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**INFESTATION OF ISOPOD PARASITES ON PRAWNS OF THE
GENUS *MACROBRACHIUM* BATE, 1868 (PALAEMONIDAE) OF
COCHIN REGION.**

By

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THESIS

Submitted in partial fulfillment of the requirement for the degree

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DEPARTMENT OF FISHERY BIOLOGY

COLLEGE OF FISHERIES

PANANGAD, COCHIN

*Dedicated to my Lord, my father and to
my guide,
Dr. K. V. Jayachandran*

DECLARATION

I hereby declare that this thesis entitled "**INFESTATION OF ISOPOD PARASITES ON PRAWNS OF THE GENUS *MACROBRACHIUM* BATE, 1868 (PALAEMONIDAE) OF COCHIN REGION**" is a bonafide record of research work done by me during the course of research and that the thesis has not formed the basis for the award to me of any degree, diploma, associateship, or other similar title, of any other University or society.

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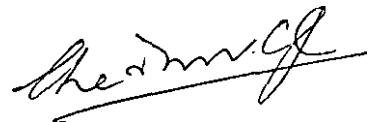
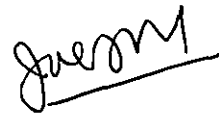
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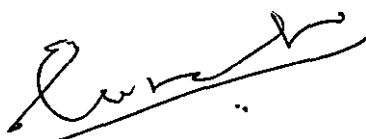


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M. Regina Jasmine

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Introduction

1. INTRODUCTION

The genus *Macrobrachium* Bate, 1868 contains more than two hundred species reported from different parts of the world (Holthuis, 1980; Jayachandran, 2001). The size of the species of this genus ranges from just 3.0 cm to more than 30 cm from tip of rostrum to tip of telson. In inland water bodies of India, the different species contribute a substantial fishery. Many species under this genus grow to a large size and are potential candidate species for aquaculture (*M. rosenbergii*, *M. malcolmsonii*, *M. hirmanicum*, *M. gangeticum*, *M. villosimanus* etc). Species like *M. idella*, *M. equidens*, *M. sulcatus*, *M. lamarrei* and *M. dayanam* are of commercial importance in certain parts of India.

The population size of this group of prawns is decreasing in natural water bodies of India. There are many regions attributed to this, like pollution of various sorts, indiscriminate capture of wild populations, hampering downward migratory path of prawns, drying up of ponds etc. Another serious threat has been diseases and their outbreak. The diseases can be of different types like those caused by viruses, bacteria, fungi, protozoans, and metazoans.

One of the interesting cases of parasitism observed in *M. idella* inhabiting Kerala waters (estuaries and freshwaters) is bopyrid isopod parasite infestation. Roughly more than 30% percent of wild populations were reported to be infested by these parasites (Deshmukh, 1984). Once infested, the general well being of the host is affected. Lot of other serious problems have also been reported in the host, like reduction in reproductive ability, lack of overlapping of secondary sexual characters, retarded growth etc. On the whole, the infestation causes lot of damage to the host (Pal and Ghosh, 1975). All these negatively affect the production of prawns.

On surveying the literature, one can find that only a few studies on these parasites from Indian waters (Chopra, 1923; 1930; Pillai, 1954; 1966; Pal and Ghosh, 1975; Deshmukh, 1984; Sree Devi, 1995; Jayaraj, 1999). However some important taxonomic studies of the bopyrids are available from different parts of the world (Richardson, 1912; Nierstrasz and Brender a Brandis, 1929; Pillai, 1954; Castro and Lima, 1974; Guzman and Contreras, 1983; Markham, 1985a, b, c; Contreras, 1993; 1996; Masunari *et al.*, 2000; Contreras and Bourdon, 2001). It is interesting to note that practically no information is available on the species specificity, preference of habitat, length - weight relationship, growth characteristics, reproductive biology and effect of parasitism on the host. The present study covers all the above aspects with emphasis on the effect of bopyrid infestation on the genus, *Macrobrachium* Bate, 1868.

Review of Literature

2. REVIEW OF LITERATURE

2.1 SPECIES DIVERSITY AND TAXONOMY OF BOPYRID

PARASITES OF COCHIN REGION.

2.1.1 Species diversity

For the effective management of the freshwater prawn resources, knowledge about the pathogenicity of parasitic infestation is also necessary. Survey of literature reveals that only limited studies are available regarding parasitic infestation on *Macrobrachium*. Ghosh (1978) made a comprehensive study of parasites and diseases of *Macrobrachium* spp of India. Among all parasites of *Macrobrachium*, the prominent infestation was that of the isopods of the family Bopyridae. So far 67 genera of bopyrid isopods are reported throughout the world. (Richardson, 1912; Chopra, 1923, 1930; Shiino, 1933 -1958; Pillai, 1954, 1966; Markham, 1972, 1973, 1980, 1985a, b, c, 1988, 1989, 1990; Castro and Lima, 1974; Pal and Ghosh, 1975; Thomas, 1977; Bourdon and Bruce, 1979, 1983; Bourdon and Markham, 1980; Bourdon, 1981; Natarajan *et al.*, 1982; Deshmukh, 1984; Cash and Bauer, 1993; Contreras, 1993, 1996; Sree Devi, 1995; Contreras and Wehrtmann, 1997; Oliveira and Masunari, 1998; Roccatagliata and Lovrich, 1999; Masunari *et al.*, 2000; Contreras and Bourdon, 2001; Contreras and Soto, 2002). Nobili (1906) reported that isopod bopyrid parasites infesting the branchial chamber or attaching to the appendages have been observed in Penaeids and Non Penaeids. There are 18 genera and 36 species of bopyrid isopods reported from prawns and shrimps of India. Reports indicate that bopyrid parasites coming under two genera, namely, *Probopyrus* and *Palaegyge* infest different species of *Macrobrachium* throughout the world. (Richardson, 1912; Chopra, 1923, 1930; Nierstrasz and Brender à Brandis, 1929; Pillai, 1954; Castro and Lima, 1974; Pal and Ghosh, 1975; Natarajan *et al.*, 1982; Guzman

and Contreras, 1983; Markham, 1985a, b, c; Contreras, 1993; 1996; Sree Devi, 1995; Jayaraj, 1999, Masunari *et al.*, 2000; Contreras and Bourdon, 2001). An extensive study of bopyrid parasites from the Tanabe Bay and South Sea island of Japan by Shiino requires special mention (Shiino, 1933, 1934, 1936, 1937, 1939a, 1939b, 1942, 1949, 1950, 1951, 1958).

From Kerala waters, first report of a bopyrid parasite is that of Chopra (1930) who described the species *Palaegyge bengalensis* infesting Palaemonids from Vembanad Lake. Pillai (1954) found the same species infesting the prawn *Palaemon carcinus* (= *Macrobrachium rosenbergii*) from the Vembanad Lake itself. The other reports those of Sreedevi (1995) and Jayaraj (1999) who recorded the incidence of *Probopyrus* sp and *Palaegyge alcocki* on *Macrobrachium idella* from Veli Lake, Trivandrum and Vembanad Lake respectively.

Only a few studies are available from other parts of India. Chopra (1923, 1930) made notable observations on the bopyrid isopods of different crustaceans of India; Chilton (1924) provided some information on the isopod fauna of Chilka Lake; Ibrahim (1962) reported the isopod infestation on *M. malcomsonii* from Godavari; Pal and Ghosh (1975) studied the infestation of the bopyrid parasite on the 3 species of *Macrobrachium* from the Hoogly river of West Bengal.

2.1.2 Taxonomy of *Palaegyge alcocki* Chopra, 1923

Among Peracarids, isopods exhibit maximum diversity in form and species richness. They are common inhabitants in almost all environments including approximately 10,000 described species, in 10 suborders. Their size ranges from 0.5 mm to 500 mm. The suborder Epicaridea contains ectoparasites on other crustaceans (malacostracans, ostracods, copepods and cirripeds). About 700 species of epicarideans have been described worldwide, in eleven families. The taxonomy of

these parasites has been well worked out (Richardson, 1905; Markham, 1975, 1977a, b, and 1985a). In India several attempts were made by many workers to study isopod parasites. Even though work on bopyrids in India was initiated as early as 1857, detailed studies were made from 1923 onwards reported in the works of Chopra (1923, 1927, 1930) who provided specific keys and taxonomic descriptions for 31 species of bopyrids from different parts of the country. Chopra (1930) clearly differentiated the closely related forms living on Palaemonids into separate genera *Palaegyge* and *Probopyrus* and this formed an important source of material for the present study.

2.2 HOST - PARASITE RELATIONSHIP

Allen (1966) made a detailed study on host - parasite relationship involving the parasite *Hemiarthrus abdominalis* and the host *Pandalus* spp. The asymmetrically shaped female bopyrid is found attached to the branchial wall inside the branchial chamber. The bopyrid parasites are blood suckers (Cameron, 1956) and feed on body fluids (Barnes, 1974) and feeding methods of these parasites are described by Bursey (1978). The male is dwarf and symmetrical and are found closely associated with the female. The presence of parasite in the gill chamber usually induces a visible swelling and discoloration of the branchiostegite (Truesdale and Mermilliod, 1977). Carvalho (1942) observed that the presence of adults of the isopod parasite is easily recognized, because they produce a conspicuous swelling in the host's branchiostegite and he considered it as an ectoparasites. *Cryptoniscus* larvae can colonize the entire host's body without provoking any swelling and hence Schuldt and Damborenea (1988) have considered these *cryptoniscus* larvae as endoparasites.

