REPRODUCTIVE BIOLOGY OF *MACROBRACHIUM CANARAE* (TIWARI, 1958) (DECAPODA, PALAEMONIDAE)

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Thesis submitted in partial fulfillment of the requirement for the degree of

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Dedicated

to

My most loving parents

&

Sister

DECLARATION

I hereby declare that this thesis entitled "REPRODUCTIVE BIOLOGY OF *MACROBRACHIUM CANARAE* (TIWARI, 1958) (DECAPODA, PALAEMONIDAE)" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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31/03/08

Sreedevi

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CERTIFICATE

Certified that this thesis entitled "REPRODUCTIVE BIOLOGY OF *MACROBRACHIUM CANARAE* (TIWARI, 1958) (DECAPODA, PALAEMONIDAE)" is a record of research work done independently by SREEDEVI, K. H under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associate ship to her.

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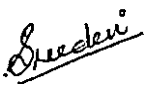

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Introduction

I. INTRODUCTION

Freshwater prawns belong to the genus *Macrobrachium* Bate, 1868. This is the largest genus under the family Palaemonidae Rafinesque, 1815 (Superfamily- Palaemonoidea Rafinesque, 1815; Infraorder - Caridea Dana, 1852; Suborder – Pleocyemata Burkenroad, 1963; Order - Decapoda Latreille, 1803). More than 200 species have been described under this genus so far (Jayachandran, 2001). Almost all of them live in freshwater, but at least spend part of their life cycle in brackish water. The genus is circumtropical and native to all continents except Europe (Ling, 1969).

The three main species of prawns of the genus cultured commercially in the world are the giant freshwater prawn *M. rosenbergii* (de Man, 1879) in many countries (Jayachandran, 2001), the oriental river prawn *M. nipponense* (De Haan, 1849) in China and Japan (Wang and Quianhong, 1999; Kutty *et al.*, 2000) and the monsoon river prawn *M. malcolmsonii* (H. Milne Edwards, 1844) in India (Kanaujia *et al.*, 1997; Kutty *et al* ., 2000).

Many species of freshwater prawns of importance in the capture fisheries point of view in the Indian subcontinent are *M. rosenbergii*, *M. malcolmsonii*, *M .gangeticum*, *M. idella*, *M. scabriculum*, *M. lamarrei*, *M. rude*, and *M. equidens* (Ibrahim, 1962; Holthius, 1980; Rajyalakshmi, 1980). In Vembanad lake almost all production is accounted for by *M. rosenbergii.* The minor species of importance are *M .idella, M. scabriculum* and *M. equidens*. Kurup *et al.* (1992) reported an annual landing of 39.27 t of scampi from Vembanad lake in 1989. The landing has increased to 399 t in 2004 as reported by Jayachandran (2005).

In addition, there is a regular sustenance to subsistence level fishery of minor *Macrobrachium* species (eg. *M. canarae, M. hendersodayanum, M. kistnense, M. lamarrei lamarrei, M. scabriculum, M. sankolli, M. tiwarii, M. unikarnatakae, M. walvanense, M. bombayense, M. kulkarnii, M. banjarae* (5.0 cm to 8.5 cm) and of genus *Caridina* (2.0 to 4.5 cm) (eg. *C. gracilirostris, C. gracilipes, C. gurneyi, C. kempi, C. panikkari, C. rajadhari, C. shenoyi, C. williamsoni*) (Jalihal, 1992; Jalihal and Sankolli, 1975; Jalihal *et al.*, 1979 a; b; 1984; 1988; 1994; Sankolli *et al.*, 1981; 1984; Shenoy *et al.*, 1993). Majority of prawns are migratory in habit. Migration route is obstructed due to construction of dams, anicuts etc. This has resulted in drastic decline in their populations. However, increasing export demand for scampi coupled with lucrative price and the concurrent near failure of marine shrimp farming has led to the evolution of sophisticated culture methods of freshwater prawns. Monospecies culture and dearth of brooders from the wild, has generated genetically weak population. With all the high-tech farming the prawn still remains beyond the reach of common man. Thus any alternative species from our rich biodiversity of freshwater prawns, which can be easily and assuredly produced at low cost and thereby affordable to common man for livelihood security, is definitely welcome.

There are several minor species of prawns belonging to the genera *Macrobrachium* and *Caridina* constituting consistent, sustenance fishery in many of our rural areas. These prawns are rather cheaply priced and within the reach of common man. These minor prawns could boost up rural production, development

and simultaneously the health of environment (freshwater bodies) with very little management.

Of these species, *Macrobrachium canarae* (Tiwari, 1958) is a small sized prawn first recorded from Karkala, South Kanara District, Karnataka. This species was recorded from Kerala by Jayachandran (1991). During a biodiversity survey of palaemonid prawns of Kerala, this species has been found to occur widely in the state. Although it does not contribute to any fishery, people along banks of Periyar consume it (Jayachandran, 2005).

In addition to the edible value, the ornamental value of *M. canarae* can be explored for the beneficial use (Jayachandran, 2005). The other palaemonid prawns of ornamental value which were identified during the biodiversity survey included

1. *M. ornatus* Jayachandran and Raji, 2004
2. *M. latimanus* (Von Martens, 1868)
3. *M. gurudeve* Jayachandran and Raji, 2004
4. *M. jayasreei* Jayachandran and Raji, 2004
5. *M. kunjuramani* Jayachandran and Raji, 2004

It is reported that these species have many advantageous characters to be considered for aquaria, such as,

1. many are coloured.

2. many have transluscent body, through which internal organs and their functions could be viewed, which is rarely possible in other organisms.

3. many can consume algae in aquaria

4. some are small sized and hence can be kept in groups

5. they have large number of appendages, the functioning of each of these appendages is quite interesting.

6. moulting in prawns is a curious biological process.

M. canarae is edible and has some qualities for consideration as ornamental species. The shining bright orange-red spot on the second cheliped is attractive. Owing to the above mentioned properties which the present species possess, various biological aspects like taxonomy, sexual dimorphism, maturity stages, ovarian development, ovulation, incubation period, fecundity and moulting have been studied for the effective management of the species and presented in this dissertation.

Review of literature

II. REVIEW OF LITERATURE

2.1. TAXONOMY

Pioneering work on Indian Palaemonids was that of Henderson (1893). This was followed by Nobili (1903) whose description was the first report on South Indian Palaemonids, on the prawns of Pondicherry. Henderson and Matthai (1910) listed nine species of the genus *Palaemon* from South India, of which two were new. Kemp (1913- 1925) extensively studied the decapod crustacea of the Indian Museum. Nataraj (1942) reported on the prawn fauna of Travancore area. Tiwari (1947) described two new species of *Palaemon* from Bengal; (1949) described a new species of *Palaemon* from Banaras, with a note on *Palaemon lanchesteri*; (1952) diagnosed new species and subspecies of Indian freshwater prawns of the Indo- Burmese region; (1961) recorded *M. latimanus* for the first time from India. Jalihal *et al.* (1984) described five new species of atyid shrimps from Karnataka; (1988) made a thorough study on the taxonomy of freshwater prawns of Karnataka. Jayachandran and Joseph (1989) reported a total of seventeen species from the south-west coast of India. Kurup *et al.* (1992) provided a key for the field identification of 15 commercially important species of *Macrobrachium* of India. Tiwari and Holthuis (1996) had revalidated taxonomic status of *M. choprai* and *M. gangeticum*. The classic work on Palaemonid prawns by Jayachandran (2001) is the latest addition in this subject. Recently 4 new species have been added (Jayachandran and Raji, 2004; Jayachandran *et al.*, 2007 a, b).

The species under investigation was originally described by Tiwari (1958) under the scientific name *Palaemon canarae* and gave only brief diagnostic characters. Jalihal *et al.* (1988) redescribed it with suitable illustrations, apparently the first illustrated account on the species.

2.2. REPRODUCTIVE BIOLOGY

Although fairly good descriptions on the various aspects of the reproductive biology of the penaeid prawns are available, the same is comparatively scanty regarding the Palaemonids (Jayachandran, 1984). The contributions are those of Menon (1938) who first recorded the larvae of *M. rosenbergii* from brackishwater areas; John (1957) who made a detailed study of the bionomics, life history and economics of *M. rosenbergii* with a detailed analysis of its migration to the feeding grounds and from there back to the breeding grounds in the brackishwater areas of the Vembanad lake. Biological information on the various aspects of *M. idella* is available from the works of Jayachandran (1984) and Jayachandran and Joseph (1989). Rajyalakshmi (1961, 1980) studied the maturation and breeding of estuarine prawns, *M. rosenbergii, M. mirabile and M. malcolmsonii* in the Hoogly estuary. The available literature on the fishery and biology of *M. rosenbergii* inhabiting Central Travancore are those of Raman (1964, 1967). The reproductive biology of *M. gangeticum* was thoroughly studied by Singh and Roy (1994).

A number of biological studies of species from other countries include those of *M. lanchesteri* from the works of Phone *et al.* (2005). The reproductive biology of *M. olfersii* was reported from Brazil (Ammar *et al.*, 2001., Camp,

2002). Studies on two South American prawns *M. jelksii* and *M. amazonicum* were carried out by Gamba (1997). Studies on *M. vollenhovenii* and *M. macrobrachion*, the two large species in Nigerian waters were carried out by Marioghae and Aylinha (1995).

2.2.1. **Sexual dimorphism**

Raman (1967) worked out the total length and carapace length relationship in *M.rosenbergii* and found that these body measurements have a linear relationship. In *M. rosenbergii* male prawns, except small males (SM) are easily recognised by longer and stronger chelipeds with larger spines than the females (New and Valenti, 2000). Mammen Koshy (1972) studied sexual dimorphism in *M. dayanum.* The results showed that the number of teeth on the upper and lower edges though variable does not differ significantly between the sexes. The study also revealed no significant variation in the 2nd cheliped in relation to cephalothorax in both sexes. However, a study of the difference in regression coefficients between the sexes separately showed significant variation in carapace length, rostrum length and length of the Ist cheliped. In this species the males are larger than females.

According to Nagamine *et al.* (1980), *M. rosenbergii* can be sexually distinguished with the first appearance of gonopores in juveniles, at 59 mm (CL) for male and 76 mm (CL) for female. Male gonopores are situated at the base of coxae of the fifth pereiopods and are covered by flaps, while female gonopores appear as oval apertures on the coxae of the third pereiopod and are covered with a membrane. New and Singholka (1985) illustrated the fact that the ventral side

of the Ist abdominal somite in *M. rosenbergii* has a central lump or point, which can be felt with a finger. This feature is absent in female. Mature females have proportionately smaller heads and claws than males (Sandifer and Smith, 1985). They exhibit a typical brood chamber, formed by the first, second and third abdominal pleurae. *Macrobrachium* also exhibit reproductive setae on the pleopods and thorax, which are functionally distinct: the ovipositing setae, which are mostly permanent, on the coxae of the last three pairs of pereiopods and pleopods guide the eggs during spawning, and the ovigerous setae, which only occur following a pre-spawning moult are used to secure the eggs to the pleopods for brooding (Nagamine *et al.*, 1980). Apart from these characteristics, and the presence of gonopores, males can also be recognised by the appendix masculina, a spinous process adjacent to the appendix interna on the endopod of the second pleopod (Sandifer and Smith, 1985).

In *M. malcolmsonii, M. gangeticum* and *M. idella* the males are larger than females. In *M. lar* the second pereiopods show considerable variation in the relative proportion of different podomeres with age as well as sex (Jayachandran, 2001).

In *M. latimanus* the males are more colourful with orange red streaks on the inner part of the second cheliped compared to female (Jayachandran, 2005)

2.2.2. **Breeding dress**

Pillai (1958) had briefly described the breeding dress in *Caridina laevis.* The details on the arrangement of setae on the pleopods was also described by Jayachandran (2005) in *M. latimanus.*

2.3. Maturity stages and ovarian development

Patwardhan (1937) was the first to publish a monograph on *M. malcolmsonii.* Basic structure of ovary of freshwater prawn is available from this book. In addition to the physical appearance of the ovaries, microscopic structure and size of ova were taken into account for distinguishing seven maturity stages in *M. idella* by Jayachandran (1984). Singh and Roy (1994) studied the breeding biology of *M. gangeticum*. They recognized five maturity stages in females, viz., premature stage, early maturing, mature, berried and spent stages. Jayachandran (1984),Rao (1986), Kanaujia *et al.* (1999) and Mohapatra (2001) studied the maturity stages of the ovary in *M. idella, M. malcolmsonii* and *M. rosenbergii*, and reported four stages of ovarian development based on the colour and size of the ovary in relation to carapace cavity and diameter of ova. Ovarian development was classified according to colour, size and outline of the ovaries in *M. rosenbergii* by Chang and Shih (1995). Seven maturity stages have been identified in *M. latimanus* by Jayachandran (1984).

The incubation period of *M. rosenbergii* is 20-21 days (John, 1957), and 19-20 days (Rao, 1965). In *M. malcolmsonii* the fertilised eggs are deep yellow in colour which turns light grey and finally becomes light slate grey before hatching. A temperature range from 28-32° C has been reported to be optimal during the incubation period (Kanaujia and Mohanty, 1992; Kanaujia *et al.*, 1998). However, at lower temperatures the incubation period is prolonged to more than 15 days (Kewalramani *et al.*, 1971; Sankolli *et al.*, 1984; Kanaujia *et al.*, 1998).

2.4. **Fecundity**

According to New and Singholka (1985), female *M. rosenbergii* can lay between 80,000 and 1,00,000 eggs in each time of spawning when fully mature, with the mean fecundity of 20 specimens estimated as 1,30,000 (Patra, 1976). But the number of eggs produced by single specimen ranged from 54,000 to 2,76,000 approximately depending on the size and condition of the individual. The relationship of fecundity with total length, carapace length, weight of the specimen and the weight of the total eggs was found to be linear.

Fecundity of *M. rosenbergii* is enumerated and the same is subjected to regression analysis to twenty five different morphometric characters in order to evolve suitable indices which can indirectly be used for the estimation of eggs of berried prawns especially for hatchery operations. Absolute fecundity varied from 30,666 to 27,27,161 for the specimen ranging in weight from 33.7 to 208.0 g. Among the twenty five morphometric parameters studied, fecundity of *M.rosenbergii* showed a very strong positive correlation with the total weight, total length and carapace length (Rajyalakshmi, 1961; Suresh Kumar and Kurup, 1998)

Based on the studies of reproductive biology of *M. equidens* the fecundity was found to vary between 448 and 8,281. The relationship between fecundity and total length was non-linear. Fecundity was linearly related to body weight and berry weight (Murthy *et al.*, 1987).

Efficiency of egg production, i.e., the number of eggs produced per female unit body weight may be size dependent and is generally assumed to increase with female size (Malecha, 1983). Rao (1991) reported that in wild population of *M. rosenbergii* from India, smaller females produced a higher number of eggs per unit body weight. In contrast Ang and Law (1991) and Cavalli *et al.* (2000) found that the number of eggs per gram body weight increased with size.

According to John (1957) the fecundity of *M.rosenbergii* was 100,000 to 160,000. Rajyalakshmi (1961) reported the fecundity of *M. mirabile* to be 550-3000. According to Nataraj (1947) the fecundity of *M. idae* was 2000-20,000 whereas it was only 6000-7000 as per Aiyer (1949).

2.3. MOULTING

Moulting and reproduction are two energy demanding processes in crustaceans. They continue to moult even after attaining sexual maturity. In natantian decapods, reproductive growth and somatic growth (moulting) are synergistic unlike the brachyuran decapods where they are antagonistic (Shyama, 1987).

Materials and Methods

III. MATERIALS AND METHODS

The live specimens of *M. canarae* were collected from the middle stretches of Periyar river at Thattekad station. Latitude 76°40'-76°45'N. Longitude 10°7'-11°E.

Of the 14 dams of the river Periyar, Bhoothathankettu dam was constructed for the irrigation purpose. In the 1960s when the Bhoothathankettu dam was commissioned large areas of natural riparian forest on either side of the river was removed. This area was later converted into the catchment area of the dam creating a large water spread area which forms the wetland habitat of the Thattekad sanctuary. Unlike other dams, annual draining is being done for maintenance work. This process makes the environment dry within a short period of one or two days resulting in severe habitat changes. Submerged and floating macrophytes like *Hydrilla, Vallisneria, Salvinia* etc. got established in the stagnant water bodies.

The prawns were collected from these water bodies covered with *Hydrilla* and *Vallisneria*. They were found to take shelter among these macrophytes. The collection was made during morning hours. Large quantities of submerged plants were removed and prawns were sorted out. They were packed in oxygen filled bags and transported to the college. A total of 200 specimens were collected.

Live specimens were stocked in cement cisterns (diameter=22 inches, height=14 inches). They were utilized for carrying out various studies on

reproductive biology and also on moulting. The rest were preserved in 8-10% formalin and utilized for the systematic, morphometric and fecundity studies.

The live specimens were reared in aquarium tanks and were fed with pelleted feed. The remains of the feed was siphoned out every morning and fresh water was added and thus the water quality parameters were kept under control.

3.1 TAXONOMY

The identity of the species was confirmed by consulting relevant literature (Tiwari, 1958; Jalihal *et al.*, 1988; Jayachandran, 2001; 2005). Structural details of all appendages were studied, drawn to scale and presented.

3.2 REPRODUCTIVE BIOLOGY

The different aspects of reproductive biology was studied.

3.2.1. **Sexual Dimorphism**

Different species of the genus exhibit wide range of sexual dimorphism. Males attain a larger size than females, and second cheliped of male excessively developed than in females. Large sized species of *Macrobrachium* exhibits sexual dimorphism in body size, size of second pereiopod, morphology of second pleopod etc. In *M. canarae,* males and females do not exhibit appreciable difference in second pereiopod. Therefore, during the present study more characters were taken into account, such as, second pleopod, size of the animal and colouration in addition to the characters mentioned above.

3.2.1.1. ***Colouration***

The arrangement of chromatophores differ in male and female. Live specimens were observed for studying colouration. Since there was difference in colour pattern between males and females, this was also made use of for establishing sexual dichromatism.

3.2.1.2. ***Morphometrics***

The morphometric measurements of 60 specimens (30 males, ranging in length from 24 - 40 mm and 30 females, ranging in length from 30 -50 mm) were taken to establish sexual dimorphism. The following measurements were taken with the help of dividers and scale. The lengths were measured to the nearest mm.

1. Total length (TL): Length from the tip of rostrum to the tip of telson.
2. Carapace length (CL): Length from the tip of rostrum to the posterior limit of dorsal carapace.
3. Post-ocular length (PoL): Length from the level of orbit to the posterior limit of dorsal carapace.
4. Rostrum length (RL): Length between the tip of rostrum to the level of the orbit.
5. Length of Telson (LT): Length between the posterior limit of abdomen and tip of telson.

The method of analysis of covariance (Snedecor and Cochran, 1975) was applied to confirm whether any significant difference in the growth rate exist between the sexes with regard to various morphometric characters.

3.2.1.3 ***Female reproductive organs***

The prawns were dissected out and the reproductive organs studied and drawn.

3.2.1.4. ***Male reproductive organs***

The prawns were dissected out and the reproductive organs studied and drawn.

3.2.2. **Breeding Dress**

It is the modification of setae on the pleopods for accommodating fertilised ova for incubation in the pleopods. Females show drastic differences in setation between berried and non-berried individuals. The pleopods I-V of berried females were dissected out and drawn. The differences in number and arrangement of setae on pleopods of berried and non-berried individuals were compared.

3.2.3. **Maturity stages and ovarian development**

Classification of maturity stages were done following the method of Jayachandran (1984).

3.2.3.1.*Size and colour of ovary*

The physical appearance of the ovary, such as colour and size in relation to the carapace cavity of the different maturity stages vary considerably between the maturity stages. A total of 30 females were dissected out and colour and sizes of different maturity stages of the ovary were recorded.

3.2.3.2. *Ova diameter measurements*

Diameter of ova increases as maturity stages advance. The ovaries in different maturity stages were treated in modified Gilson's fluid. This fluid has been used by many investigators for similar studies. The fluid helped to liberate them and break down the ovarian tissue. To clean the eggs, Gilson's fluid was decanted and replaced by water. The periodic shaking had liberated most of the eggs but the remaining were separated manually.

Gilson's fluid: Composition

60 % alcohol --100 ml

80% Nitric acid -- 15 ml

Saturated formalin --20 ml

Water – 880 ml

Glacial acetic acid –18 ml

The ova diameter measurements were taken using a monocular microscope with 5X x 40X magnification, after standardizing the calibration of the ocular micrometer using a stage micrometer. Inside the ovary the ova are seen in varying shapes and therefore uniformly maximum diameter was taken for the present study.

The exoskeleton of the prawn is transparent. The growth of ovary to different maturity stages can be judged through the exoskeleton.

3.2.3.3. ***Ovulation***

The prawns of this genus incubate eggs in the brood chamber, which is in contradistinction to the Penaeid prawns. The ovulation takes place after the premating moult and ova are released to the brood chamber. The ovulation process was studied.

3.2.3.4 ***Incubation***

Live berried females were maintained in aquarium tanks and the incubation period was noted by recording the day from which the eggs are released into the brood chamber to the day when the larvae hatched out.

3.2.4.**Fecundity**

25 berried females in the size range 48- 59 mm were employed for the study. The Total length (TL), Post-ocular length (PoL) (mm), Weight of animal (WA) of preserved specimens was measured. The eggs were carefully removed out of the brood chamber using forceps and needle and weight of brood (WB) was taken in an electronic balance (g). The separation of the eggs from the pleopods as a mass was possible because of the presence of cementing substance on the eggs. The scatter diagram was drawn and the best fitting curves were fitted. The relationship between TL-fecundity, PoL-fecundity, WA-fecundity and WB-fecundity was established. The methodology followed by Jayachandran (1984) was made use of in the present study.

3.2.4.1. ***Egg growth in the brood***

The incubating eggs in the brood show slight increase in the size. The diameters of the eggs were taken along the longest axis by using a monocular microscope (5X x 40X magnification). Two stages were recognised and presented.

3.3. MOULTING

Crustaceans grow by moulting, and is a periodic phenomenon. The process consists of shedding of the old exoskeleton, beneath which a new exoskeleton is generated. The moulting behaviour of 5 prawns in the size range 37-40 mm was observed in aquarium tanks. Aquatic plants and pebbles were

introduced to the aquarium to prevent cannibalism of moulted ones. The dates of successive moults were noted and moulting frequency and growth was thus studied in captivity.

