael points out that juvenile moults once or twice to reach the first adult instar and undergoes nine adult instars in a life span of about 12 days. However, Murugan observed two preadult and 18 adult instars. Kanaujia's observation of 25 adult instars and life span of 31 days suggests the possibility of extrinsic factors such as temperature and availability of food, influencing the moulting and life span. Kanaujia (1982) has also studied the influence of temperature on the life span, instar duration and egg production of this species

and observed 17 adult instars and 46 days of life span at water temperature of 16-25°C.

In the present study, the mean number of eggs produced by each female during the life span has been found to be 67.3 while Michael (1962) and Murugan (1975) observed 42 and 194 eggs respectively. Kanaujia (1988) suggested the difference in the latitude of locality from where the collections have been made as a possible factor in determining the number of eggs produced. However, the present study does not support this as there is no significant difference in the latitude of the present locality (10°22'N) and Madurai (10°00'N) from where Murugan has collected the specimens. It is possible that both genetic and environmental factors such as temperature and food availability may influence the egg production.

Figure I indicates the mean length and width of individuals and the number of eggs produced at each instar during the present study. It showed a rapid increase in the size of the animals upto the 10th instar, after which there has been practically no increase in their size. Michael (1962), however, observed that there was no increase in size after the 6th moult. The number of eggs/brood which appeared for the first time at the 3rd instar gradually increased reaching a maximum at the 8th instar, after which there has been a steady fall in the egg production till their death.

ACKNOWLEDGEMENTS

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REFERENCES

Alikunhi, K. H. 1952. On the food of young carp. **J. Zool. Soc. India, 4:** 77-84.

Alikunhi, K. H. Chaudhuri, H. and Ramachandran, V. 1955. On the mortality of carp fry in nursery ponds and the role of plankton in their survival and growth. **Ind. J. Fish., 2 :** 257-313.

Byars, J. A. 1960. A freshwater pond in New Zealand. **Aust. J. Mar. Fresh. Res., 11 :** 222-240.

Edmondson, W. T. 1956. Seasonal life history of *Daphnia* in an arctic lake. **Ecology, 36 :** 439-455.

Green, J. 1956. Growth size and reproduction in *Daphnia* (Crustacea : Cladocera) **Proc. Zool. Soc. London, 126 :** 173-204.

Kanaujia, D.R. 1982. Instar duration, instar number, egg production and longevity in *Ceriodaphnia cornuta* at two temperature ranges. **J. Bombay Nat. Hist. Soc., 79 (2) :** 441-445.

Kanaujia, D.R. 1988. Prelimiary observations on the life history and culture of *Ceriodaphnia cornuta* (Cladocera : Daphnidae). **Ind. J. Anim. Sci., 58(1) :** 150-154.

Michael, R. G. 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.

Murugan, N. 1975. Biology of *Ceriodaphnia cornuta* Sars (Cladocera : Daphnidae) **J. Inland Fish. Soc. India, 7 :** 80-87.

Thresiamma, J., Mercy, T.V.A. and Thampy, D. M. 1991. Production and population density of *Moina micrura* Kurz culture in different media. **J. Zool. Soc. Kerala, 1(1)** : 21-31.

PART-II
LABORATORY STUDIES ON THE LIFE CYCLE OF SIMOCEPHAL US SERR ULATUS KOCH

K. K. Subhash Babu “Studies on freshwater Cladocera ” Thesis. Department of Zoology, Christ college Irinjalakuda , University of Calicut, 2000

Chapter-8

LABORATORY STUDIES ON THE LIFE CYCLE OF *SIMOCEPHALUS SERRULATUS* KOCH

LABORATORY STUDIES ON THE LIFE CYCLE OF *SIMOCEPHALUS SERRULATUS* KOCH 1881 (CLADOCERA: CRUSTACEA)[1]

[2]Subash Babu and C.K.G. Nayar

(*With one plate*)

Key words: *Simocephalus serrulatus*, Cladocera, life cycle, instar, parthenogenetic, ephippium.

The life cycle of the cladoceran *Simocephalus serrulatus* has been described on the basis of laboratory culture. The neonates produced from the same brood pouch may be all female, all male or both male and female. The female neonates pass through 3 preadult instars and 18 adult instars, while the males have only 2 preadult instars and there is no moulting in the adult stage. Egg production starts at the 4th instar. The maximum number of eggs is produced during 10th to 12th instars.

Introduction

The successful culture of Cladocera depends on our knowledge of the biology and life cycle of individual species.Several investigators have attempted to study the life cycle of a few species of Indian Cladocera. These include the works of Navaneethakrishnan and Michael (1971) on *Daphnia carinata*, Murugan and Sivaramakrishnan (1973) on *Simocephalus acutirostratus*, Murugan (1975a) on *Moina micrura*, Murugan and Sivaramakrishnan (1976) on *Scapholeberis kingi*, Murugan (1975b) on *Ceriodaphnia cornuta*, Murugan and Venkataraman (1977) on *Daphnia carinata*, Murugan and Job (1982) on *Leydigia acanthoceroides*, Kanaujia (1982) on *Ceriodaphnia cornuta*. Kanaujia (1983) on *Daphnia lumholtzi* and Kanaujia (1987) on *Simocephalus vetulus*. Recent study of Thresiamma *et al.* (1991) on the production and population density of *Moina micrura* is the only report on similar studies from Kerala. The above papers give good accounts of the life history of parthenogenetic females,but they do not give sufficient information about the role of males and ephippial females in the life cycle. The present study is a detailed investigation of the life cycle of *Simocephalus serrulatus*, a common cladoceran species of Kerala.

Material and Methods

Simocephalus serrulatus is a large cladoceran found among the littoral weeds and sediments of ponds. The specimens for the present study were collected from a shallow pond situated near Christ College campus and brought live to the laboratory. Twenty-five healthy, egg-bearing females were sorted out under a stereoscopic microscope and were transferred into an earthern pot of 5 litre capacity containing the culture medium. This was maintained as the stock culture. The culture medium was prepared in pond water and filtered through a net made of No. 25 bolting silk. Powdered groundnut cake (500 mg/l) was used as manure for growing algal cells. The medium contained mainly unicellular alga *Chlorella* sp. at a density of about 10×10^3 cells/l.

One ovigerous female was isolated from the stock culture with the help of a pipette and inoculated into a beaker containing 250 ml of the

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same culture medium. This female was kept under constant observation so as to isolate the newly hatched young neonates. They were individually reared in 20 different petri dishes containing the culture medium which was changed every 24 hours. The time of hatching and moulting, number of neonates hatched in each brood and the life span of all the individuals were regularly recorded until their death. The experiments were repeated thrice and mean values were taken. All observations were made at room temperature 27±2°C.

The ephippial females were also collected from the stock culture and isolated under the microscope. Free ephippia found in large numbers floating on the surface of the culture medium as well as sticking onto the sides of the container were easily collected with the help of a brush or a pipette. Another set of 5 individuals was simultaneously reared in the same medium for dissection, using microtungsten needle. Measurements were made with a calibrated ocular micrometer.

Observations

In the culture medium, the females were generally found clinging on to the side wall of the container with the help of their antennal hooks. They kept their body upside down while swimming. The males were found to be more active than the females, and always swimming in the medium. During mating, the male remained adhered to the hind end of the female. The mating behaviour is found to be similar to that of *Pleuroxus denticulatus*, as described by Shan (1969).

In the first set of experiments, out of the 20 neonates produced from a brood, 16 were found to be females and the rest males. The female neonates measured a mean length of 0.615 mm while males measured 0.55 mm. But in the second set all the neonates produced were males while in the third set all the neonates were parthenogenetic females. In addition to their smaller size, the males could also be distinguished by the presence of two sensory setae on the middle of the antennule and prehensile claws on the first thoracic leg. Unlike other daphnids, the antennule of the male is not elongated. The newly hatched young were found to be similar to the adults in morphology except for their miniature size. (Plate 1, Fig. 1).

The female neonates pass through 3 preadult instars and 18 adult instars in a life span of 35.8 days, with an average instar duration of 40.9 hours. The males, however, had only 2 preadult instars and there was no moulting in the adult stage. The average instar duration of a male was 56 hours with a life span of 6.5 days. The males matured after two moults. A pair of elongated testes extending over one-third of the length of the animal was distinctly visible at this stage. The mature males had a mean length of 0.675 mm (Plate 1, Fig. 2)

In mature females, the ovaries were seen as a pair of elongated sacs on each side of the alimentary canal. The contents of the ovaries were discharged through a small opening at the posterior end into the brood-pouch. This discharged mass later became spherical and formed the eggs. (Plate 1, Fig. 3). The relationship between mean size of each instar and the number of eggs produced from each brood, and instar duration are given in Table 1.

The morphological features of the embryonic stages of *S. serrulatus* are given below, following the terminology of Green (1956):

Early stage: At this stage, the newly formed eggs are spherical with a mean diameter of 0.27 mm. They are green in colour with a transparent marginal zone (Plate 1, Fig. 4).

Middle stage: At this stage the embryo is somewhat elongated. The head lobe and rudiments of thoracic legs and antennae are visible. Numerous fat globules are also present (Plate 1, Fig. 5).

Final stage: The head is distinct and the eyes are well developed. Antennae are elongated and segmented. A transparent carapace is formed

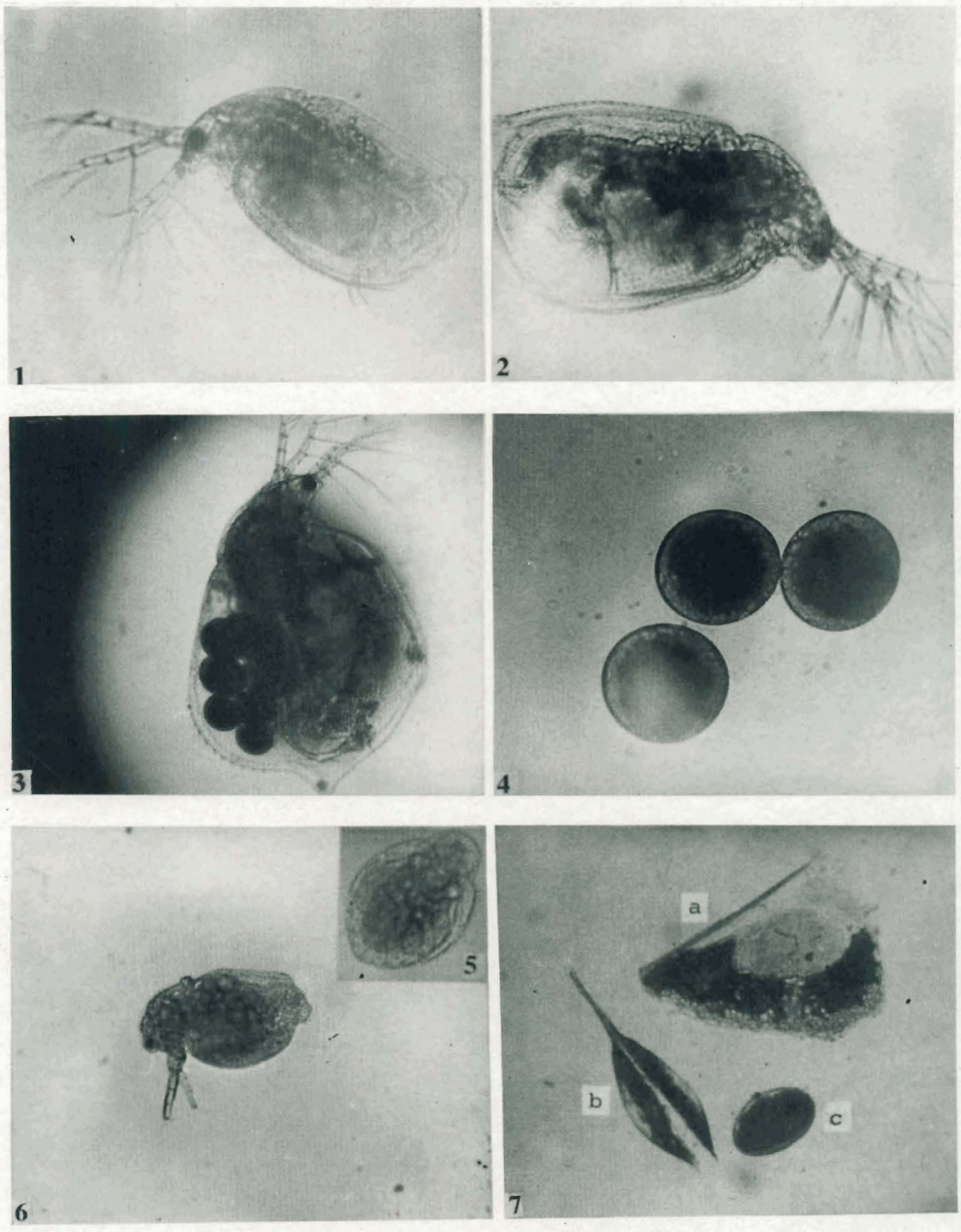

Fig. 1. Newly hatched young (0.6 mm); 2. Mature male (0.67 mm);
3. Parthenogenetic female (1.6 mm); 4. Parthenogenetic eggs (0.25 mm);
5. Developing embryo (0.304 mm) (inset); 6. Embryo with well developed antennae. (0.329 mm);
7a. Ephippium (0.63 mm); 7b. Leathery chorion (0.63 mm);
7c. Resting egg showing outer membrane. (0.27 mm).

TABLE 1
VARIATION IN SIZE AND DURATION OF INSTARS OF *SIMOCEPHALUS*

Instar No.	Mean leanth (mm)	Mean height (mm)	Eggs/brood	Cumulative no. of eggs	Instar duration in hours	Cumulative duration of instar in hrs.
1	0.615	0.42	—	—	32.15	32.15
2	0.87	0.52	—	—	32.30	67.45
3	1.05	0.67	—	—	35.30	99.75
4	1.27	0.90	4.6	4.6	38.00	137.75
5	1.46	1.05	7.2	11.8	38.67	176.42
6	1.65	1.20	14.3	26.1	41.82	218.24
7	1.73	1.33	14.6	40.7	41.58	259.82
8	1.82	1.46	25.6	66.3	36.30	296.12
9	1.90	1.50	32.6	98.9	40.30	336.42
10	2.00	1.60	35.8	134.7	39.45	375.87
11	2.05	1.65	35.2	169.9	41.82	417.69
12	2.15	1.68	37.4	207.3	43.32	461.01
13	2.20	1.72	29.6	236.9	40.28	501.29
14	2.25	1.75	32.4	264.3	42.17	543.46
15	2.28	1.76	27.5	296.8	40.30	583.76
16	2.35	1.85	22.8	319.6	46.30	630.06
17	2.45	1.87	19.5	339.1	44.35	674.41
18	2.47	1.88	17.6	356.7	46.22	720.63
19	2.47	1.88	12.6	369.3	44.42	765.05
20	2.47	1.88	7.6	376.9	46.18	811.23
21	2.48	1.88	7.6	384.5	48.65	859.88

enclosing the body appendages and postabdomen. Alimentary canal is fully extended (Plate. 1, Fig. 6). Towards the end of this stage the appendages are fully developed and the young starts exhibiting movements.

The total duration of embryonic development was observed to be 40-42 hours, after which the young were released from the brood-pouch by jerking movements of the postabdomen of the mother. This took place at any time before the mother passed through the next moult. Immediately after moulting, another clutch of eggs was discharged into the brood-pouch and the parthenogenetic cycle was repeated.

The ephippial females could be distinguished from the parthenogenetic females by their smaller size and by the absence of the blunt posterior spine on the carapace. The ephippium is a modified brood pouch formed on the dorsal half of the valves and is slightly yellowish in colour,its outer surface ornamented with a honeycomb pattern. It is somewhat triangular in shape, with a mean length of 0.63 mm and contains only the resting egg. (Plate 1. Fig. 7a). The resting egg was encased by two membranes, an inner vitelline transparent membrane and an outer thick leathery chorion. When the ephippial females collected from the stock culture were transferred to the beaker containing fresh culture medium, many of them cast off their ephippia along with the moult. The newly released ephippia floated on the surface of the medium for some time and then sank to the bottom or remained adhered to the side walls of the container.

DISCUSSION

Simocephalus acutirostratus and *S. vetulus* are the other two tropical species of the genus *Simocephalus* whose life cycles have been studied by Murugan (1977) and Kanaujia (1987)

TABLE 2
COMPARISON OF THE LIFE CYCLES OF THREE SPECIES OF *SIMOCEPHALUS* FROM INDIA

Species	No. of preadult instars		No. of adult instars		Total number of eggs	Average instar duration	Total lifespan
	Female	Male	Female	Male			
S. acutirostratus	4	—	18	—	248	47.61 hrs.	44 days
S. vetulus	3-4	—	20	—	496	45.10 hrs.	41 days
S. serrulatus	3	2	18	nil	384	40.80 hrs.	35.7 days

similarities, particularly in the number of preadult instars, adult instars and instar duration (Table 2). The effect of temperature and food on the number and duration of instars has been studied by a few workers. Anderson and Jenkin (1942), Murugan and Sivaramakrishnan (1976) have observed that differences in the culture medium might cause variation in the number of instars. Kanaujia (1988) pointed out in *S. vetulus* that temperature is one of the factors influencing the number of adult instars, and lack of food and temperature above 20°C might increase the number of pre-adult instars. In the present study, however, no such variation was observed. Murugan (1975a) and Venkataraman (1981) could not observe any variation in the number of instars in *Moina micrura* and *Daphnia carinata* respectively. Since the number of instars is likely to be hereditary and species-specific, the influence of extrinsic factors on the number of instars needs further study.