2.3 INTENSITY OF PARASITIC INFESTATION IN WILD POPULATION OF PALAEMONID PRAWNS

A few studies are available regarding the above aspect. Chopra (1923) observed the percentage of infected prawns as above 50% in the Gangetic region, whereas Kunju (1956) stated that 9.9% of *Leander styliferus* was infected with isopods from the same. Kunju (1981) found the incidence of parasitism at Bombay region varied from 0.7 to 1.5% during 1960 to 68. At the same region the infestation of *Bopyrus squillarum* on *Nematopalaemon tenuipes* was found to be 1.78% during 1979 – 1981 (Deshmukh, 1984). Studies on the intensity of parasitic infestation on shrimps and prawns are limited (Thomas, 1977; Deshmukh, 1984; Jayaraj, 1999; Masunari *et al.*, 2000).

There are studies regarding the sexwise preference of infestation in prawns. Deshmukh (1984) observed that the parasitic invasion of *Bopyrus squillarum* on males and females of *Nematopalaemon tenuipes* are nearly equal and there is no preference to either sex in contrast to *Leander styliferus* in which parasitism was twice as common in males as in females (Kunju, 1956). But Allen (1966) observed that the parasite *Hemiarthrus abdominalis* was found to attach only to females of *Spirontocaris* and *Eualus pusiolus*. Similar observations were made by Kunju (1956) and Thomas (1977). Jayaraj (1999) reported a higher preference of female host by the parasite *Palaegyge alcocki*. Natarajan *et al.*, (1982) studied on the parasite of *M. equidens* from Netravati River of Karnataka. Jayaraj (1999) reported that the incidence of *P. alcocki* on *M. idella* was higher in females than that in males. There are similar studies on penaeid prawns (Nobili, 1906; Dawson, 1958; Chopra, 1923; 1930; Pillai, 1966) and alpheid shrimps (Thomas, 1977; Markham, 1985a). The close association of male and female parasites in

the same host has been reported by Oliveira and Masunari (1998) and Masunari *et al.*, (2000).

There are also studies on the sidewise preference (either left or right) in the branchial chamber of the host. Deshmukh (1984) observed that there is only one parasite in either left or right branchial cavity except in two instances. Roccata gliata and Lovrich (1999) reported that most branchial bopyrids occur nearly equally in the right and left gill chambers of their hosts but individual specimens are infested only in one chamber.

Generally the association of parasite and host are durable. But there are instances in which the parasites are shed (Hiraiwa, 1936; Pike, 1954; 1960; Bourdon, 1968; Beck, 1980; Somers and Kirkwood, 1991; Cash and Bauer, 1993; Roccata gliata and Lovrich, 1999).

2.4 BIOLOGY OF *PALAEGYGE ALCOCKI* CHOPRA, 1923

Pal and Ghosh (1975) studied the length-weight relationship of parasites *Palaegyge prashadi* and *Palaegyge bengalensis*. He concludes that *Palaegyge prashadi* infects smaller sized prawns, which have comparatively lesser space in the branchial chamber. Beyond a certain stage the parasite cannot grow in length but continues to gain in weight. *P. bengalensis* parasitizes the branchial chamber of larger prawns, where the branchial chamber is bigger and hence the parasite has more space for attaining greater length.

Deshmukh (1984) studied the size and growth of *Nematopalaemon tenuipes* infested by *Bopyrus squillarum* at Bombay in which the parasitised individuals appeared weak and slender than the normal ones. This is reflected in their length-weight relationship. Roccata gliata and Lovrich (1999) reported that the length of the mature female bopyrid *Pseudione* increased with the length of the crab, *Paralomis*. In some palaemonids, bopyrids show a highly positive

correlation between the length of the adult parasite and that of the host (Truesdale and Mermilliod, 1977; Cash and Bauer, 1993).

2.5 REPRODUCTION AND LIFE CYCLE OF BOPYRID ISOPODS

2.5.1 Male and female association

The finding of Cash and Bauer (1993) on the association of male and female parasite has been quite useful for the present study. The female parasite is tightly lodged within the branchial chamber of the host, producing a characteristic bulge in its branchiostegite. The male parasite is tightly wedged among the pleopods of the female.

2.5.2 Mature female

Roccatagliata and Lovrich (1999) classified the female parasites as either immature (with rudimentary oostegites, not meeting medially) or mature (with well developed oostegites slightly or completely overlapping each other). Masunari *et al.*, (2000) differentiated mature and immature stages of *Probopyrus floridensis* infesting *Macrobrachium potiuna* from the Perequé River as the mature females with incubatory lamellae, asymmetrical and ovarian bosses whereas immature females with symmetrical body and without incubatory lamellae and ovarian bosses. No much study is available on the subject.

2.5.3 Fecundity of *Palaegyge alcocki*

No studies are available on the bopyrid parasites.

2.5.4 Marsupial brooding

Markham (1985a) provides an excellent diagram of the brood chamber and oostegites and Cash and Bauer (1993) studied the reproduction of the parasite in relation to host ecdysis.

2.5.5 Embryonic developmental cycle

Cash and Bauer's (1993) observations are the only previous report on this area of research.

2.5.6 Preovulatory moult and ovulation

Isopods characteristically moult the posterior half of the cuticle before the anterior half and males usually copulate with the females in the half moulted condition, before the anterior part of the marsupium is fully formed. Moulting of the host is also a critical point in the reproduction of the *Probopyrus* sp. Walker (1984) reported that the hatching and releasing of epicaridium larvae takes place before the moult and a new spawning occurred after the moult. Beck (1980) also reported that the cycle of spawning to larval release occurred during the host intermoult. Cash and Bauer (1993) pointed out that the moment before and after the moulting, the female parasite flexed its body and this possibly related to its adjustment and firm attachment inside the new branchial chamber.

2.5.6.1 Host ecdysis and ovulation of parasite

Anderson (1977; 1990) reported that *Probopyrus pandalicola* is retained in *Palaemonetes pugio* even after a host moult. But Cash and Bauer (1993) reported a low percentage (2.7%) of parasite pairs having not survived after host ecdysis.

2.5.7 Incubation, 2.5.8 Hatching and 2.5.9 Epicaridea stage

Except for the work of Oliviera and Masunari (1998) on the cryptoniscus stage of bopyrid infesting porcelain crab, practically no other information is available on the subject.

2.6 EFFECTS OF BOPYRID INFESTATION ON THE SIZE, SEX AND BEHAVIOUR OF PALAEMONID PRAWNS

The effects of the parasitism are known for some host species. In the parasitized specimens, the primary and secondary sexual characteristics remain imperfectly developed or rudimentary or in degenerated condition irrespective of the size of the prawn and its maturity condition (Chopra, 1923; Menon, 1953; Thomas, 1977; Cash and Bauer, 1993). In *M. ohione* there was a reduction in the number of eggs due to *Probopyrus bithynis* infestation. Verdi and Schuldt (1988) reported that in *Palaemonetes argentinus* vitellogenesis is prevented due to the infestation of bopyrid, *Probopyrus ringueleti*. Hiraiwa and Sato (1939) found the gonads of parasitized individuals reduced or, in some males, completely atrophied. Majority of the workers recorded marked retardation of growth (Menon, 1953; Kunju, 1956; Dugan and Frakes, 1973) and ovarian development (Thomas, 1977; Walker, 1977) in bopyrid infested host species. Although the infestation does not cause immediate death it would probably affect the natural growth of the hosts to a great extent.

Materials and Methods

3. MATERIALS AND METHODS

3.1 SPECIES DIVERSITY AND TAXONOMY OF BOPYRID PARASITES OF COCHIN REGION

A total of 2033 prawns were collected from 3 stations of Cochin area (Perumbavoor, Panangad and Champakkara) for the present study. The period of collection was July 2002 to July 2003 for Perumbavoor and Panangad and October 2003 to September 2004 for Champakkara. From Perumbavoor and Panangad fortnightly collections were taken whereas monthly collections were taken from Champakkara. The collections were taken using cast net. Samples were also obtained from the fishermen.

The size of the prawns collected ranged between 2.0 cm and 9.9 cm. The infested prawns were sorted out from the whole collection and it was found that there were 266 cases of infestation.

The hosts were identified to species level with the help of literature (Jayachandran, 2001). It was found that there were five species represented in the collection of prawns (*Macrobrachium idella*, *M. scabriculum*, *M. equidens*, *M. sulcatus* and *M. rosenbergii*).

The identification of parasites was done by consulting the detailed descriptions already available for the bopyrids (Chopra, 1923, 1930; Markham, 1985a). The specimens were drawn to scale. It was found that *M. idella* and *M. scabriculum* were infested with different parasites. A whole mount preparation was also made. Photographs were taken using microscopic camera and digital camera.

3.2 HOST - PARASITE RELATIONSHIP

The mode of attachment was studied in preserved specimens by cutting open the host's branchiostegite. The parasite was exposed. The

type of attachment was studied under the microscope. The following observations were made.

1. Lengths of the host and parasite of 30 specimens each were accurately measured.
2. Length of male and female parasites was separately taken.

Infested live specimens were reared in aquarium tanks (3 x 1.5 x 1.25 feet) and daily observations were made to study the behaviour of host and parasite. Under these conditions moulting of the host as well as parasites could be observed and data recorded.

From the data collected minimum size of infestation and maximum size of infestation as well as predominant infestation size could accurately calculated. The data were analysed from the samples collected from all 3 stations and presented separately. A summary of relationship (consolidated picture) was also calculated from the above data.

3.3 INTENSITY OF PARASITIC INFESTATION IN WILD POPULATION OF PALAEMONID PRAWNS OF COCHIN REGION.

From the 2033 prawns (*Macrobrachium* spp) collected, the specimens of 1353 *M. idella* were sorted out and subjected to further analysis. The following data were collected.

1. Total number of prawns observed 1353 – it is the summation of all the prawns collected during the period from July 02 to July 03 at Perumbavoor and Panangad and October 03 to September 04 at Champakkara.
2. Total number of prawns infested 261 – it is the sum of all infested prawns during the above period from 3 stations.