Results

IV. RESULTS

4.1. TAXONOMY

Macrobrachium canarae (Tiwari, 1958)

Phylum	:	Arthropoda von Siebold & Stannius, 1845
Class	:	Crustacea Brunnich, 1772
Subclass	:	Malacostraca Latreille, 1802
Series	:	Eumalacostraca Grobben, 1892
Order	:	Decapoda Latreille, 1802
Suborder	:	Pleocyemata Burkenroad, 1963
Infraorder	:	Caridea Dana, 1852
Superfamily	:	Palaemonoidae Rafinesque, 1815
Family	:	Palaemonidae Rafinesque, 1815
Genus	:	*Macrobrachium* Bate, 1868
Species	:	*Macrobrachium canarae* (Tiwari, 1958)

Synonym : *Palaemon canarae* Tiwari, 1958

Description: Rostrum very long, extending beyond antennal scale by 1/5 of its length, distal end upturned, upper margin with 7-11 teeth, of which 2 teeth post-orbital, proximal 8-9 teeth more closely-set, remaining teeth widely separated. Ventral margin with 4-7 teeth. Small setae present between teeth of both dorsal and ventral margins.

Carapace smooth, antennal and hepatic spines characteristic of the genus present, the latter situated below and behind the level of the former.

Abdomen also smooth; pluerae of somites I-III broadly rounded at postero-ventral margins, that of IV and V are directed backwards and of VI ending in a sharp point.

Telson robust, reaching beyond level of outer lateral spine of the uropodal exopod; dorsal surface with 2 pairs of spines of which anterior pair situated slightly proximal to midlength, posterior pair slightly proximal to midway between anterior pair and tip of telson. 3 plumose setae present between inner pair of movable spines (Fig.9a)

The protopodite of antennule consists of three segments- precoxa, coxa and basis in the ratio 4.5: 2: 2.5; precoxa with a pointed stylocerite, antero-lateral spine sharp; basis carries two feelers, outer bifid and fused for first 8-10 segments. Antenna biramous (Fig. 1a, b)

Mandibles consist of apophysis, molar and incisor processes; the incisor process tridendate; mandibular palp 3 segmented; middle segment smallest. Other two segments of the palp are equal sized and covered with setae, (Fig. 2a).

Maxillulae are leaf like, lying behind the labium. The inner borders of coxa and basis are covered with pointed stiff spines which project inwards as gnathobases; endopodite forms a hook-like curved process bifurcated at the apex, (Fig. 2b).

Maxillae are leaf-like appendages lying behind maxillulae; provided with protopod, endopod and exopod; protopod bisegmented having spines on the outer margin; endopod is small, devoid of setae while the exopod beset with setae (Fig. 2c).

First maxillipeds leaf like with inner borders of coxa and basis forming the endites; endopodite smaller than exopodite, which gives out a plate like process from its base, (Fig. 3a).

Second maxilliped bears a podobranch. The basis carries a long slender and unjointed exopodite covered with setae along its distal half and a five segmented

endopodite- ischium, merus, carpus, propodus and dactylus; inner margins of propodus and dactylus possess setae, (Fig. 3b).

The basis of the third maxilliped supports a long slender and unsegmented exopodite, covered with setae along its distal half and a three jointed endopodite (Fig. 3c).

The walking legs five in number, the first two of which are chelate.

The first chelate legs slender, not reaching the tip of merus of second pereiopod when extended; two segmented protopodite; ischium, merus, carpus, propodus and dactylus. Ischium is shorter than merus and merus shorter than carpus; protopodite and ischium bear setae along the outer margin; carpus longest segment, equal to length of ischium and chela together; palm slightly longer than fingers; tufts of setae present at the tip of fingers, (Fig. 4a).

The second chelate legs strong, equal; ischium shorter than merus; merus and carpus equal sized; palm longer than fingers; outer margin of ischium, merus, carpus and chela bear setae; fingers slender, equal in size, entirely pubescent; one to three denticles present on proximal part of cutting edges of both movable and immovable fingers (Fig. 4b).

Three pairs of non chelate legs almost equal sized; dactyl simple (Fig. 5,6 a,b).

Pleopods simple in structure; endopod of first pleopod reduced (much reduced in female) (Fig. 7a); second pleopod sexually dimorphic, males with appendix masculina and appendix interna in addition to endopodite and exopodite (in female only appendix interna) (Fig. 7b,c); remaining pleopods typical (Fig. 8a,b,c).

Uropods large and lie on either side of the telson; protopod single segmented and triangular, bearing endopodite and exopodite; the exopodite devoid of acessory spine (Fig.9b).

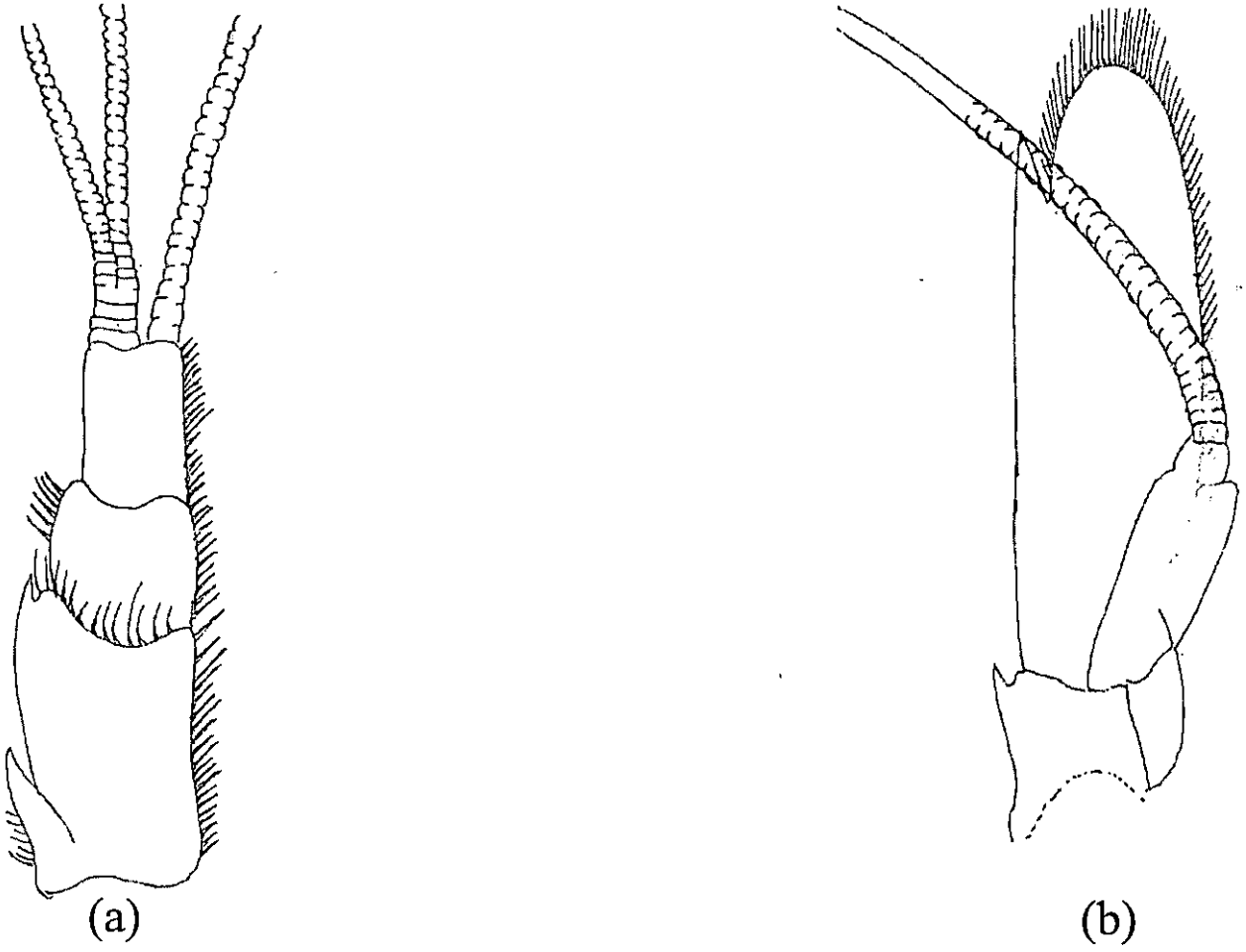


Fig 1. *M. canarae:* Cephalic appendages (a) Antennule (b)Antenna

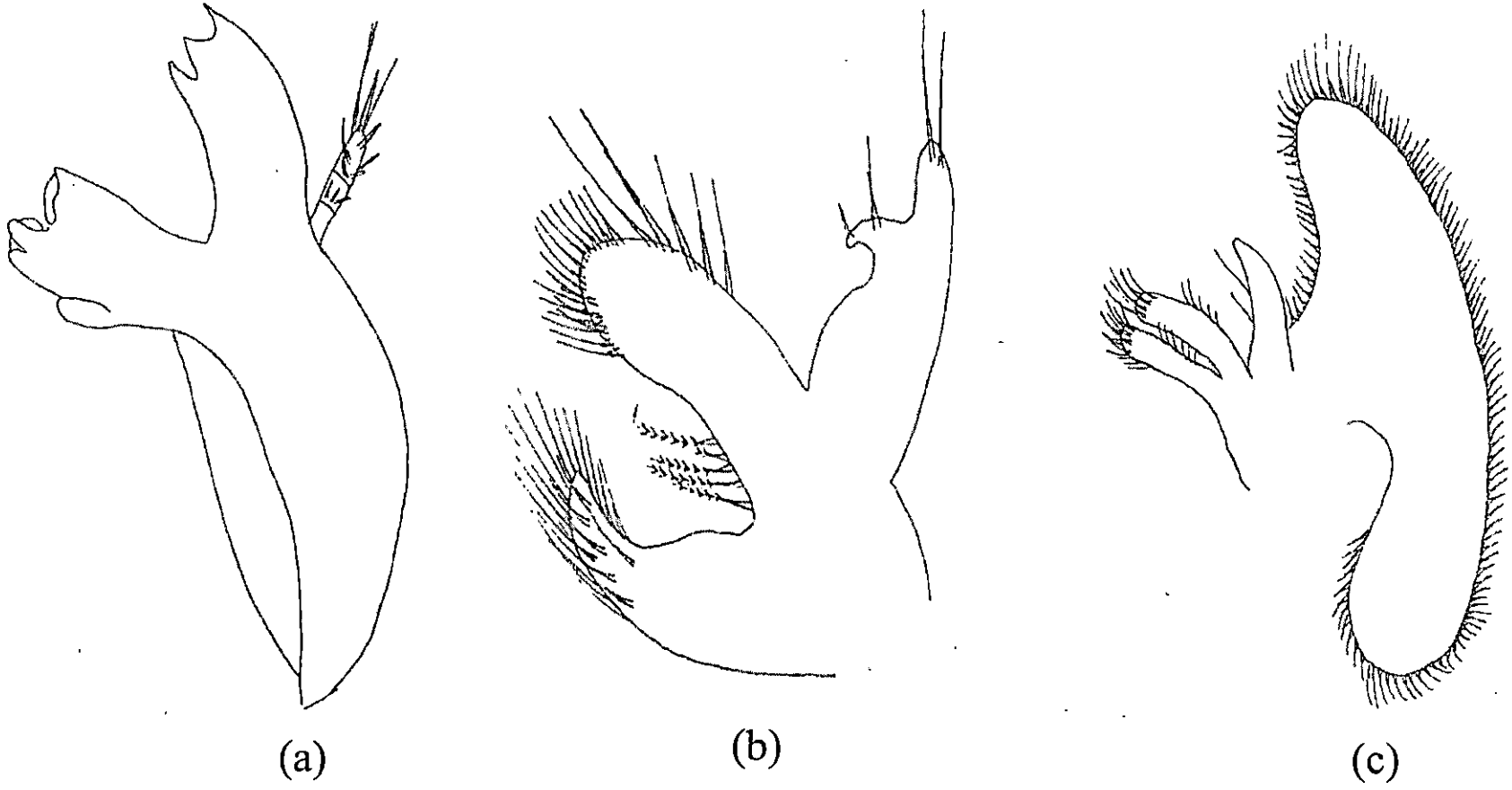


Fig 2. *M. canarae:* Cephalic appendages (a.) Mandible (b) Maxillulae (c) Maxillae

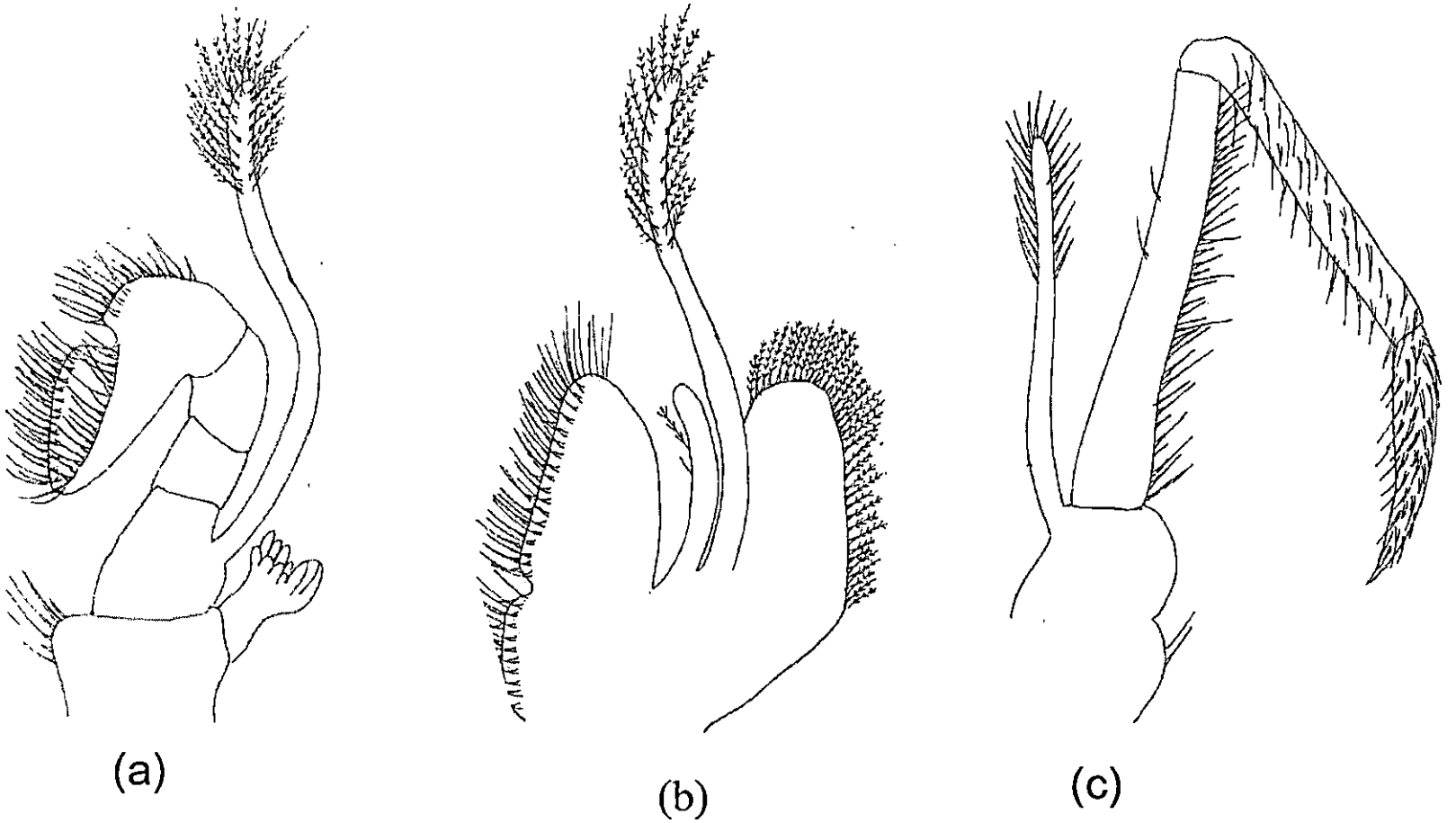


Fig 3. *M. canarae* : Thoracic appendages (a) First maxilliped (b) Second maxilliped (c) Third maxilliped

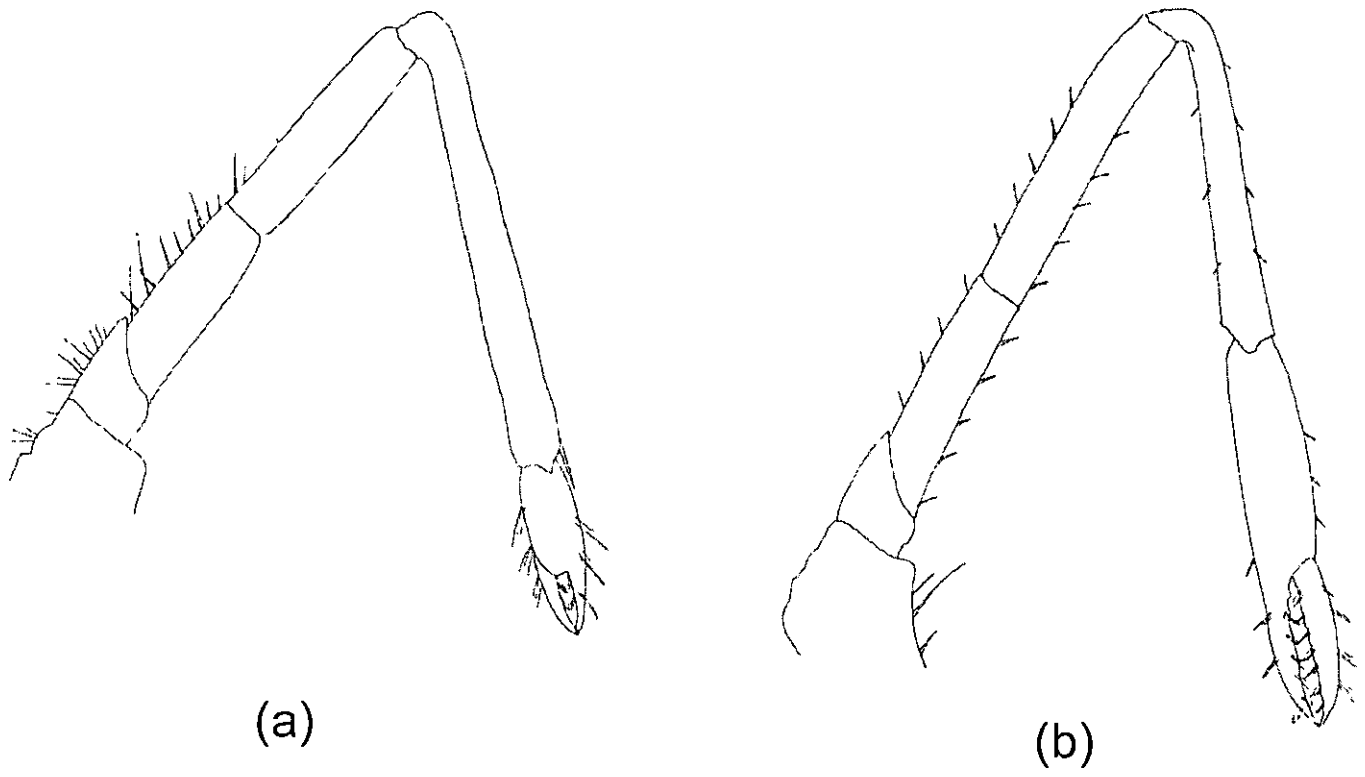


Fig 4. *M. canarae* :Thoracic appendages (a) First chelate leg (b) Second chelate leg

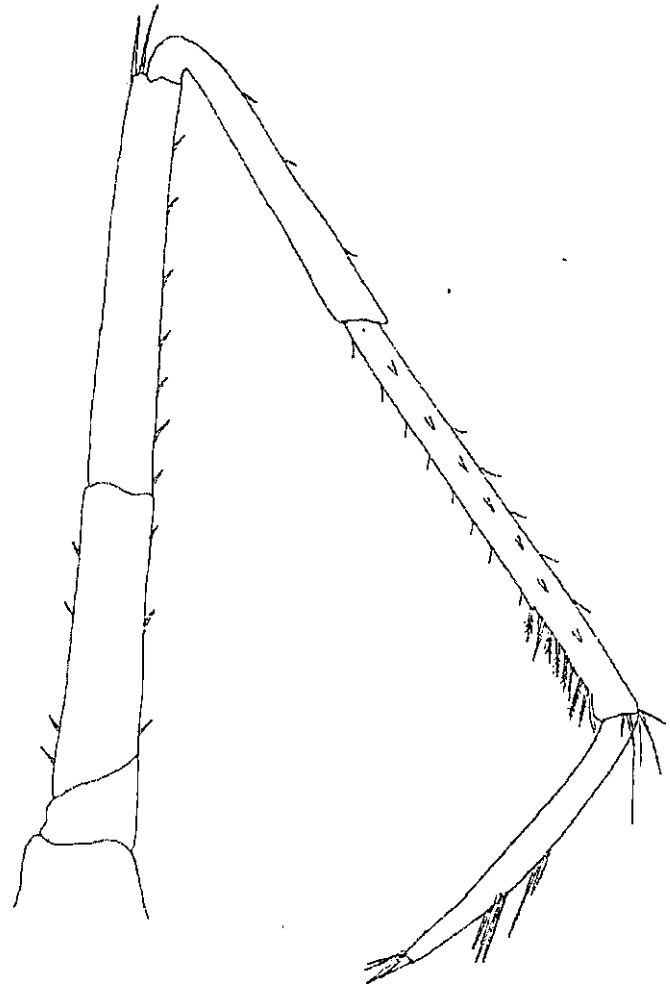


Fig 5. *M. canarae:* Thoracic appendage Third walking leg

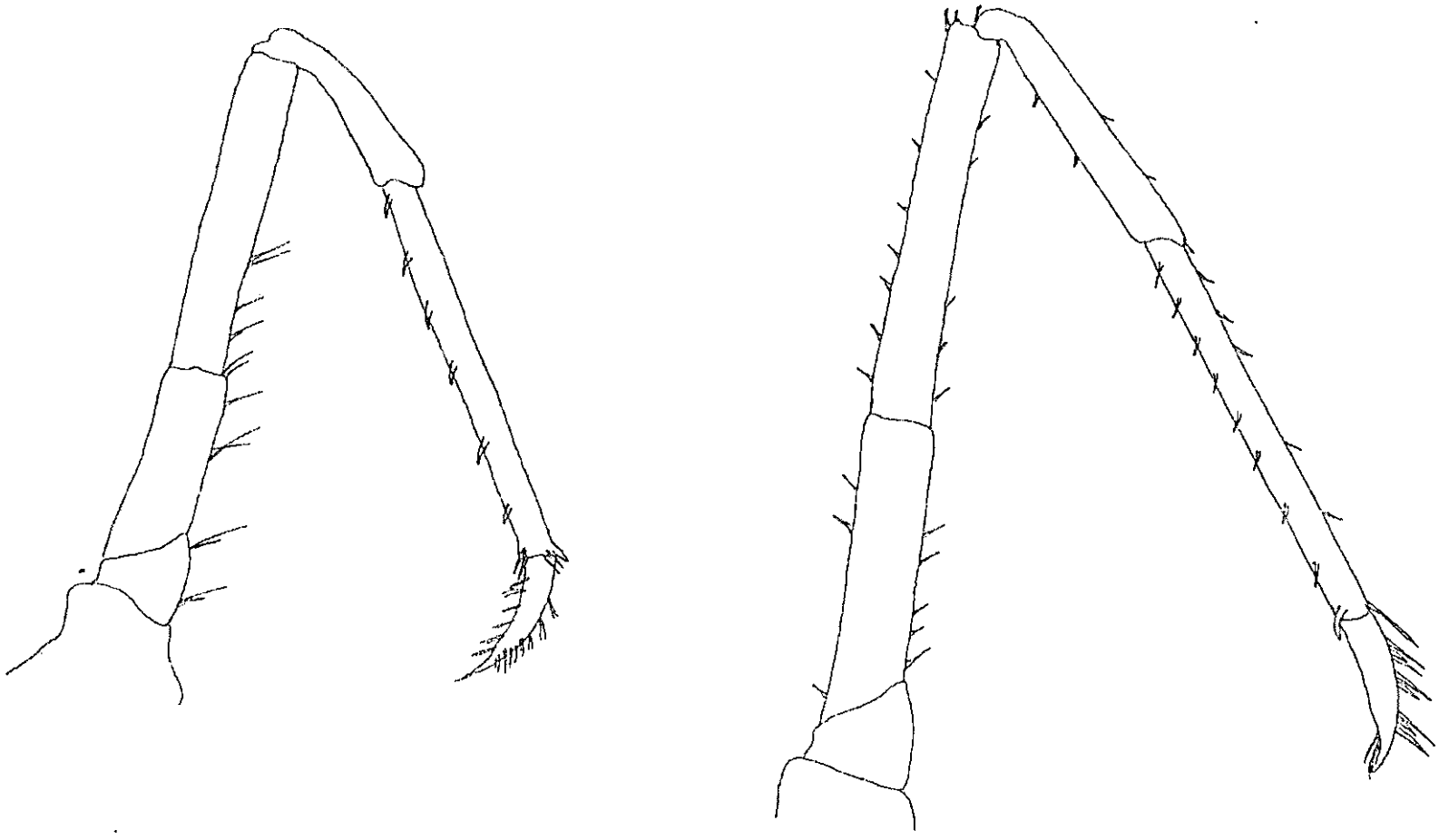


Fig 6. *M. canarae* :Thoracic appendages (a) Fourth walking leg (b)Fifth walking leg