Increase in the size of the individual at each instar is found to be more rapid during the preadult phase and gradually slows down towards the later stages of the life cycle (Table I). Green (1956) also observed the maximum growth rate in the early preadult instars of many daphnids. Murugan and Job (1982) have observed uniform preadult instar durations in *Leydigia acanthoceroides*. In the present study, however, both preadult and adult instar duration varied widely. But the duration of preadult in star was always shorter than the adult instar duration. Primiparous instar had a longer duration than the longest preadult instar duration. Murugan and Job (1982) have also observed a long primiparous instar duration in *L. acanthoceroides*.

In *S. serrulatus* the egg production was initiated at the fourth instar and the maximum number of eggs per brood was found during the 10th to 12th instars, after which there was a decline. Similar observations were also made by Green (1956), and Kanaujia (1988). However, Navaneethakrishnan and Michael (1971) observed in *Daphnia carinata* that the egg numbers gradually increased from the first to the last instar. In *L.acanthoceroides*, Murugan and Job (1982) observed only two eggs in all adult instars, without any increase or decrease in egg-production rate.

Reduced number of preadult instars with long instar duration, absence of adult instars and short life-span of males observed in the present species are likely to apply to other species as well. The rare occurrence of males in the natural population of cladoceran species indicates that the appearance of males is not obligatory in their life cycle. The male, however, is important in the production of ephippial females, which enable the species to tide over drought and other unfavourable environmental conditions. In the present study, a large number of ephippial females appeared in the stock culture when the population attained its peak, with a density of 29,000 individuals per litre of culture medium. Pennak (1953), Michael (1962) and Hutchinson (1967) also observed the presence of a large

number of ephippial females when the culture medium became overcrowded.

An important observation in this study is the development of both males and females from the same brood of parthenogenetic females. This has also been observed by Muthu (1983) in *Moina micrura*. Factors responsible for this phenomenon are not yet understood.

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REFERENCES

ANDERSON, B.G. & J.C. JENKINS (1942): A time study of events in the life-span of *Daphnia magna*. *Biol. Bull. 83*:260-272.

GREEN, J. (1956): Growth size and reproduction in *Daphnia* (Crustacea: Cladocera). *Proc. zool. Soc. Lond. 126*: 173-204.

HUTCHINSON, G.E. (1967): A treatise on limnology. Vol. II. John Wiley & Sons. Inc., New York. pp 1115.

KANAUJIA, D.R. (1982): Instar duration, instar number, egg production and longevity in *Ceriodaphnia cornuta* at two temperature ranges. *J. Bombay nat. Hist. Soc. 79(2)*: 441-445.

KANAUJIA, D.R. (1983): Life history, ephippia development, cyclomorphosis and temperature effect on life cycle in *Daphnia lumholtzi* Sars Cladocera: Daphnidae). *J. Bombay nat. Hist. Soc. 80(2)*: 442-448.

KANAUJIA, D.R. (1987): Biology and ephippia development in *Simocephalus vetulus* (O.F. Muller, 1976) (Cladocera: Daphnidae). *Indian J. Animal Sci. 57(1)*: 1153-1160.

KANAUJIA, D.R. (1988): Life cycle of *Simocephalus vetulus* (O.F. Muller, 1976) (Cladocera: Daphnidae) under laboratory conditions and the effect of food on the life history. *Indian J. Anim. Sci. 58(2)*: 1462

MICHAEL, R.G. (1962): Seasonal events in a natural population of the cladoceran *Ceriodaphnia cornuta* Sars and observations on its life cycle. *J. zool. Sci. India, 14*: 211-218.

MURUGAN, N. (1975a): Egg production, development and growth in *Moina micrura* Kurz 1874 (Cladocera: Moinidea). *Freshwater Biol. 5*:245-250.

MURUGAN, N. (1975b): Biology of *Ceriodaphnia cornuta* Sars (Cladocera: Daphnidae). *J. Inland Fish. Soc. India, 7*:80-87.

MURUGAN, N. (1977): The biology of *Simocephalaus acutirostratus* King (Cladocera: Daphnidae). Hatchability of parthenogenetic egg cultured in artifial media. *Hydrobiologia 54*: 273-277.

MURUGAN, N. & K.G. SIVARAMAKRISHNAN (1973): The biology of *Simocephalus acutirostratus* King (Cladocera: Daphnidae). Laboratory studies on life span, instar duration, egg production, growth and stages in embryonic development. *Freshwater Biol., 7*:80-87.

MURUGAN, N. & K.G. SIVARAMAKRISHNAN (1976): Laboratory studies on the longevity, instar duration, growth, reproduction and embryonic development in *Scapholeberis kingi* Sars (1903) (Cladocera: Daphnidae). *Hydrobiologia 50*:75-80.

MURUGAN, N. & K. VENKATARAMAN (1977): Study of the *in vitro* development of the parthenogenetic egg of *Daphnia carinata* King (Cladocera: Daphnidae). *Hydrobiologia 52(2-3)*: 129-134.

MURUGAN, N. & S.V. JOB (1982): Laboratory studies on the life cycle of *Leydigia acanthoceroides* Fisher (1854) (Cladocera: Chydoridae). *Hydrobiologia 89*: 9-16.

MUTHU, M.S. (1983): Culture of live feed organisms III, Cladoceran *Moina* sp. Technical Paper No. 14. C.M.F.R.I., Cochin.

NAVANEETHAKRISHNAN, P. & R.G. MICHAEL (1971): Egg production and growth in *Daphnia carinata* King. *Proc. Indian Acad. Sci. 73*: 117-123.

PENNAK, R.W. (1953): Freshwater invertebrates of the United States. Ronald Press, New York.

SHAN, K. (1969): Life cycle of a chydorid cladoceran *Pleuroxus denticulatus* Birge. *Hydrobiologia 34*: 513-523.

THRESIAMMA, J., T.V.A. MERCY & D.M. THAMPY (1991): Production and population density of *Moina micrura* Kurz. cultured in different media. *J. zool. Soc. Kerala* I(1): 21-31.

VENKATARAMAN, K. (1981): Field and laboratory studies on *Daphnia carinata* King (Cladocera: Daphnidae) from a seasonal tropical pond. *Hydrobiologia 78*: 221-225.

CONCLUSION

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Chapter-9

CONCLUSION

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A review of the literature on the freshwater Cladocera of India clearly indicates the paucity of information about this important group from this part of the country. One of the major objectives of the present study was to make a humble attempt to fill this gap. During this study nearly 73 samples has been collected and analysed. Based on these samples 54 species has been reported. Kerala state possesses a rich cladoceran fauna. However, a more extensive study will definitely increase this numbers. In modern biology, systematic and faunastic study has assumed added importance because of the thrust given to the concept of biodiversity and conservation. Although much has been said about biodiversity due importance is not yet given to aquatic biodiversity especially of the freshwater of Kerala. The present study, I hope will throw some light on this aspect and will be helpful for future workers.

Cladocerans are well known to be an important food item of all fish larvae and many planktivorous adult fishes. Recently attempts are also being made to culture of cladocerans to be given as live feed in aquaculture. Knowledge about the biology of these microcrustaceans is therefore a prerequisite. A comparative study of the bionomics of the locally available species that can be used for aquaculture. Present study made on the biology of three species is a beginning of that direction. Additional information to be added by the future workers will enable us to have a comprehensive knowledge about the taxonomy and bionomics of the cladoceran species of our country.

REFERENCES

REFERENCES

Alikunhi,K. H. 1952. On the food of young carp. *J. Zool. Soc. India.*, **4**: 77-84.

Alikunhi, K.H., Chaudhuri, H & Ramachandran, V. 1955. On the mortality of carp fry in nursery ponds and the role of plankton in their survival and growth. *Ind. J. Fish.*, **2**: 257-313.

Anderson, B. G & Jenkins, J. C. 1942. A time study of events in the life span of *Daphnia magna. Biol. Bull.*, **83**: 260-272.

Arora, G.L., 1931. Fauna of Lahore. 2. Entomostraca (water fleas) of Lahore. *Bull. Dept. Zool. Punjab Univ. Lahore.*, **1**: 62-100.

Banta, A. M & Wood, T. R. 1939. General studies in sexual reproduction, *In Banta.*, 1939 : 131-181.

Baird,W.1860. Description of two new species of Entomostracous Crustaceans from India. *Proc. Zool. Soc.*, **28**:445-446.

Battish, S.K. 1981. On some chydorid and macrothricid (Crustacea: Cladocera) from Punjab with the description of three new species. *Research on crustacea.*, **11**.17-35.

Battish, S.K. & Parminder Kumari, 1986. Effects of Physico-Chemical factors on the seasonal abundance of Cladocera in a typical pond at village of Rabbi, Ludhiana. *Indian J. Ecol.*, **13**(1): 146-151.

Battish, S.K. 1992. Freshwater zooplankton of India. *Oxford & I B H Publishing. Co.* New Delhi, 233pp.

Bening, A.L. 1941. Kavkaza(Cladocera of the caucasus). *Visok. Biol.Sta.Nauk.Gruz. SSR. Tbilisi.*, 384pp.

Birge, E.A. 1910. Notes on Cladocera. *Lbid.*, **16**:1017-1066.

Birge, E.A. 1918. The waterfleas (Cladocera). H. B Ward and G. C. Whipple, Eds. *Freshwater Biology* (New York, John Wiley Sons)., **22**: 676-740.

Biswas, S. 1964a. A new species of the cladoceran genus *Latona straus* 1820 (Crustacea: Cladocera: Sididae) from Rajastan, India *Proc. Zool. Soc. Culcutta.*, **17:**149-152.

Biswas, S. 1964b. Five species of Daphniidae(Crustacea : Cladocera) from Simla Hills in India, with a new record of *Alona costata* Sars from NEFA. *J. Zool. Soc. India.*, **16**:92-98.

Biswas, S. 1966. A new species of the genus Chydorus Leach, 1843 (Crustacea: Cladocera: Chydoridae) from Rajastan, India. *Crustaceana.*, **11**:113-114.

Biswas, S. 1971. Fauna of Rajastan, India. Part II (Crustacea: Cladocera). *Rec. Zool. Surv. India.*, **63**: 95-141.

Brehm, V. 1933 Die Cladoceren der Deutschen Limnologischen Sundra-Expedition. *Arch. Hydrobiol.*, Suppl., **11**: 631-771.

Brehm, V. 1936. Yale North India Expedition. Report on Cladocera. *Article XVI. Mem. Conn. Acad, Arts. Sci.*, **10**: 283-297.

Brehm, 1950. Contibutions to the freshwater fauna of India, Parts I & II. *Rec. Ind. Mus.*, **48**: 1-3,9-28.

Brehm, 1952. *Diaphanosoma hydrocephalus* nov. spc., eine eigenartige Sidide aus Vorder *Indien. Zool. Amz.*, **14-9**: 138-140.

Brehm, V. 1953. Indische Diaptomiden, Psedodiaptomiden und Cladoceren. *Ost. Zool. Zeit.*, **4**: 241-345.

Brehm, V. 1963. Einige Bemerkungen zu vier Indischen Entomostraken. *Int. Rev. ges. Hydrobiol.*, **48**:159-172.

Brooks J. L. 1959. Cladocera in: *Freshwater biology*, W.T. Edmondson (ed). 587-656. John Wiley & Sons, New York.

Byars, J. A. 1960. A freshwater pond in New Zealand. Aust. J. Mar. Fresh. Res., **11**: 222-240.

Chandini, T. 1991. Reproductive value and the cost of reproduction in *Daphnia carinata* and *Echinisca triserialis* (Crustacea:Cladocera) exposed to food and Cadmium stress. *Bull. Environ. Contam. Toxicol.*, **47** (1) : 76-83.

Daday, E. 1898. Mikroskopische Susswasserthiere aus Ceylon. Anhangsheft Zum xxi. *Bande der termeszetrajzi Fuzetek.* Budapest: 1-122.

Daday, E. 1910. Untersuchungen uber die Susswasser-Mikrofauna *Deutsch-Ostafrikas:* Cladocera. *Zoologica. Stuttgart.*, **23**: 120-158.

Daday, E. 1911. Egy uj Cladocera-faj keletindiabol. *Allattani kozlemenyek.*, 10:63-68, 110-112.

Dodson, S.I. 1981. Morphological variation of *Daphnia pulex* Leydig(Crustacea: Cladocera) and related species from North America. *Hydrobiologia.*, **83**:101-114.

Dodson, S. I. 1989. Predator-induced reaction norms. *Bioscience.*, **39** : 447-452.

Dodson, S. I & Frey, D. G. 1991. Cladocera and other Branchiopoda. Pages 723-786 In: James H. Thorp and Alan P. Covich, Editors. *Ecology and Classification of North American Freshwater Invertebrates*, Academic Press, Inc. San Diego.

Dumont, H.J. & Van de Velde, I. 1977. Report on a collection of Cladocera and Copepoda from Nepal. *Hydrobiologia.*, **53**:55-65.

Dumont, H.J. 1987. Groundwater Cladocera : A synopsis. *Hydrobiologia.*, **145**:169-173.

Edmondson, W. T. 1956. Seasonal life history of Daphnia in a arctic Lake. *Ecology.*, 439-455.

Edmondson, W. T. 1971. A manual on Methods for the Assessment of Secondary Productivity in Freshwaters. *I B P Hand book No. 17.* Black well Scientific Publications, Oxford.

Fernando, C.H. 1974. Guide to the Freshwater Fauna of Ceylon (Sri Lanka) supplement 4 *Bull. Fish. Res. Stl., Sri Lanka,* Vol.25, Nos.**1** and **2**, 27-81pp.

Fernando, C.H. & Kandaru, A. 1984. Some remarks on the latitudinal distribution of Cladocera on the Indian subcontinent. *Hydrobiologia.*, **113**:69-76.

Fischer, S. 1854. Abhandlung uber einige neue order nicht genau beknnte Arteu Vom Daphniden und Lynceiden als Beitrag Zur Fauna Russlands. *Bull. Soc.Imp. Nat. Mosc.*, **27**:423-434.

Forbes, S.A. 1893. A preliminary report on the aquatic invertebrate fauna of the Yellowstone National Park, Wyoming, and the Flathead region of Montana. *Bull. U.S. Fish common.*, **11**:207-256.

Frey, D.G. 1980. The non-swimming chydorid Cladocera of wet forest, with description of a new genus and two new species. *Int. Rev. Hydrobiol.*, **65**:613-641.

Frey, D.G. 1982. Relocation of *Chydorus barroisi* and related species (Cladocera, Chydoridae) to a new genus and descriptions of two new species. *Hydrobiologia*, **86**:231-269.

Frayer, G. 1957. Free living freshwater Crustacea from Lake Nyasa amd adjoining waters. Part II. Cladocera and Conchostraca. *Archi Hydrobiol.*, **53**:223-239.

Frayer, G. 1974. Evolution and adaptive radiation in the Macrothricidae(Crustacea:Cladocera) a study in comparative functional morphology and ecology. *Phil.Trans. Roy. Soc.*, **269**:137-274.

Frayer, G. 1987. A new classification of the branchiopod Crustacea. *Zoological Journal of the Linnean Society.*, **91**:357-383.

George, M.G. 1966. Comparative plankton ecology of five fish tanks in Delhi. *Hydrobiologia*, **27**(1-2): 81-108.

Gouder, B.Y. & Joseph, K.J. 1961. On correlation between the natural populations of freshwater Zooplakton(Cladocera, Copepoda and Rotifera) and some ecological factors. *J.Karnatak Univ. Sci.*, **6**:89-96.

Goulden, C. E. 1968. The systematics and evolution of Moinidae. *Trans. Amer. Phil. Soc.*,**58** : 1-101.

Green, J. 1956. Growth size and reproduction in *Daphnia* (Crustacean: Cladocera). *Proc. Zool. Soc. Lond.*, **126** : 173-204.

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

Green, J. 1965. Chemical embryology of Crustacea. *Biol. Rev.*, **40**: 580-600.

Gurney, R. 1906. On some freshwater Entomostraca in the collection of the Indian museum, Calcutta. *J. Asiatic Soc. Bengal.*, (N.S) **2**:273-281.

Gurney, R.1907. Further notes on Indian freshwater Entomostraca. *Rec. Indian. Mus.*, **1**:21-33.

Gurney, R. 1916. On some freshwater Entomostraca from Ceylon. *Proc. Zool. Soc. London.*, 333-343.

Han, B. J. 1984. Influence of temperature on life history characteristics of two sibling species of *Eurycercus* (Cladocera : Chydoridae). *Canadian Journal of Zoology.*, **63** : 891-898.

Harding, J.P. & Petkovski, T. 1963. *Latonopsis australis* Sars(Cladocera) in Jugoslavia with notes on its synonymy and distribution. *Crustaceana.*, **6**:1-4.

Havel, J. E. & Dodson, S. I. 1987. Reproductive costs of Chaoborus induced polymorphism in *Daphnia pulex. Hydrobiologia.*, **150** : 273-281.

Herbert, P. D. N. 1978. The population biology of *Daphnia* (Crustacea : Daphnidae). *Biological Review.*, **53** : 387-426.

Herbert, P. D. N. 1987 Genetics of *Daphnia.* Pages; 439-469 In R. H. Peters and R. de Bernardi, Editors' Daphnia 'Memorie dell' Istitu to Italiano di Idro. *Biologia.*, Voll. 45.

Hrbacek, J. 1958. Density of the fish population as a factor influencing the distribution and speciation of the species of *Daphnia.* Pages 794-796 in: *Proceedings of the 15th International Congress of Zoology.* Section 10.