3. Total number of prawns with parasites 248 – it is the sum of all infested prawns with parasite inside the branchial chamber during the above period for 3 stations.
4. Total number of prawns with swelling of branchiostegite but without parasites 13. In some cases the host was found to have a swelling in the branchiostegite but no parasite was seen inside. Probably the parasites must have been lost during the moulting of the host. The numbers of such prawns were also taken from 3 stations during moulting of the host. The numbers of such prawns were also taken from the 3 stations during the above period.
5. Infestation on left side / right side: Either one of the sides of the prawns was infested with isopods. Such details of individuals were taken and recorded.
6. Sex of the prawn was determined by examining the second pleopod. In males, the second pleopod contains exopod, endopod, appendix masculina and appendix interna. In females, appendix masculina is absent. No other sexually linked characters could be noticed in infested prawns (In prawns not infested with the parasite, the second pereopod of male is overdeveloped than in females).

From this data, calculations were made for the following aspects.

1. Intensity of infestation
2. Sexwise infestation
3. Sidewise infestation
4. Sizewise infestation
5. Indication of infestation
6. Monthwise infestation

3.4 BIOLOGY OF *PALAEGYGE ALCOCKI* CHOPRA, 1923

From the 238 infested specimens of prawns of the Perumbavoor station, 30 specimens were randomly selected for studying the length – weight relationship of both host and parasite.

Length of the parasite was taken from anterior tip of the body to the tip of the sixth abdominal segment with the help of a divider. Length of the host was measured from the tip of rostrum to tip of telson. In both host and parasite weight was measured with the help of an electronic balance high accuracy class II (Contech Instrument Company, Mumbai).

Similarly carapace length of the host (from tip of rostrum to posterior end of carapace) and total length of male parasite and female parasite were also measured. Relation between total length of host and total length of parasite; carapace length of the host and total length of male and female parasite and total length of male and female parasites were worked out by using least square method.

3.5 REPRODUCTION AND LIFECYCLE OF *PALAEGYGE ALCOCKI* CHOPRA, 1923

The male parasite is diminutive and usually seen in between the pleopods of the female parasite. For studying the association of male and female parasite, preserved specimens were utilized. The branchiostegite of 5 specimens were cut off and the position of attachment was studied under microscope. The male - female association was also observed in live specimens under laboratory conditions.

Mature and immature female parasites were distinguished mainly based on the following characters are given below.

1. Size
2. Pigmentation of the thoracic region.

3. Oostegites (whether well developed or otherwise)
4. Ovarian development (Ovarian bosses)
5. Body shape (symmetrical or asymmetrical)

Fecundity of the parasite was estimated by removing the eggs from the brood chamber. The total weight of the brood was taken. The total length of the parasite, total width of the parasite, total weight of the parasite were noted and the total number of eggs was estimated by actual counting

From the above data, the fecundity was correlated with total length, total weight, total width and total brood weight by using regression analysis. Correlation of brood weight and female parasite weight were also worked out. The data were fitted to least square method.

Live specimens were collected from Perumbavoor station (Periyar River) and brought to laboratory for further study. Daily observations were made in order to study the marsupial brooding, embryonic developmental cycle, size of ova, preovulatory moult and ovulation, host ecdysis and subsequent ovulation of parasite, hatching and the first post-embryonic stage. Embryonic stages were assessed based on colour of ova (during embryonic development colour changes from white to brown).

3.6 EFFECTS OF *PALAEGYE ALCOCKI* ON THE SIZE, SEX AND BEHAVIOUR OF *MACROBRACHIUM IDELLA*

The observations made above were utilized for discussing territorial behaviour of prawns, secondary infections, parasitic effect on reproduction, loss of gill plates and reduction of respiratory efficiency. The observations were made in both live and preserved specimens.

Results

4. RESULTS

4.1 SPECIES DIVERSITY AND TAXONOMY OF BOPYRID PARASITES OF COCHIN REGION.

4.1.1 Species diversity

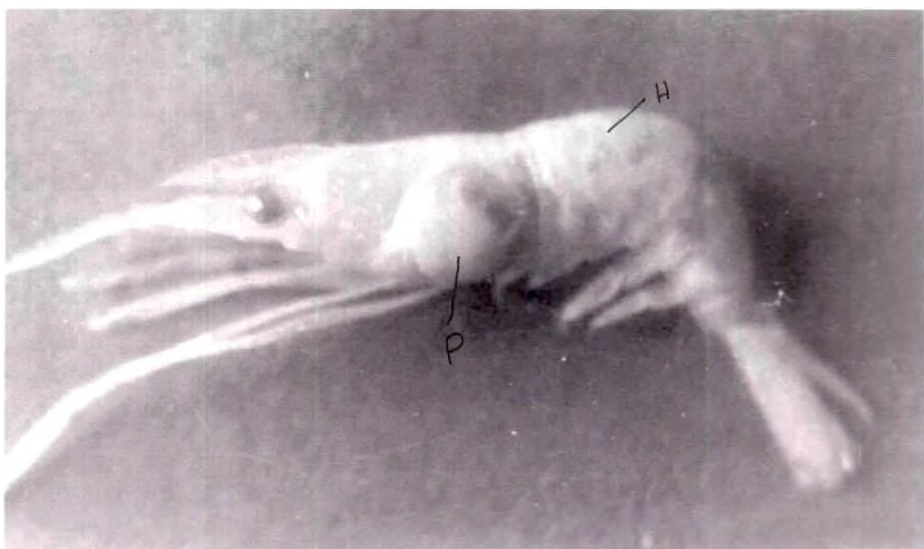
Five species of fresh water prawns have been reported from the Cochin region namely, *Macrobrachium rosenbergii* (De Man), *M. idella* (Hilgendorf), *M. equidens* (Dana), *M. sulcatus* (Henderson & Matthai) and *M. scabriculum* (Heller). During the present study, all of them were collected from different regions of Cochin backwaters and also from Periyar River at Perumbavoor. They were subjected to further studies for parasitic infestation. The details of infestation are given in Table 1. It was found that out of the five species, only two species namely *M. idella* and *M. scabriculum* were infested with bopyrids. The infestation was found to be maximum on *M. idella* and it was only a stray occurrence on *M. scabriculum*. The parasites thus collected were identified to species level. It was found that the bopyrid parasites of the two species, though showing close similarity, differ in certain characters. The major characters by which they differ are given in Table 2. The bopyrid parasite of *M. idella* has been identified as *Palaegyge alcocki* Chopra, 1923 whereas that of *M. scabriculum* as a new variety of *P. alcocki*, *P. alcocki* var. nov. *cochinensis* (Plate. 1, A, B)

Table 1. Percentage infestation of bopyrids on different species of *Macrobrachium* Bate, 1868 of Cochin region.

| S. No | Host species | Total no of prawns examined | Total no of prawns infested | Percentage of infestation |
|-------|-----------------------|-----------------------------|-----------------------------|---------------------------|
| 1 | <i>M. idella</i> | 1353 | 261 | 19.29 |
| 2 | <i>M. scabriculum</i> | 150 | 5 | 3.33 |
| 3 | <i>M. equidens</i> | 265 | 0 | 0 |
| 4 | <i>M. rosenbergii</i> | 120 | 0 | 0 |
| 5 | <i>M. sulcatus</i> | 145 | 0 | 0 |

Table 2. A comparison of characters of bopyrids from *M. idella* and *M. scabriculum* of Cochin region.

| Characters of parasite | From <i>M. idella</i> | From <i>M. scabriculum</i> |
|---------------------------|--------------------------------|----------------------------|
| Body shape | Asymmetrical | Highly asymmetrical |
| Total Length (mm) | 10-12 (size of host- 45 to 65) | 12(size of host- 45) |
| Cephalothorax shape | Round | Oval |
| Cephalothorax length (mm) | 6 | 8 |
| Cephalothorax width (mm) | 9 to 10 | 8 |
| Abdomen | Wider | Narrow |
| Abdomen length (mm) | 4 | 4 |
| Abdomen width (mm) | 5 | 4 |
| Pleotelson | Triangular; deeply cleft | Round, not deeply cleft |
| Last pleon | Tip darkly pigmented | Tip not pigmented |



(A)



(B)

Plate 1. Bopyrid infestation: (A) Bopyrid parasite *Palaegyge alcocki* on *Macrobrachium idella* (B) Bopyrid parasite *P. alcocki* var. nov. *cochinensis* (P – parasite; H – host).

4.1.2 Taxonomy of *Palaegyge alcocki* Chopra, 1923, (Isopoda: Bopyridae)

4.1.2.1 Systematic position of *Palaegyge alcocki* Chopra, 1923

| | | |
|------------|---|--|
| Subphylum | : | Crustacea Pennant, 1777 |
| Class | : | Malacostraca Latreille, 1806 |
| Subclass | : | Eumalacostraca Grobben, 1892 |
| Superorder | : | Peracarida Calman, 1904 |
| Order | : | Isopoda Latreille, 1817 |
| Suborder | : | Epicaridea Latreille, 1831 |
| Family | : | Bopyridae Rafinesque, 1815 |
| Subfamily | : | Bopyrinae Rafinesque, 1815, |
| Genus | : | <i>Palaegyge</i> Giard and Bonnier, 1888, |
| Species | : | <i>P. alcocki</i> Chopra, 1923 |

4.1.2.2 Diagnostic characters of the order *Isopoda* Latreille, 1817

1. Body dorsoventrally flattened, divided into three distinct regions: cephalon, pereon and pleon.
2. Cephalon with a pair of sessile compound eyes; covers segments bearing paired antennules, mandibles, maxillulae, maxillae and maxillipeds.
3. Long thorax of eight pereomeres, of which the first segment fused with head and the remaining seven segments, each bear pairs of uniramous pereopods, appear more or less alike (iso = alike; podo = appendage)
4. Abdomen short of six pleomeres, the last of which fused with telson forming pleotelson. It bears six pairs of biramous pleonal appendages including five pairs of pleopods and a single pair of uniaarticulate uropods.