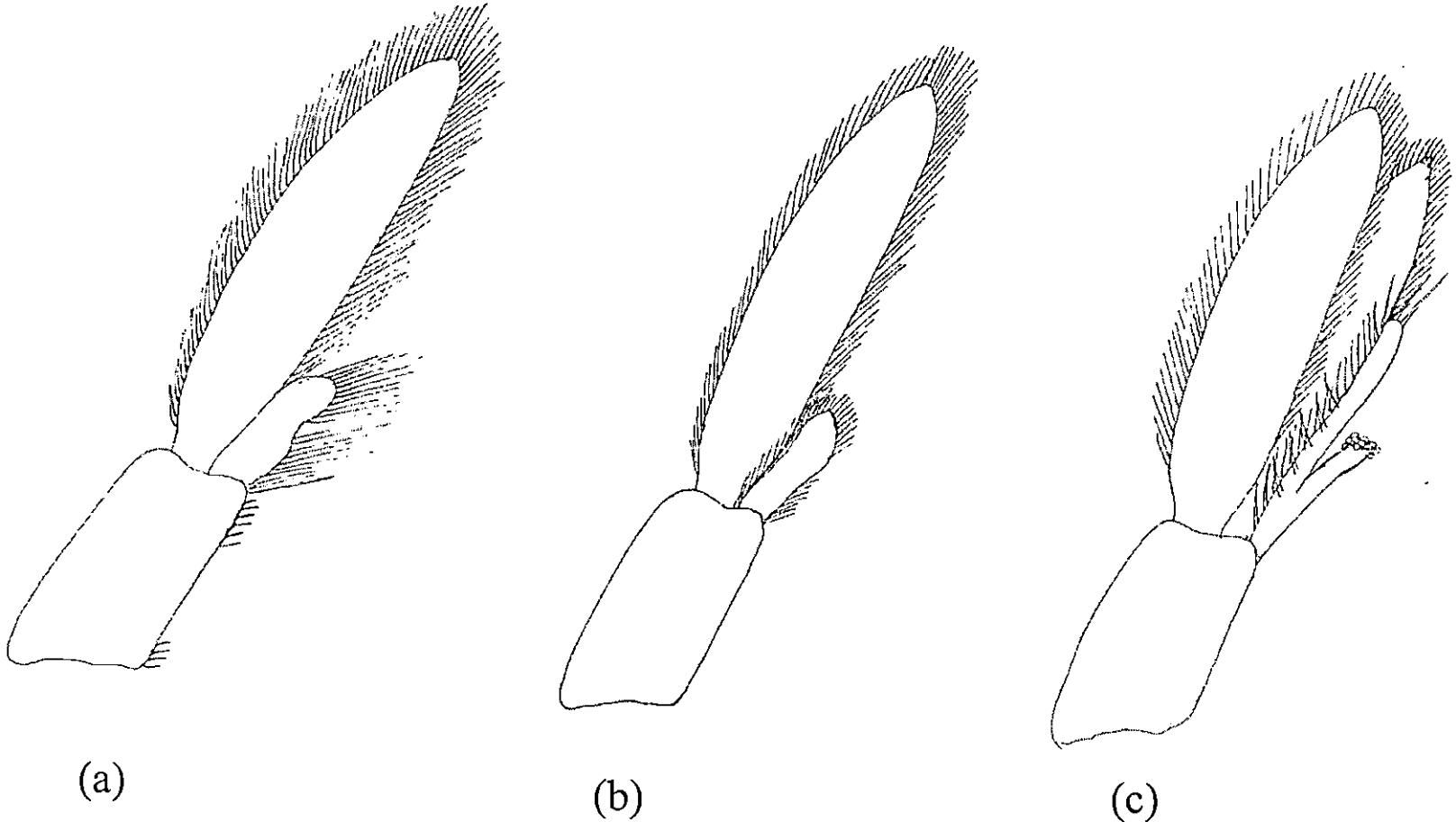


Fig 7. *M. canarae* :Abdominal appendages (a) First pleopod (b) Second pleopod in female (c) Second pleopod in male

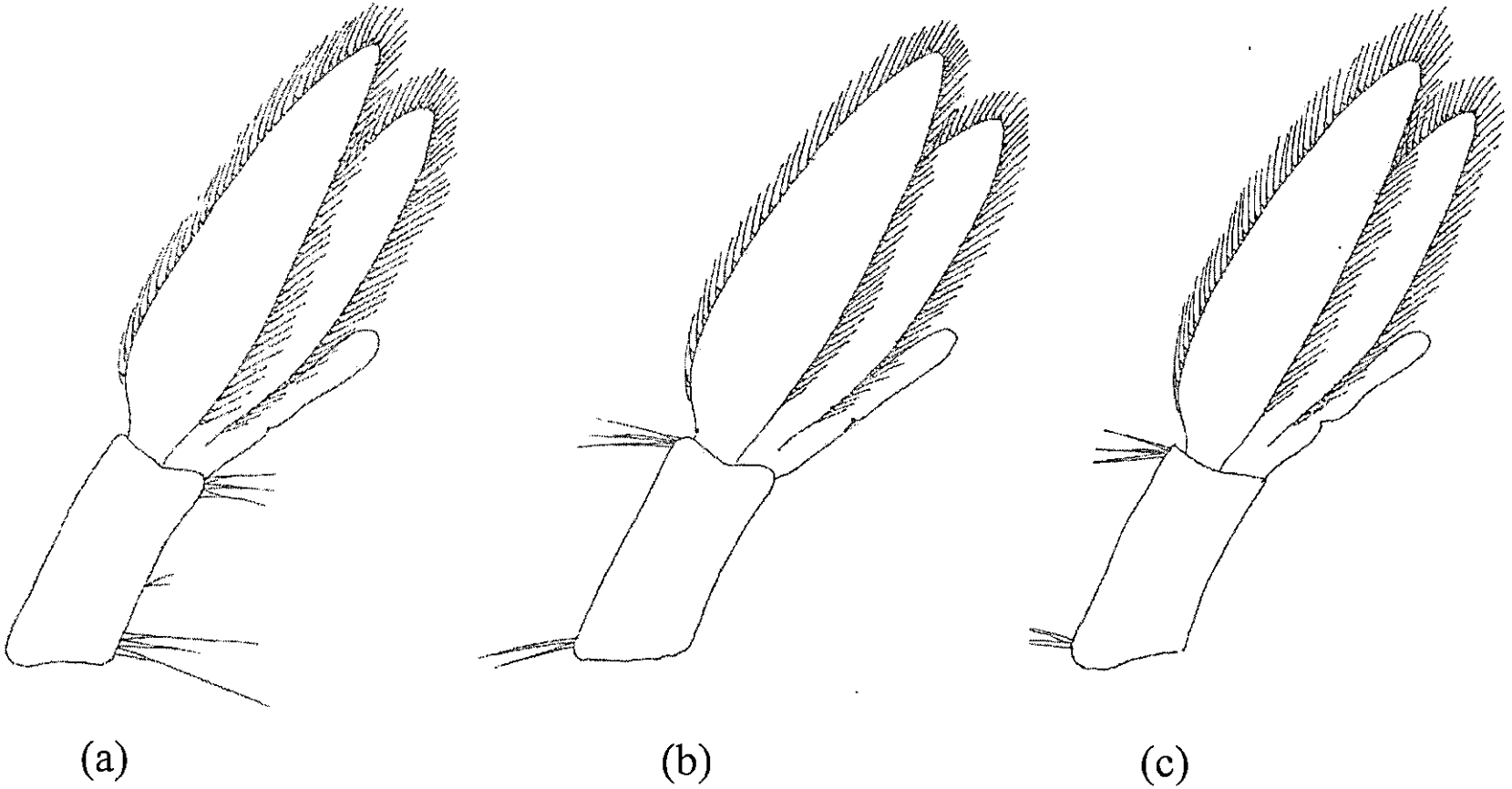


Fig 8. *M. canarae* :Abdominal appendages (a)Third pleopod (b) Fourth pleopod (c) Fifth pleopod

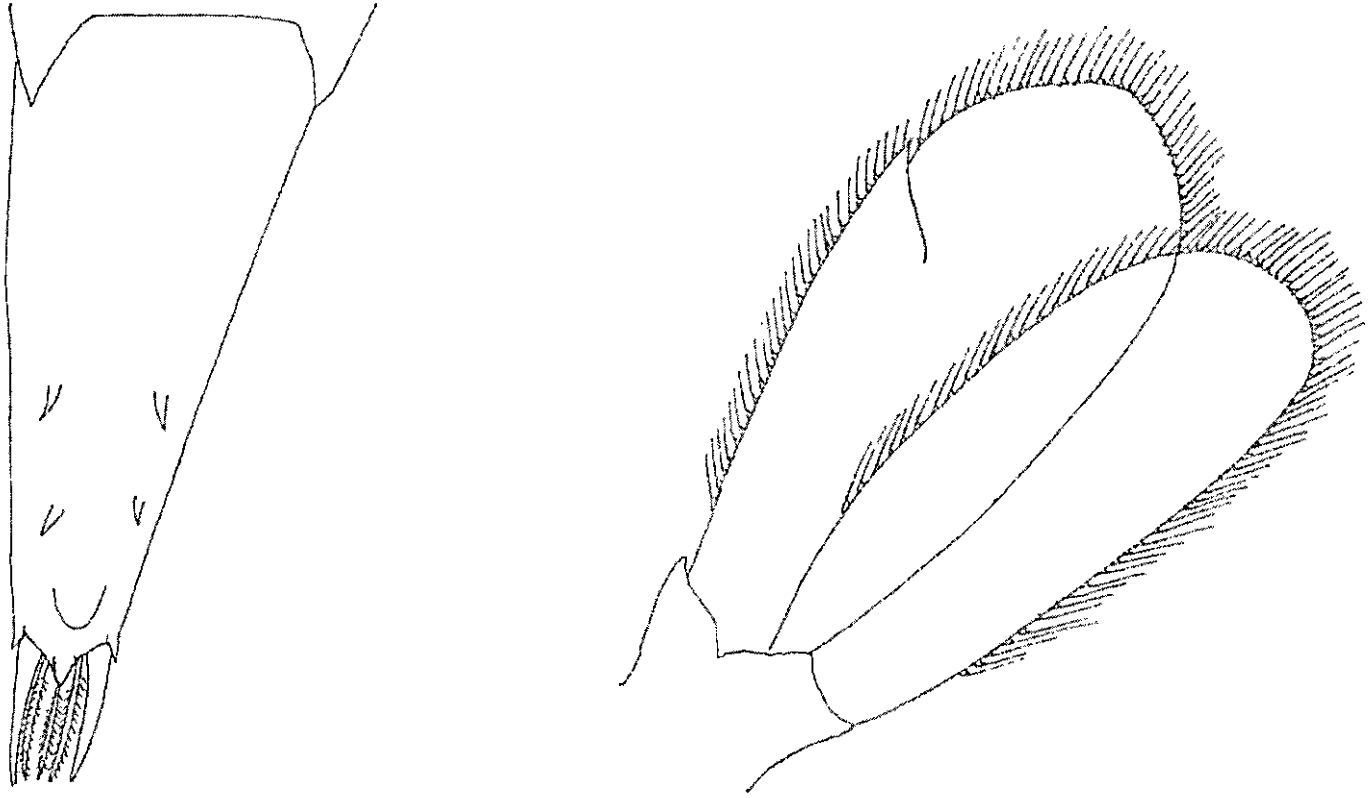


Fig 9. *M. canarae:* (a) telson (b) uropod

4.2. REPRODUCTIVE BIOLOGY

The different aspects of reproductive biology of the species, such as, sexual dimorphism, breeding dress, maturity stages, ovarian development and fecundity are described here.

4.2.1. **Sexual dimorphism**

The genital aperture is situated on the coxa of 5th pereiopod in male and on the coxa of 3rd pereiopod in female. Pleurae of 1-3 abdominal segments of female are elongated and broad. A brood chamber is formed in mature female.

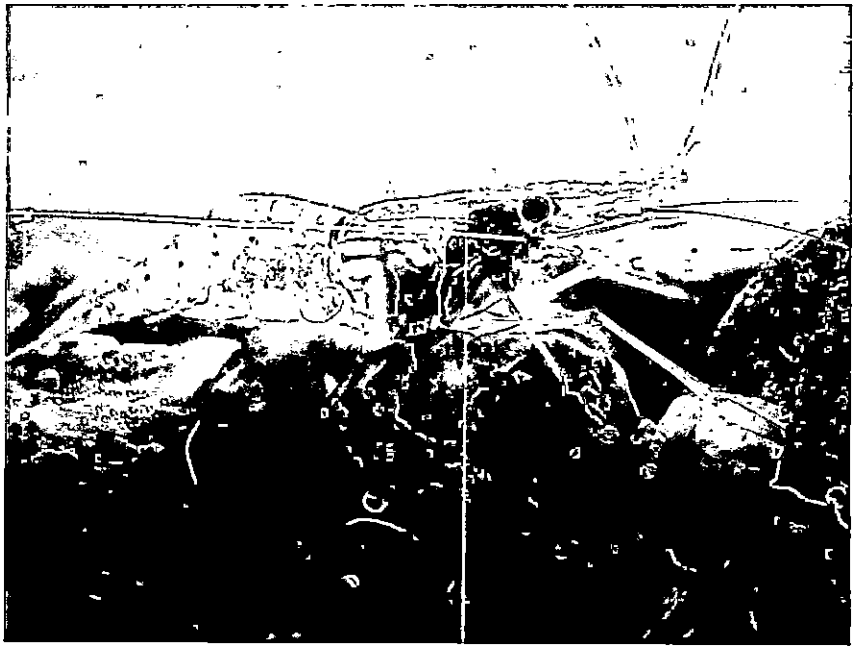
The abdominal appendages are also different in male and female. There is no considerable difference in the structure of exopod of Ist pleopod between the sexes. But the endopod of the Ist pleopod is more broad in female compared to male. The exopod is 3.63 times as long as endopod in both sexes. But they exhibit differences in the arrangement of setae on the basis and on the endopod. The inner margin of basis of the Ist pleopod of female bear long plumose setae which are rudimentary in male. The central region of endopod is devoid of any setae in male in contrast to the female bearing endopod fully covered with setae (Fig. 10a,b). The 2nd pleopod possesses both appendix masculina and appendix interna, in addition to exopod and endopod in male, where appendix interna is present in female. In female the endopod on its inner aspect bears a small truncated structure, truncated at its tip bearing a few rows of hooks, the appendix interna. The hooks of appendix interna of a pair of appendages of one segment get coupled together so that they can function together as a single unit. There is also difference in the arrangement of setae on different parts of the 2nd pleopod. The 2nd

pleopod of male is having short setae on the entire inner margin of basis whereas setae will be present only on the outer margin of basis in female (Fig. 11a,b).

4.2.1.1. ***Colouration***

Even though they do not exhibit appreciable differences in the size, they show differences in the colour of the antennular flagellum as well as the colour of chromatophore patterns on the carapace. Both are coloured black in male and reddish brown in female. The orange red chromatophores at the joints between palm and fingers of the second cheliped is more brilliantly coloured in male compared to female. The thin band of black chromatophore patterns on the dorsal side of the sixth abdominal segment is more prominent in male compared to female (Plate 1a,b).

(a)



(b)

Plate 1. Sexual dichromatism in *M. canarae*, (a) Male (b) Female

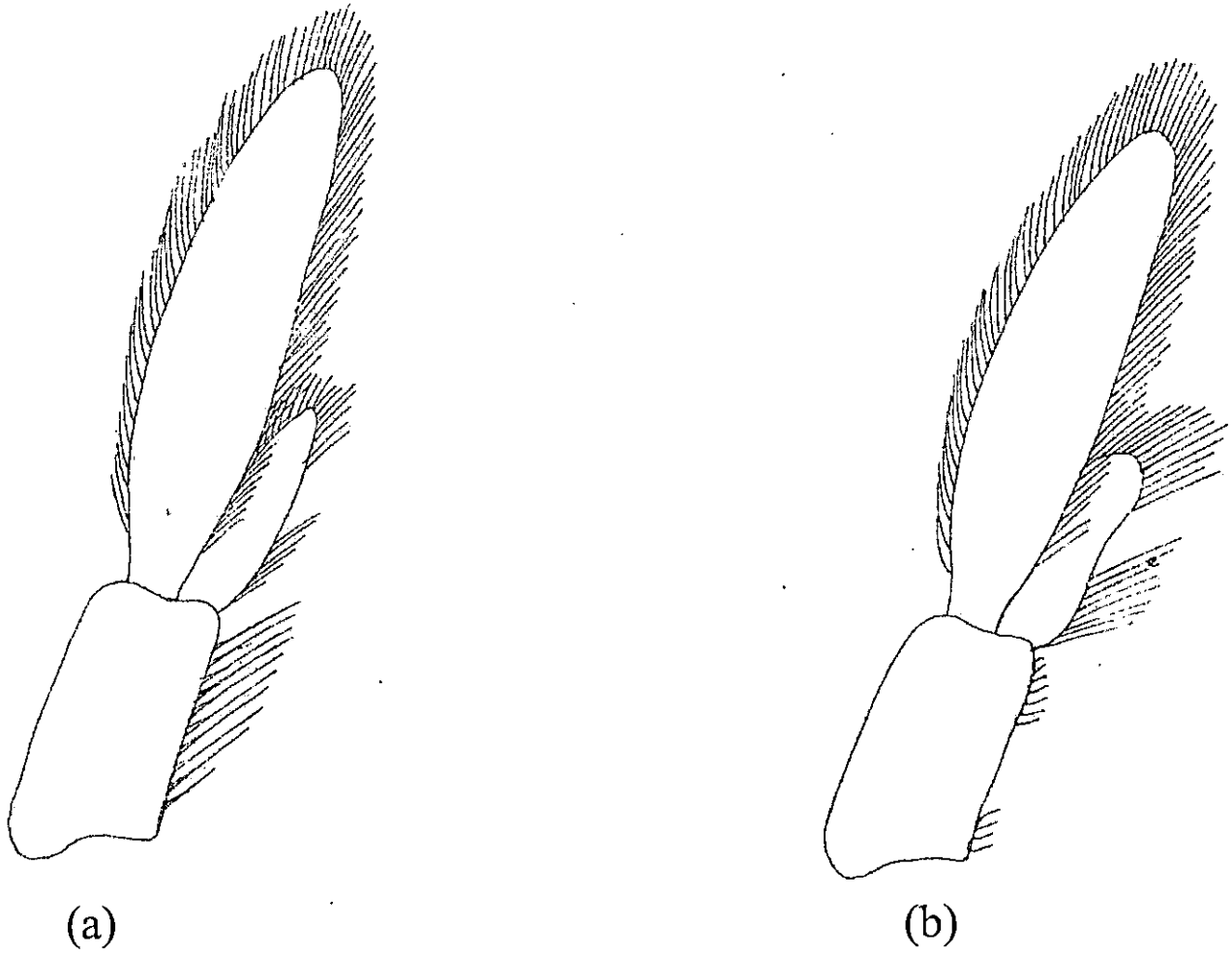


Fig 10. *M. canarae:* Sexual dimorphism in first pleopod (a) Male (b) Female

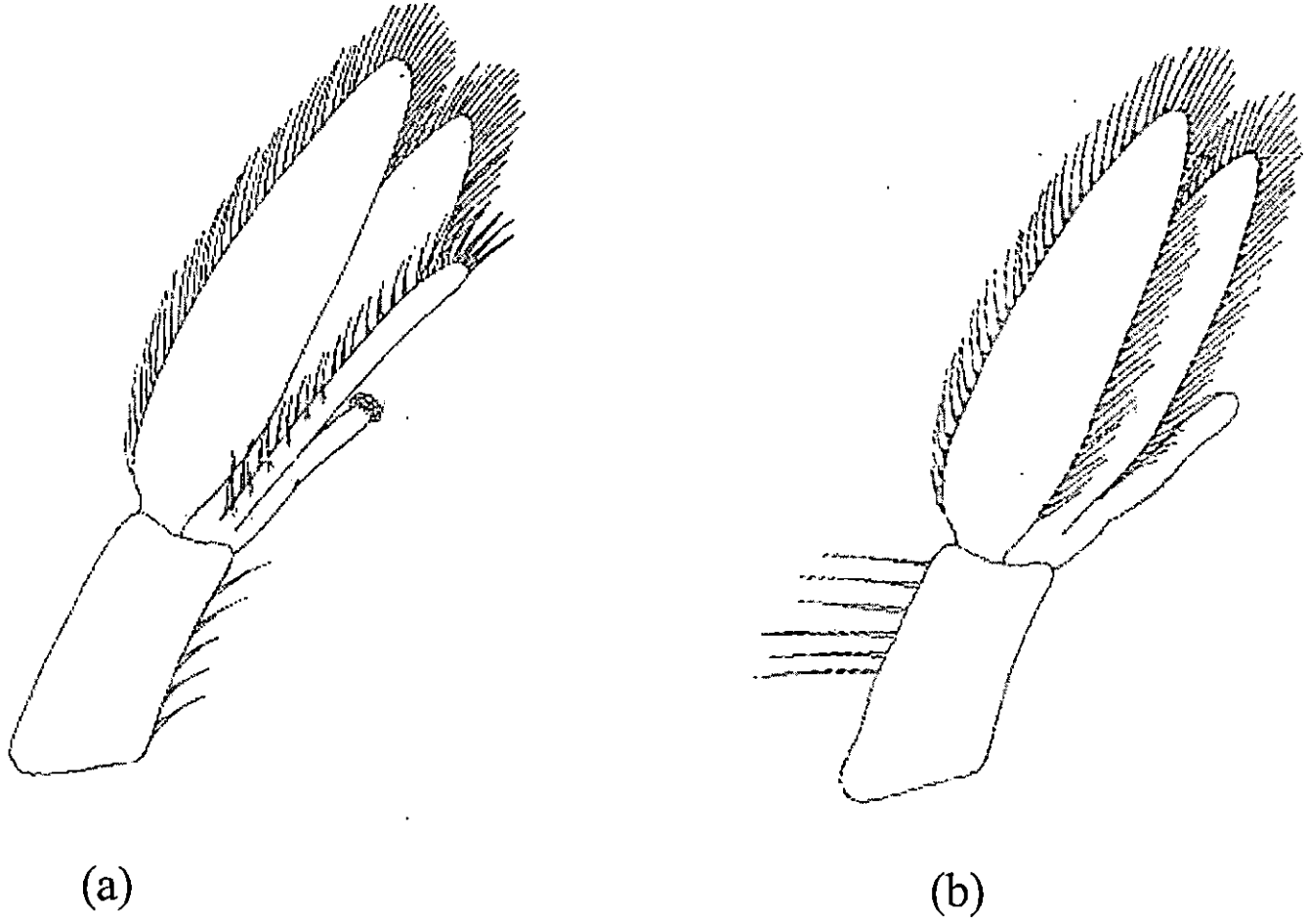


Fig 11. *M. canarae:* Sexual dimorphism in second pleopod (a) Male (b) Female

4.2.1.2. ***Morphometrics***

The morphometric studies of 30 males and 30 females were also carried out to find out whether the species exhibit sexual dimorphism in this regard. The data for males and females were analyzed separately to fit regression lines and thus the growth pattern between and within the sexes was studied. In this study, TL was treated as the independent variable and was compared with CL, PoL, RL and LT (dependent variables). The relationship between the independent variable and the dependent variables were analysed, the scatter diagram was drawn and the regression line fitted for TL - CL, TL - PoL, TL - RL and TL – LT (Fig. 12, 13, 14,15).