Hutchinson, G. E. 1967. *A treatise on Limnology.*, Voll.II. Introduction to lake biology and the Limnoplankton. Wiley, NewYork.

Idris, B.A.G. 1983. *Freshwater zooplankton of Malaysia* (Crustacea:Cladocera) Perenbit University, Pertanian, Malaysia 153pp.

Igor Hudec, 1987. *Moina oryzae* n.sp(Cladocera:Moinidae) from Tamil Nadu(S.India) *Hydrobiologia.*, 145:147-150.

Kanaujia, D. R. 1982. Instar duration, instar number, egg production and longevity in *Ceriodaphnia cornuta* at two temperature ranges. *J. Bombay Nat. Hist. Society.*, **79**(2) : 441-445.

Kanaujia, D. R. 1984. Life history, ephippia development, cyclomorphosis and temperature effect on life cycle in *Daphnia lumholtzi* Sars (Cladocera: Daphnidae). *J. Bombay Nat. Hist. Society.*, **80**(2) : 442-448.

Kanaujia, D. R. 1987. Biology and ephippia development in *Simocephalus vetulus* (O. F. Muller, 1976). (Cladocera : Daphnidae). *Ind. J. Animal Sci.*, **57**(1): 1153-1160.

Kanaujia, D. R. 1988. Preliminary observations on the life history and culture *Ceriodaphnia cornuta* (Cladocera : Daphnidae). *Ind. J. Anim. Sci.*, **58**(1): 150-154.

Khan, M.A., Subla, B.A. & Zutshi, D.P. 1978. A new Crustacean for India. *Geobios.*, **5**:81.

King, R.L. 1853. On some of the species of Daphnidae found in New south Wales. *Pap. Proc. R. Soc. Van Diemans Land.*, **2**:243-263.

Korinek, V. 1984. Cladocera. In: J.J. Symoens (ed). *Hydrobiological survey of the Lake Bangweulu Lauapula River Basin.*, **13**:1-117.

Korovchinsky, N.M. 1992. Sididae & Holopediidae Guides to the identification of the Microinvertebrates of the Continental waters of the world. 3.SPB. Academic publishing bv: 82pp.

Malhotra, Y. R. & Langer, S. 1990. Biological aspects of *Moina macrocopa* in relation to temperature variations. J. Freshwat. Biol., **2**(2) : 111-115.

Margaritora, F.G., Ferrari, I. & Crosetti, D. 1987. A far east Moina, *M. Weismanni* Ishikawa, 1896. Found in a Italian rice field., *Hydrobiologia*, **145**:93-103.

Michael, R. G. 1962. Seasonal events in a natural population of the cladoceran *Ceriodaphnia cornuta* Sars and observations on its life cycle. *J. Zool. Soc. Ind.*, **14** : 211-218.

Michael, R.G. 1968. Studies on the Zooplankton of a tropical pond. *Hydrobiologia.*, **32**(12):47-68.

Michael, R.G. 1973. A guide to the study of freshwater organisms. *Jour. Madurai Univ., Suppl.* I : *Cladocera.*, Chapter **6**: 71-85.

Michael, R.G. & Hann, B.J. 1979. On the resurrection of the cladoceran species *Chydorus recticulatus* Daday, 1898(Chydoridae: Cladocera) and its relationship *Chydorus ventricosus* Daday, 1898. *Hydrobiologia.*, **65**:225-232.

Michael, R.G. & Sharma, B.K. 1988. Indian Cladocera (Crustacea: Branchiopoda: Cladocera). *Zoological Survey of India, Culcutta.*, 262pp.

Moitra, S.K. & Mukherjee, S.K. 1972. Studies on the freshwater plankton of a fishpond at Kalyani, West Bangal. *Vest. csl. Spol. Zool.*, **34**:23-28.

Murugan, N. 1975a. Egg production, developement and growth in *Moina micrura* Kurz(1874) (Cladocera:Moinidae). *Freshwat. Biol.*, **5**:245-250.

Murugan, N. 1975b. The biology of Ceriodaphnia cornuta Sars. J. Inland. Fish. Soc. India. Vol. **VII** : 80-87.

Murugan, N. & Sivaramakrishnan, K. G. 1976. Longivity, instar duration, growth, reproduction and embryonic development in *Scapholeberis kingii* Sars (1903) (Cladocera: Daphnidae). *Hydrobiologia.*, **50** : 75-80.

Murugan, N. 1977. The biology of *Simocephalus acutirostratus* King (Cladocera: Daphnidae) hatchability of the parthenogenetic egg cultured in artificial media. *Hydrobiologia.*, **54**(3) : 273-277.

Murugan, N. & Venkataraman, K. 1977. Study of the in vitro development of the parthenogenetic egg of *Daphnia carinata* King (Cladocera: Daphnidae). *Hydrobiologia.*, **52**(2-3) : 129-134.

Murugan, N. & Jobe, S. V. 1982. Laboratory studies on the life cycle of *Leydigia acanthocercoids* Fischer (1854) (Cladocera : Chydoridae). *Hydrobiologia.*, **89** : 9-16.

Murugan, N. & Moorthy, R. K. 1988. Laboratory studies on the life span, growth, fecundity and embryonic development of *Daphnia cephalata* King (Crustacea: Daphniidae). *Proc. Indian Acad. Sci (Anim. Sci).*, **97**(4) : 367-377.

Murugan, N., Murugavel, P. & Kodarkar, M.S. 1998. Cladocera (The biology, classification, identification and ecology) *IAAB Publication Hydrabad.* No: **5**:55pp.

Muthu, M. S. 1983. Culture of live feed organisms III, Cladocera *Moina* sp. Technical paper *No.14*. C. M. F. R. I. Cochin.

Nasar, S.A. K. 1977. The Zooplakton fauna of Bhagalpur(Bhihar) II. Cladocera. Carcinological Society of Japan. *Research on Crustacea.*, No.**8**:32-36.

Navaneethakrishnan, P. & Michael, R. G. 1971. Egg production and growth in *Daphnia carinata* King. *Proc. Ind. Acad. Sci.*, **72**: 117-123.

Nayar, C.K.G. 1971. Cladocera of Rajastan. *Hydrobiologia.*, **37**: 509-519.

Negrea, S. & Pospisil, P. 1995. Contribution a la connaissanee des eaux souterraines du Danube a Vienna. *Annales Limnol* **31**(3): 169-178.

Paggi, J.C. 1972. Nota sistermatica acerca de algunos cladoceros del genero *Chydorus* Leach, 1843 de la republica Argentina. *Physis.*, **31**:223-236.

Parabrahmam, M., Khan, A. N. & Lakshminarayana, J. S. S. 1967. Occurrence, growth and feeding habits of *Moina dubia* Gurney and Richard and its role in the stabilisation sewage. *J. Mar. Biol. Asian India*, Symposium on Crustacea part-II., 586-594.

Patil, S.G. 1976. Freshwater Cladocera (Arthropoda: Crustacea) from NorthEast India. *Curr. Sci.*, **45**(8): 312-313.

Patil, C.S. & Gouder, B.Y. 1988. Cladocera of Dharward (Karnataka state) *J. Bombay Nat. Hist. Soc.*, **85**(1): 112-117.

Pennak, R. W. 1953. Freshwater invertebrates of the United States, Ronald press, New York. 769 pp.

Pennak, R. W. 1991. *Freshwater Invertebrates of the United States*, 3rd Ed. John Wiley & Sons. Inc. New York.628pp.

Petkovski, T.K. 1966. Eine neue Cladocera Gattung aus dem Western Indiens, *Indialona ganapati* n.gen. et.n.sp. *Fragmenta Balcanica musci macedonici Scintiarum naturalium.*, **V.2:**157-165.

Quadri, M.Y. & Yousuf, A.R. 1978. Some new records of Crustacea from Kashmir. *Curr. Sci.*, **46**:859-860.

Raghunathan, M. B. 1989. Cladocera (Crustacea) from Wynad district, Kerala, *Geobios new reports.*, **8**(2):195-196.

Rane, P.D. 1985a. A new species of the genus *Camptocercus* Baird, 1843 (Cladocera) from Madhya Pradesh, Central India. *Crustaceana.*, **48**(2):113-116.

Rane, P.D. 1985b. A new species of genus *Simocephalus* Schoedler 1858(Cladocera: Daphniidae) from Madhya Pradesh, India *J. Bombay Nat. Hist. Soc.*, **82**(1): 159-162.

Rane, P.D. & Jafri, S.N. 1990. A new species of Cladocera, *Daphnia madhuriae* sp. nov. from Madhya Pradesh, India. *Crustaceana* **59**(1): 62-68.

Rane, P.D. 1992. New distributional record for *Indialona ganapati* Petkovski(Crustacea: Cladocera) from Ujani Wetland, Maharashtra with first description of male and reproductive female. *J. Bombay Nat. Hist. Soc.*, **89**(1): 263-265.

Richard, 1894. Cladocere's recueillis par le Dr. Theod Barrois in Palestine, in Syrie et en Egypte. *Revue. Biol. Nord. France.*, **6**: 360-378.

Sars, G.O. 1862. Meddeelte en af talrige Afbildninger ledsaget Oversight af de af ham I Oemgmen af Christiana iagttagne Crutacea, Cladocera. For-handl. Vidensk. Selask. *Christiania.*, (**1861**):144-167.

Sars, G.O. 1888. Additional notes on Australian Cladocera, raised from dried mud. For the Viedensk. Selsk. *Christiania.*, **7**:1-74.

Sars, G.O. 1895. On some South African Entomostraca raised from dried mud. Vidensk. Selsk. Skrifter I. Math. Naturv. *Klasses*: 1-56.

Sars, G.O. 1901. Contributions to the knowledge of the freshwater Entomostraca of South America as shown by artificial hatching from the dried mud. Part. I. Cladocera. *Arch. Math. Nat.*, **23**:1-102.

Schwartz, S. S. 1984. Life history strategies in *Daphnia*: a review and predictions. *Oikos.*, **42** : 114-122.

Sewell, R.B.S. 1935. Studies on the bionomics of freshwater in India II. On the fauna of the tank in the Indian Museum compound and the seasonal changes observed. Int. Rev. *Hydrobio.*, **31**:203-238.

Shan, R. K. 1969. Life cycle of a chydorid cladoceran *Pleuroxus denticulatus* Birge. *Hydrobiologia.*, **34** : 513-523.

Sharma, B.K. 1978. A note on freshwater cladocerans from West Bengal. *Bangladesh J. Zool.*, **6**:149-151.

Sharma, B.K. & Michael, R.G. 1987. Review of taxonomic studies on freshwater Cladocera from India with remarks on biogeography. *Hydrobiologia.*, **145**:29-33.

Sharma, S., Sharma, B. K. & Michael, R. G. 1981. Laboratory studies on the longevity, instar duration and growth of male of *Daphnia lumholtzi* Sars (Cladocera:Daphniidae) *Curr.*, **50** : 200.

Sharma, S. & Sharma, B. K. 1989. Observations on the longevity instar duration, fecundity, growth and embryonic development in *Simocephalus exspinosus* (Koch) (Cladocera: Daphniidae). *Indian. J. Anim. Sci.*, **59**(9): 1206-1210.

Shirguar, G.A. & Naik, A.A. 1977. Observations on morphology, taxonomy, ephippial hatching and laboratory culture of a new species of Alona (*Alona taraporevalae* Schirgur & Naik) a chydroid cladoceran from back bay. Bombay. *Proc. Symp. Warm water Zooplankton, special publication.* 48-59.

Singh, D. K. & Datta-Munshi, J. S. 1991. Some aspects of biology of cladocerans of River Ganga. *Freshwat. Biol.*, **3**(2): 187-191.

Smirnov, N.N. 1974. Fauna of the U.S.S.R. Crustacea:Chydoridae(Translated from Russian) *Israel Programme for scientific transalations*, Jerusalem., **1**(2):1-644.

Smirnov, N.N. 1976. Macrothricidae, Moinidae fauny mira. Fauna SSSR, novaya seriya, N112. Rakoobraznye T.I, 3 Leningrad: Nauka.237pp. (Macrothricidae and Moinidae of the world fauna).

Smirnov, N.N. 1992. The Macrothricidae of the world. *Guides to the identification of the Microinvertebrates of the continental waters of the world.* SPB Academic publishing bv, The Netherland., 143 pp.

Smirnov, N.N. 1996. Cladocera. *The Chydorinae and Sayciinae(Chydoridae) of the world* No.11 SPB Academic publishing bv, The Netherland., 197pp.

Subhash Babu, K. K. & Nayar, C. K. G. 1993. Observations on the life cycle of *Ceriodaphnia cornuta* Sars. *J. Zool. Soc. Kerala.*, **3**(2) : 13-17.

Subhash Babu, K. K. & Nayar, C. K. G. 1997. Laboratory studies on the life cycle of *Simocephalus serrulatus* Koch 1881 (Cladocera: Crustacea). *J. Bombay Nat. Hist. Soc.*, **94** (2): 317-321.

Thresiamma, J., Mercy, T. V. A. & Tl amby, D. M. 1991. Production and population density of *Moina micrura* Kurz culture in different media. *J. Zoo. Soc. Kerala.*, **1**(1) : 21-31.

Venkataraman, K. 1981. Field and laboratory studies on *Daphnia carinata* King (Cladocera: Daphnidae) from a seasonal tropical pond. *Hydrobiologia.*, **78** : 221-225.

Venkataraman, K. & Krishnaswamy, S. 1984. On the occurrence of *Leydigia ciliata* Gauither 1939(Cladocera:Chydoridae) from Madurai, South India. *Current science.* **53**(20): 1097-1098.

Venkataraman, K. 1990. New records of Cladcera of Keoladeo National Park, Bharatpur-III. *J. Bombay Nat. Hist. Soc.* **87**(1): 166-168.

Venkataraman, K. 1992a. Cladocera of Keoladeo National Park, Bharatpur and its environs. *J. Bombay Nat. Hist. Soc.*, **89**(1): 17-26.

Venkataramam, K. 1992b. Cladocera of Keoladeo National Park, Bharatpur, IV. New records: *Camptocercus cf. australis* Sars 1896 and *Indialona globulosa* (Daday, 1898). *J. Bombay Nat. Hist. Soc.*, 89(1): 140-142.

Venkataraman, K. & Das, S.R. 1992. *Bosminopsis deitersi* Richard, 1895 A New record for West Bengal (Crustacea : Cladocera). *J. Bombay Nat. Hist. Soc.*, **89**(1): 265-266.

Venkataraman, K. 1993. Sididae of Tamil Nadu (Crustacea: Cladocera). *J. Bomabay Nat. Hist. Soc.*, **90**(1): 50-57.

Venkataraman, K. 1994a. Two new records of Cladocera of the Genera *Echinisca* Lievin and *Disparalona* Fryer from India. *J. Bombay Nat. Hist. Soc.*, **91**(2): 334-337.

Venkataraman, K. 1994b. Occurrence of Palaearetic Cladocera *Diaphanosoma brachyurum* (Lieven) in West Bengal. *J. Bombay Nat. Hist. Soc.*, **91**(3): 466-467.

Venkataraman, K. & Das, S.R 1995. On *Sidacrystallina(*O.F. Muller, 1776) and *Acroperus harpae* (Baird, 1834) (Crustacea:Cladocera) from Tripura state. *J. Bombay Nat. Hist. Soc.*, **92**(1): 128-131.

Venkataraman, K. 1995. Cladoceran males from the Indian region. *J. Bombay Nat. Hist. Soc.*, **92**(3): 378-385.

Venkataraman, K. & Das S.R. 1998. On *Chydorus faviformis* Birge, 1893 from W. Bengal (Crustacea:Cladocera:Chydoridae) *J. Bombay Nat. Hist. Soc.*, **95**(2): 364-367.

Welch, P.S. 1952. *Limnology*; Mc Graw-hill book company Inc. 538pp.

Yousuf, A.R. & Quadri, M.Y. 1977. Cladocera of Malpur Sar, Kashmir. *J. Sci. Univ. Kash.*, **3**:87-92.

PLATES

Plate-1

Figs: a-e: *Pseudosida bidentata* Herrick

a. Female
b. Antennule
c. Antenna
d. Shell gland on valve
e. Postabdomen.

Figs: f-i: *Latonopsis australis* (Sars).

f. Female
g. Shell gland
h. Postabdomen
i. Antennule.