The Order Isopoda contains nine Suborders, namely, Phreatoicidea, Anthuridea, Microcerberidea, Flabellifera, Asellota, Calabazoidea, Valvifera, Oniscidea and Epicaridea. Isopoda includes both free living as well as parasitic forms and parasitic isopods of the present study come under the Suborder Epicaridea.

4.1.2.3 Diagnostic characters of the Suborder Epicaridea Latreille, 1831 (Based on Markham, 1985)

1. Ectoparasites on other crustaceans (Malacostracans, Ostracods, Copepods, Cirripeds)
2. Body divided into cephalon, pereon and pleon.
3. Carapace absent.
4. Eyes sessile compound.
5. Cephalon covers five cephalic and one thoracomere; pereon usually with seven segments; pleon usually with five segments and a pleotelson.
6. Segments of the cephalon bear paired reduced appendages: antennules, antennae, mandibles, maxillulae, maxillae and maxillipeds.
7. Thoracopods reduced or absent.
8. Abdominal appendages reduced.

The Suborder Epicaridea is divided into two Superfamilies- Bopyroidea Rafinesque, 1815 and Cryptoniscidea Kossmann, 1880

4.1.2.4 Diagnosis of families of Bopyroidea Rafinesque, 1815

(Based on Markham, 1985)

1. Body of female without indication of rigid exoskeleton, seemingly undifferentiated, but body divisions and segmentation present; pereonites expanded laterally into thin plates; maxillipeds are the only recognizable mouth parts; pereopods stubby or absent; endoparasites in

body cavity of decapod crustaceans**Entoniscidae** Kossmann, 1881

2. Body of female distinctly segmented; pereonites not expanded laterally into thin plates; mouth parts rudimentary; pereopods prehensile; seven present on one side, but all except first may be absent on the other side; parasites of branchial cavity or on pleopods of decapod crustaceans**Bopyridae** Rafinesque, 1815

The present species *Palaegyge alcocki* belongs to Family Bopyridae and it is dealt in detail below. The members of the family exhibit extreme sexual dimorphism; males are much smaller than females.

4.1.2.5 Diagnostic characters of family Bopyridae Rafinesque, 1815

4.1.2.5.1 Female:

Body distinctly segmented, dorso-ventrally flattened (depressed) slightly to greatly asymmetrical. Head occasionally fused with first pereomere, sometimes enclosed by frontal lamina; posteroventral border of head usually with one or two lateral projections on each side; antenna rudimentary; maxilliped of two segments often with anteromedial palp. All pereomeres usually distinct; pereopods reduced, usually of seven pairs, although up to six occasionally absent from one side; prehensile, dorsal to lateral, isomorphic; oostegites of five (rarely seven) pairs loosely fringing to completely concealing ventral surface. Pleon of three to six pleomeres with sides often produced into lateral plates resembling pleopodal rami; pleopods generally present on all but final pleomere; pleopods rudimentary or modified for respiration, uniramous or biramous, isomorphic; uropods, when present, terminal, uniramous or biramous, often of same form as pleopods or lateral plates.

4.1.2.5.2 Male:

Body much smaller than that of female, at least twice as long as wide, symmetrical, distinctly segmented. Head rounded anteriorly,

occasionally fused with first pereomere; antennae often prominent. Pereon of seven distinct pereomeres; pereopods paired and ventral, prehensile, usually isomorphic except first and sometimes second rarely conspicuously larger than others. Pleon of one to six pleomeres; if unisegmented, usually lacking appendages; if multisegmented, often with sessile to flaplike uniramous or biramous pleopods on each pleomere but last; uropods, if present, uniramous or biramous and terminal. Ectoparasites of decapod crustaceans.

4.1.2.6 Key to Subfamilies of Bopyridae Rafinesque, 1815 of India

(Based on Markham, 1985)

1. Brood pouch extending far beyond sides of pereon, at least partly formed by five pairs of loosely overlapping, stiff oostegites of nearly equal size; pleopods, when present, not pedunculate; infesting hosts bronchially 2
- Brood pouch large, flaccid sac extending slightly to far beyond at least one side of pereon, tightly enclosed by flexible oostegites, usually fewer than five pairs and of unequal sizes; pleopods and lateral plates, when present, pedunculate; infesting hosts abdominally..... 5
2. Brood pouch completely enclosed by oostegites; usually infesting brachyurans or anomurans 3
- Brood pouch usually completely open, most or all of ventral surface of pereon exposed (if brood pouch nearly closed, pleon almost fused or sharply twisted; infesting carideans) 4
3. Lateral plates sometimes absent, at most ovate, none directed forward; pleopodal rami ovate to lanceolate, both with smooth margins; infesting anomurans or, rarely, carideans **Pseudioninae**
- Lateral plates and pleopodal rami always present, elongate, with tuberculate to digitate margins; at least first lateral plates directed forward; infesting brachyurans **Ioninae**

4. Head oval or fusiform, never fused with pereon; lateral plates pedunculate; pleopods knoblike, uniramous..... **Argininæ**
- Head subrectangular or subtriangular or more or less fused with pereon. Lateral plates, if present, not pedunculate; pleopods flaplike, usually biramous **Bopyrinæ**
5. Body highly asymmetrical; brood pouch formed by oostegites on one side of body only and extending far to opposite side; infesting carideans ventroabdominally **Hemiarthrinæ**
- Body large, oval, larger than broad and slightly asymmetrical. Epimera of thoracic somites being highly developed with rounded upper margins. Rami of abdominal appendages covered with warts and tubercles **Orbioninæ**

Palaegyge alcocki Chopra 1923 belongs to the Subfamily Bopyrinæ

4.1.2.7 Key to genera of Subfamily Bopyrinæ of India

(Based on Chopra, 1930; Markham, 1985)

1. Pleon with posterior edge pointing forward. Body markedly asymmetrical. Lateral plates of abdominal somites present and the last pleonite cleft posteriorly. Uropods rudimentary..... *Palaegyge* Giard and Bonnier, 1888
- Pleon extending straight back or nearly so 2
2. Head and pereon separate 3
- Head completely fused with first pereomere; body elongate; pleomeres fused, sutures not indicated laterally..... *Bopyrella* Bonnier, 1900
3. Pleomeres (five to six in number) separate and laterally distinct 4
- Pleomeres distinctly separated on long side but completely fused on short side..... *Bopyrina* Kossmann, 1881
4. Five pairs of biramous pleopods, two lateral projections on each side

- of posteroventral border of head; first oostegite extended into prominent posterolateral point*Probopyrus* Giard and Bonnier, 1888
- Three or four pairs of uniramous or biramous pleopods as obscure ridges; maxilliped palp not articulating with maxilliped*Bopyroides* Stimpson, 1864

So far there are 67 genera reported under the subfamilies Pseudioninae, Ioninae, Argeiinae, Bopyrinae, Athelginae, Hemiarthrinae, Orbioninae. The genera reported under Pseudioninae are: *Asymmetrione*, *Bopyrissa*, *Parapagurion*, *Aporobopyrina*, *Pleurocryptosa*, *Anuropodione*, *Pseudione*, *Pontobopyrus*, *Aporobopyrus*, *Pleurocryptella*, *Parapleurocryptella*, *Pleurocryptina*, *Galathocrypta*; Genera under Ioninae are: *Procepon*, *Upogebione*, *Hypocepon*, *Coxalione*, *Metacepon*, *Allokepon*, *Kepon*, *Megacepon*, *Trapezicepon*, *Tylocepon*, *Dactylocepon*, *Ionella*; Genera under Argeiinae: *Argeia*; under Bopyrinae the genera reported are: *Metabopyrus*, *Probopyrus*, *Parabopyrella*, *Bopyrella*, *Bopyrinella*, *Bopyrina*, *Bathygyge*, *Probopyrinella*, *Urobopyrus*, *Parabopyriscus*, *Probopyria*, *Schizobopyrina*, *Bopyroides*, *Bopyrione*, *Ovobopyrus*, *Synsynella*, *Palaegyge*, *Bopyrus*, *Bopyrinina*, *Palaemonellione*, *Probynia*; Genera under Athelginae: *Pseudostegiae*; Hemiarthrinae contains 16 genera which are: *Diplophryxus*, *Hemiarthrus*, *Allodiplophryxus*, *Eophryxus*, *Loki*, *Dicropleon*, *Hyperphryxus*, *Metaphryxus*, *Azygopleon*, *Mesophryxus*, *Stegophryxus*, *Hypophryxus*, *Eriphryxus*, *Mediophryxus*, *Filophryxus*, *Stegoalpheon*; Genera under Orbioninae: *Orbione*, *Epipenaeon*, *Parapenaeon*. So far 18 genera and 36 species of bopyrid isopods reported from India, coming under six subfamilies namely Pseudioninae, Ioninae, Argeiinae, Bopyrinae, Hemiarthrinae, Orbioninae. The genera are *Palaegyge*, *probopyrus*, *Bopyrina*, *Bopyroides*, *Bopyrella*, *Bopyrus*, *Pseudione*, *Stegoalpheon*,

Hemiarthrus, Diplophryxus, Hypophryxus, Megacepon, Tylocepon, Epipenaeon, Annina, Argeia, Parapleurocrypta, Orbione.

4.1.2.8 Diagnostic characters of *Palaegyge alcocki* Chopra, 1923

4.1.2.8.1 Female (Fig. 1, 2; Plate. 2. A, B)

Measurements (mm): Total length 10 to 12 (from anterior border of cephalon to tip of sixth pleonite); maximum width 9 to 10 (at third pereonite); abdomen length 2 to 5 (from anterior of first pleonite to posterior of sixth pleonite); abdomen width 2 to 6 (at second pleonite).