The analysis of covariance was carried out and the results showed that there is no significant difference in the regression coefficients and hence was inferred that the regression lines are parallel which was confirmed from the regression lines obtained. From these regression lines it can be inferred that there is no significant difference in the growth rates between the sexes. Since there is no sexually dimorphic growth pattern in the species, the external sexual characters and characters of the reproductive organs were taken into account for distinguishing sex of the species. The structure of male and female reproductive organs are discussed below.

Table1.Regression equations of various morphometric characters related to total length in males and females of *M. canarae*

Sl no	Characters	Male	Female
1	TL-CL	y= 0.4024x+2.6101	y =0.4868x-0.8317
2	TL-PoL	y=0.2733x+0.3677	y=0.3561x-3.3656
3	TL-RL	y=0.1351x+2.1548	y=0.118 x+3.2709
4	TL-LT	y=0.0937x+2.4246	y=0.0459x+4.4

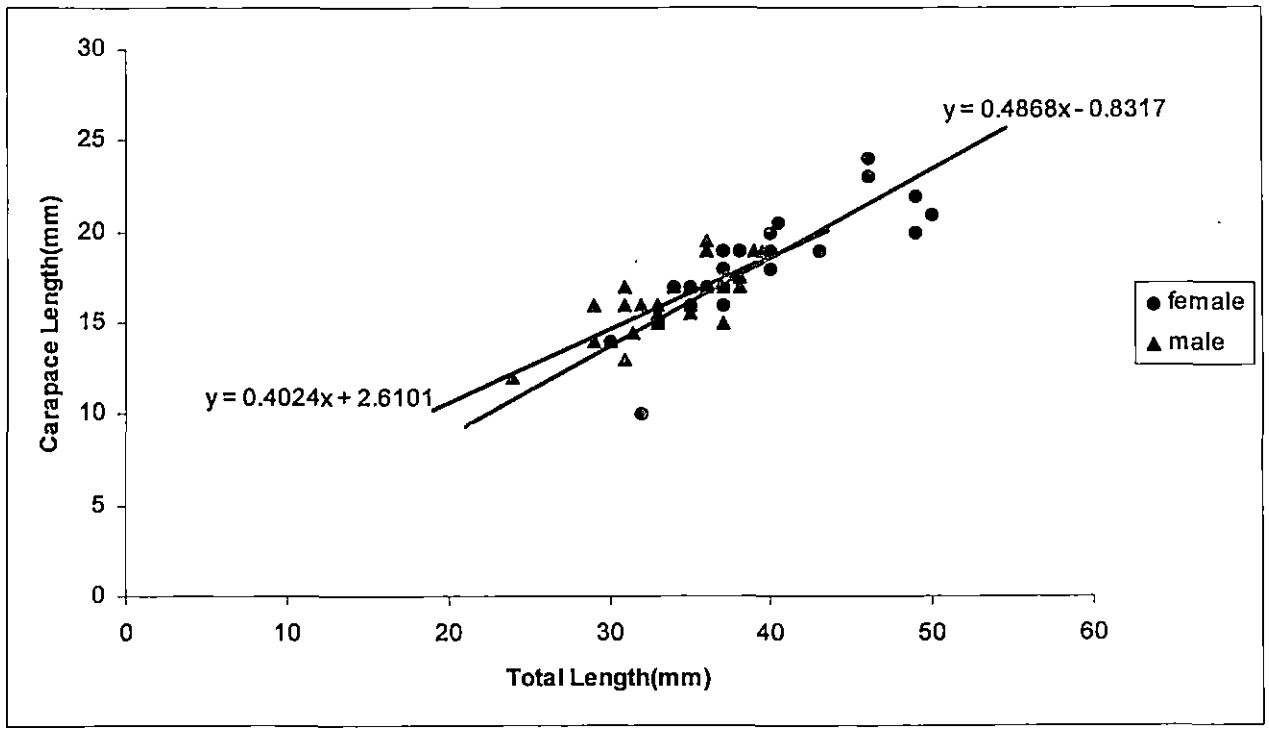


Fig 12. Relationship between Total Length(TL) and Carapace Length (CL) (mm)

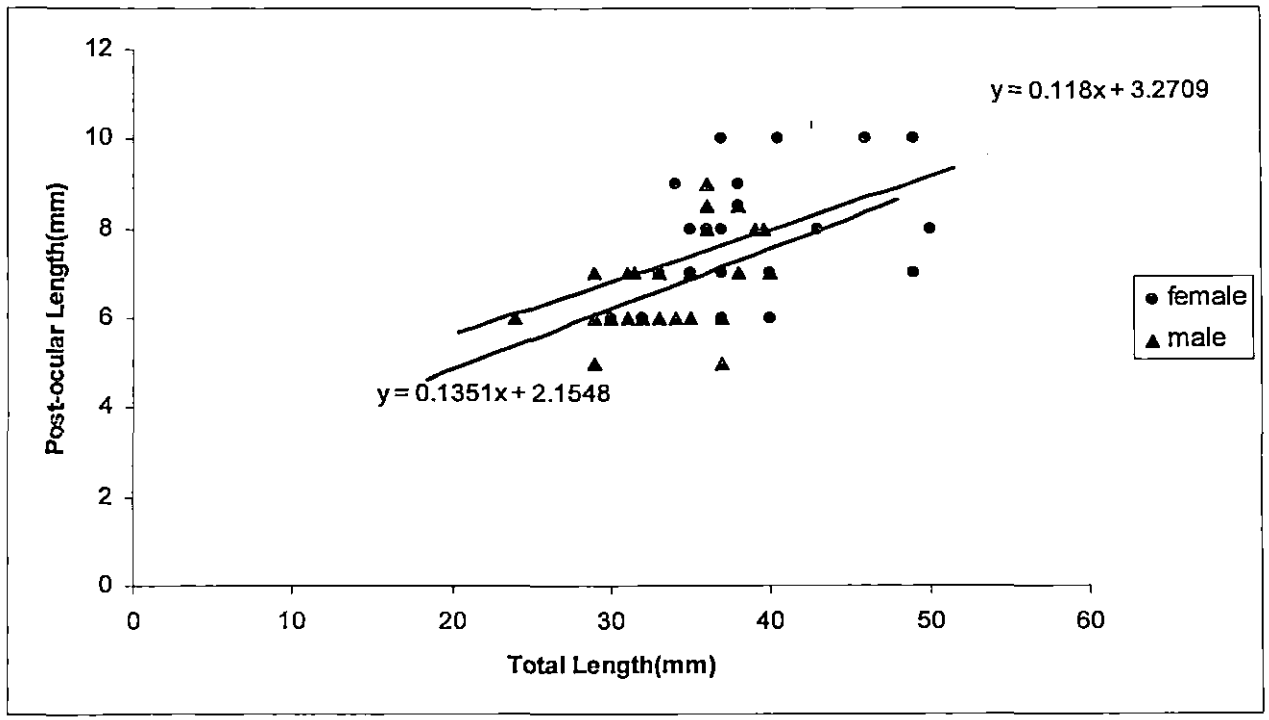


Fig 13. Relationship between Total Length (TL) and Post-ocular Length (PoL) (mm)

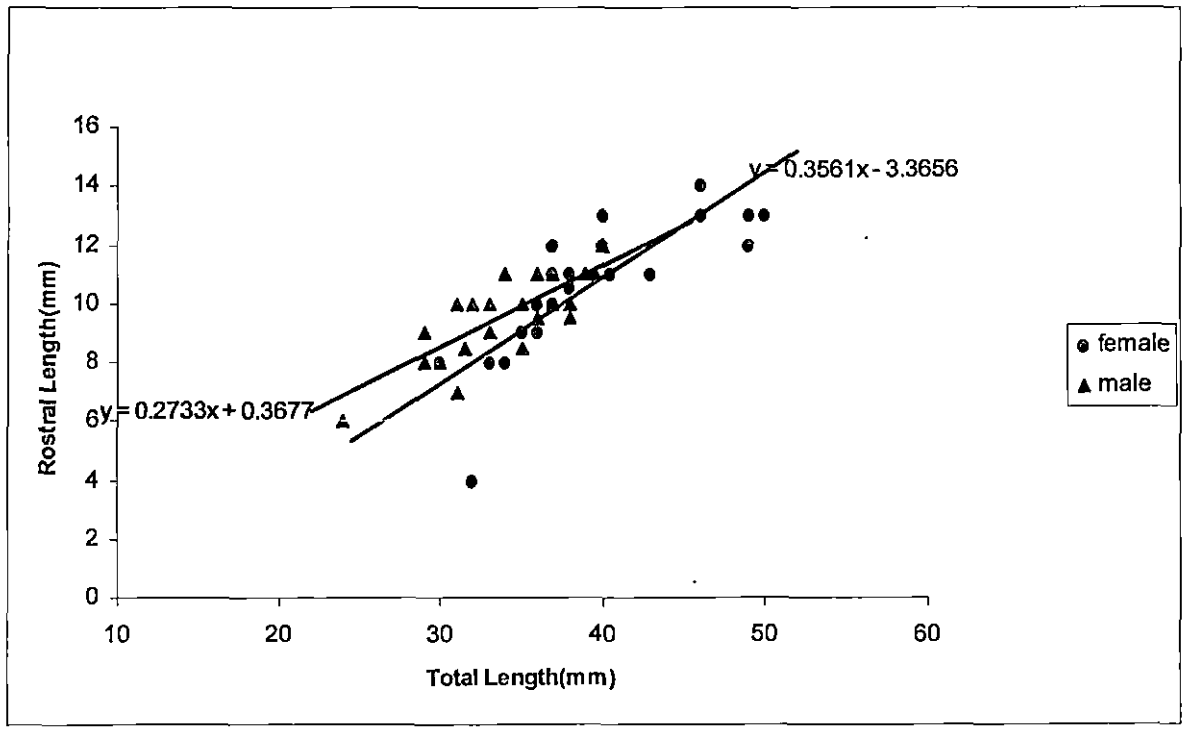


Fig 14. Relationship between Total Length (TL) and Rostral Length (RL) (mm)

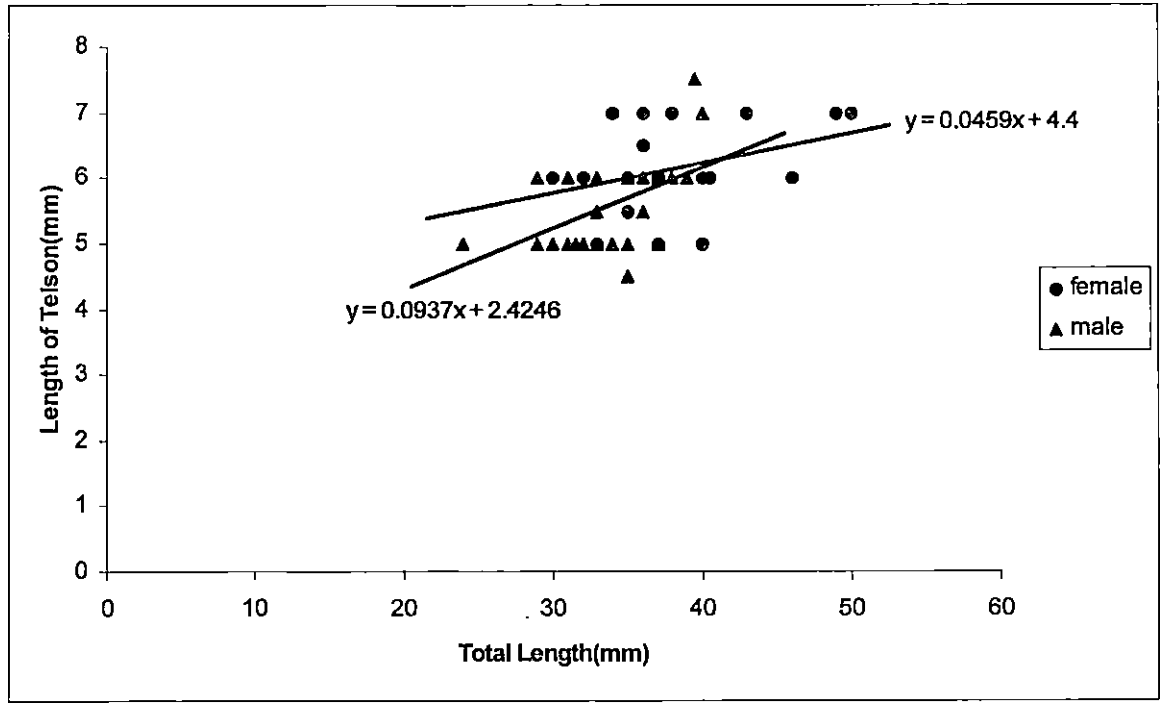


Fig 15. Relationship between Total Length(TL) and Length of Telson (LT) (mm)

4.2.1.3. ***Female reproductive organs***

The reproductive organs in female consist of a pair of ovaries, oviducts, gonopores and spermatophore attachment area (Fig.16). The ovaries are confined to the posterior half of the carapace cavity. They are flattened and triangular. The ovaries lie dorsal to the hepatopancreas and below the heart. When fully developed, ovaries occupy the entire space of the carapace cavity. The oviduct is a thin walled tube which arises from the middle lobe of the ovaries.

4.2.1.4. ***Male reproductive organs***

The reproductive organs in male consist of a pair of testes, vas deferens and terminal ampoules (Fig. 17). The testes lie in the thoracic cavity above hepatopancreas. The testis is transluscent and about 20 mm in length. Each testis consists of a mass of coiled seminiferous tubules. From the posterior part of each testis, a long coiled narrow tube originates, the vas deferens. Anterior part of vas deferens is highly coiled than the remaining part. It swells into a club shaped terminal ampoule and opens into the coxae of 5^{th} pair of walking legs through gonopore.

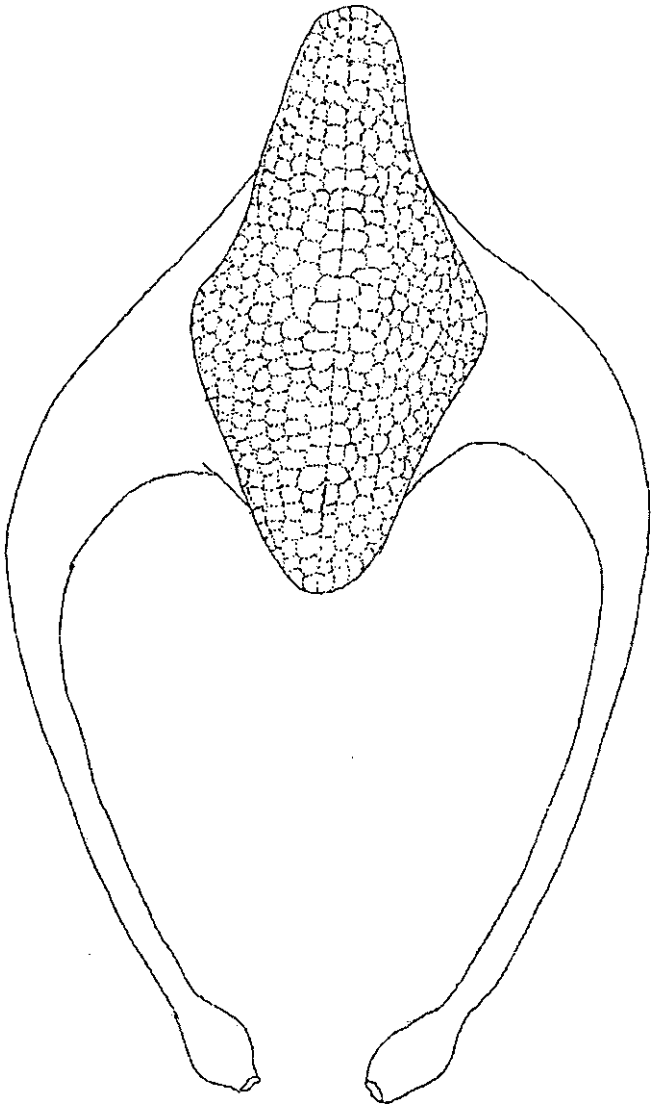


Fig 16 . *M. canarae:* Female reproductive organs

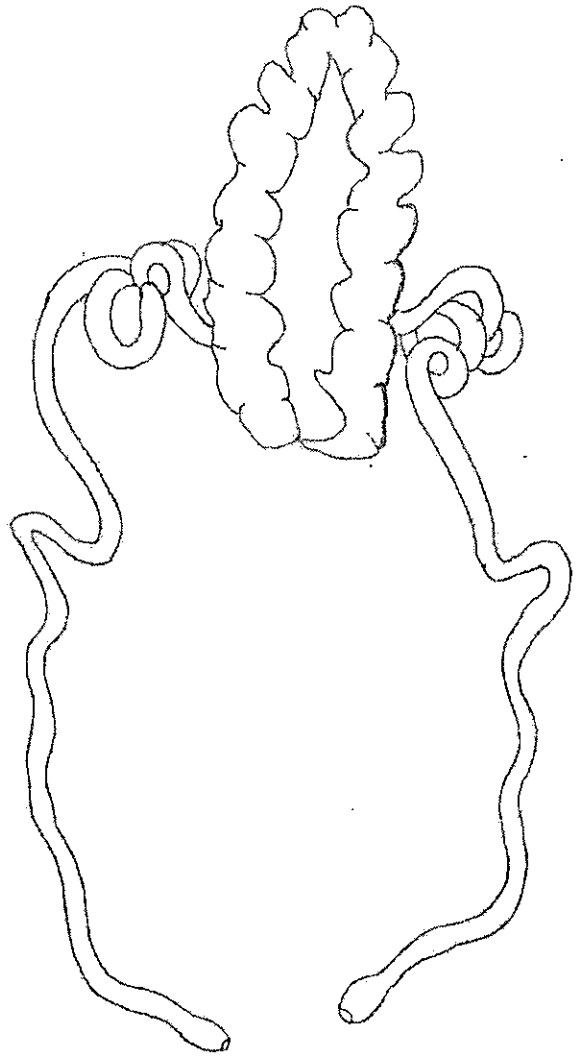


Fig 17. *M. canarae:* Male reproductive organs

4.2.2. **Breeding Dress**

During the breeding season, the pleopods of female develop a large number of specialised setae for holding the fertilised eggs for incubation. These setae are exceptionally long, arranged in peculiar fashion. These long tufts of setae present on the inner and outer sides of basis are responsible for holding the eggs for incubation and they are developed after premating parturial moult.

The abdomen bears five pairs of pleopods which are efficient as natatory organs. The protopodite of a typical pleopod consists of two segments. The proximal segment is the smallest, the distal one elongated and often stout. The two rami, endopod and exopod, are often flattened and unsegmented, and bear a marginal fringe of natatory setae. A comparison of pleopods I-V of berried and non-berried females are given below, (Tables 2-6).

4.2.2.1. ***First pair of pleopods***

In the non-berried female the basis is provided with endopod and exopod of which the endopod is very small in size compared to exopod. Exopod is $2^1/_2$ times longer than endopod. Plumose setae are present on endopod and exopod at the margin, (Fig. 18a).

In the berried females, the basis is concave mesially, having upper and lower ridges. Ovigerous setae are present on these ridges throughout, the setae of the upper ridge carry the eggs while the setae of lower ridge close the brood pouch from below and enclose the egg mass, (Fig. 18b).

4.2.2.2.*Second pair of pleopods*

The protopodite of second pleopod also consists of 2 segments. The basis bears the flattened, unjointed exopod and endopod. The endopod on its inner aspect bears a small structure, the appendix interna, truncated at its tip bearing a few rows of hooks. The hooks of appendix interna of one segment get coupled together so that they can function as a single efficient unit. The basis of non-berried female has stiff pointed setae in group, at the proximal, middle and distal regions, whereas the basis of berried females possess stiff setae in two bunches on the outer and long ovigerous setae on the inner ridges as well as on the appendix interna, (Fig. 19 a, b).