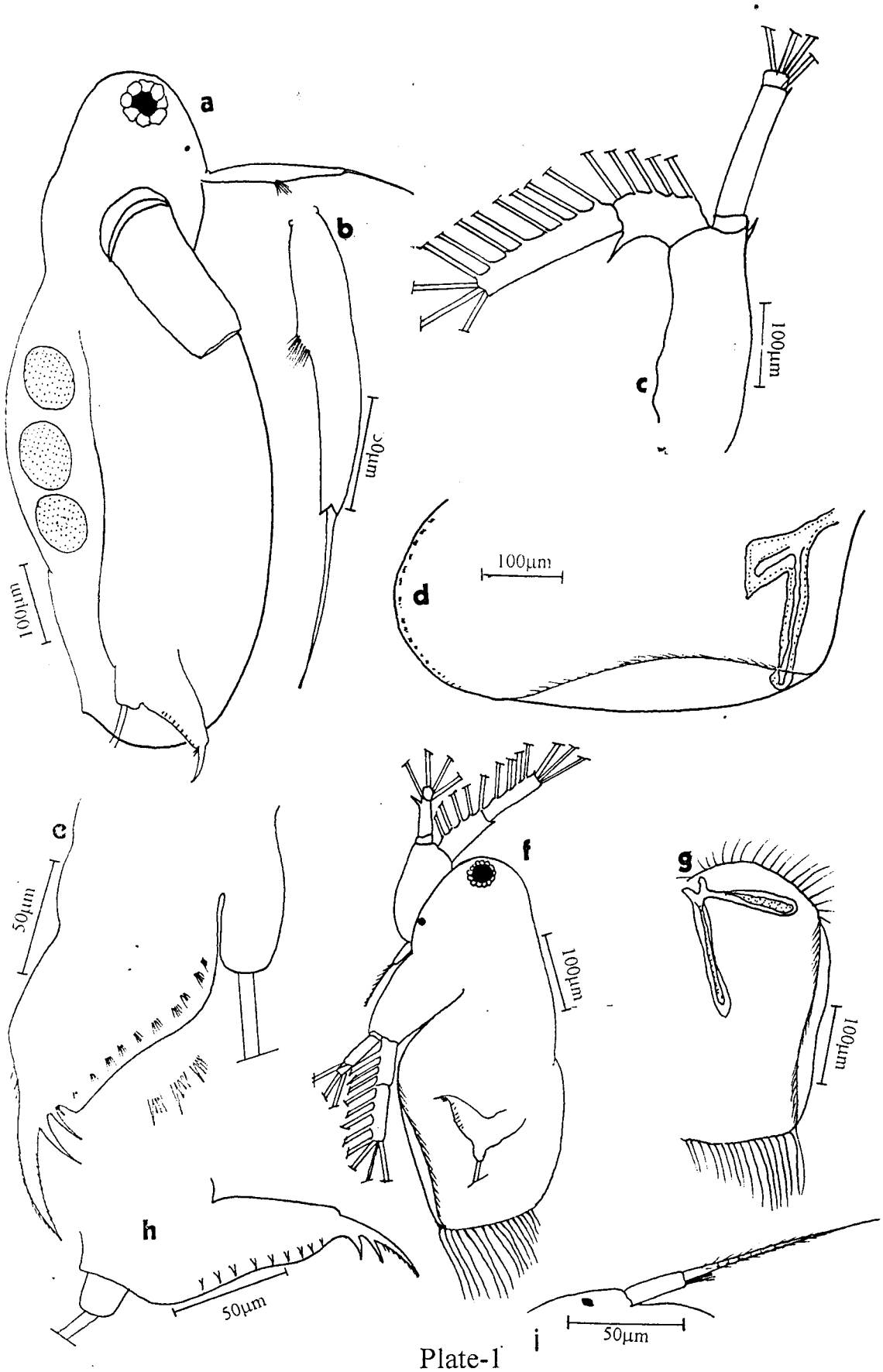

Plate-1

Plate-2

Figs: a-d: *Diaphanosoma excisum* Sars (Female)

a. Female
b. Valve duplicature and spines
c. Spines on valve (enlarged)
d. Postabdomen

Figs: e-k: *Diaphanosoma sarsi* Richard (Female)

e. Female
f. Posteroventral corner of the valve
g. Postabdomen (Female)
h. Ephippial female with sexual egg
i. Male
j. Terminal portion of 1st thoracic leg
k. Postabdomen.

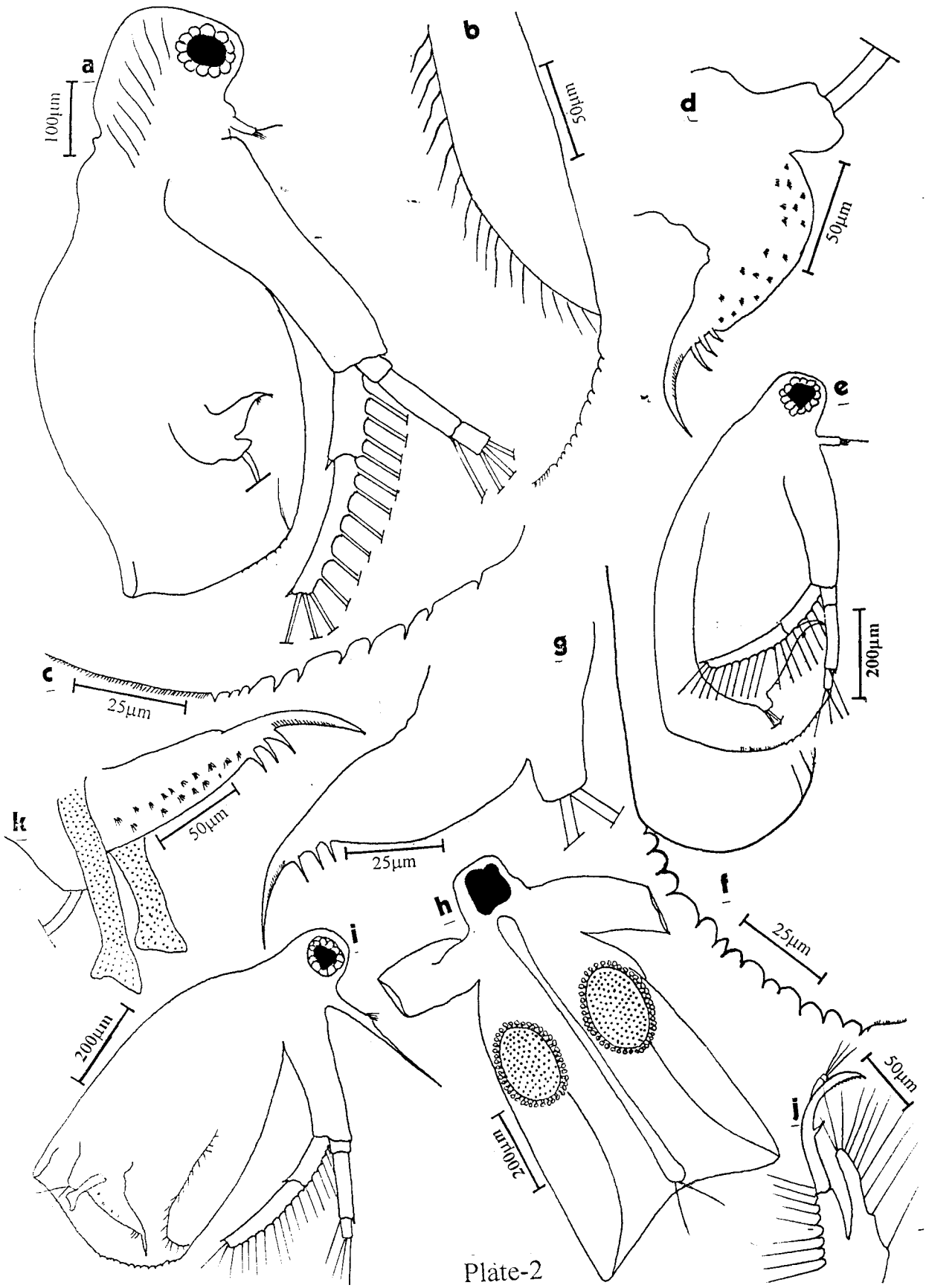
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Plate-2

Plate-3

Figs: a-c: *Ceriodaphnia laticaudata* P. E. Muller

a. Female
b. Head with antennule
c. Postabdomen

Figs: d-h: *Ceriodaphnia cornuta* Sars

d. Female
e. Postabdomen
f. Male
g. 1st thoracic leg of male
h. Antennule (enlarged).

Figs: i-l: *Simocephalus serrulatus* (Koch)

i. Female
j. Head enlarged
k. Postabdomen
l. Male.

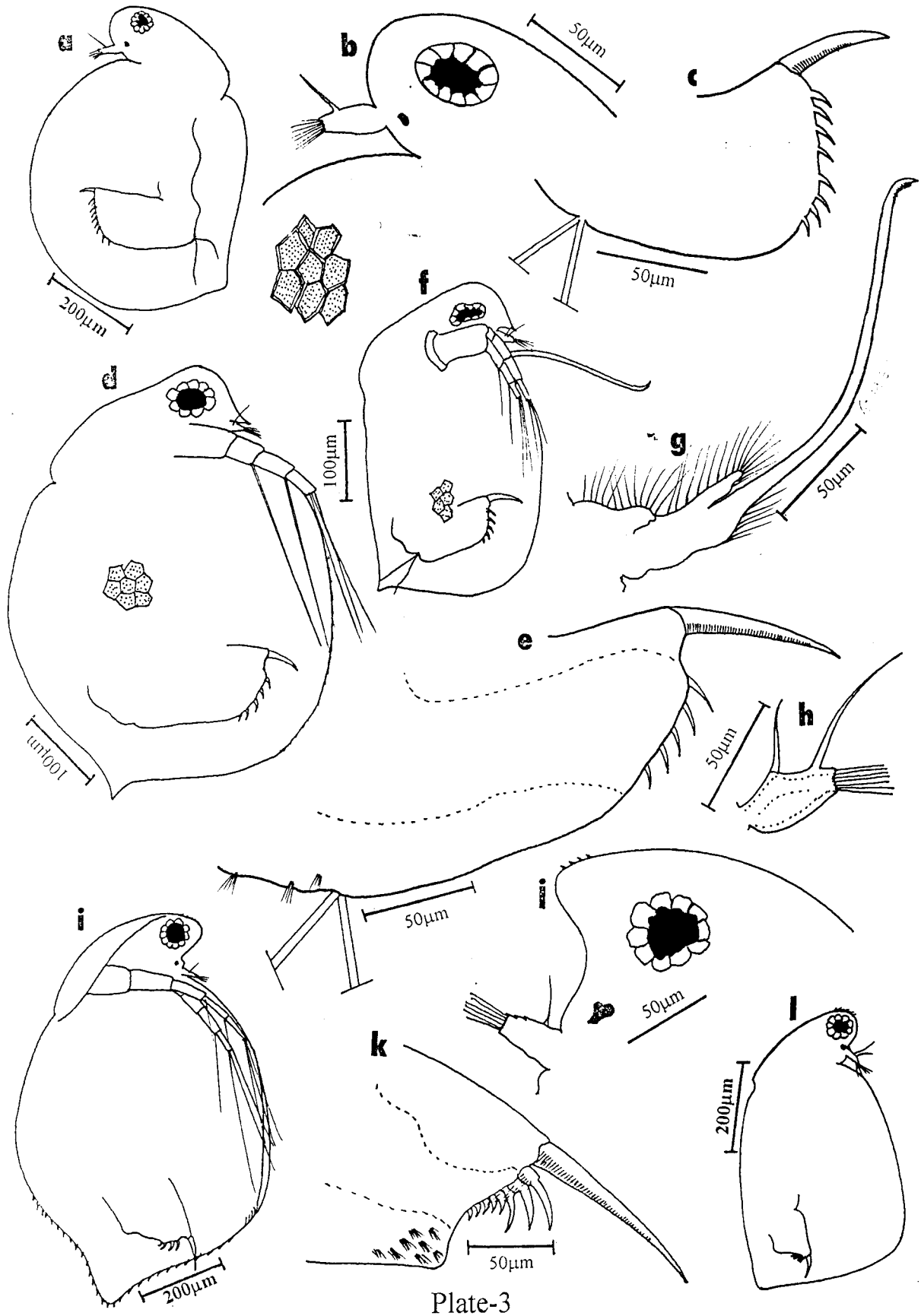
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Plate-3

Plate-4

Figs: a-b *Simocephalus serrulatus* (Koch)

a. Head of male (enlarged)
b. Postabdomen.

Figs: c-e: *Simocephalus latirostris* Stingelin

c. Female
d. Head of female (enlarged)
e. Postabdomen

Figs: f-g: *Simocephalus exspinosus* (Koch)

f. Female
g. Postabdomen

Figs: h-i: *Simocephalus vetulus* (O. F. Muller)

h. Female
i. Postabdomen (enlarged).

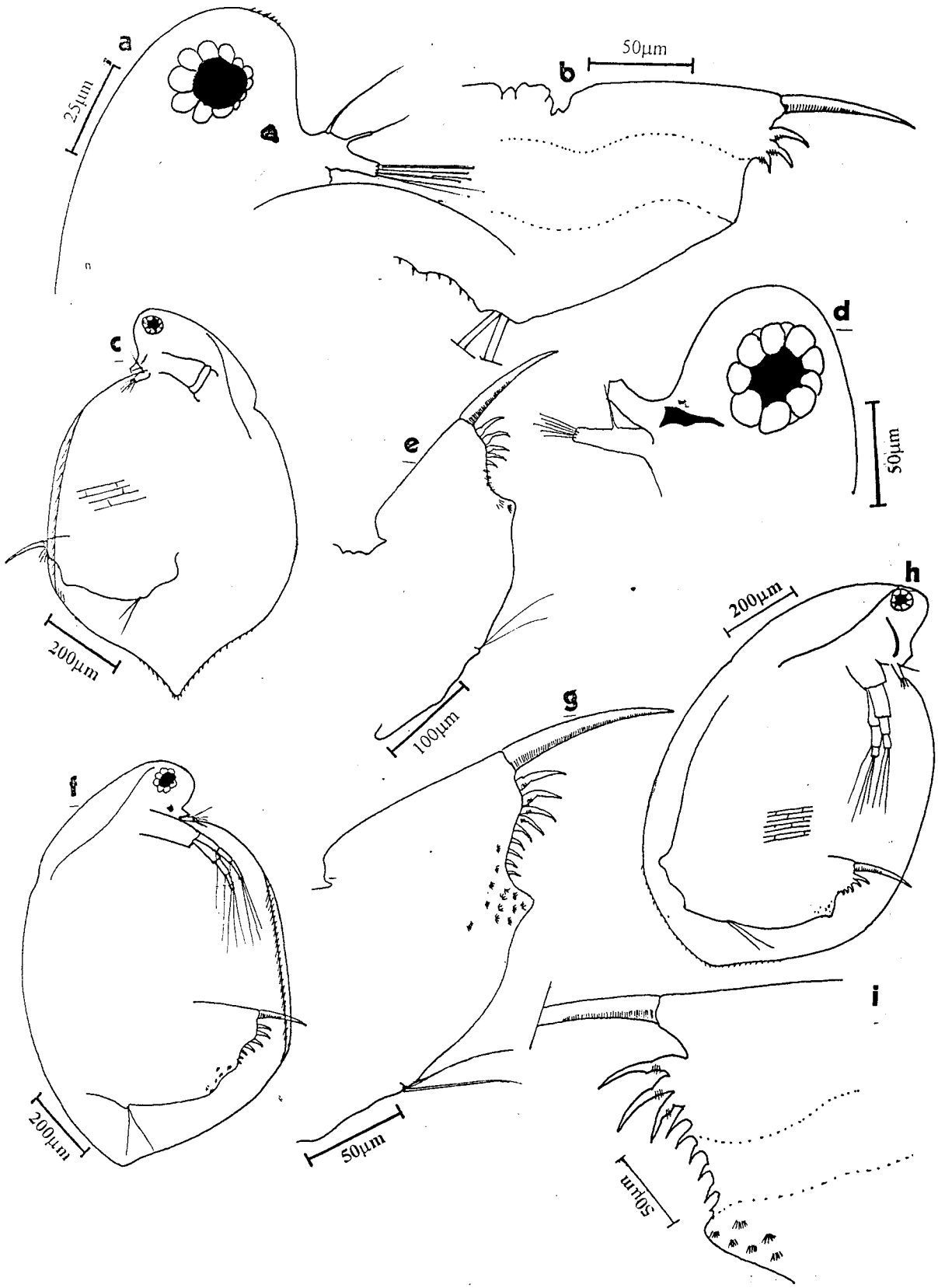

Plate-4

Plate-5

Figs: a-c: *Scapholeberis Kingi* Sars

a. Female
b. Antennule (enlarged)
c. Postabdomen.

Figs: d-k: *Moina micrura* Kurz

d. Female
e. Antennule (enlarged)
f. Postabdomen (one portion enlarged)
g. Ephippial female with egg
h. Male
i. Antennule of male (enlarged)
j. Hook of 1st thoracic leg of male
k. Postabdomen of male (enlarged).