Body highly dorsoventrally flattened and consists of Cephalon, Pereon and Pleon. Body pale yellow; pigmentation or dark spots appear in the posterodorsal border of head and in 7 pereomeres on the concavity of the shorter side of the body. The dextral females have the body axis distorted on the ventral side with right side longer, head displaced to left and they are found in the right gill chamber of hosts. The sinistral females found in the left gill chamber have the body axis distorted with left side longer and head displaced to right (Plate. 3 A, B).

Cephalon almost as wide as long, front rounded, separated from the first pereomere, enclosed by frontal lamina, mid longitudinal groove shows the appearance of two halves, posteroventral border of the head produced into lateral projection and anterior border is regularly rounded. Antennae are greatly reduced than antennule; maxilliped bisegmented. Eyes are totally absent.

The first thoracic segment is short compared to the second segment. Distinct seven pereomeres, isomorphic pereopods usually of 7 pairs, occasionally 6, found on the deformed side. Thick fleshy ridges on the mid ventral thorax. Ovarian bosses well developed. Oostegites of 5 pairs loosely fringing to completely sealing the ventral surface. Caudal lobe of the oostegite is rounded and narrow. The first and second pair of oostegites appears in the cephalon extending to pereon region. Third and

fourth pair of oostegites in the sides of the thoracic region; and the last and fifth pair of oostegites in the posteroventral thoracic border bearing stiff hairs. The first and fifth pair of the non-deformed side is overlapping the deformed side of the parasite. All the 5 pairs of oostegites are shown in Fig. 3.

Pleon has 6 pleomeres and covers the entire surface of the abdomen. The sides of pleomeres produce lateral plates resembling the rami of pleopods. Pleopods are rudimentary, isomorphic and modified for respiration. The rudimentary uropods are present at the base of the sixth segment. The tip of the last pleon is darkly pigmented.

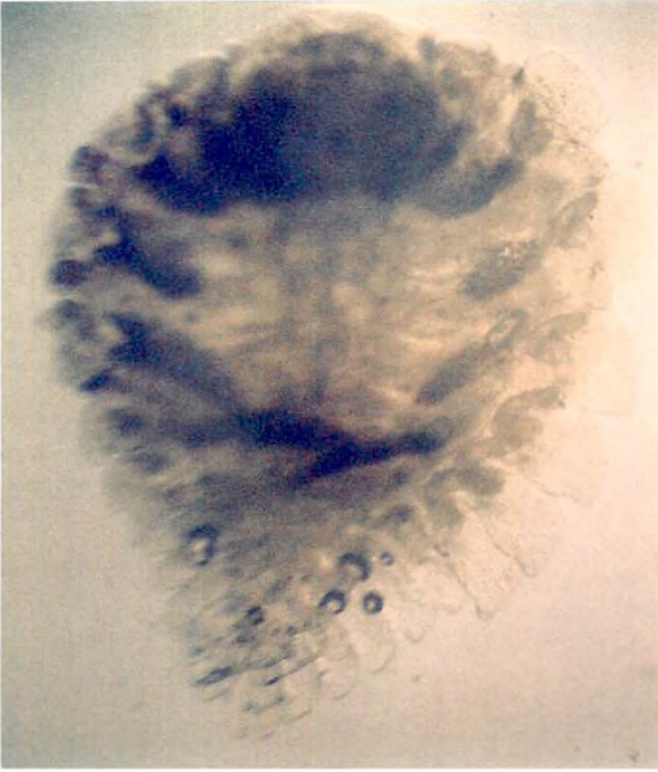
4.1.2.8.2 *A new variety female (Fig 4)*

The characters specific to *P. alcocki* are applicable here also. But the new variety is characterized by the absence of colouration at the tip of the last pleon, abdomen is narrower, one part of the anterior side of body is highly elongated, cephalothorax is oval in shape and pleotelson is round and not deeply cleft. Hence it is included as a new variety.

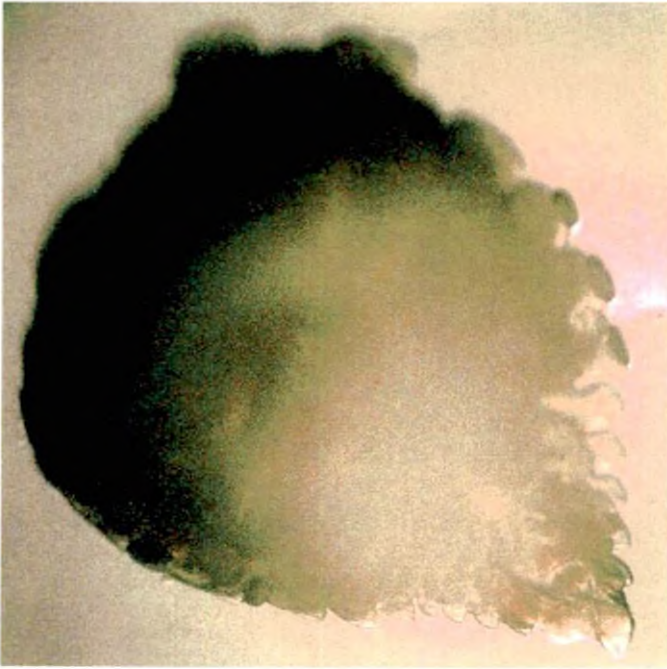
4.1.2.8.3 *Male (Fig. 5; Plate 4 A, B; 5C)*

Measurements: Total length 2-3 mm, maximum width 1.5-1.75 mm; body unpigmented, whitish; much smaller than the female nearly one third to one fourth of its length; at least thrice as long as wide; body symmetrical and distinctly segmented.

Head twice as wide as long, antennae bisegmented, antennular peduncle three segmented. A pair of small eyes present. Mandibles long and curved, maxillae is present behind the mandible, maxilliped absent. Distinct seven thoracic segments; seven pairs of isomorphic pereopods. Six pleonites; the first four segments of pleon are distinct; fifth pleomere very small and protrudes before the sides of the sixth segment; 4 pairs of pleopods present. Uropod rudimentary.



(A)



(B)

Plate 2. *Palaegyge alcocki*: (A) Ventral side (B) Dorsal side

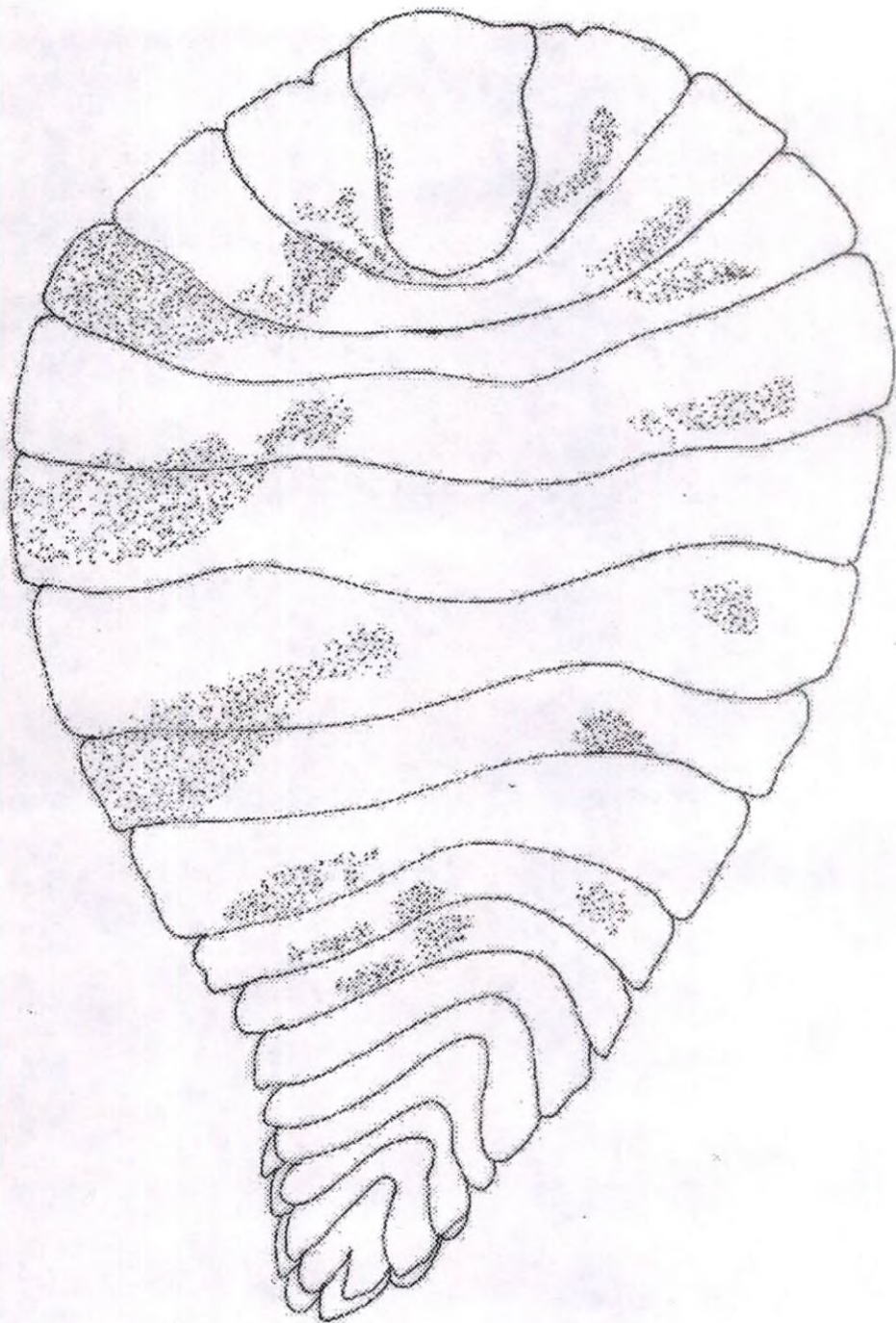


Fig. 1. *Palaegyge alcocki* Chopra, 1923, Cochin, India. Female in dorsal view.