4.2.2.3. *Third pair of pleopods*

Third pair of pleopod is having similar structure. The basis bears the unjointed exopod, endopod and appendix interna. In the non berried females there are tufts of setae on the proximal,middle and posterior regions on the basis. Berried females bear elongated setae on the proximal and distal part of basis and also on the distal part of appendix interna.They also bear numerous setae on the inner ridge of basis, (Fig. 20 a,b).

4.2.2.4.*Fourth pair of pleopods*

In the case of non berried females the basis bears two tufts of long setae on the proximal and distal regions of basis and none on the appendix interna. In the

berried females, setae are present at the proximal,distal and middle regions and also on the inner margins of appendix interna. The number of setae on the inner ridge of basis is less compared to the third pair of pleopods, (Fig. 21 a,b).

4.2.4.5. ***Fifth pair of pleopods***

The structure of fifth pleopod is similar to the fourth pleopod. The non berried female bears two tufts of setae at the proximal and distal regions. In the berried females, there are long setae on the entire margin of basis and a few number of setae on the appendix interna. The number of setae on the inner ridge of basis is only few, 4 in number, (Fig 22 a,b).

Table 2. Comparison of the first pleopod of non-berried and berried females to show the nature of breeding dress

Characters	Non-berried	Berried
Number and nature of setae on the inner margin of basis	Inner margin bears 7 distal and 4 proximal very short setae	Inner margin with 2 rows of setae; anterior border with two sets of 20 and 4 elongated setae and posterior border with a single set of elongated setae arranged linearly
Number and nature of setae on the outer margin of basis	No setae	24 elongated plumose setae are present along the outer margin of basis

Table 3. Comparison of the second pleopod of non-berried and berried females to show the nature of breeding dress

Characters	Non-berried	Berried
Number and nature of setae on the inner margin of basis	No setae	Inner margin with 2 rows of setae; anterior border with three tufts of elongated setae and posterior border with more than 10 elongated setae arranged linearly
Number and nature of setae on the outer margin of basis	6 long setae	41 setae are closely set
Number and nature of setae on the appendix interna	No setae	10 elongated plumose setae distributed along distal part and 6 short non-plumose setae along the proximal part

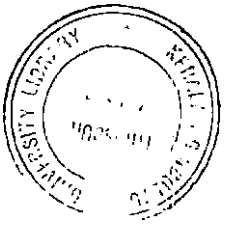


Table 4. Comparison of the third pleopod of non-berried and berried females to show the nature of breeding dress

characters	Non-berried	Berried
Number and nature of setae on the inner margin of basis	Three tufts of setae at proximal, middle and posterior regions	Numerous elongated setae arranged linearly along the anterior and posterior ridges
Number and nature of setae on the outer margin of basis	No setae	Two tufts of elongated setae at the proximal and distal regions
Number and nature of setae on the appendix interna	Devoid of any setae	12 plumose setae arranged along the distal inner margin of appendix interna

Table 5. Comparison of the fourth pleopod of non-berried and berried females to show the nature of breeding dress

characters	Non-berried	Berried
Number and nature of setae on the inner margin of basis	No setae	Numerous elongated setae along the anterior ridge and sparse setae along the posterior ridge.
Number and nature of setae on the outer margin of basis	Two tufts of 2 and 3 elongated setae at the proximal and distal regions	Three tufts of elongated setae at the proximal, middle and posterior regions
Number and nature of setae on the appendix interna	No setae	10 long plumose setae are distributed along the distal margin

Table 6. Comparison of the fifth pleopod of non-berried and berried females to show the nature of breeding dress

characters	Non-berried	Berried
Number and nature of setae on the inner margin of basis	No setae	Anterior margin with 12 long linearly arranged setae and a few short setae on the posterior margin
Number and nature of setae on the outer margin of basis	Two tufts of setae at the proximal and distal regions	Numerous setae along the outer margin
Number and nature of setae on the appendix interna	No setae	A few setae are present on the distal inner margin

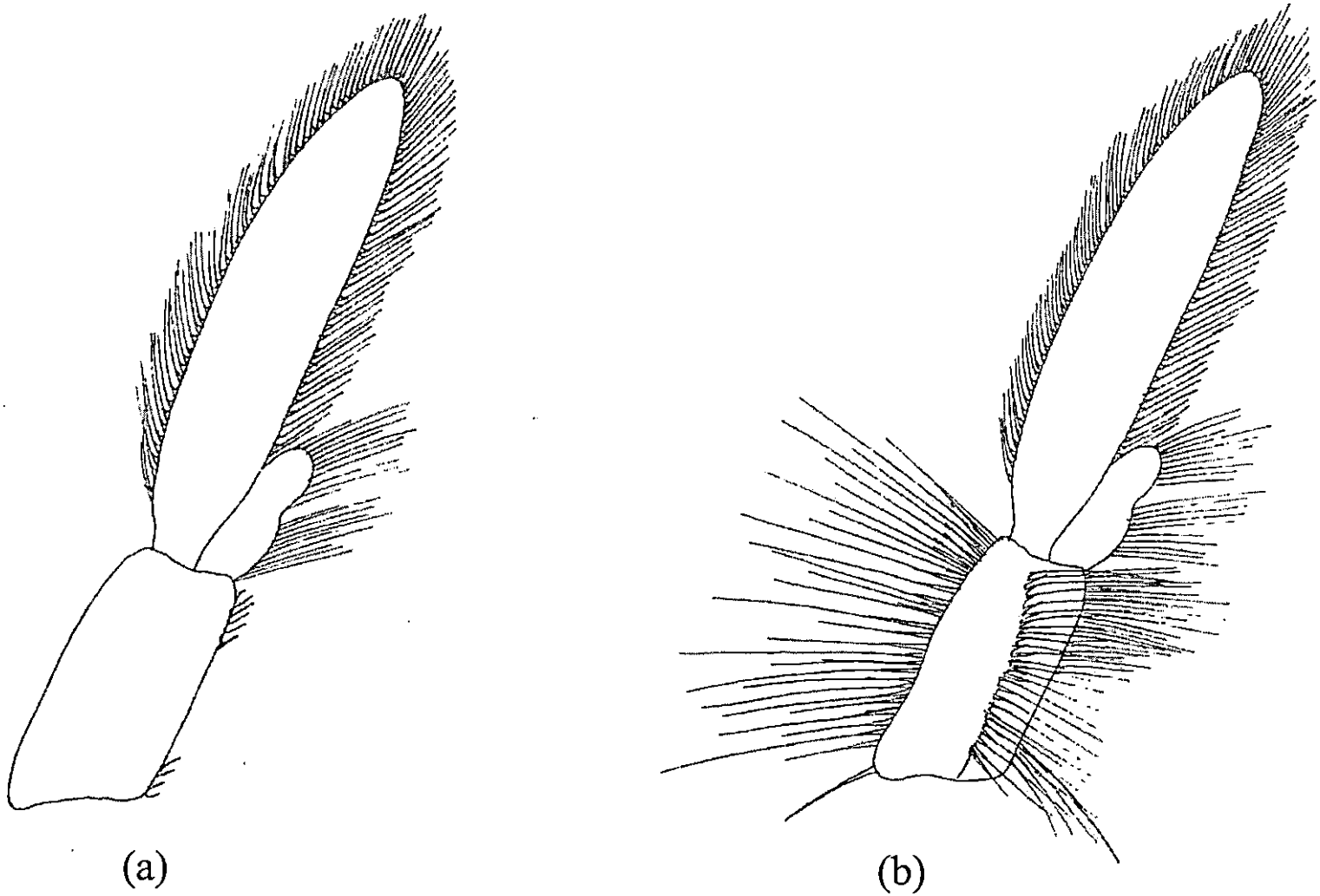


Fig 18 *M. canarae:* Comparison of first pleopods of non-berried (a) and berried (b) females to show the nature of breeding dress

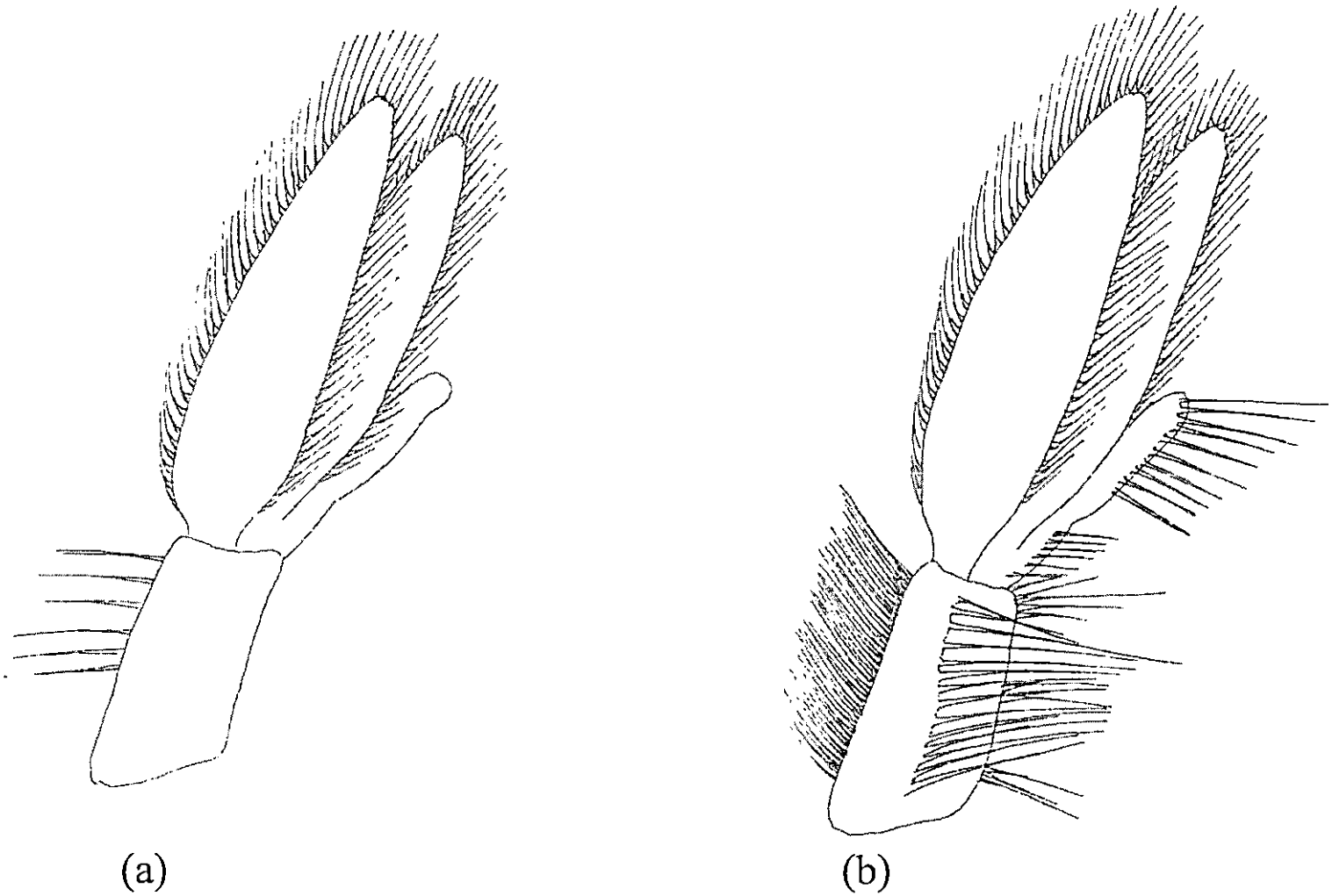


Fig 19 *M. canarae:* Comparison of second pleopods of non-berried (a) and berried (b) females to show the nature of breeding dress

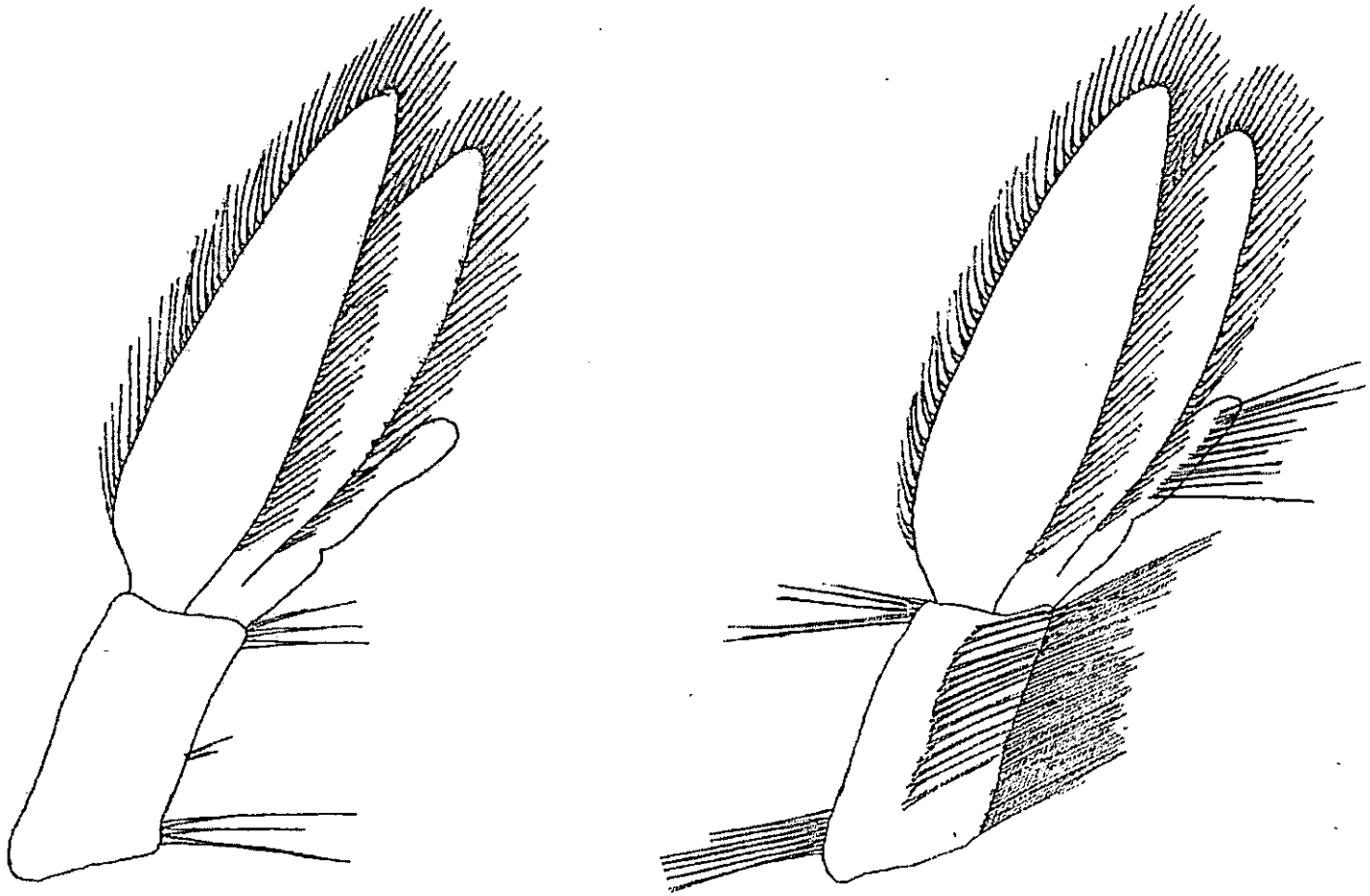
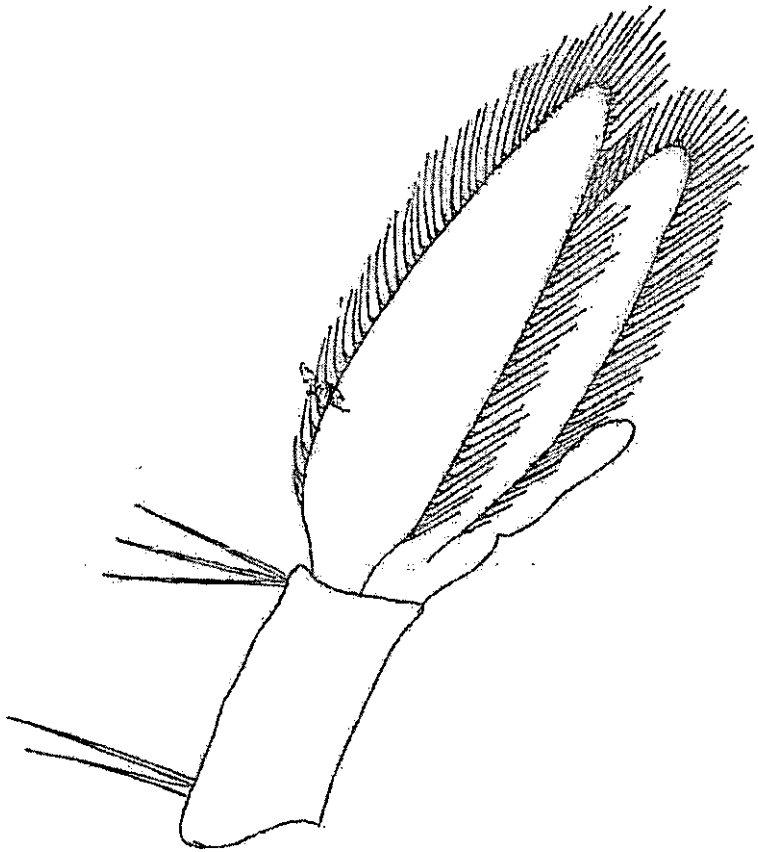
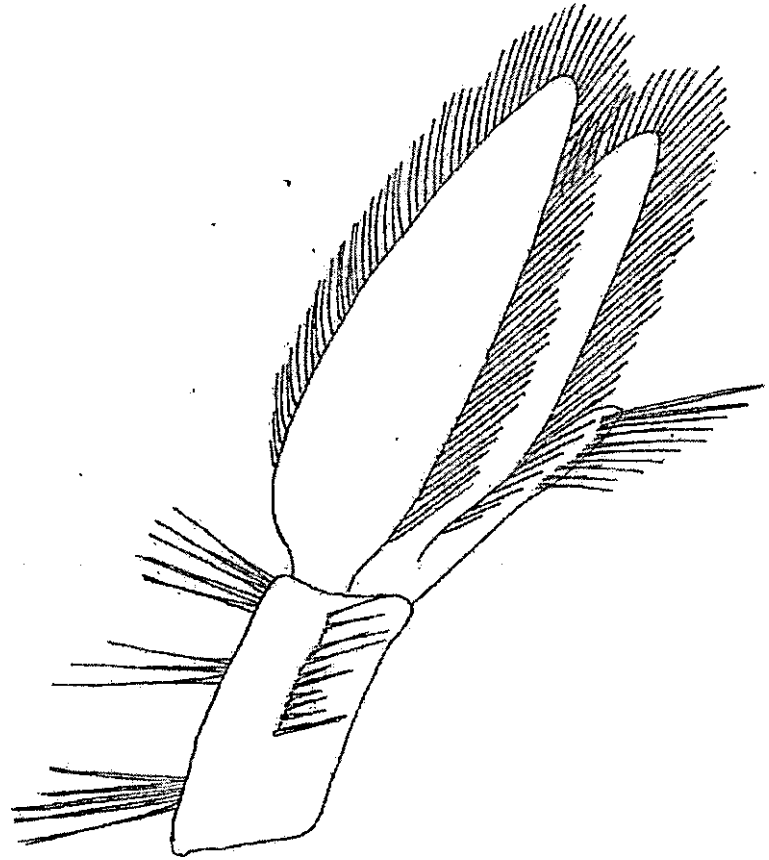


Fig 20 *M. canarae:* Comparison of third pleopods of non-berried (a) and berried (b) females to show the nature of breeding dress



(a)



(b)

Fig 21 *M. canarae:* Comparison of fourth pleopods of non-berried (a) and berried (b) females to show the nature of breeding dress

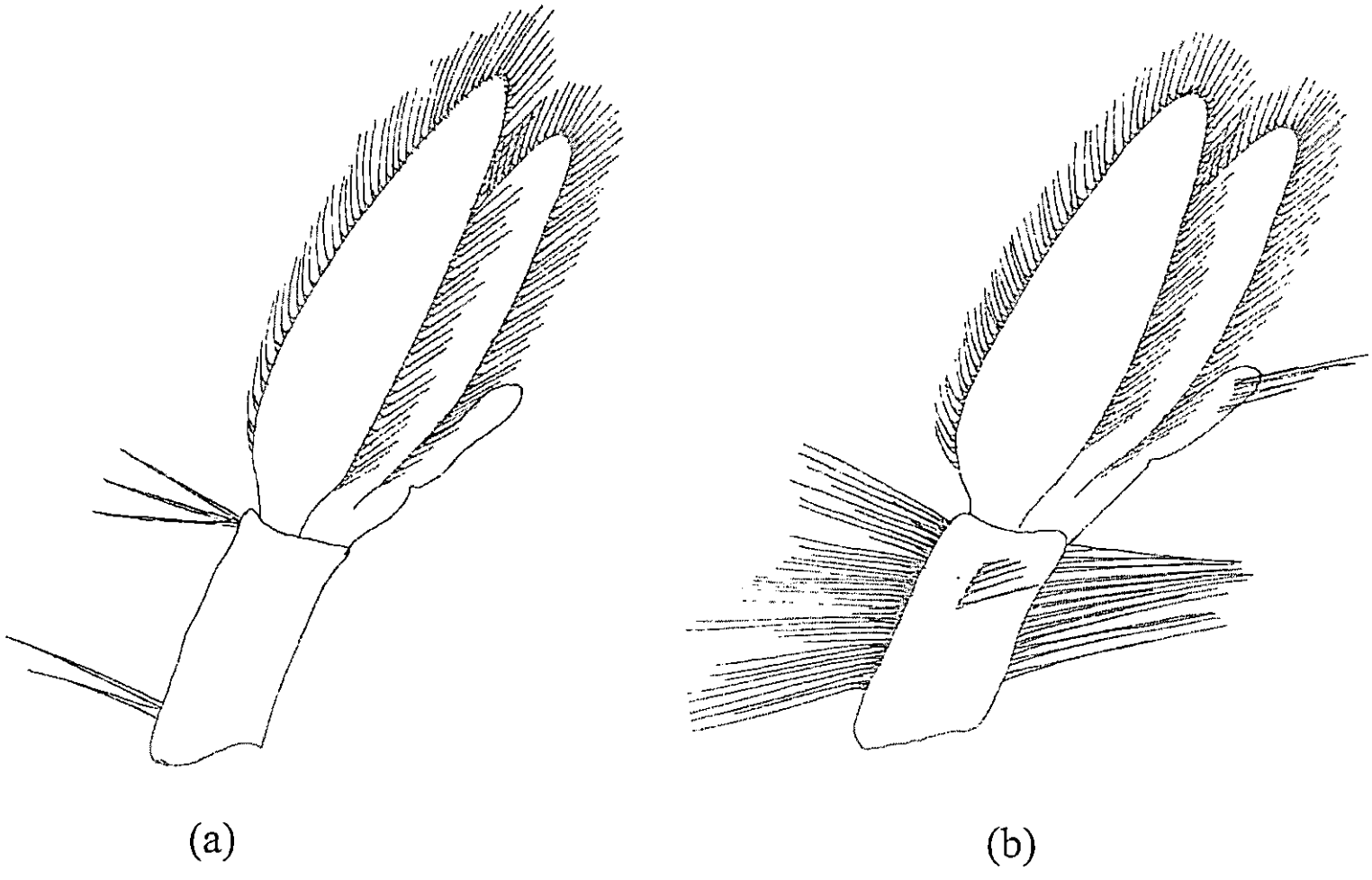


Fig 22 *M. canarae:* Comparison of fifth pleopods of non-berried (a) and berried (b) females to show the nature of breeding dress

4.2.3. MATURITY STAGES AND OVARIAN DEVELOPMENT

The maturity stages were distinguished by taking into account the ova diameter measurements, colour of the fresh and preserved ovary and size of the ovary i.e., the space it occupies in relation to carapace cavity. The maturity stages are distinguished and quantified into seven stages based on the morphology of ovary (Plate 2).