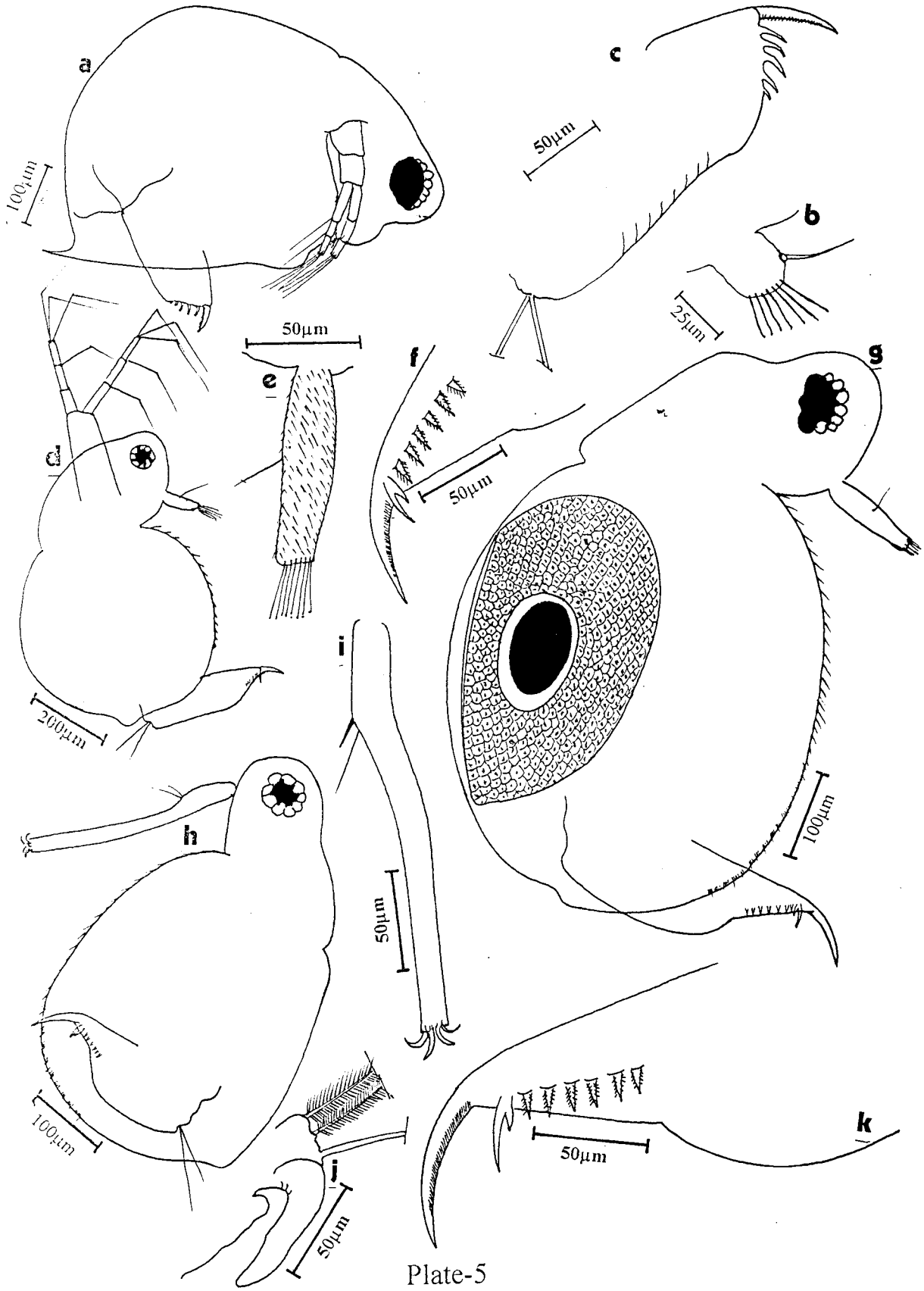
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Plate-5

Plate-6

Figs: a-f: *Moina brachiata* (Jurine)

a. Female
b. Antennule (enlarged)
c. Ventral margin of valve
d. Anterior setae on the ultimate and penultimate segment of 1st thoracic leg
e. Postabdomen
f. Postabdomen (Terminal portion enlarged)

Figs: g-k: *Moina macrocopa* (Straus)

g. female
h. Antennule (enlarged)
i. Ventral portion of valve
j. Anterior setae on the ultimate and penultimate segment of 1st thoracic leg
k. Postabdomen (Terminal portion enlarged).

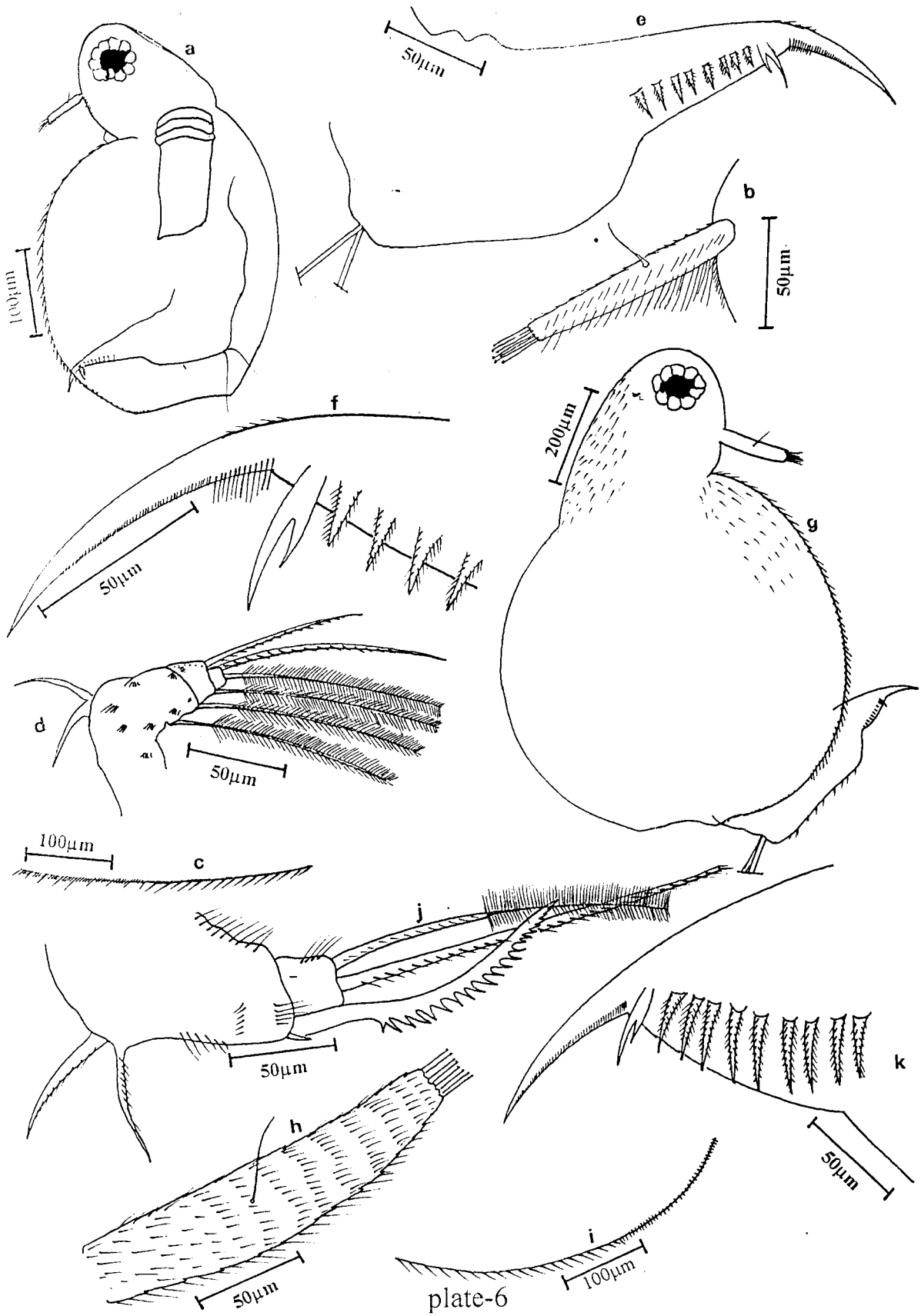
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plate-6

Plate-7

Figs: a-f: *Moina macrocopa* (Straus)

a. Ephippial female with egg
b. Ephippial egg (Sexual egg)
c. Male
d. Terminal portion of male antennule (enlarged)
e. 1st thoracic leg of male with hook
f. postabdomen of male.

Figs: g-h: *Moina* sp.

g. Female
h. Antennule (enlarged).

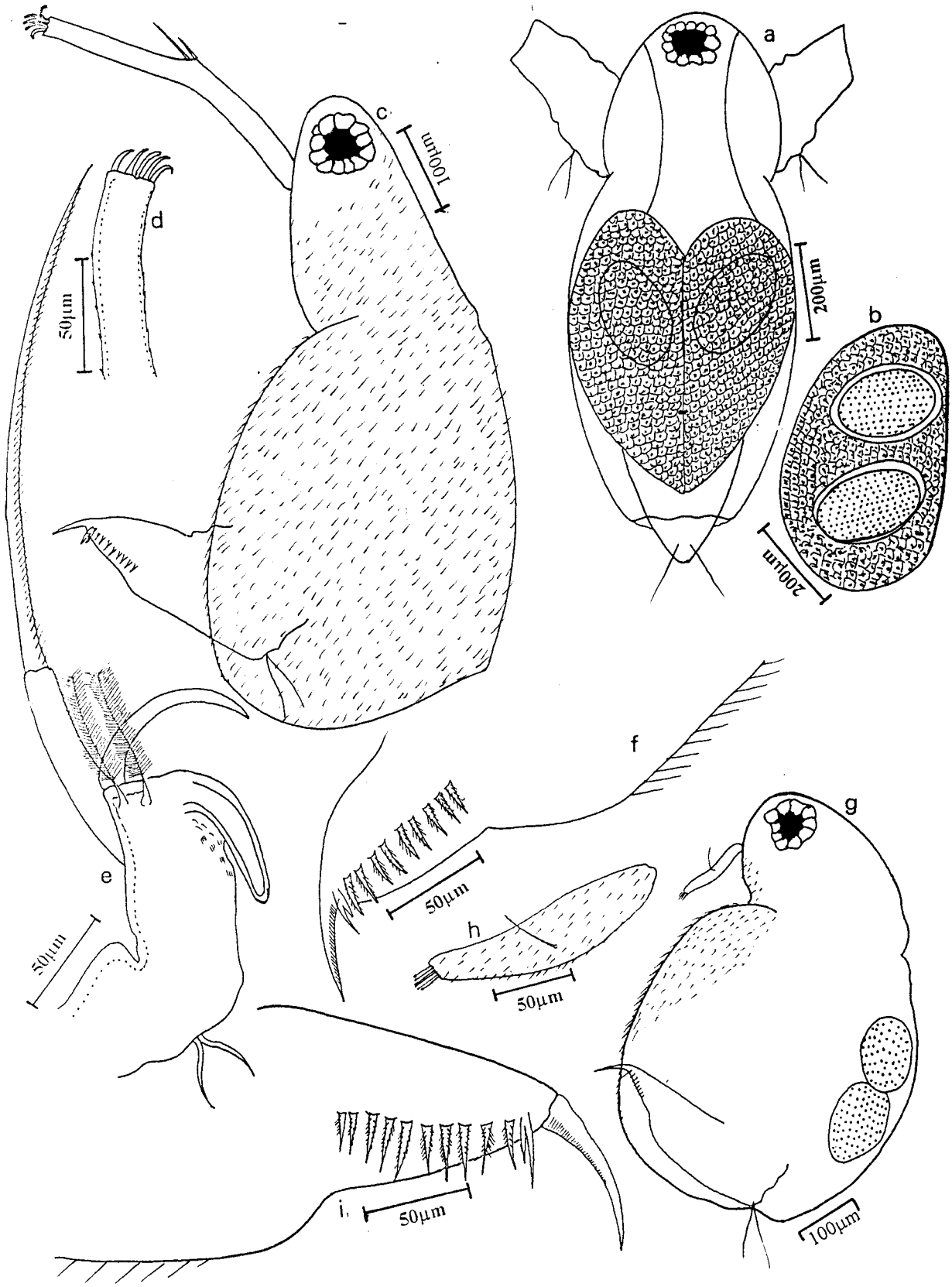

Plate-7

Plate-8

Figs: a-e: *Moina* sp.

a. First thoracic leg of female
b. Ventral margin of valve (one portion)
c. Male
d. First thoracic leg of male
e. Postabdomen (Female).

Figs: f-j: *Moinodaphnia macleayi* (King)

f. Female
g. Antennule (enlarged)
h. Postabdomen
i. Ephippial female with egg
j. Labral keel with setules.

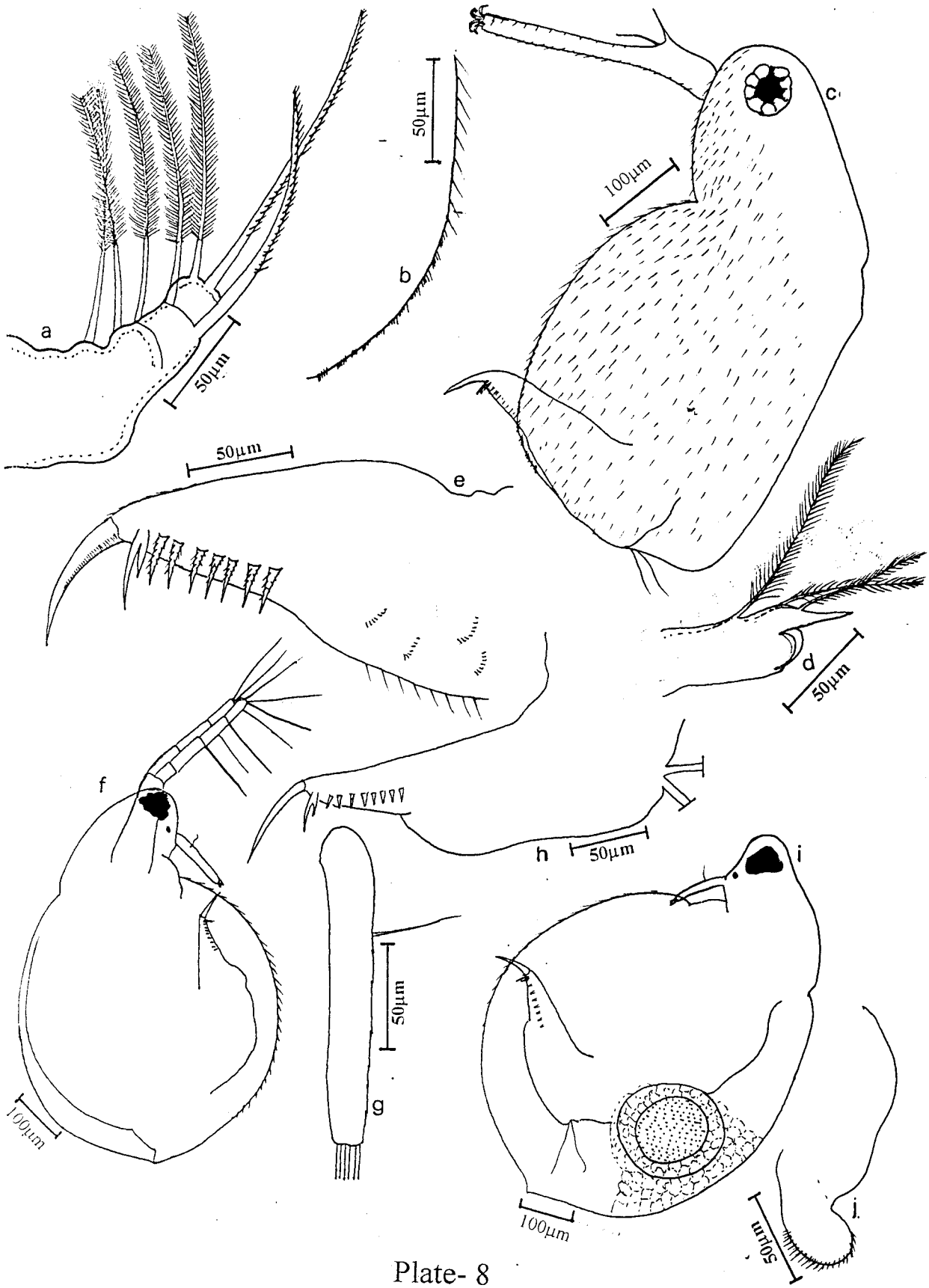
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Plate- 8

Plate-9

Figs: a-b: *Moinodaphnia macleayi* (King)

a. Male
b. Antennule (male)

Figs: c-e: *Bosmina longirostris* (O. F. Muller)

c. Female
d. Antennule
e. Postabdomen

Figs: f-h: *Bosminopsis deitersi* Richard

f. Female
g. Antennule
h. Postabdomen

Figs: i-l: *Macrothrix spinosa* king

i. female
j. Antennule (enlarged)
k. Ventral margin of valve (enlarged)
l. Postabdomen.