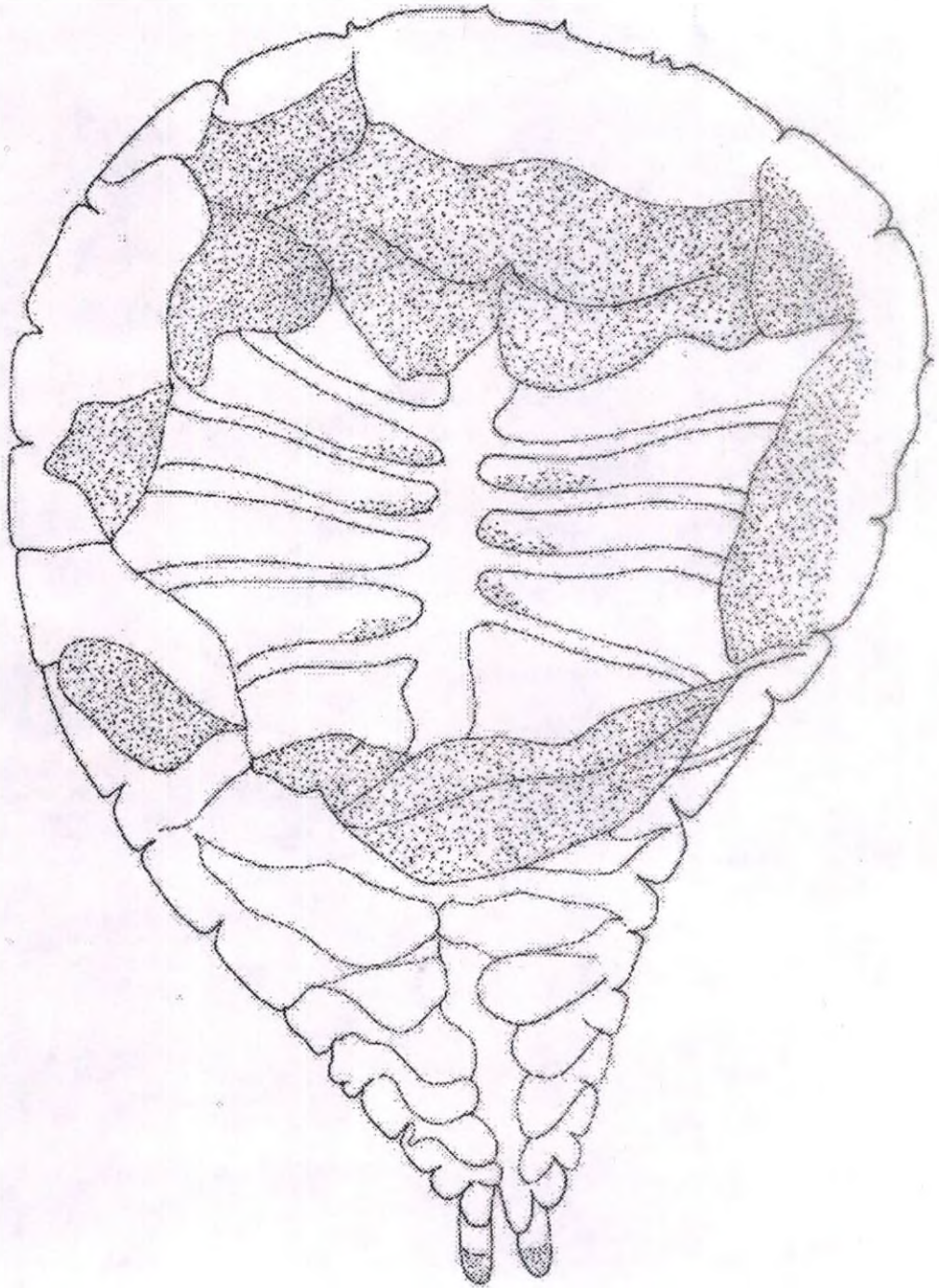
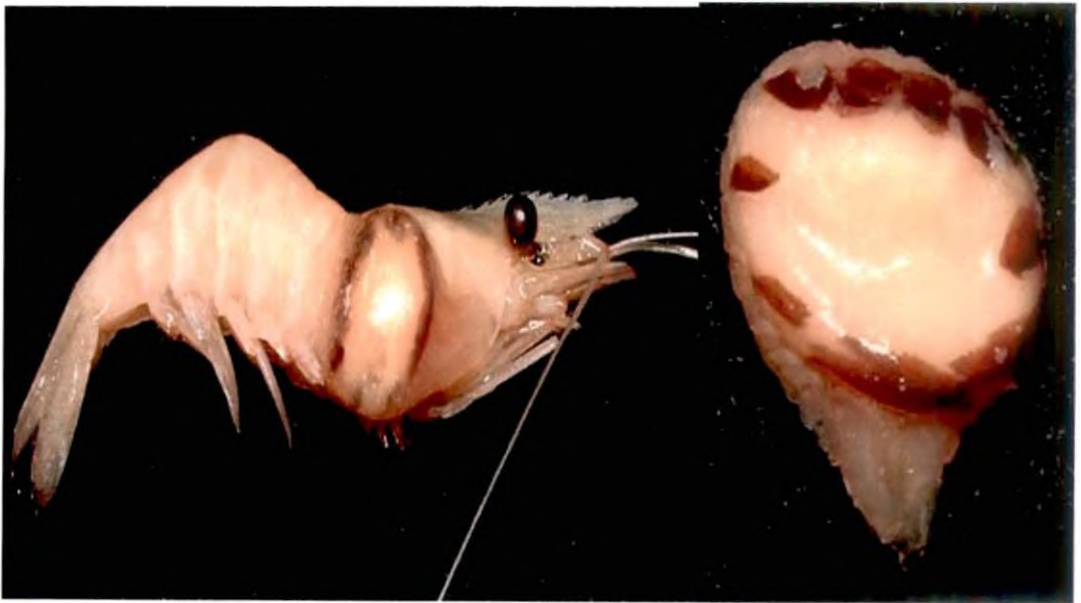


Fig. 2. *Palaegyge alcocki* Chopra, 1923, Cochin, India. Female in ventral view.



(A)



(B)

Plate 3. *Palaegyge alcocki* infestation on *Macrobrachium idella*: (A)

Sinistral females B) Dextral females

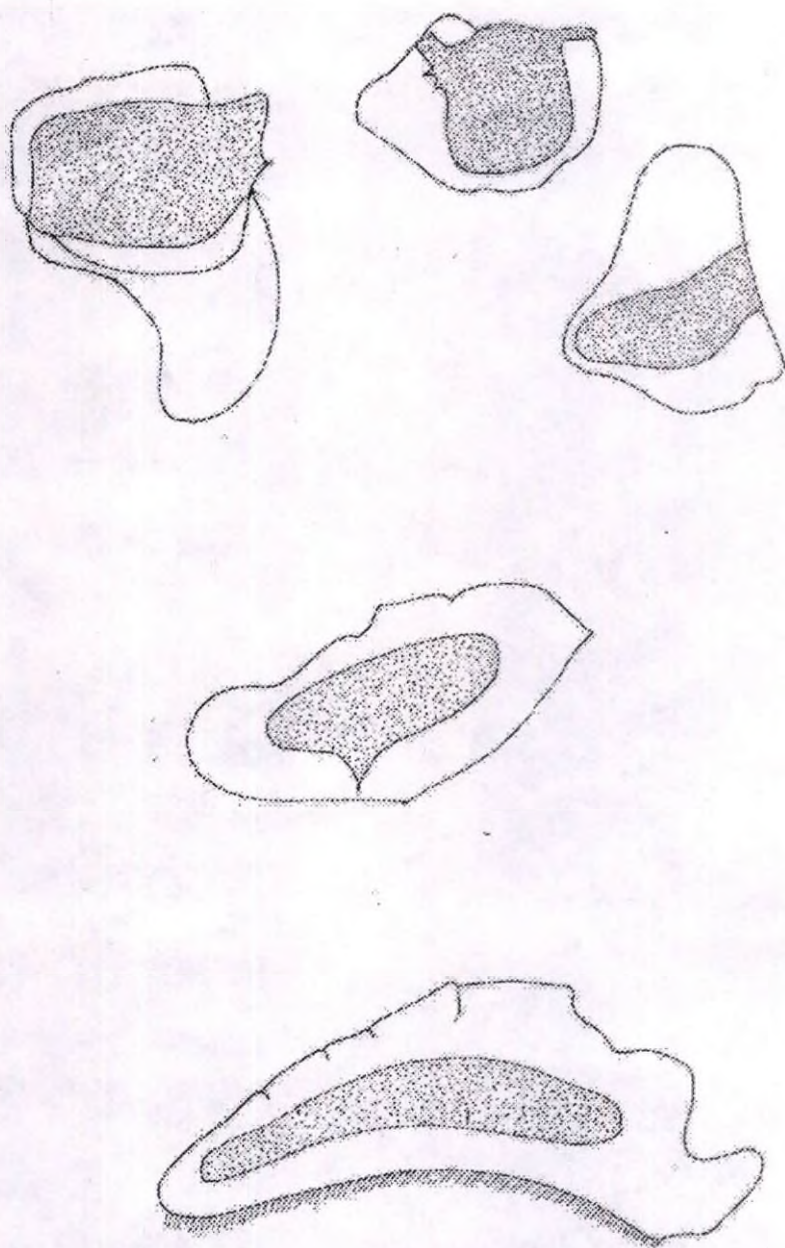


Fig. 3. Oostegite 1 – 5 pairs from *Palaegyge alcocki* Chopra, 1923.