4.2.3.1. **Size and colour of ovary**

Stage I

The ovary occupies the posterior region of the carapace cavity. The ovary appears transluscent in colour characterized by complete absence of chromatophores. The percentage frequency of ova diameter in maturity stage I is given in Fig. 23a

Stage II

The ovaries occupy 2/6 th the carapace cavity. The ovary is light green in live specimen and yellowish in colour in preserved specimens with a band of black chromatophores along the margins. The ova are not visible to the naked eye and have just started yolk formation. This stage is seen in both immature and spent recovering individuals. The percentage frequency of ova diameter in maturity stage II is given in Fig. 23b

Stage III

Ovary occupies ¼ th the carapace cavity. The ovary appears green when fresh and light yellow when preserved. The anterior lobe of the ovary start developing. The black chromatophores have diffused and are found along margins and are distributed all over

the ovary. The size of the ova ranges from 80.35 μ-562.4 μ. The percentage frequency of ova diameter in maturity stage III is given in Fig. 24a

Stage IV

Ovary occupies ½ th carapace cavity. The proximal part of ovary bulges out laterally. There is an even distribution of black chromatophores all over the ovary and there appears a decrease in the number of chromatophores. The ova have accumulated yolk and appear opaque. The ovary appears green when fresh and light orange when preserved. The size of ova ranges from 158.3 μ-1266.4 μ. The percentage frequency of ova diameter in maturity stage IV is given in Fig. 24b

Stage V

The ovary occupies ¾th the carapace cavity. The ova are opaque due to heavy deposition of yolk. The anterior lobe of the ovary has developed. The size of ova ranges from 316.6 μ-1583 μ. The percentage frequency of ova diameter in maturity stage V is given in Fig. 25a

Stage VI

Ovary completely fills the carapace cavity. The narrow anterior lobe and posterior lobe together with the broad middle lobe gives lanceolate shape to the ovary. The ovary is dark green in live condition and dark orange in preserved specimens. The ova are opaque. The size of ova ranges from 316.6 μ-1899.6 μ. The percentage frequency of ova diameter in maturity stage VI is given in Fig. 25b

Stage VII

The ovary is transluscent and shrunken. The ovary contains unovulated eggs and occupies the posterior end of the carapace cavity. The percentage frequency of ova diameter in maturity stage VII is given in Fig. 26

Plate 2. Different maturity stages of ovary in *M.canarae*

4.2.3.2. **Ova diameter measurements**

Details of the ova diameter measurements are given in Table 7. It can be seen that the diameter of the ova progresses from stage I to stage VII. From the ova diameter measurements, it can be inferred that there are 2 stocks of fully mature ova in the ovary. This indicates that they may ovulate more than once during the breeding season.

Table 7. Percentage frequency of different size groups of ova of different maturity stages (stages I-VII)

Ova diameter(μ)	Percentage frequency						
Maturity stages	Stage I	Stage II	Stage III	Stage IV	Stage V	Stage VI	Stage VII
0-100	100	100	19	–	–	–	28
100-200	–	–	38	2	3	–	71
200-300	–	–	20	–	3	–	–
300-400	–	–	15	3	4	2	–
400-500	–	–	2	4	3	2	–
500-600	–	–	1	2	–	–	–
600-700	–	–	–	25	11	13	–
700-800	–	–	–	13	10	6	–
800-900	–	–	–	11	2	1	–
900-1000	–	–	–	21	21	27	–
1000-1100	–	–	–	9	8	–	–
1100-1200	–	–	–	7	13	17	–
1200-1300	–	–	–	3	10	22	–
1300-1400	–	–	–	–	2	–	–
1400-1500	–	–	–	–	5	4	–
1500-1600	–	–	–	–	4	2	–
1600-1700	–	–	–	–	–	–	–
1700-1800	–	–	–	–	–	–	–
1800-1900	–	–	–	–	–	–	1

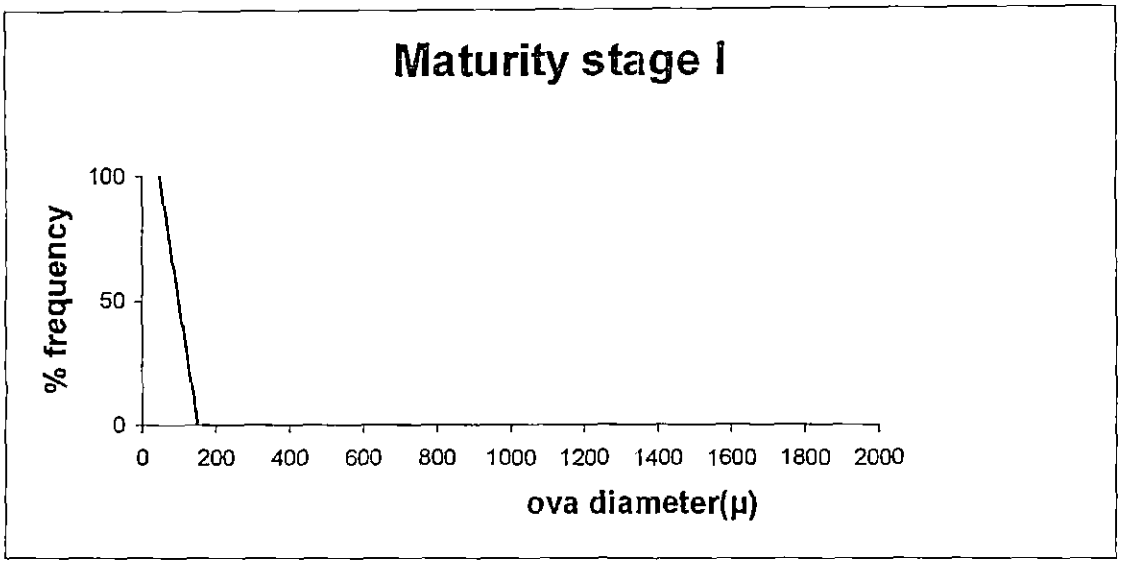


Fig. 23a Percentage frequency of ova diameter in maturity stage I

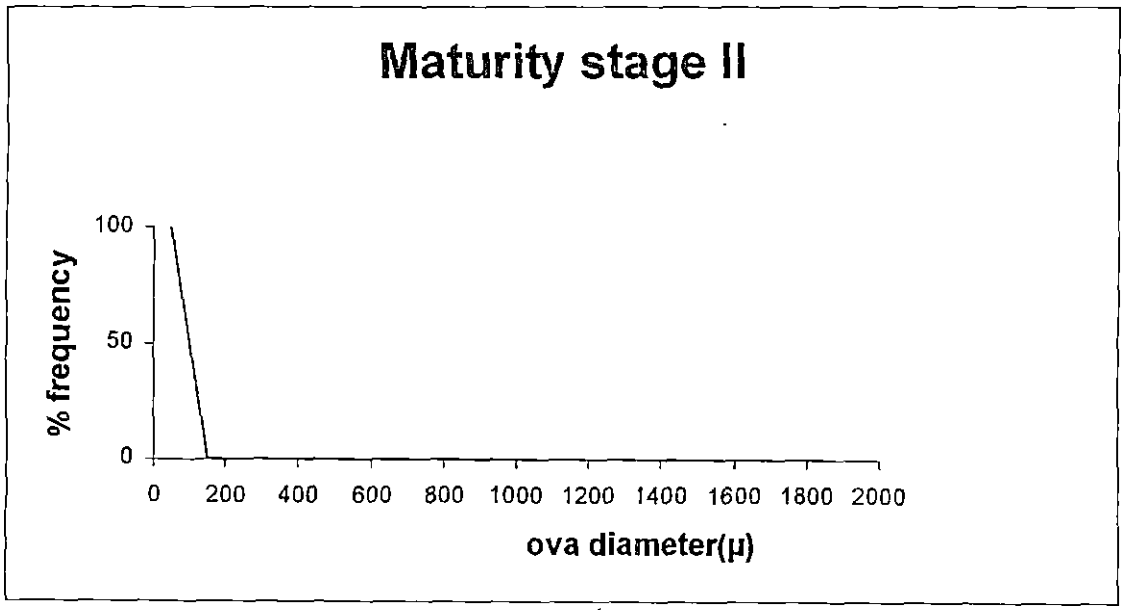


Fig 23b. Percentage frequency of ova diameter in maturity stage II

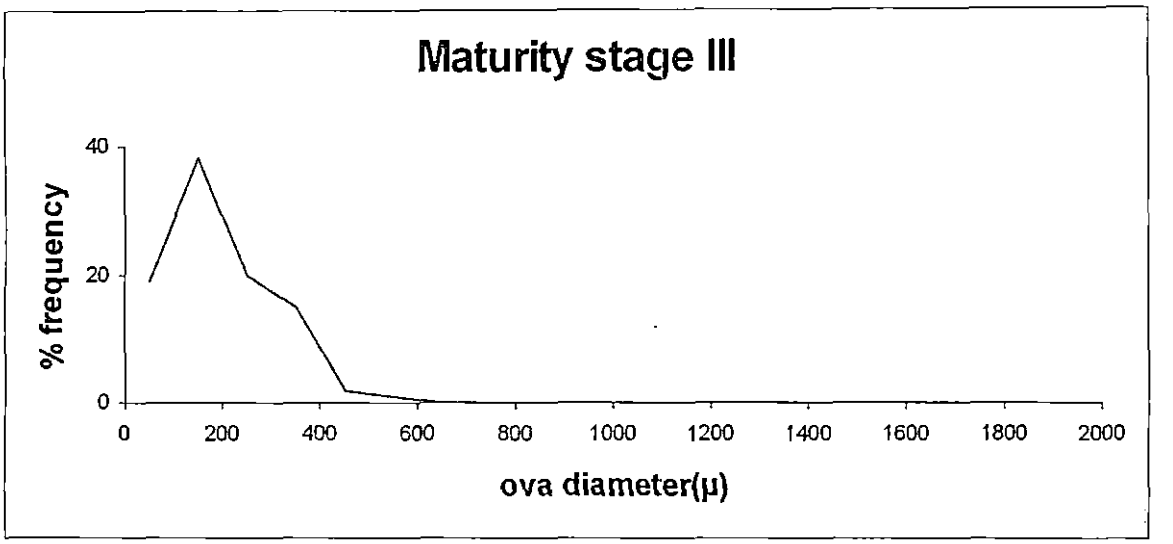


Fig. 24 a. Percentage frequency of ova diameter in maturity stage III.

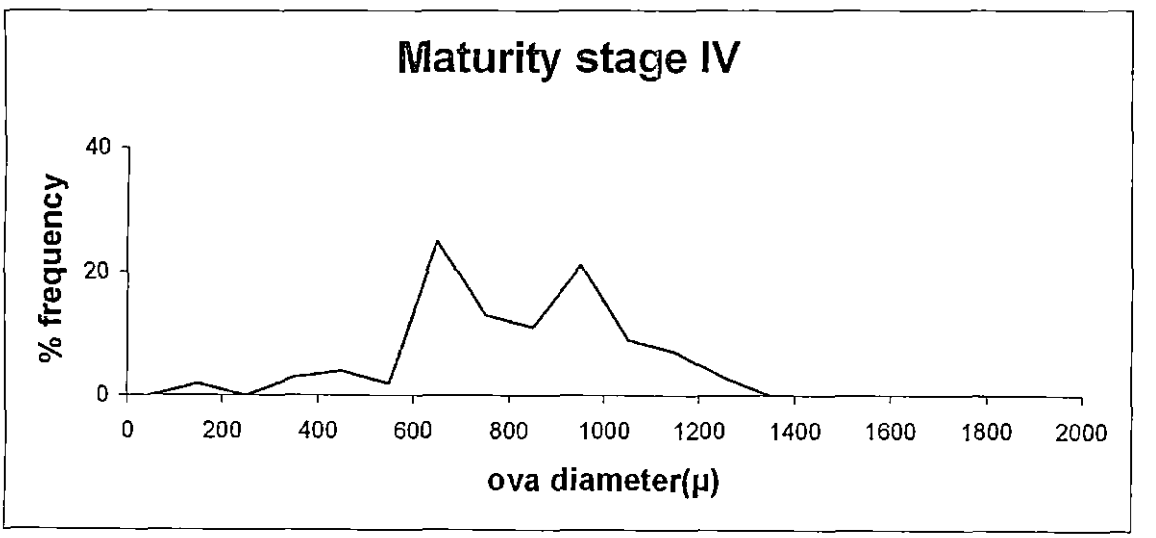


Fig 24 b. Percentage frequency of ova diameter in maturity stage IV

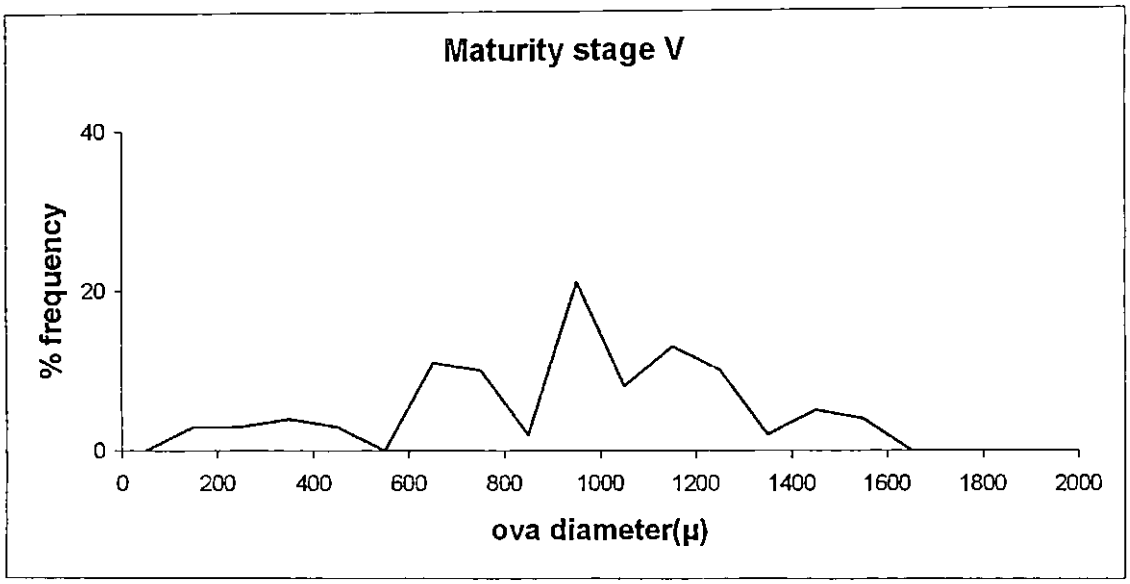


Fig. 25a. Percentage frequency of ova diameter in maturity stage V

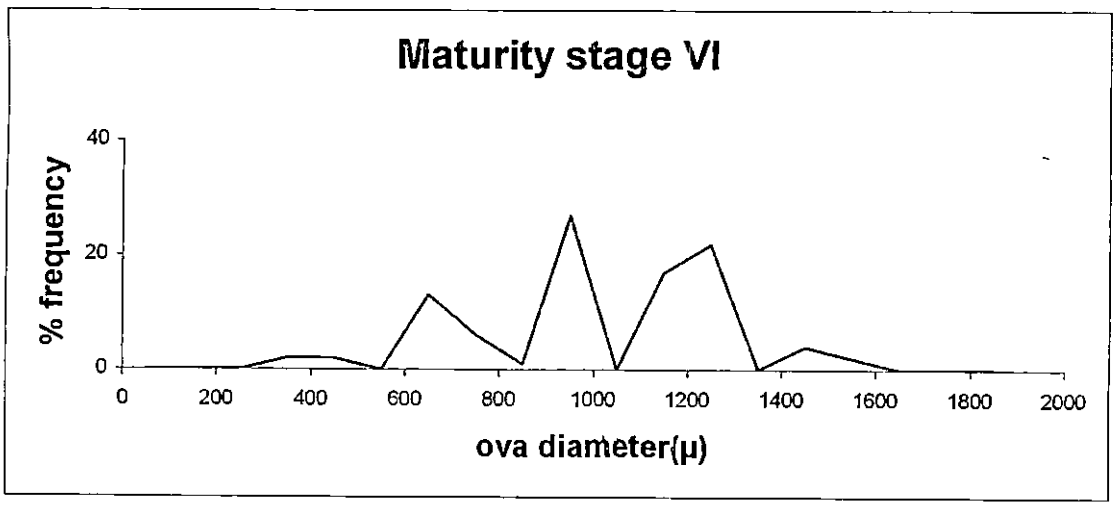


Fig. 25b.Percentage frequency of ova diameter in maturity stage VI

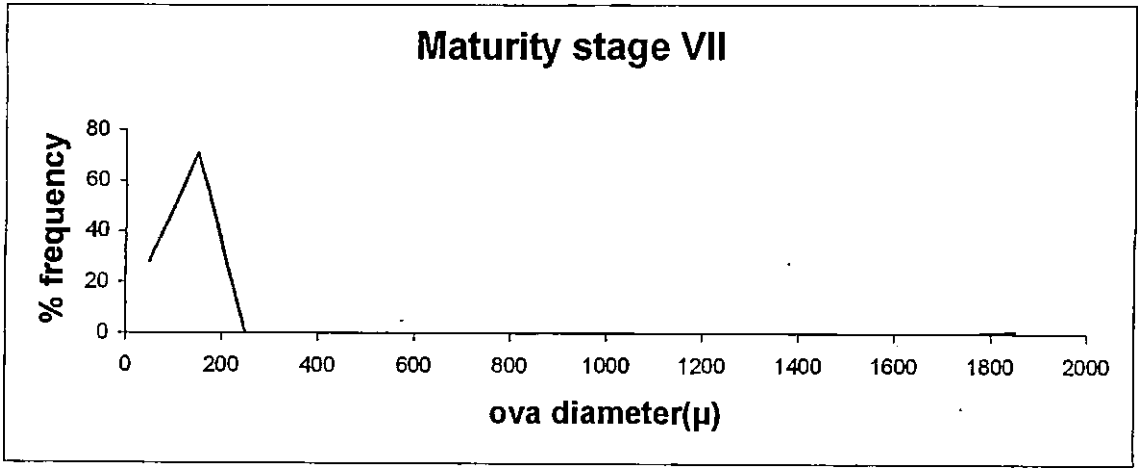


Fig 26. Percentage frequency of ova diameter in maturity stage VII

4.2.3.3. ***Ovulation***

Ovulation took place 18-24 hours after the premating moult. The dark green eggs in the ovary had been fully developed and can be demarcated as separate spherical eggs. The ovulation of the first egg took place at 6 p.m. The eggs passed through the oviduct and was released through the gonopore of the third pereiopod. The egg was fertilised by the spermatophore attached to the thoracic sterna of the third to fifth pereiopod. The egg passed to the brood chamber. By the time the ova had passed through the oviduct, the spherical shape was obtained. The second egg was released after one hour and thereafter the eggs were released to the brood chamber simultaneously. By 3.0 a.m all the eggs were released to the brood chamber.

4.2.3.4. ***Incubation***

Prawns of this genus incubate eggs in the brood chamber, which is in contrast to the penaeid prawns. The female prawn carries her brood and takes care of them until they hatch. Incubation period ranges from 24-27 days. When the eggs are released into the brood chamber they are light green in colour. After 5-7 days the eggs turn golden yellowish in colour. Pleopods move back and forth to provide aeration for the eggs which is noticed throughout the incubation period.

4.2.4.Fecundity

A total of 25 females in the sizes ranging from 48-59 mm in total length were made use of in the study of fecundity. The number of eggs in the brood ranged from 44-158. The details of Total Length (TL), Post-ocular Length (PoL), Weight of Animal (WA), Weight of Brood (WB), Fecundity and number of specimens is given in Table 8.

The scatter diagram showed linear correlation between TL-fecundity, PoL-fecundity, Weight of animal-fecundity and Weight of brood-fecundity.

1. The relationship between Fecundity (F) and Total length (TL) is given by

   F = 6.9283 TL -286.99 (Fig. 27)

   Where correlation coefficient (r) = 0.6912 which is significant at 5% level

2. The relationship between Fecundity (F) and PoL can be expressed as

   F =10.083 POL – 33.731(Fig. 28)

   Where correlation coefficient (r) = 0.4566 which is significant at 5% level

3. The relationship between Fecundity (F) and weight of animal(WA) can be expressed as

   F = 54.734 WA+ 1.6797(Fig. 29)

   Where correlation coefficient (r) = 0.7266 which is significant at 5% level

4. The relationship between Fecundity (F) and weight of brood(WB) can be expressed as

   F = 534.91 WB + 29.512 (Fig. 30)

   Where correlation coefficient (r) = 0.4993 which is significant at 5% level

From the above correlation coefficients it can be inferred that strong positive linear correlation exists between TL-fecundity, PoL- fecundity, Weight of animal- fecundity and Weight of brood-fecundity. The strongest correlation exists between fecundity and weight of animal since the correlation coefficient for the relationship is 0.7266.