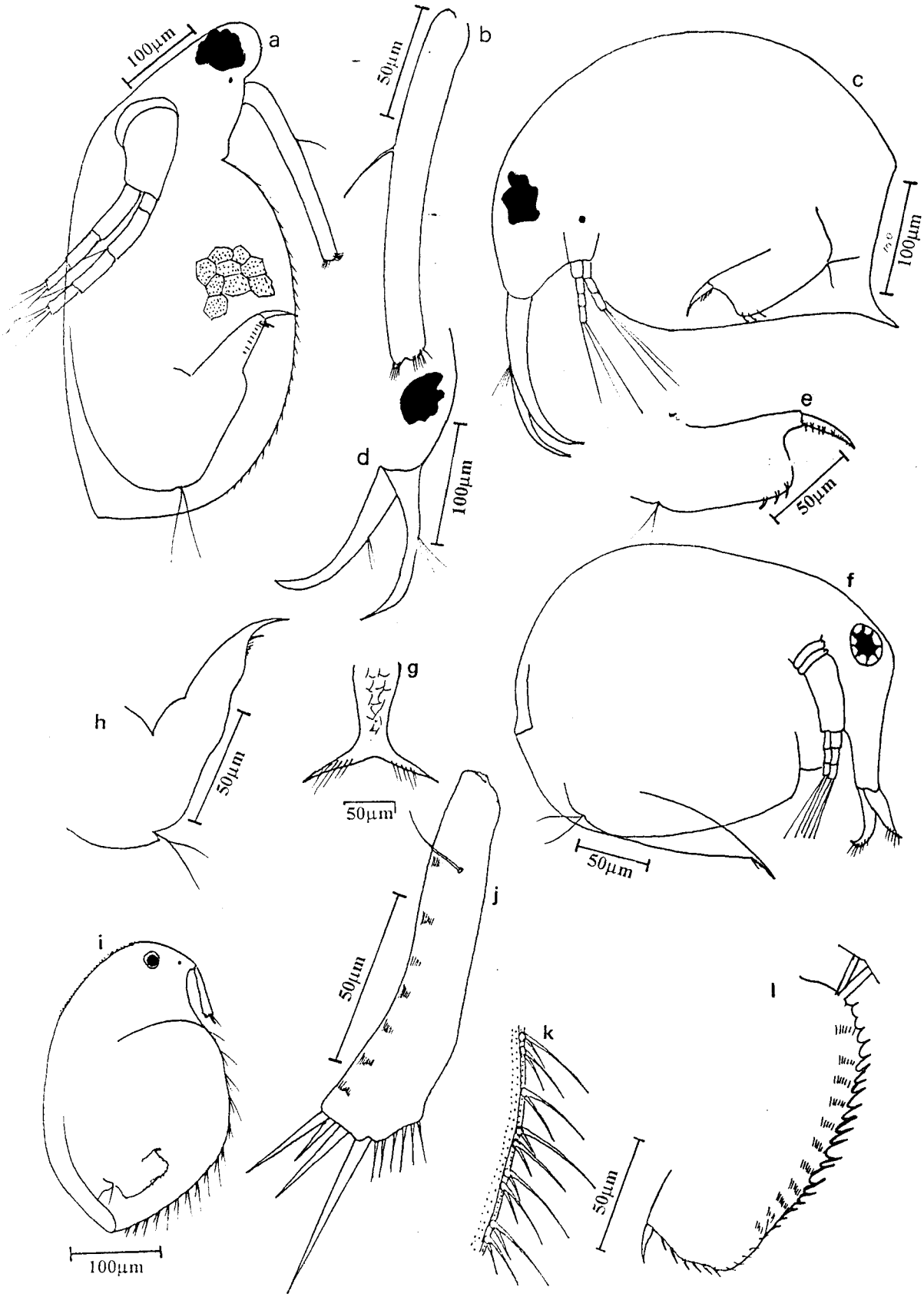
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Plate-9

Plate-10

Figs: a-c: *Macrothrix spinosa* King

a. Male
b. Antennule (male)
c. Postabdomen(male)

Figs: d-h: *Macrothrix triserialis* (Brady)

d. Female
e. Antennule
f. Postabdomen
g. Male
h. Postabdomen(male)

Figs: i-k: *Macrothrix odiosa* (Gurney)

i. Female
j. Antennule
k. Postabdomen

Figs:l-n: *Grimaldina brazzai* Richard

l. Female
m. Antennule
n. Postabdomen

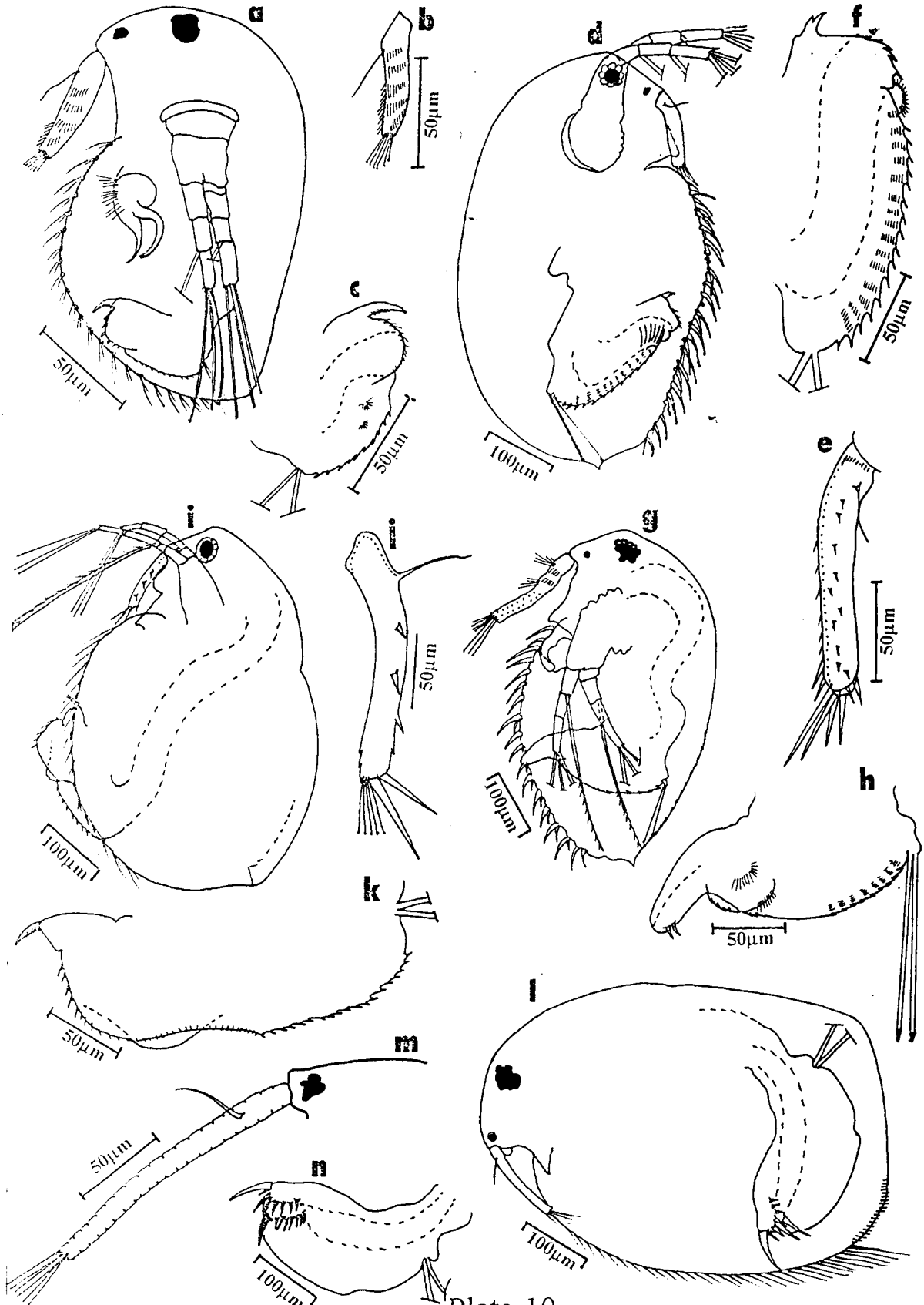

Plate-10

Plate- 11

Figs: a-d: *Ilyocriptus spinifer* Herrick

a. Female
b. Antennule
c. Valve margin with plumose setae
d. Postabdomen

Figs: e-h: *Picripleuroxus similis* (Vavra)

e. Female
f. Plate of labrum
g. Head shield with head pores
h. Postabdomen

Figs: i-m: *Picripleuroxus laevis* Sars

i. Female
j. Labral plate
k. Head shield with head pores
l. Posterior corner of the valve
m. Postabdomen

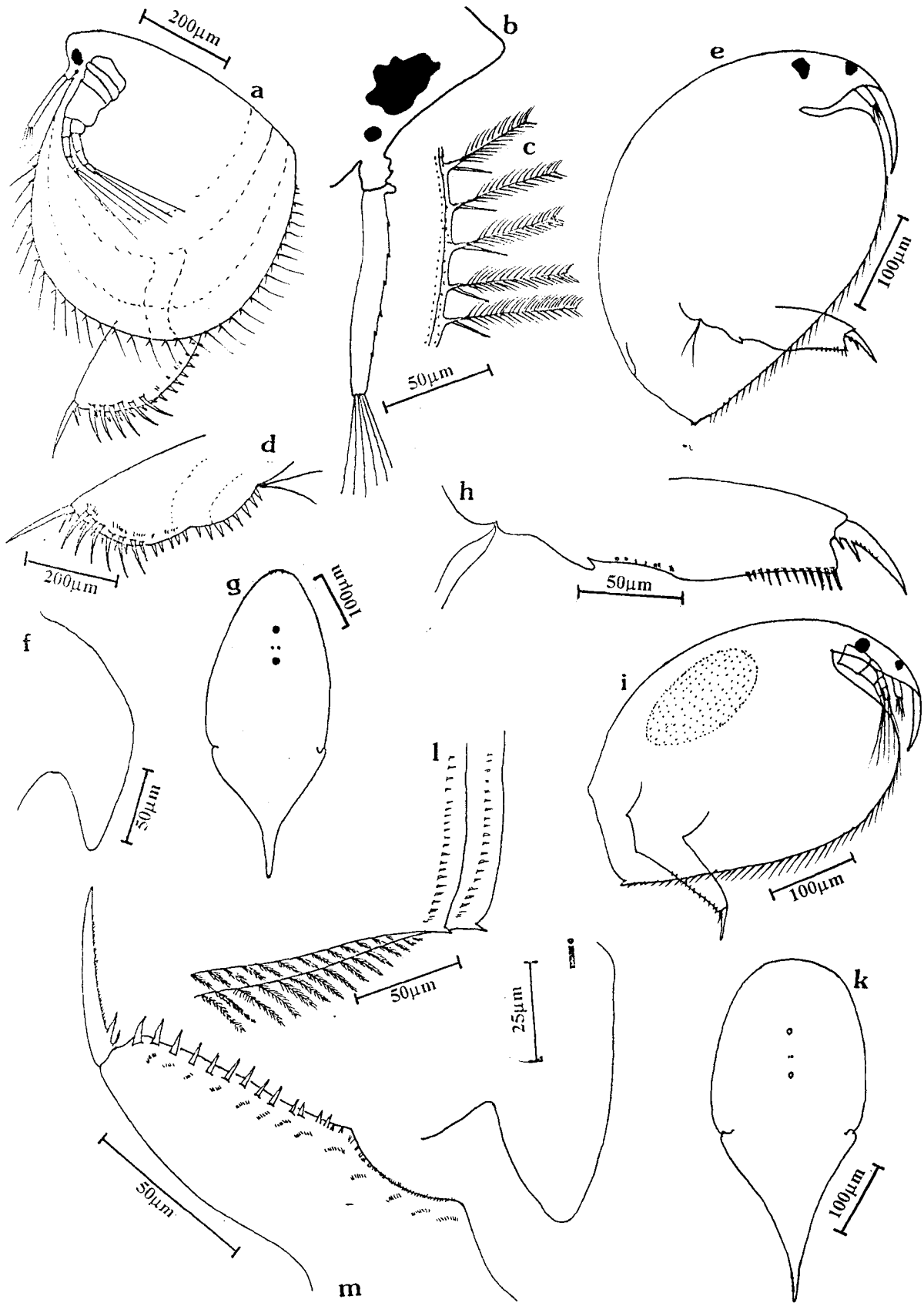
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Plate-11

Plate- 12

Figs:a-b: *Picripleuroxus denticulatus* Birge

a. Female
b. Postabdomen

Figs:c-g: *Alonella clathratula* Sars

c. Female
d. Head shield with pores
e. Labral plate
f. valve ornamentation
g. Postabdomen

Figs:h-i: *Chydorus pubescens* Sars

h. Female
i. Postabdomen

Figs:j-m: *Chydorus sphaericus* (O.F.Muller)

J. Female
k. labral plate
l. head shield
m. Postabdomen

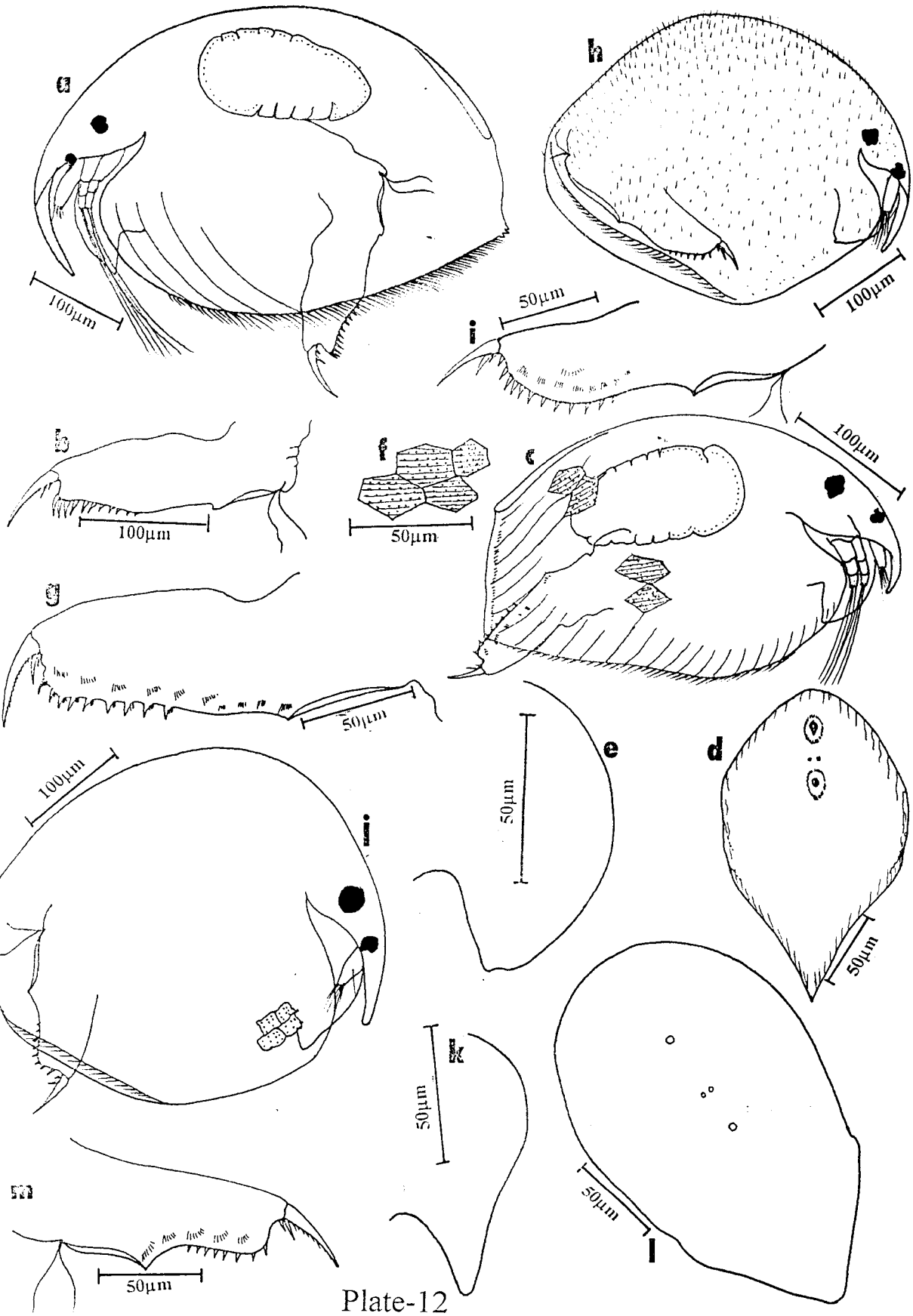
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Plate-12

Plate-13

Figs: a-e: *Chydorus parvus* Daday

a. Female
b. Head shield with pores
c. Labral plate with pores
d. Anterior margin of valve showing two large tubercles
e. Postabdomen

Figs: f-g: *Chydorus faviformis* Birge

f. Female
g. Postabdomen

Figs: h-j: *Ephimeroporus barroisi* Richard.