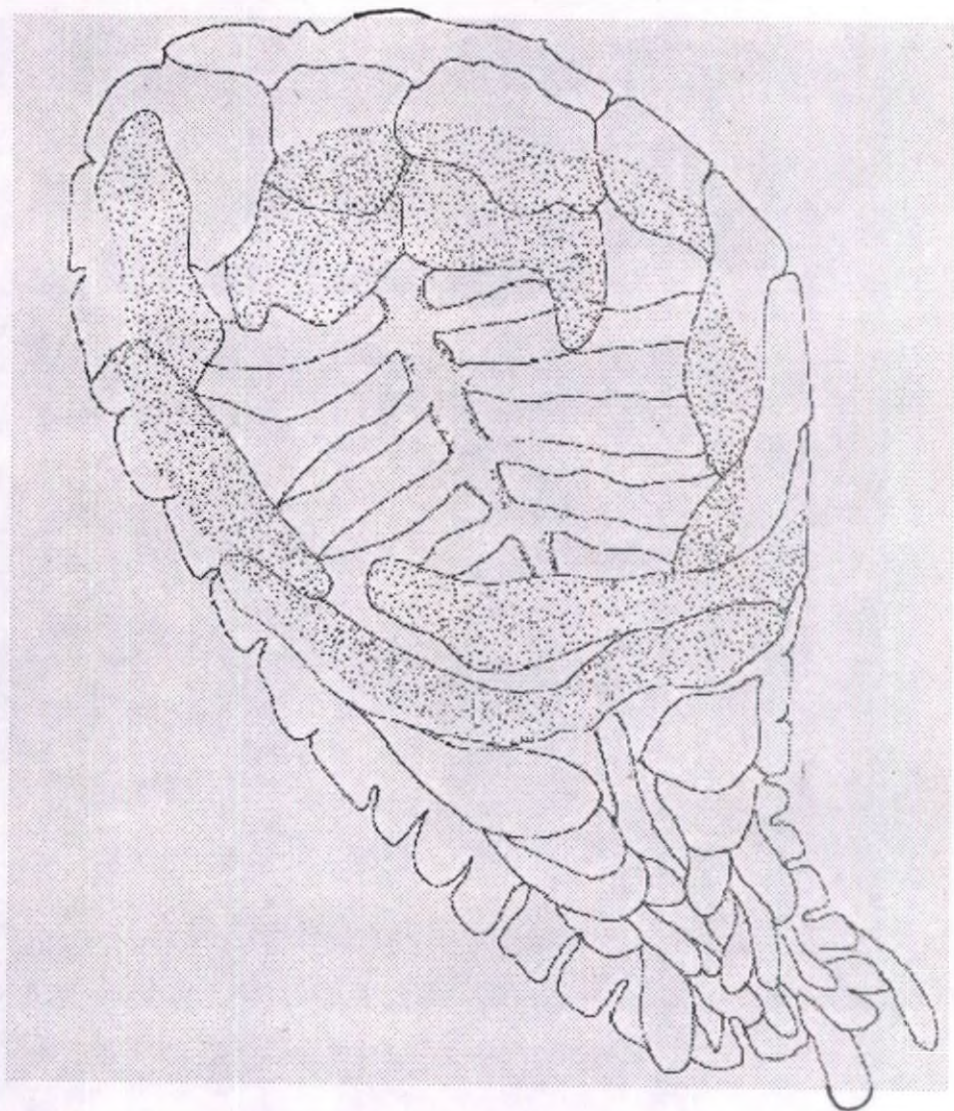


Fig. 4. Isopod bopyrid, *Palaegyge alcocki* var. nov. *cochinensis*, female in ventral view from *M. scabriculum*, Cochin, India.



(A)



(B)

Plate 4. Male *Palaegyge alcocki* (whole mount slides): (A) Dorsal side
(B) Ventral side

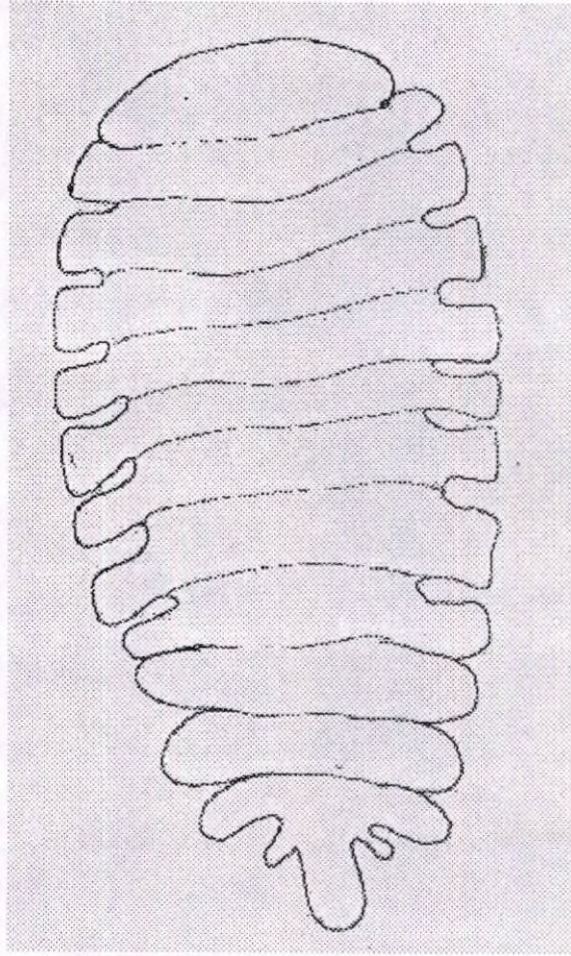


Fig. 5. Male of *Palaegyge alcocki*, dorsal view.

4.1.2.8.4 A new variety male

Measurements: Total length 2 mm; maximum width 1 mm; abdomen length 4 mm; abdomen width 4.5 mm. Body unpigmented, whitish; much smaller than the female nearly one third of its length; at least thrice as long as wide; body symmetrical and distinctly segmented. Head wider, second thoracic somite is bigger than the first and then succeeding ones are consequently reducing in size. The structural details are same as above.

4.1.2.9 Key to species of Palaegyge infesting Macrobrachium in India (modified from Chopra, 1930)

1. Uropod present between the 5th pleonite and pleotelson; Last pleonite deeply cleft *Palaegyge borrei* Giard and Bonnier, 1888
- Uropod in advance or posterior extreme of pleotelson; body yellowish with or without prominent patch or spots 2
2. Uropods in advance of posterior extreme of pleotelson; body light yellow with no prominent spots.. *Palaegyge bengalensis* Chopra, 1923
- Uropod at posterior extremity of pleotelson; Last pleonite large and triangular 3
3. First thoracic segment shorter than second; body pale yellow with broad colour patches 4
- First thoracic segment longer than second; body more yellowish with dark spots... .. *Palaegyge pica* Chopra, 1923
4. Last pleon with dark pigmentation concentrated at the tip, abdomen wider... .. *Palaegyge alcocki* Chopra, 1923
- Last pleon without pigmentation at the tip, Abdomen narrow... .. *P. alcocki* var. nov. *cochinensis*.

Table 3. Characters, which would differentiate adult female parasite (*Palaegyge alcocki*, *P. pica* and *P. bengalensis*)

| Sl.no | Characters | <i>P. alcocki</i> | <i>P. pica</i> | <i>P. bengalensis</i> |
|-------|-------------------------------|--|---------------------------------------|---|
| 1 | Host | <i>M. idella</i> and <i>M. malcomsonii</i> | <i>Leander</i> and <i>Palaemon sp</i> | <i>M. malcomsonii</i> and <i>M. rosenbergii</i> |
| 2 | Body shape | Asymmetrical | Asymmetrical | Asymmetrical |
| 3 | Eyes | Absent | Absent | Absent |
| 4 | Adult size (length, width) mm | 10 to12; 9 to10 | 9; 8 | Details not available |
| 5 | Body colour | Pale yellow | More yellowish | Light yellow |
| 6 | Pigmentation | Broad colour patches | Dark spots | No prominent spots |
| 7 | Thoracic somite | First somite shorter than second | First is longer than second | Details not available |
| 8 | Abdominal last somite | Large and triangular | Large and triangular | Narrow and deeply cleft |
| 9 | Oostegites | 5 pairs | 5 pairs | 5 pairs |
| 10 | Caudal lobe (Oostegite) | Rounded; narrow not broader | Details not available | Rounded; not broader |
| 11 | Pleon | Longer exopodites | Longer endopodites | Details not available |
| 12 | Uropods | Rudimentary at base of sixth segment | Posterior extremity of pleotelson. | Posterior margin of pleotelson |

Table 4. Characters, which would differentiate adult male parasite (*Palaegyge alcocki*, *P. pica* and *P. bengalensis*).

| No | Characters | <i>P. alcocki</i> | <i>P. pica</i> | <i>P. bengalensis</i> |
|----|-------------------|------------------------------|------------------------------------|------------------------------|
| 1 | Body shape | Symmetrical | Symmetrical | Symmetrical |
| 2 | Size | 2-3 mm | 1.5-3mm | Details not available |
| 3 | Colour | Translucent | Translucent | Translucent |
| 4 | Pigmentation | No prominent pigment spots | Longitudinal 3 discontinuous bands | No pigment spots |
| 5 | Abdomen | Two-fifth the length of body | One-third the total length | Two-fifth the length of body |
| 6 | Abdominal somites | Distinct | Distinct | Distinct |
| 7 | Pleotelson | Finger shape | Semicircular | Rounded |
| 8 | Pleopods | 4 pairs | 3 pairs; perhaps 4 | 4 pairs |
| 9 | Uropods | Present | Wanting | Wanting |

4.2 HOST -PARASITE RELATIONSHIP

4.2.1 Mode of attachment and association

Bopyrid isopods are typical ectoparasites of shrimps, seen on the branchial chamber. The presence of the parasite on the host can be easily distinguished by the characteristic swelling of the branchiostegite at region where the parasite is seen. Usually the male and female parasites live in close association (Plate. 5A). The male parasite is dwarf, symmetrical and resides in between the pleon of the female parasite (Fig. 6). While in this position, the female parasite punctures the host and sucks the haemolymph. Adult parasites are asymmetrical in shape. The dorsal surface of the female parasite closely invests on the host's gills from posterior to anterior ones and its ventral surface is protected by the carapace of the host. The pereopods do not seem to be the organs for attachment to the host. The male and female parasite depends on the host for respiration, protection and living space. The lifecycle of the parasite is fully adapted for peculiar reproductive aspects such as brood aeration, marsupial brooding, hatching, larval releasing etc.