Table 8. Details of TL, PoL, WA, WB, Fecundity and No. of specimens analysed in respect of *M. canarae*

TL(mm)	PoL(mm)	WA(g)	WB(g)	Fecundity(no)	No. of specimens
48-51	10-12	1.159-1.271	0.064-0.080	44-93	6
52-55	12-14	1.671-2.034	0.137-0.170	91-125	10
56-59	12.9-14.1	1.452-2.052	0.098-0.136	92-130	9
Range	10-14.1	1.159-2.052	0.064-0.136	44-130	25

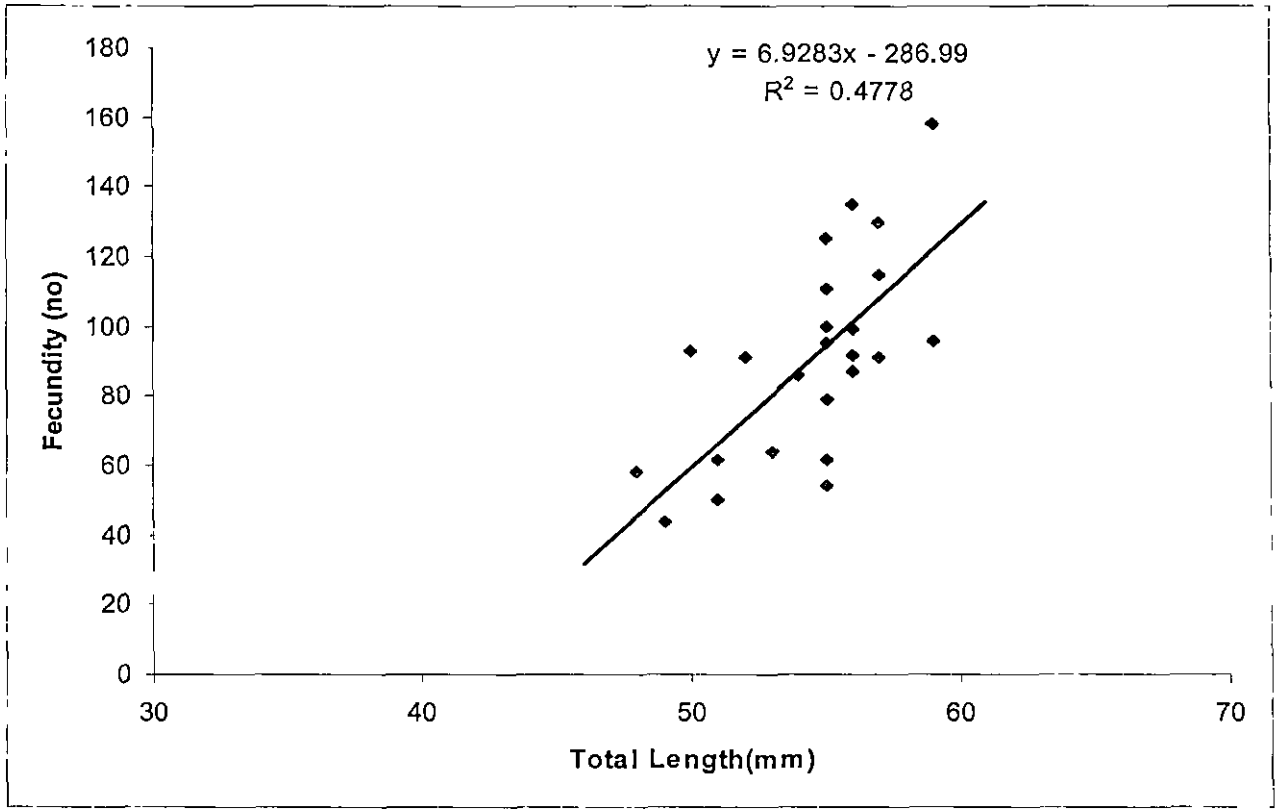


Fig. 27 Relationship between Total Length (TL) and Fecundity (F) (mm)

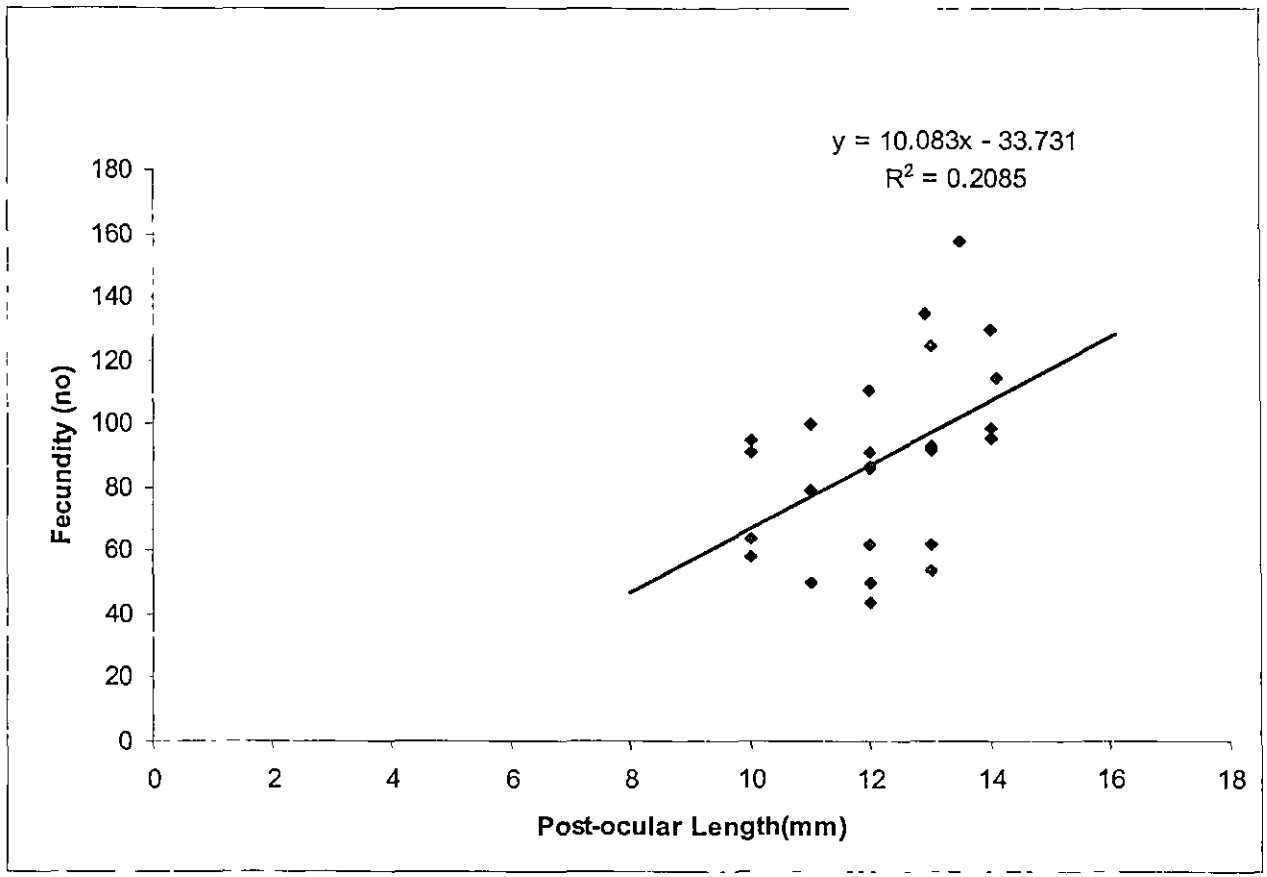


Fig.28 Relationship between Post-ocular Length (PoL) and Fecundity (F) (mm)

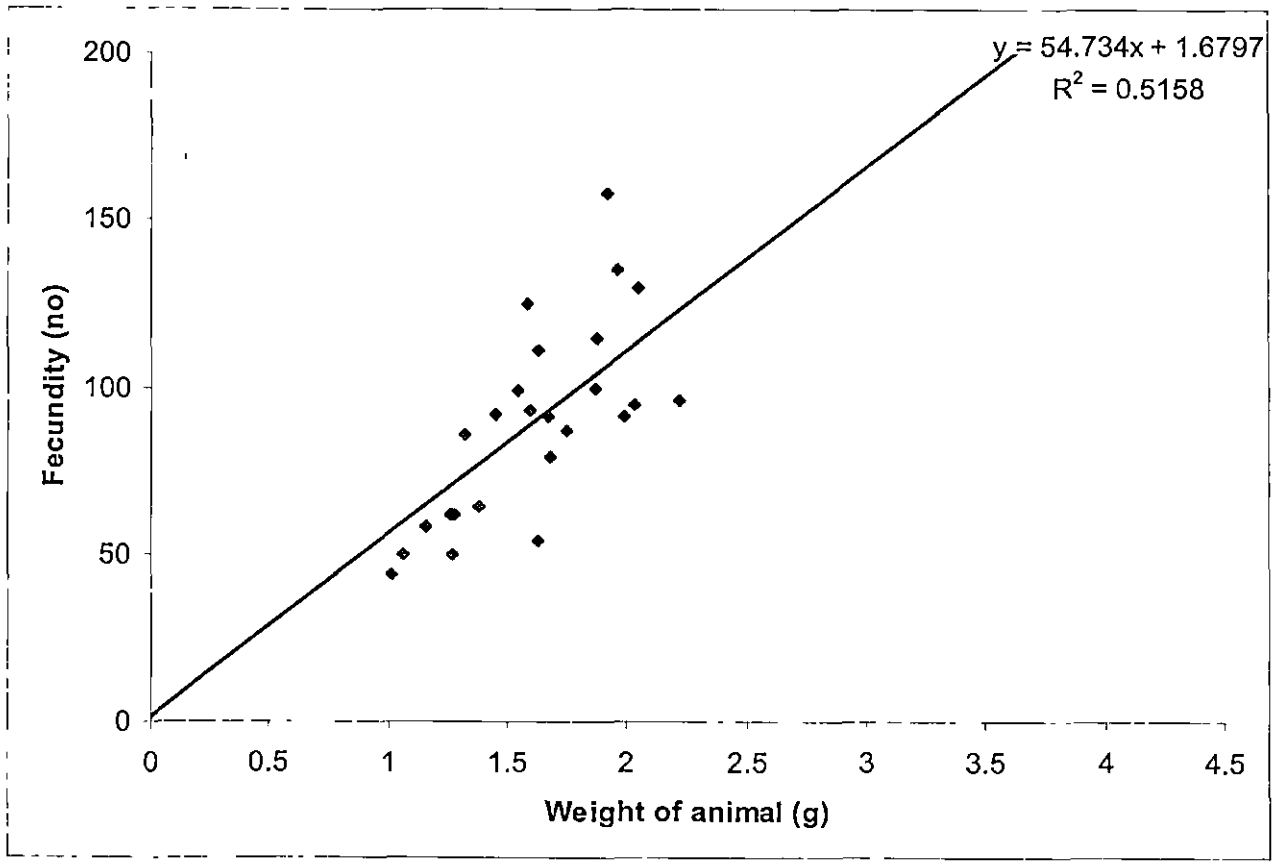


Fig.29 Relationship between Weight of animal (WA) and Fecundity (F)

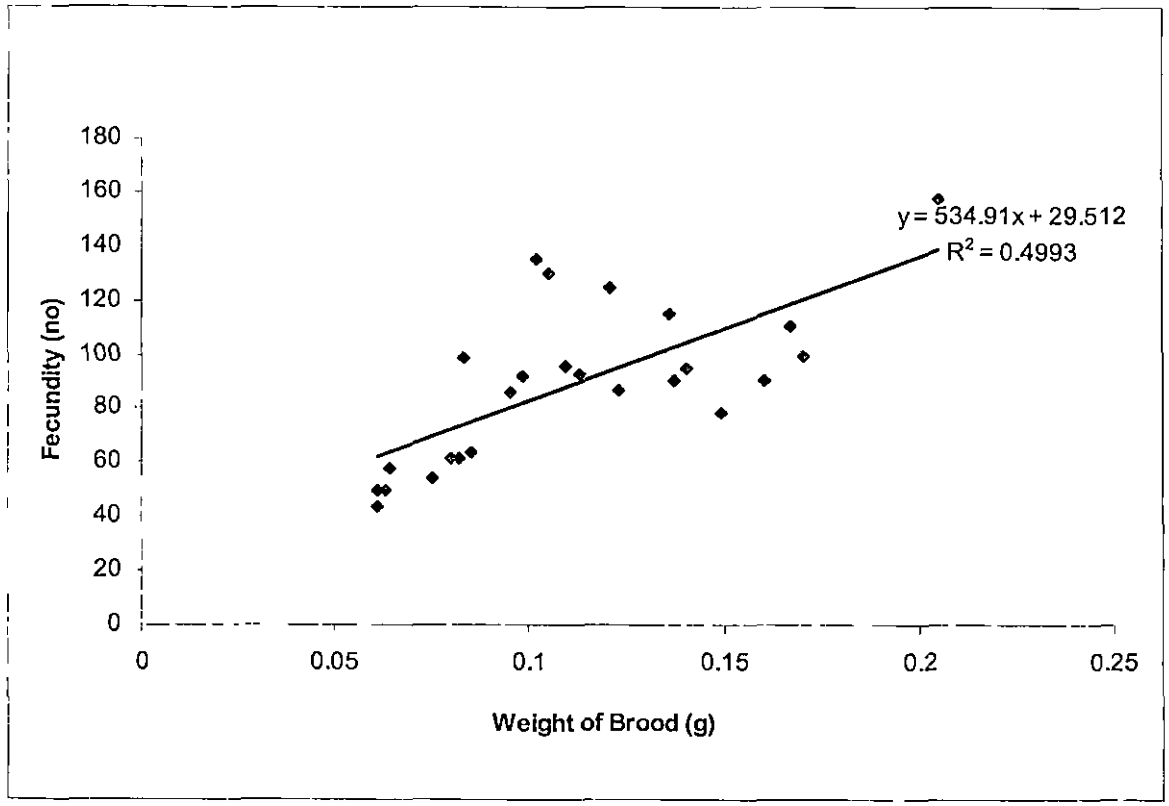


Fig.30 Relationship between Weight of Brood (WB) and Fecundity (F)

4.2.4.1.**Diameter of eggs in the brood**

The data on the diameter of the fertilised eggs in the brood is categorised into two stages

Stage I

More or less round in shape, yolk moved to the posterior side.

Size of egg varies in width from 1.04 mm-1.456 mm (1044 μ - 1456 μ)

Length varies from 1.10 mm- 1.7 mm (1108 μ- 1709 μ)

Stage II

Eyes have fully developed. Yolk is highly reduced.

Size of egg varies in width from 0.981 mm-1.424 mm (981μ-1424 μ)

Length varies from 1.424 mm-1.624 mm(1424 μ-1624μ)

4.3.MOULTING

Moulting is a periodic phenomenon in crustaceans. The process consists of shedding of the old exoskeleton, beneath which a new exoskeleton is formed. Temperature, quantity and quality of food intake, sex and physiological condition of the animal affect the frequency of moulting.

The moulting interval is prolonged in female. The premating moult takes place only after the complete development of the ovary which takes about 28 days. When ovarian development is completed, premating moult is followed for mating and egg laying. In the case of males the somatic growth dominates development and as a result intermittent, non-reproductive moults take place. The interval between successive moults was 16-18 days in males of size range 37-40 mm.

Discussion

VII. DISCUSSION

The freshwater prawns belonging to the genus *Macrobrachium* are known to be taxonomically a very complex group owing to their extreme range of variations and overlapping of characters. Size wise, it comprises small to medium sized as well as fairly large-sized species with their own distinctive characters (referred as 'minor' and 'major' *Macrobrachium* respectively). The minor species coming under the genus are *M. canarae, M. hendersodayanum, M. kistnense, M. lamarrei lamarrei, M. scabriculum, M. sankolli, M. tiwarii, M. unikarnatakae, M. walvanense, M. bombayense, M. kulkarnii* and *M. banjarae.* Large sized species include: *M. rosenbergii, M. malcolmsonii, M. gangeticum, M. villosimanus, M. josephi* and *M. schenkeli.*

5.1. TAXONOMY

Based on the study of minor *Macrobrachium* spp. from Karnataka and Maharashtra, two taxonomic characters are prominent. They are

1. Presence or absence of a prominent orange-red chromatophore on second cheliped (base of fingers)
2. Presence or absence of accessory spine on uropodal exopod.

The orange-red chromatophore on the second cheliped may be one or two in number. The species like *M. lanchesteri, M. tiwarii, M. unikarnatakae, M. bombayense* have only one such chromatophore. *M. kistenense, M. kulkarnii* and *M. gurudeve* have 2 orange red chromatophores, one at the base of the fingers and the other at the base of the chela. In *M. canarae* there is a shining orange red

chromatophore on the second cheliped which shows the affinity of this species to the group.

The accessory subapical spine on uropod is absent in *M. canarae* which shows its affinity to other *Macrobrachium* species like *M. kulkarnii, M. lamarrei lamarrei, M. kistnense* and *M. tiwarii.* This spine is present in other minor *Macrobrachium* species like *M. sankolli, M. unikarnatakae* and *M. bombayense.*

Tiwari (1958), the original author of *canarae*, gave only a diagnostic account of the species without any illustrations. This species was described in detail for the first time by Jalihal *et al.* (1988). *M. canarae* closely resembles both the subspecies of *M. lamarrei* i.e., *M. lamarrei lamarrei* and *M. lamarrei lamarroides* in general appearance, shape of rostrum and absence of uropod accessory subapical spine. They differ from one another in the case of rostral formula, appendix masculina and presence or absence of orange red cheliped chromatophore. Rostral formula for *M. canarae* is 7-10/ 4-7, whereas for *M. lamarrei lamarrei* is 5-11/ 5-9 and for *M. lamarrei lamarroides* 4-8/ 3-5.

Both the subspecies of *M. lamarrei* i.e., *M. lamarrei lamarrei* and *M. lamarrei lamarroides* have a common characteristic feature of the male pleopod viz., a long, slender, almost non-hairy appendix masculina that extends at least up to the tip of endopod, unlike the usual short, stout and hairy one, which is a unique feature amongst the species of the genus (Tiwari, 1951)

The collection of palaemonid prawns from the upper stretch of Meenachil river at Palai, Kerala included specimens of *M. canarae* and was recorded for the first time by Jayachandran (1991). The dorsal rostrum is with 6-8 teeth of which

usually one or two teeth are seen beyond the edentulous part of the distal rostrum. The first ventral tooth is situated at the level of the distal end of the antennular peduncle and is in variance with the observation by Jalihal *et al.*(1988) in which it is described as situated at midway of the middle segment of the antennular peduncle.

The affinity of *M. canarae* with American species *M. amazonicum* was studied by Jayachandran *et al.* (2007a). Both species have a slender rostrum which extends much beyond the antennal scale with 2 post orbital teeth. The rostral formula for *M. canarae* is 7-12/ 4-8 which is similar to the rostral formula of *M. amazonicum* i.e., 10/ 6-10. Number of teeth on distal group is 1-3 in both species.

Mariappan and Richard (2006) carried out studies on the freshwater prawns of the family Atyidae and Palaemonidae from Kanchipuram and Thiruvallur districts of Tamil Nadu. It was found that *M. canarae* collected from areas was devoid of any remarkable colour pattern eventhough other taxonomic characters were distinct.

M. canarae shows very limited distribution. The species utilized for the study fully agree with the characters already available for the species (Tiwari, 1958; Jalihal *et al.*, 1988) and hence the status of the species is confirmed.

5.2. REPRODUCTIVE BIOLOGY

The different aspects of reproductive biology are discussed below.

5.2.1. **Sexual dimorphism**

In minor *Macrobrachium* species sexual dimorphism is not as distinctive as in larger *Macrobrachium* species. The second pair of chelipeds are slender, shorter than body, length equal sized and similar in both sexes without exhibiting sexual dimorphism. So other sexually dimorphic characters were taken into account. The first evidence of the sexual dimorphism is the presence of gonopores on the 5th pereiopod and 3rd pereiopod in female and male respectively. The species also shows differences in the structure of first and second pleopod.

Another interesting observation in this respect is that the species exhibits variation in the colour of antennular flagellum between the sexes. This type of colour variation seems not exhibited by other minor *Macrobrachium* species.

Morphometric measurements were analysed and the results showed no significant difference in growth rate exist between the sexes. On comparing the cephalothoracic characters with carapace length, in *M. idella idella* the proportions of both the characters showed no significant difference between the sexes (Jayachandran, 1984).

5.2.2. **Breeding dress**

The breeding dress gives an information on how the eggs are stored in brood chamber during embryogenesis. Differences are noticed in the arrangement of ovigerous setae on the ridges of basis, endopodites and on the appendices internae of berried and non-berried females. Ovigerous setae are totally absent on

the ridges of basis in non-berried females. Ovigerous setae are temporary structures formed only during pre-parturial moults. After the eggs are hatched out, the animal moults immediately and along with this the "breeding dress" is cast off (Pillai, 1958).

5.2.3. **Maturity stages and ovarian development**

Seven maturity stages are distinguished in *M. canarae* taking into account the external characters of the ovary and the ova diameter measurements. These maturity stages are similar to that of *M. idella*, described by Jayachandran (1984).

The ovulation takes place 18-24 hours after the premating moult. During spawning ova stream the oviducts and exit the gonopores as separate, unattached eggs is apparently the action of some hormone during the late pre-spawning period.

The incubation period in *M. canarae* was found to range between 27-30 days. Usually the incubation period of minor *Macrobrachium* species ranges from 30-45 days at low temperature (Sankolli *et al.*, 2007). During periods of extreme temperature in summer the hatching of eggs get extended beyond its normal incubation period. As in the case of other minor *Macrobrachium* species, the eggs of the species are green in colour which turns brown on maturation.

The genus *Macrobrachium* shows three basic types of larval development. I. Prolonged type, (*M. rosenbergii, M. malcolmsonii* in which the eggs are small (0.5 mm-0.6 mm in diameter), development prolonged with several stages and essentially salinity-dependent for metamorphosis but larval survival is minimal; II. Partially abbreviated type-3+1 stages (*M. canarae, M. kistnense, M. lamarrei*

lamarrei, M. sankolli, M. tiwarii, M. unikaranatakae, M. bombayense, M. kulkarnii and M. banjarae, size of eggs range from 0.8mm-1.4 mm X 1.1 mm-1.9 mm); III. Completely abbreviated type, *M. hendersodayanum*, the development is reduced to 1+1 stages.

5.2.4. **Fecundity**

The fecundity of *Macrobrachium* prawns is variable depending on size. The highest fecundity of this genus is observed in major *Macrobrachium* species like *M. rosenbergii* and *M. carcinus*, where females can lay between 80,000-10,0000 eggs each time of spawning when they are fully mature (New and Singolka, 1985). In the case of minor *Macrobrachium*, even though the number of eggs is less, offsprings display high survival and fitness. The present study reveals that fecundity of *M. canarae* ranges between 44-158. (size range 48-59 mm in total length). Earlier reports say that the fecundity of *M. canarae* is 50 (size range 40 - 45 mm in total length) (Jalihal *et al.*, 1988). The fecundity of *M. lamarrei* ranged between 65-275, *M. sankolli* 60-90, *M. unikarnatakae* 70-120, *M. kistnense* ranged between 140-170 (Sankolli *et al.*, 2007).

5.3. MOULTING

The prawn moults at an interval of 16-18 days. It has been reported that *M. rosenbergii* moults at an interval of 23 days (New, 2002).

The above results are valuable for the management of the species under captive conditions.