h. Female
i. Labral plate
j. Postabdomen

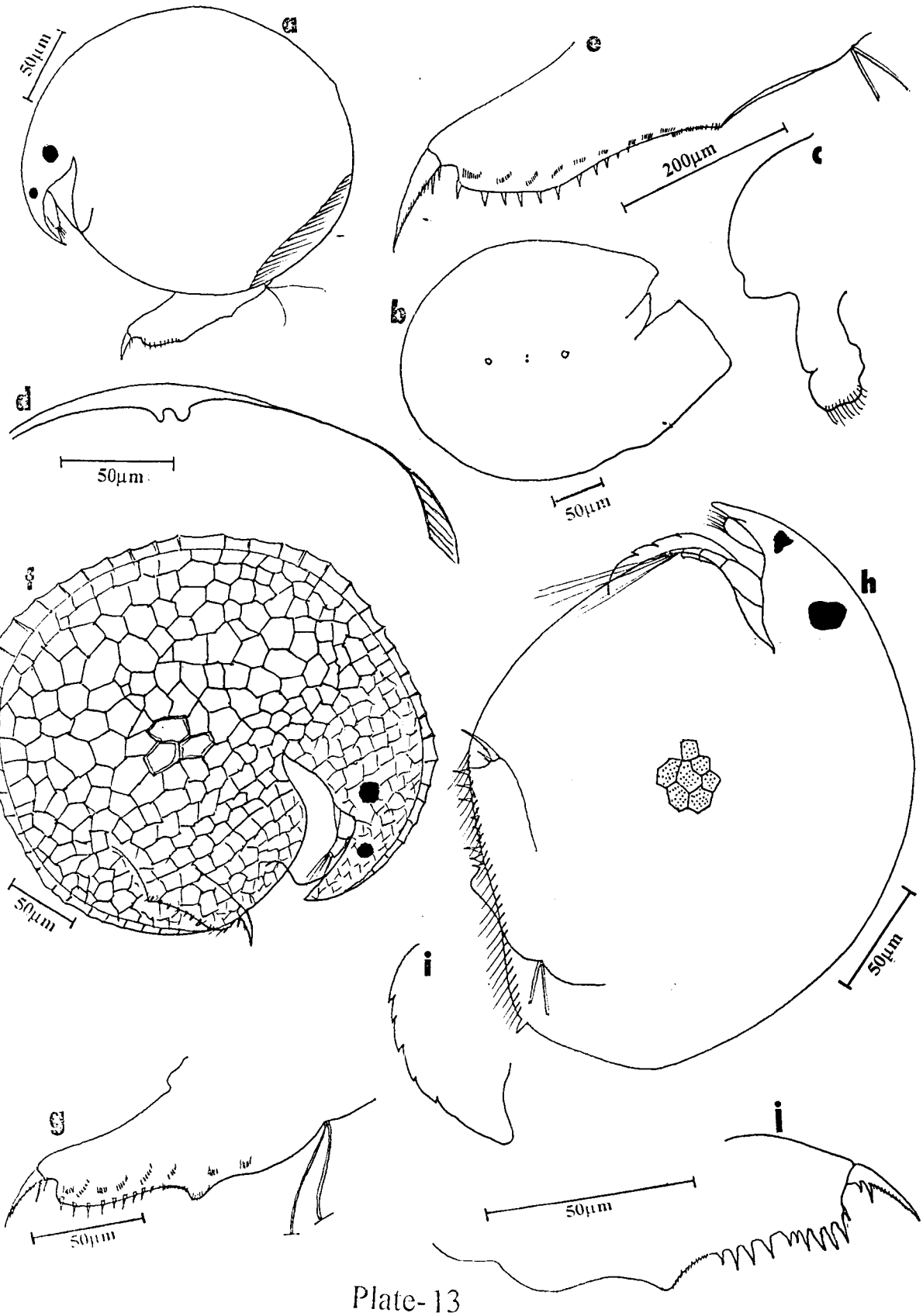

Plate-13

Plate-14

Figs: a-d: *Chydorus ventricosus* Daday

a. Female
b. Labral plate
c. Head shield with pores
d. Postabdomen

Figs: e-g: *Chydorus eurynotus* Sars

e. Female
f. Head shield with pores
g. Postabdomen

Figs: h-i: *Pseudochydorus globosus* (Baird)

h. Female
i. postabdomen

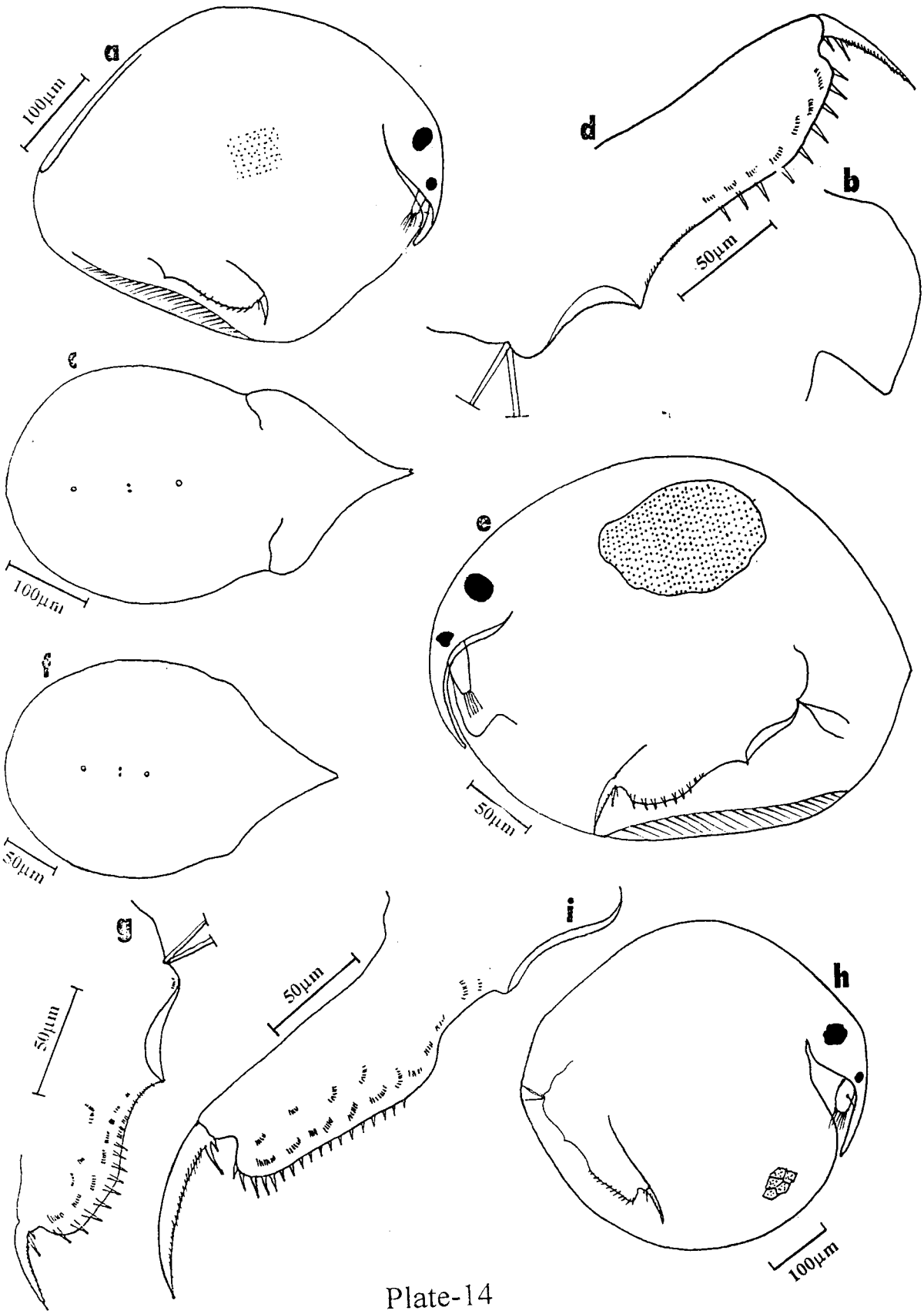

Plate-14

Plate-15

Figs: a-c: *Dunhevedia crassa* King

a. Female
b. Head shield with pores
c. Postabdomen

Figs: d-g: *Dunhevedia serrata* Daday

d. Female
e. Posterior ventral corner of valve
f. Plate of labrum
g. Postabdomen

Figs: j-m: *Alona monocantha tridentata* (Stingelin)

j. Female
k. Posterior ventral corner of valve
l. Plate of labrum
m. Postabdomen.

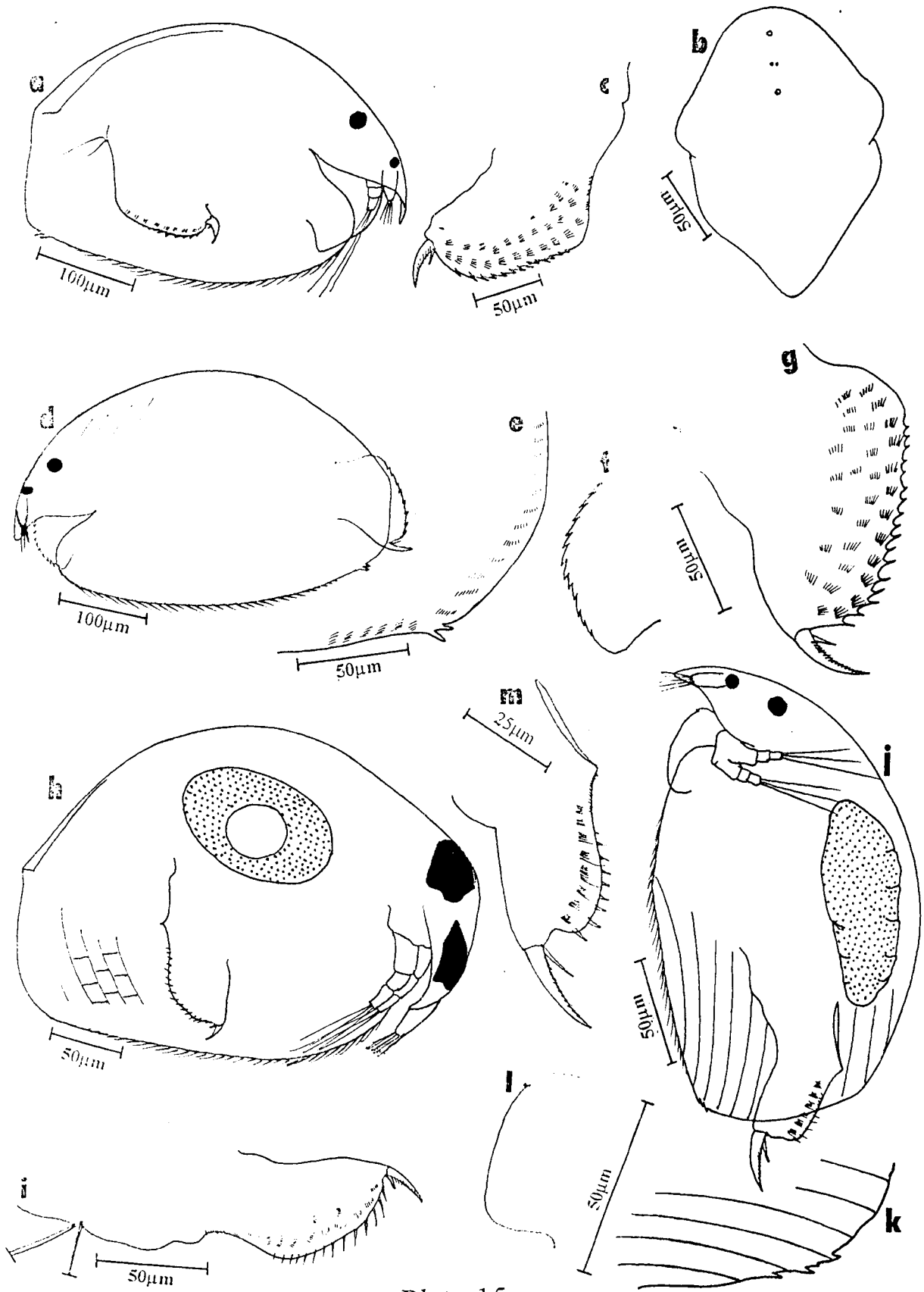
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Plate-15

Plate-16

Figs:a-d: *Alona davidi punctata* (Daday)

a. Female
b. Plate of labrum
c. Head shield with pores
d. Postabdomen.

Figs: e-h: *Alona pulchella* King

e. Female
f. Head portion enlarged
g. Head shield
h. Postabdomen

Figs: I-k: *Alona* sp.

i. Female
j. Plate of labrum
k. Postabdomen.

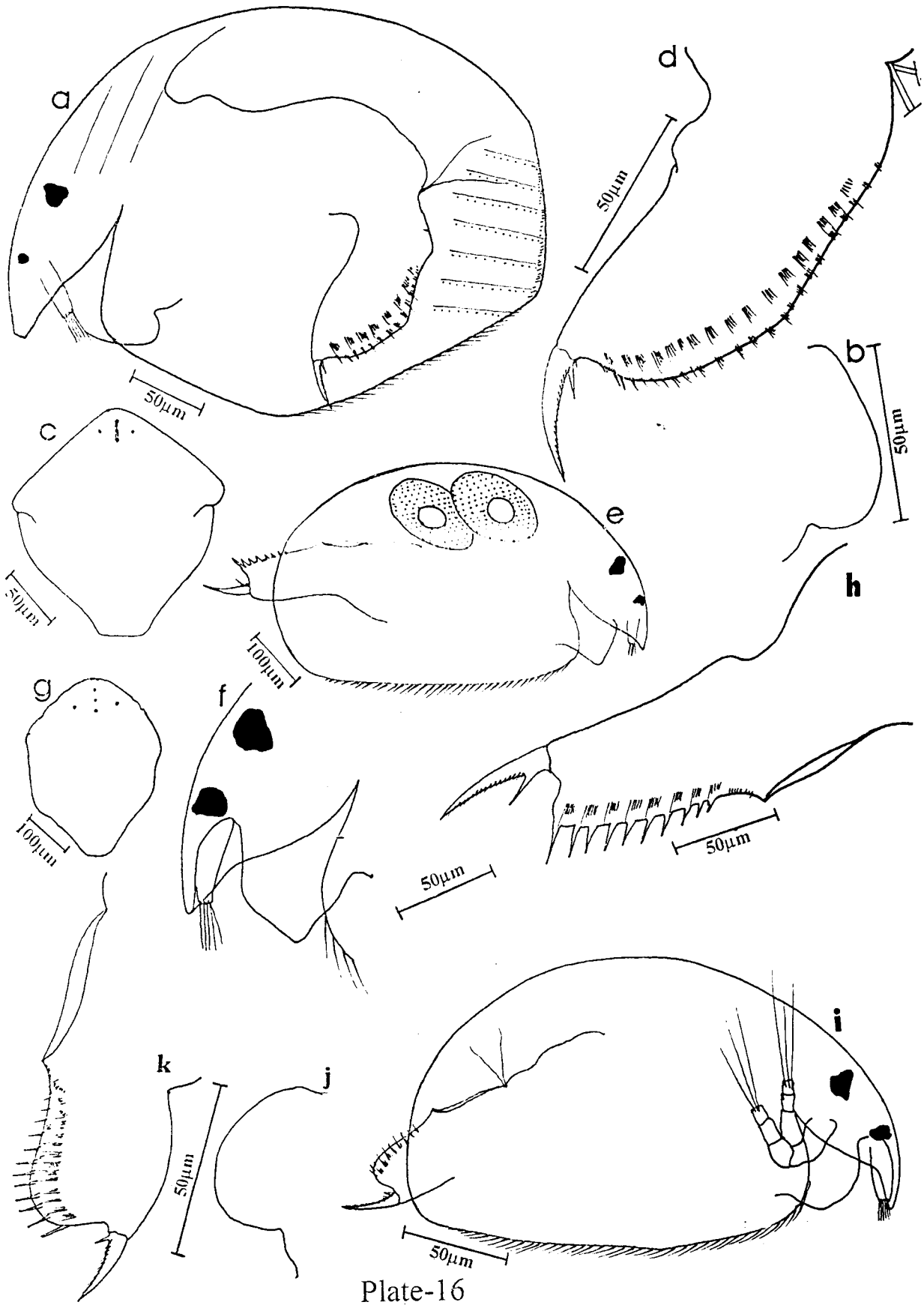
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Plate-16

Plate-17

Figs: a-d: *Alona guttata* Sars

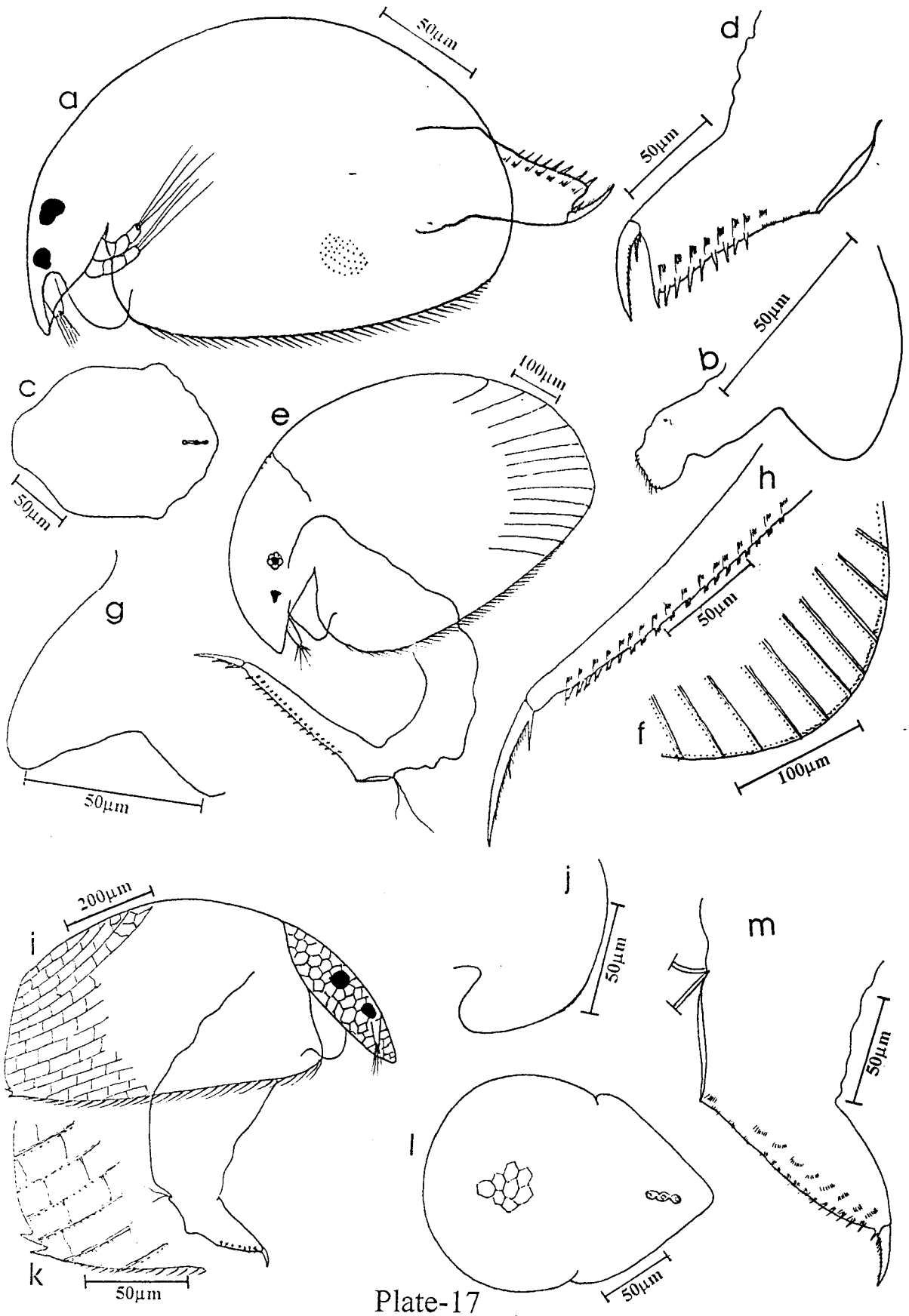
a. Female
b. Plate of labrum
c. Head shield with pores
d. Postabdomen

Figs: e-h: *Camptocercus uncinatus* Smirnov

e. Female
f. Posteroventral corner of valve
g. Plate of labrum
h. Postabdomen

Figs: i-m: *Graptoleberis testudinaria* (Fischer)

i. Female
j. Plate of labrum
k. Postero ventral corner of valve
l. Head shield
m. Postabdomen.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c
50µm
100µm
e
g
50µm
h
50µm
f
100µm
200µm
i
j
50µm
m
50µm
k
50µm
l
50µm

Plate-17

Plate-18

Figs:a-e: *Leydigia acanthocercoides* (Fischer)

a. Female
b. Head with labral plate
c. Head shield with pores
d. Postabdomen
e. Postabdominal Claw (enlarged)

Figs: f-j: *Biapertura affinis* (Leydig)

f. Female
g. Posteroventral corner of valve
h. Head portion enlarged
i. Head shield with head pores
j. Postabdomen

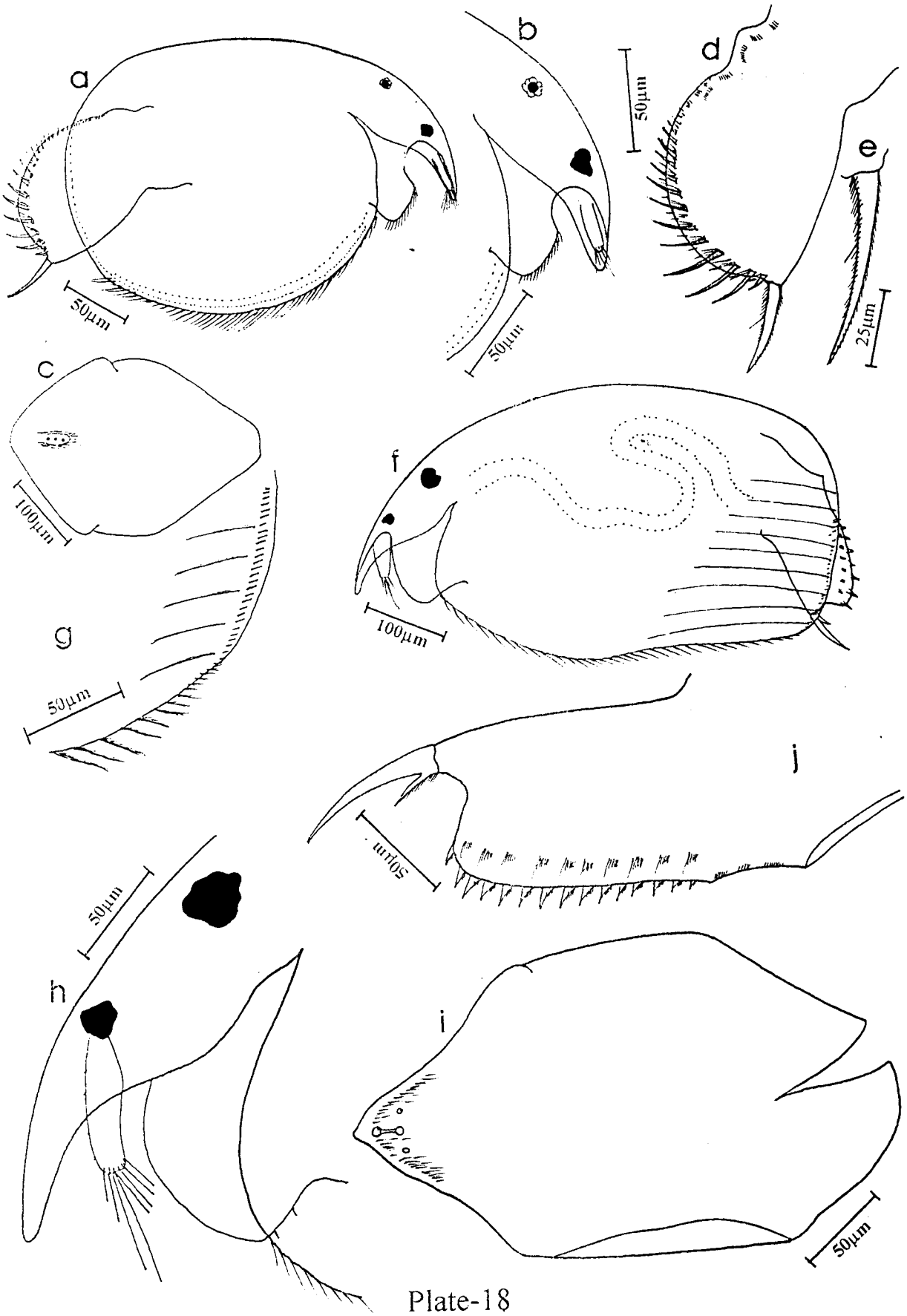
a
50µm
b
50µm
50µm
d
e
25µm
c
100µm
f
100µm
g
50µm
j
50µm
50µm
h
i
50µm

Plate-18

Plate-19

Figs:a-d: *Biapertura karua* (King)

a. Female
b. Plate of labrum
c. Head shield with pores
d. Postabdomen

Figs: e-g: *Biapertura verrucosa* (Sars)

e. Female
f. Labral plate
g. Postabdomen

Figs:h-j: *Biapertura intermedia* (Sars)

h. Female
I. Postero ventral corner of valve
J. Postabdomen

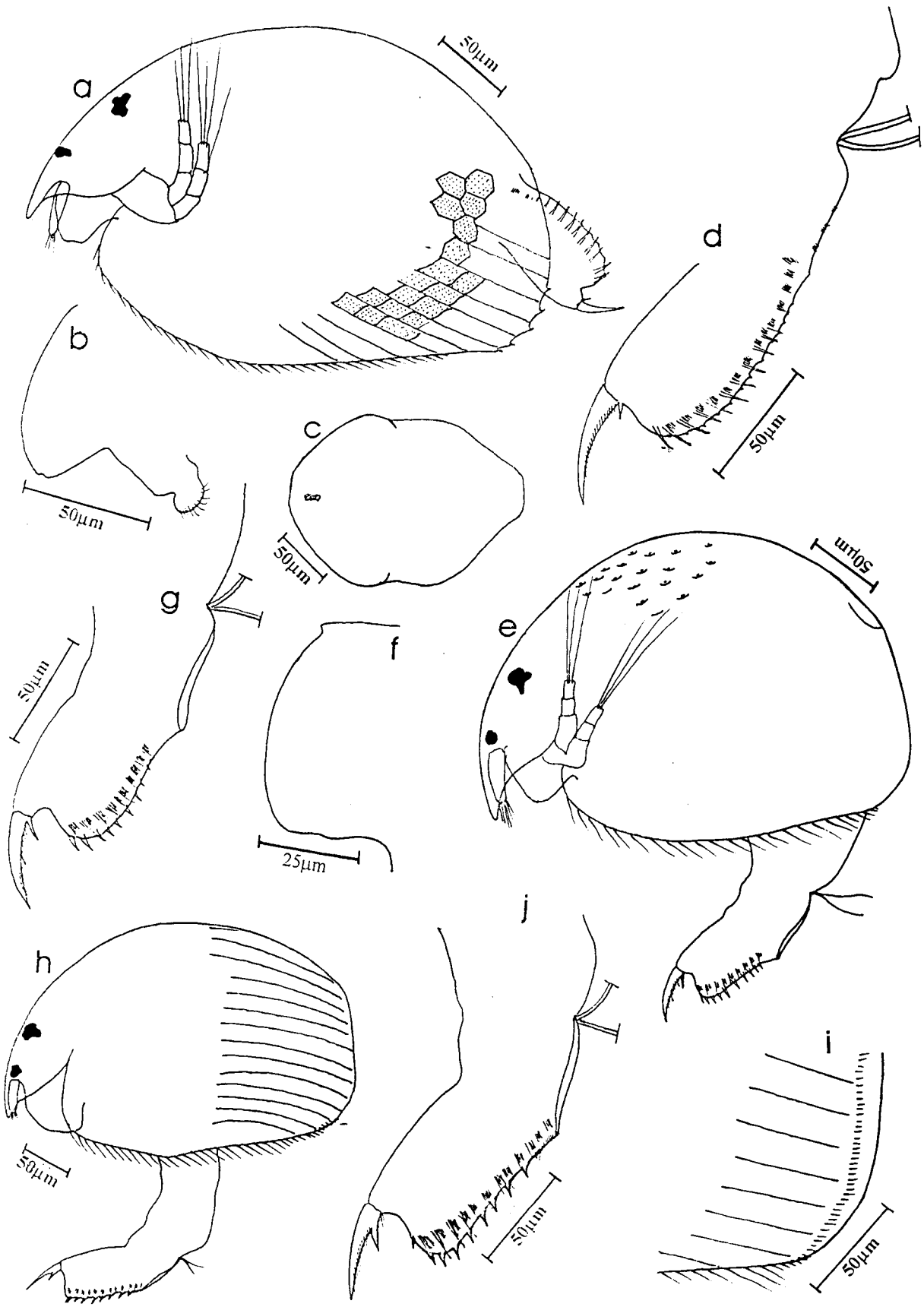
a
50µm
b
50µm
c
50µm
d
50µm
e
50µm
f
25µm
g
50µm
h
50µm
i
50µm
j
50µm

Plate-19

Plate- 20

Figs:a-e: *Oxyurella singalensis* (Daday)

a. Female
b. Posteroventral corner of valve
c. Head enlarged
d. Head shield
e. Postabdomen

Figs:f-h: *Kurzia longirostris* (Daday)

f. Female
g. Head shield with pores
h. Postabdomen

Figs:i-j: *Euryalona orientalis* (Daday)

i. Female
j. Postabdomen

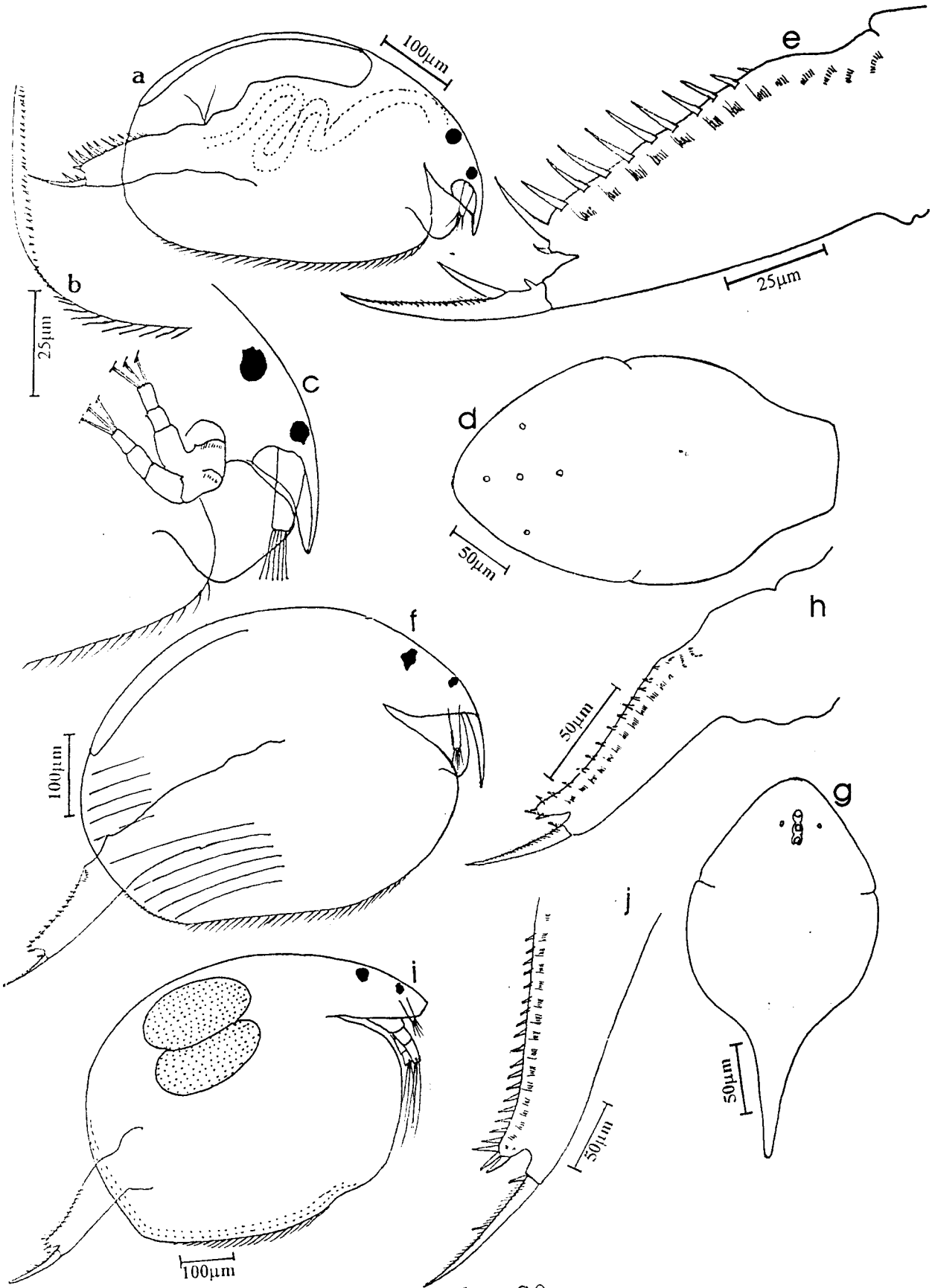

Plate-20

Plate-21

Figs:a-d: *Notolona globulosa* (Daday)

a. Female
b. Head shield with pore
c. Structural variations in plate of labrum
d. Postabdomen.

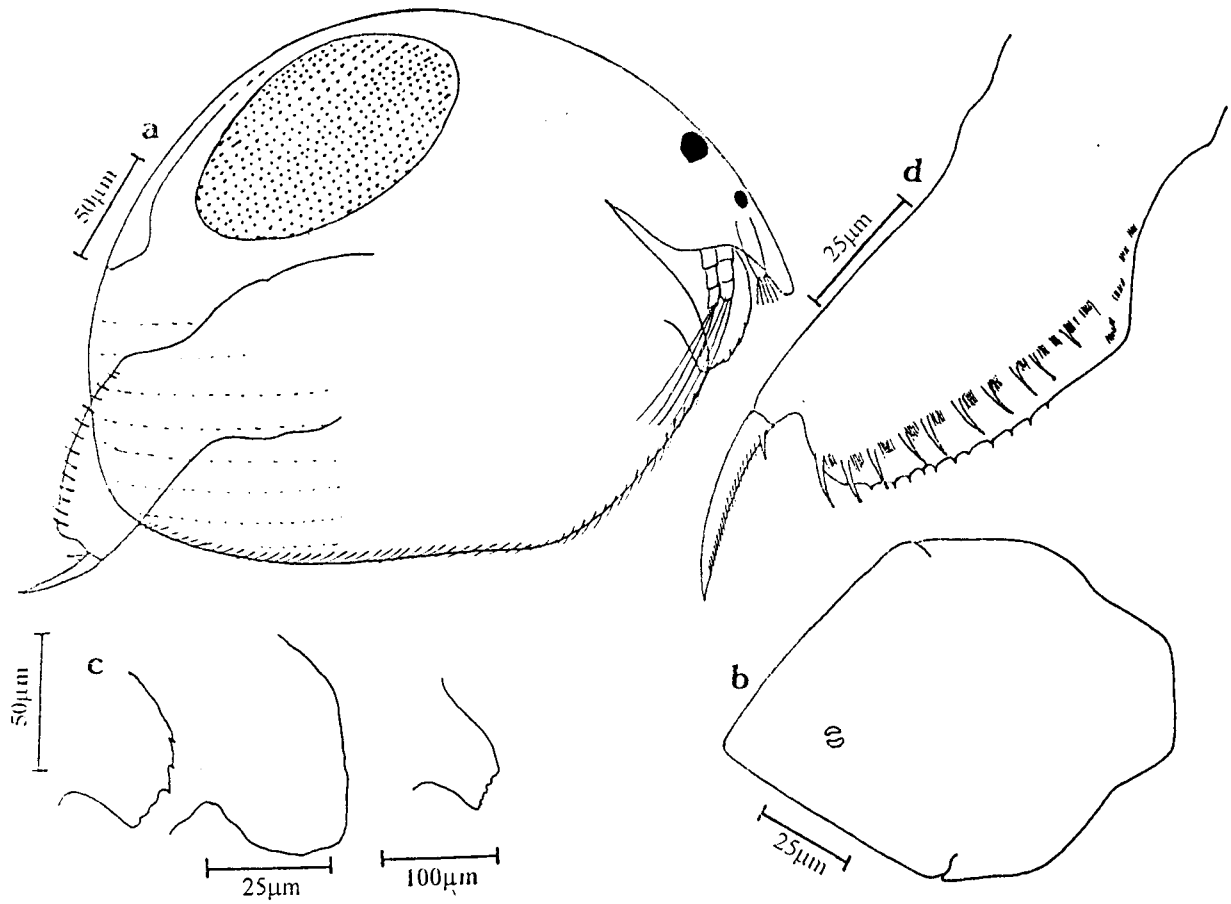

Plate-21

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