Summary

VI. SUMMARY

Macrobrachium canarae is a freshwater prawn which has been reported to occur widely in Kerala state. In addition to the edible value, the species exhibits some characters of ornamental value which can be explored for the beneficial use of man (Jayachandran, 2005). The *Macrobrachium canarae* has an orange red shining spot on the second cheliped and stripes on the carapace which attributes to its ornamental value. The species also breeds in captivity. For the effective management of the species in the aquarium, a thorough knowledge of the various aspects of reproductive biology is essential. Under this objective a detailed investigations on the following aspects have been carried out

1. Taxonomy
2. Sexual dimorphism
3. Breeding dress
4. Maturity stages and ovarian development
5. Fecundity
6. Moulting

1. Detailed taxonomic description of the species has been given in the text. Also discussed its taxonomic status and affinity with other species.

2. The species do not exhibit sexual dimorphism in the size of second pereopod as in the other *Macrobrachium* species. It exhibits differences in the colour of antennular flagellum and chromatophores on the carapace. Both are coloured black in male and reddish brown in female. The species also exhibits sexual

dimorphism in the morphology of the first and second pleopod between the sexes. The endopod of the first pleopod is more bulbous in male compared to female. The second pleopod possesses both appendix masculina and appendix interna, in addition to exopod and endopod in male where appendix interna is only present in female.

4. The morphometric studies rules out the possibility of sexual dimorphism. There is no significant difference in the growth rate between sexes. Total Length was used as the reference dimension and was compared with Carapace Length, Cephalothoraic Length, Rostral Length and Length of Telson (dependent variables) and the regression lines were fitted for Total Length-Carapace Length, Total Length- Post-ocular Length, Total Length-Rostral Length and Total Length-Length of Telson.

5. Since there is no sexually dimorphic growth pattern in the species, the external sexual characters and characters of the reproductive organs were taken into account for distinguishing sex of the species. The structure of the male and female reproductive organs are given along with results.

6. The breeding dress gives an account of the arrangement of setae on the five pleopods of the female during the breeding season. The breeding dress gives an idea of how the eggs are stored in the brood chamber during embryogenesis. The berried and non-berried females can be distinguished by the difference in the arrangement of setae on the basis and appendix interna.

7. Seven maturity stages were distinguished in the species taking into account the ova diameter measurements, colour of the fresh and preserved ovary and size of the ovary i.e., the space it occupies in relation to the carapace cavity. From the ova diameter measurements it was also inferred that there are two stocks of fully mature ova in the ovary.

9. The incubation period of *Macrobrachium canarae* ranges between 24-27 days. The dark green eggs turn brown just before hatching.

10. Fecundity studies show that the number of eggs in the brood chamber ranged from 44-158. The regression analysis shows that positive correlation exists between Total Length-Fecundity, Post-ocular Length-Fecundity, Weight of animal-Fecundity and Weight of brood-Fecundity.

11. Diameter of the eggs in the brood

Stage I

Size of egg varies in width from 1.04 mm-1.456 mm (1044 μ - 1456 μ)

Length varies from 1.10 mm- 1.7 mm (1108 μ- 1709 μ)

Stage II

Size of egg varies in width from 0.981 mm-1.424 mm (981μ-1424 μ)

Length varies from 1.424 mm-1.624 mm(1424 μ-1624μ)

12 In the case of females premating moult takes place only after 28 days. The interval between successive moults was 16-18 days in males of size range 37-40 mm.

References

VII. REFERENCES

Aiyer, R. P. 1949. Life history and behaviour of Indian prawns. *Proc. Zool. Soc. Bengal.* 2 (2): 101-148

Ang, K. J. and Law, Y. K. 1991. Fecundity changes in *Macrobrachium rosenbergii* (De Man) during egg incubation. *Aquacult. Fish. mgmt.* 22: 1-6

Ammar, D., Mueller, Y. M. R and Nazari, E. M. 2001. Reproductive biology of *Macrobrachium olfersii* (Wiegman) (Crustacea, Decapoda, Palaemonidae) collected at Santa Catarian's Island, Brazil. *Rev. Braz. Zool.* 18: 529-537

Camp, D. K. 2002. Reproductive biology of *Macrobrachium olfersi* (Decapoda, Palaemonidae) in Sao Sebastio, Brazil. *J. Crust. Biol.* 22 (2): 367-376

Cavalli, R.O., Lavens, P and Sorgeloos, P. 2001. Reproductive performance of *Macrobrachium rosenbergii* females in captivity. *J. Wld. Aquacult. Soc.* 32: 60 – 67

Chang, C.F and Shih, T. W. 1995. Reproductive cycle of ovarian development and vitellogenin profiles in the freshwater prawn *M. rosenbergii. Invert. Reprod. Devel.* 27: 11-20

Gamba, A. L. 1997. Reproductive biology of *Macrobrachium jelksii* (Miers, 1877) and *Macrobrachium amazonicum* (Heller, 1862) in Venezuela (Crustacea, Decapoda, Palaemonidae). *Acta. Cien. Ven.* 48: 19-26

Henderson, J. R. 1893. A contribution to Indian Carcinology. *Trans. Linn. Soc. Lond. Zool.* 5 (2): 325 – 458

Henderson, J. R. and Matthai, G. 1910. On certain species of *Palaemon* from South India. *Rec. Indian Mus.* 5: 277 – 305

Holthuis, L. B . 1980. FAO species catalogue shrimps and prawns of the world. An Annotated Catalogue of Species of Interest to fisheries . *FAO.*1 (125): 1-272

Ibrahim, K. H. 1962. Observation on biology and fishery of fresh water prawn *Macrobrachium malcolmsonii* (Milne Edwards) of river Godavari. *Indian. J. Fish.* 9(2): 443-465

Jalihal. D. R. 1992. Erroneous records of the Malayan Riceland prawn *Macrobrachium lanchesteri* (De Man) from India- Larval evidence (Decapoda, Caridea, Palaemonidae). *Crustaceana.* 62(1): 101-105

Jalihal, D. R. and Sankolli, K. N. 1975. On the Palaemonid prawn *Macrobrachium hendersodayanum* (Tiwari) from the Malaprabha River. *J. Karnataka Univ. Sci.* 20:297-304

Jalihal. D. R., Shenoy Shakuntala and Sankolli, K. N. 1979 a. On the freshwater prawn *Macrobrachium kistnensis* (Tiwari) from the river Krishna, Wai (Maharashtra). *Bull. Fish. Fac. Konkan. Agr. Univ. India.* I(1): 57-66

Jalihal. D. R., Shenoy Shakuntala and Sankolli, K. N. 1979 b. Laboratory culture studies on the freshwater prawns. I- *Macrobrachium kistnensis* (Tiwari) from the river Krishna, Wai (Maharashtra). *Bull. Fish. Fac. Konkan. Agr. Univ.India.* I(1): 73-82

Jalihal. D. R., Shenoy Shakuntala & Sankolli, K. N. 1984. Five new species of freshwater atyid Shrimps of the genus *Caridina* H. Milne Edwards from Dharwar area (Karnataka State, India). *Rec. Zool. Sur. India.* 69: 1-40

Jalihal. D. R., Shenoy Shakuntala and Sankolli, K. N. 1988. Freshwater prawns of the genus *Macrobrachium Bate*, 1868 (Crustacea, Decapoda, Palaemonidae) from Karnataka. India. *Rec. Zool. Sur. India.* 112:1-74

Jalihal. D. R., Almelkar, G. B and Sankolli, K. N. 1994. Atyid Shrimps of the genus Caridina H. Milne Edwards 1837. Potential Crustacean material for experimental biology. Proceedings of the First European Crustacean Conference, 1992. *Crustaceana*. 66(2): 178-183

Jayachandran, K.V. 1984. Studies on the biology of the palaemonid prawns of the South-West coast of India. Ph. D. Thesis, University of Kerala, Trivandrum, p. 1-470

Jayachandran, K. V. 1991. First record of *Macrobrachium canarae* (Tiwari, 1958) and *M. Sankollii* Jalihal and Shenoy, 1998 outside the type locality. *Mahasagar*. 24(2): 139-142

Jayachandran, K. V. 2001. *Palaemonid prawns Taxonomy, Biodiversity, Biology and management*. Science publishers, Inc., USA, p 624

Jayachandran, K. V. 2005. *Biodiversity survey of Palaemonid prawns of Kerala and studies on the biology of Macrobrachium latimanus* (Von Marten, 1868). ICAR adhoc scheme, Final Report, p 83

Jayachandran, K.V and Joseph, N. I. 1985. A new species of *Macrobrachium* (Decapoda, Palaemonidae) from the south-west coast of India from Kerala waters. *J. Inland Fish. Soc. India*. 14: 86-87

Jayachandran, K.V and Joseph, N. I. 1989. Palaemonid prawn resources on the Southwest coast of India. *J. Aquacult. Trop.* 4: 65-76

Jayachandran, K. V and Raji, A. V. 2004. Three new species of *Macrobrachium* Bate,1868 (Decapoda, Palaemonidae) from Western Ghat region of Kerala. *Crustaceana.* 77(10): 1179-1192

Jayachandran, K. V., Simon, S and Raji, A. V. 2007a. Rostral variation, morphometrics and length weight relationship of *Macrobrachium canarae* (Tiwari, 1958) and a note on its affinities with other species of the genus. In: Freshwater Prawns: Advances in Biology, Aquaculture & Marketing. *Proceedings of Freshwater Prawns 2003, International Symposium on Freshwater Prawns, 20-23 August 2003, Kochi, India* (ed. Nair, C. M. & Nambudiri,D, D). Allied Publishers, New Delhi, India, pp. 178-185

Jayachandran, K. V., Lal Mohan, R. S and Raji, A. V. 2007b. A new species of *Macrobrachium* Bate, 1868 (Decapoda, Palaemonidae) from the Kulsi River, N. India, possibly under threat. *Zool. Anz.* 246: 43-48

John, M. C. 1957. Bionomics and life history of *Macrobrachium rosenbergii*(de Man). *Bull. Cent. Res. Inst. Univ. Trivandrum.* 5: 93-102

Kanaujia, D. R and Mohanty, A. N. 1992. Breeding and large scale seed production of the Indian river prawn *Macrobrachium malcolmsonii* (H.M. Edwards). *J. Aquaculture.* 2: 7-16

Kanaujia, D. R., Mohanty, A. N and Tripathi, S. D. 1997. Growth and production of Indian River prawn *Macrobrachium malcolmsonii* (H. Milne Edwards) under pond conditions. Aquaculture. 154: 79 – 85

Kanaujia, D. R., Das, B. K., Mohanty, A. N and Das, K. M. 1998. Recycling of used water for seed production of *Macrobrachium malcolmsonii* (H.M. Edwards). *J. Aqua. Trop.* 13(3): 223-232

Kanaujia, D. R., Mohanty, A. N and Tripathi, S.D. 1999. Year round breeding and seed production of Indian river prawn *Macrobrachium malcolmsonii* (H.M. Edwards) under controlled conditions. *J. Aqua. Trop.* 14(1): 27-36

Kemp, S. 1913. Crustacea Decapoda, Zoological results of the Arbor Expedition 1911-1912. XX. *Rec. Indian Mus.* 8: 289 – 310

Kemp, S. 1915. Crustacea. Decapoda. Fauna of the Chilka Lake. *Mem. Indian. Mus.* 5: 199 – 325

Kemp, S. 1917.. Notes on Crustacea Decapoda in the Indian Museum IX *Leander styliferus*, Milne Edwards, and related forms. *Rec Indian. Mus.* 13 : 203 –231

Kemp, S. 1918. Crustacea Decapoda of the Inle Lake basin. *Rec. Indian Mus.* 14 : 81 – 102

Kemp, S. 1922. Pontoniinae. Notes on Crustacea Decapoda of the Indian Museum. XV. *Rec. Indian Mus.* 24: 113- 288

Kemp, S. 1925. On Various Caridea. Notes on Crustacea Decapoda in the Indian Museum. XVII. *Rec. Indian Mus.* 27 : 249 – 343

Kewalramani, H. G., Sankolli, K.N and Shenoy, S.S. 1971. On the larval rearing history of *Macrobrachium malcolmsoni* under captivity. *J. Indian Fish. Assoc.* 1 (1): 1 –25

Kurup, B. M., Sebastian, M. J., Sankaran, T. M. and Rabindranath, P. 1992. *Fishery and biology of Macrobrachium spp. of the Vembanad lake.* Proc. National Symposium on Freshwater prawns (Macrobrachium spp) 12-14 December, Kochi, (eds Silas, E. G.,). Kerala Agricultural University, Thrissur, Kerala. pp 78-79

Kutty, M. N., Herman, F and Le Menn, H. 2000. *Culture of other prawn species.* In: Freshwater Prawn Culture: The Farming of *Macrobrachium rosenbergii*(eds. New, M. B and Valenti, W. C). Blackwell Science, Oxford, pp 393-410

Ling, S. W. 1969. The general biology and development of *Macrobrachium rosenbergii. FAO.* 57 (3) : 589-606

Malecha, S. R. 1983. Aquaculture of the freshwater prawn *Macrobrachium rosenbergii* in Hawai. History, present status and Application to other areas. *Ann. Fish. Res. Cent.* : 1- 28

Mammen Koshy. 1972. A comparitive study on the segments of the chelipeds in the two sexes of *Macrobrachium lamarrei* (H. Milne Edwards) (Decapoda, Caridea). *J. inland. Fish. Soc. India.* 4: 10-14

Mariappan, N and Richard, J. 2006. Studies on freshwater prawns of the family Atyidae and Palaemonidae from Kanchipuram and Thiruvallur districts, Tamil nadu, India, including one new species of the genus *Caridina* H. Milne Edwards, 1837. *Rec. Zool. Sur. India..*243: 1-80

Marioghae, I. E and Aylinha, O. A. 1995. The reproductive biology and culture of *Macrobrachium vollenhovenii* (Herklots, 1857) and *Macrobrachium*

macrobrachion (Herklots, 1851) in Nigeria. Tech. Paper. Niger. Inst. Oceanogr. Mar. Res no: 100. NIOMR, Port Harcourt,Nigeria, p 16

Menon, M. K. 1938. The early larval stages of two species of *Palaemon*. *Proc. Indian. Acad. Sci.* 8: 288-294

Mohapatra, J. 2001. Studies on the comparitive breeding and larval biology of Indian river prawn *Macrobrachium malcolmsonii* (H.M. Edwards) and giant freshwater prawn, *Macrobrachium rosenbergii* (de Man). Ph.D. Thesis, Utkal University, Bhubaneswar, Orissa. p 280

Murthy, D., Rajagopal, K. V., Varghese, T. J and Udapa, K.S. 1987. Reproductive biology of the freshwater prawn *Macrobrachium equidens equidens* (Dana). *Indian J. Anim. Sci.* 57 (9): 1026 – 1034

Nagamine, C., Knight, W. A., Maggenti, A and Paxman, G. 1980. Effects of Androgenic gland ablation on male primary and secondary sexual characteristics in the Malaysian prawn, *Macrobrachium rosenbergii* (de Man) (Decapoda, palaemonidae), with first evidence of induced feminization in a nonhermaphroditic Decapod. *Gen. Comp. Endocrinol.* 41: 423-441

Nataraj, S. 1942. A note on the prawn fauna of Travancore. *Curr. Sci.* 11 : 468-69

Nataraj, S. 1947. On some species of Acetes(Crustacea, Sergestidae) from Travancore. *Rec. Indian Mus.*45: 139-147

New, M. B. 2002. Farming freshwater prawns. A manual for the culture of giant river prawn (*Macrobrachium rosenbergii*). FAO Technical Paper no 328. FAO, Rome, Italy,p 212

New, M. B and Singholka, S. 1985. *Freshwater prawn farming. A Manual for the culture of Macrobrachium rosenbergii.* FAO Technical Paper no 225. FAO, Rome, Italy, p 118

New, M. B and Valenti, W. C. 2000. *Freshwater Prawn Culture.* Blackwell Science, Oxford, England. p443

Nobili, G. 1903. Crostacei di Pondichery, Mahe, Bombay etc. *Bull. Mus. Zool. Ant. comp. Torino.* 18 (455): 1-39

Pillai, R. S. 1958. Studies on *Caridina laevis* Heller (Decapoda, Arthropoda). Ph.D.Thesis, University of Kerala, Trivandrum, p 350

Patra, R. W. R. 1976. The fecundity of *Macrobrachium rosenbergii* de Man. *Bangladesh J. Zool.* 4(2) : 63-71

Patwardhan, S. S. 1937. *Palaemon* (The Indian River Prawn) In: BAHL, K. N., The Indian Zoological Memoirs on Indian Animal Types, vol.6: 1-100

Phone, H. Suzuki, H and Ohtomi, J. 2005. Reproductive biology of the freshwater palaemonid prawn. *Macrobrachium lanchesteri* (De Man, 1911) from Myanmar. *Crustaceana.* 78(2): 201-213.

Raman, K. 1964. On the location of a nursery ground of the giant prawn *Macrobrachium rosenbergii* (De Man). *Curr. Sci.* 1: 27-28

Raman, K. 1967. Observations on the fishery and biology of the giant freshwater prawn *Macrobrachium rosenbergii* (De Man). *Curr. Sci.* 1 : 27-28

Rajyalakshmi, T. 1961. Studies on the maturation and breeding in some estuarine prawns. *Proc. Natl. Inst. Sci. India.* 27(4): 179-188

Rajyalakshmi, T. 1980. Comparitive study of the biology of the freshwater prawn, *Macrobrachium malcolmsonii* of Godavari and Hoogly river systems *Proc. Indian. Natn. Sci. Acad.* 46(1): 72-89

Rao, R. M. 1965. Breeding behaviour in *Macrobrachium rosenbergii* (De Man). *Fish. Technol.* 2(1) : 19-25

Rao, K. J. 1986. *Life history and behaviour of Macrobrachium malcolmsonii* (H. Milne Edwards) In: Training in giant freshwater prawn farming. CIFRI, Bull., no.47: 60-64

Rao, K. J. 1991. Reproductive biology of the giant freshwater prawn *Macrobrachium rosenbergii* (De Man) from Lake Kolleru (Andhra Pradesh). *Indian J. Anim. Sci.* 61(7): 780-787

Sandifer, P. A. and Smith, T. I. J. 1985. *Freshwater prawns.* In: Crustacean and Mollusc Aquaculture in the United States (eds Huner, J.V & Brown,E.E.). AVI publishing Co, Westport, pp 63-125

Sankolli, K.N., Shenoy Shakuntala and Jalihal, D. R. 1981. *Freshwater prawns as possible biological agents in the management of the pond ecosystem.* In: Proceedings of the Symposium of Ecology on Animal Populations. *Zool. Surv. India.*2:127-132

Sankolli, K.N., Shenoy, S., Jalihal, D. R and Akmelkar, G. B. 1984. Egg-to egg mass culture technique of the Godavari prawn *Macrobrachium malcolmsonii*

(H. Milne Edwards) in a static culture system. In. Proc. Sem. Freshwater Fisheries and Rural Development. Rourkela, Orissa, pp. 15-18

Sankolli, K. N, Shakuntala Shenoy and Pawase, A. S. 2007. Low cost farming potential of prawn species of minor *Macrobrachium* Bate, 1868 (family Palaemonidae) and Caridina H. Milne Edwards, 1837 (family Atyidae) in India. In: Freshwater Prawns: Advances in Biology, Aquaculture & Marketing. Proceedings of Freshwater Prawns 2003, International Symposium on Freshwater Prawns, 20-23 August 2003, Kochi, India (ed. Nair, C. M. & Nambudiri,D, D). Allied Publishers, New Delhi, India, pp. 186-195

Shenoy shakuntala, Jalihal, D. R and Sankolli, K. N. 1993. Ecological diversity with reference to aesthetacs in freshwater prawns. Proceedings of the First European Crustacean Conference, 1992. *Crustaceana*. 65(3):300-308

Shyama, S. K. 1987. Studies on moulting and reproduction in the prawn, *Macrobrachium idella* (Heller). *Mahasagar*. 20(1): 15-21

Singh, S. R. and Roy, D. 1994. Reproductive cycle of the freshwater prawn, *Macrobrachium choprai* (Tiwari). *Asian Fish. Sci*. 7:77-89

Snedecor, G. W and Cochran, W. G. 1967. *Statistical Methods*. 6th edn. Oxford and IBH Publishing Co., New Delhi, India.p 563

Sureshkumar, S. and Kurup, B. M. 1998. Biochemical characterization of different male morphotypes of *Macrobrachium rosenbergii* (De Man). *Fish. Technol.* 35 (1) : 18-25

Tiwari, K. K. 1947. Preliminary descriptions of two new species of *Palaemon* from Bengal. *Rec. Indian. Mus.* 45 : 329-331

Tiwari, K. K. 1949. On a new species of *Palaemon* from Banaras, with a note on *Palaemon lanchesteri* de Man. *Rec. Indian Mus.* 45: 333-345

Tiwari, K.K. 1951. Studies on the Indo Burmese prawns of the genus *Palaemon* Fabricius. Ph. D. Thesis. University of Nagpur. p 336

Tiwari K.K. 1952. Diagnosis of new species and subspecies of the genus *Palaemon* Fabricius (Crustacea : Decapoda). *Ann. Mag. Nat. Hist.* 5: 27-32

Tiwari, K.K. 1955. New species and subspecies of Indian Freshwater prawns. *Rec. Indian Mus.* 53 : 297-300

Tiwari K.K. 1958. New species and subspecies of Indian freshwater prawns. *Rec.Indian. Mus.* 53: 297-300

Tiwari K.K. 1961. Occurrence of the freshwater prawn *Macrobrachium latimanus* (Von Martens) in India and Ceylon. *Crustaceana*. 3(2) : 98-104

Tiwari K.K and Holthuis, L.B. 1996. The identity of *Macrobrachium gangeticum* Bate, 1868 (Decapoda, Caridea, Palaemoridae) *Crustaceana*. 69 (7) : 922-926

Wang G and Qianhong, S. 1999. Culture of freshwater prawns in China. *Aquacullt. Asia*.4(2):14-17

REPRODUCTIVE BIOLOGY OF *MACROBRACHIUM CANARAE* (TIWARI, 1958) (DECAPODA, PALAEMONIDAE)

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ABSTRACT OF A THESIS

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ABSTRACT

The aim of this project is to introduce the freshwater prawn *Macrobrachium canarae* (Tiwari, 1958) as a candidate species in a community aquarium. The orange red shining spot on the second cheliped where the movable finger joins with palm makes it appealing in the aesthetic sense. This species is found to breed in captivity also. For the effective management of the prawn in the aquarium, a thorough knowledge on the various aspects of its reproductive biology is a prerequisite.

The various aspects of reproductive biology dealt with are

1. Taxonomy
2. Sexual dimorphism
3. Breeding dress
4. Maturity stages and ovarian development
5. Fecundity
6. Moulting

Since the species do not exhibit sexual dimorphism in size, it is difficult to identify male and female. The difference in colour of antennular flagellum between sexes becomes useful especially when they are bred in captivity.

The data on maturity stages and also the time of ovarian development finds its use especially in the aquarium rearing.

The fecundity studies gives an idea of the number of offsprings which could be produced from a single brood .