Parasite as well as host exhibits concurrent development. Table 8 clearly indicates that the parasite grows along with the host. The parasite infests the juvenile *M. idella*, at its early stage of lifecycle. It was observed that the parasite infests prawns at a size less than 2.5 cm in samples from Perumbavoor, Panangad and Champakkara stations (Tables 5, 6, 7 and 8). However the stage at which it infests could not be ascertained.

It was of great interest to observe that during moulting the parasites were retained in the chamber. In order to confirm this, live specimens were reared in aquarium and observed repeatedly for 15 times. It was also observed that the parasite brooding never coincided with the moulting of the host. The host moulting and parasite spawning occurs sequentially so that the parasite life cycle is not affected.

Another notable observation was that the parasite could not prolong life after the death of the host. When the parasite was removed from the host, it died after 5-10 min. It was observed under lab conditions, that when the host was dead, the parasite tried to change its position and flexed its body for 5-10 minutes. Later the parasite was found to be motionless and eventually dead. Hence, there exists a dependant relationship between parasite and the host.

Tables 5, 6, 7 and 8 reveal that the parasites (both male and female) grow along with host's body. The minimum size of host at which the parasite infests the prawns is 2.5 cm and the minimum size at which the male parasite attaches the female is around 0.35 cm length of the female parasite. The maximum size of the host with parasite was 6.2 cm and maximum size of parasite is 1.2 cm (female) and 0.37 cm (male).

Table 5. Relationship between sizes of host and parasite of Perumbavoor station.

| Total length of host (cm) | Parasite size (cm) | | | |
|---------------------------|--------------------|-------|--------|-------|
| | Female | | Male | |
| | Length | Width | Length | Width |
| 2.0-2.9 | 0.7 | 0.6 | - | - |
| 3.0-3.9 | 0.7 | 0.6 | - | - |
| 4.0-4.9 | 0.9 | 0.8 | 0.25 | 0.15 |
| 5.0-5.9 | 1.0 | 0.85 | 0.30 | 0.13 |
| 6.0-6.9 | 1.2 | 1.0 | 0.35 | 0.18 |

Table 6. Relationship between sizes of host and parasite of Panangad station.

| Total length of host (cm) | Parasite size (cm) | | | |
|---------------------------|--------------------|-------|--------|-------|
| | Female | | Male | |
| | Length | Width | Length | Width |
| 4.0-4.9 | 0.8 | 0.7 | 0.25 | 0.15 |
| 5.0-5.9 | 1.0 | 0.8 | 0.3 | 0.175 |
| 6.0-6.9 | 1.2 | 1.0 | 0.3 | 0.2 |

Table 7. Relationship between sizes of host and parasite of Champakkara station.

| Total length of host (cm) | Parasite size (cm) | | | |
|---------------------------|--------------------|-------|--------|-------|
| | Female | | Male | |
| | Length | Width | Length | Width |
| 4.0-4.9 | 0.8 | 0.7 | 0.25 | 0.15 |
| 5.0-5.9 | 1.0 | 0.8 | 0.3 | 0.175 |
| 6.0-6.9 | 1.1 | 0.9 | 0.3 | 0.175 |

Table 8. Summary of relationship between sizes of parasite and host of Cochin region.

| Sl. No | Host length (cm) | Female parasite (cm) | Male parasite (cm) |
|--------|------------------|----------------------|--------------------|
| 1 | 2.5 | 0.35 | - |
| 2 | 3.0 | 0.45 | - |
| 3 | 3.9 | 0.95 | - |
| 4 | 4.2 | 0.95 | 0.23 |
| 5 | 4.6 | 1.0 | 0.25 |
| 6 | 4.8 | 1.2 | 0.25 |
| 7 | 5.0 | 1.0 | 0.25 |
| 8 | 5.2 | 1.1 | 0.3 |
| 9 | 6.0 | 1.2 | 0.25 |
| 10 | 6.1 | 1.2 | 0.3 |



(A)



(B)



(C)

Plate 5. (A) Host – parasite association (B) Male and female parasite association (C) Male parasite (M – male; F – female).

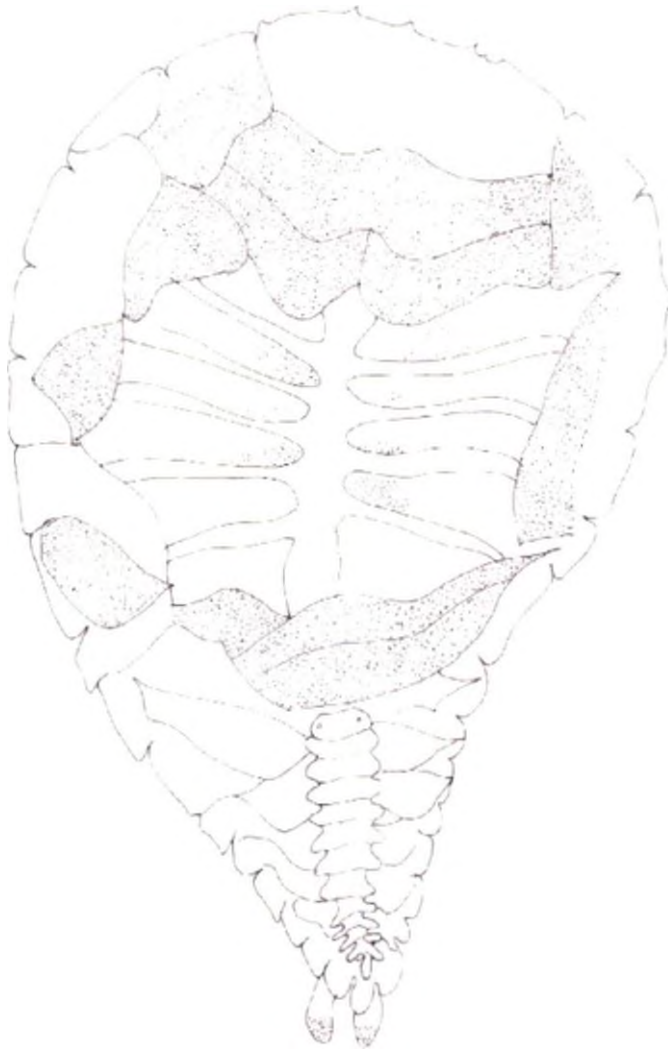


Fig. 6. Ventral view of female bopyrid (*P. alcocki*) with empty marsupium, showing male bopyrid on abdomen of female.

4.3 INTENSITY OF PARASITIC INFESTATION IN WILD POPULATION OF PALAEMONID PRAWNS OF COCHIN REGION

In order to study the nature, incidence and intensity of infestation, monthly samples were collected from three selected centres, namely, Perumbavoor station (Periyar River) and Panangad and Champakkara stations (Vembanad Lake) and the results are presented below.

4.3.1 Perumbavoor station (Periyar River).

Monthly data collected during the period from July 2002 to July 2003 has been consolidated and presented in Table 9.

Table 9. Nature, sexwise incidence and intensity of infestation of *Palaegyge alcocki* on *Macrobrachium idella* at Perumbavoor station (period July 2002 to July 2003)

| Incidence and Intensity of infestation | Male | | Female | | Total | |
|---|------|------|--------|------|-------|-------|
| | No | % | No | % | No | % |
| Total No. of prawns observed | 272 | 34.4 | 519 | 65.6 | 791 | 100 |
| Total No. of prawns infested | 20 | 8.0 | 229 | 92.0 | 249 | 100 |
| Total No. of prawns with parasites | 16 | 6.7 | 222 | 93.3 | 238 | 100 |
| Total No. of prawns with the swelling of branchiostegite, but without parasites | 4.0 | 36.4 | 7.0 | 63.6 | 11.0 | 100 |
| Infestation on left side of prawn | 13 | 9.8 | 120 | 90.2 | 133 | 100 |
| Infestation on right side of prawn | 7.0 | 6.0 | 109 | 94.0 | 116 | 100 |
| Prawns with parasites on both the sides | 0 | 0 | 0 | 0 | 0 | 0 |
| Intensity of infestation in percentage | - | - | - | - | 249 | 31.48 |
| Sexwise infestation in percentage | 20 | 2.5 | 229 | 29.0 | - | - |
| Indication of infestation in percentage | 4.0 | 0.5 | 7.0 | 0.9 | 11.0 | 1.4 |

Monthly collections were taken from Perumbavoor station of the Periyar River for the period from July 2002 to July 2003. The data are

presented in Tables 9 to 13 and Figs 7 to 10. Table 9 is consolidated data of the total prawns collected and the nature, incidence and intensity of *Palaegyge alcocki* Chopra, 1923 on *Macrobrachium idella* Hilgendorf, 1898. It can be seen that the percentage infestation of the parasite was 31.48 (92.0 female; 8.0 male). Among the infested prawns, the females were infested the maximum (92%) when compared to males (8.0%). There was a lower incidence of 1.4% of prawns in which the host showed swelling of the branchiostegite but parasite were not found. It was of interest to note that the parasite infestation was slightly more on the left side than on the right side. None of the host was infested with parasites on both sides.

Table 10. Monthwise and sexwise infestation (July 2002 to July 2003) of *Palaegyge alcocki* on *Macrobrachium idella* as well as sex ratio of prawn at Perumbavoor station.

| Month/ Year | Total no of prawns | Sex and ratio | | | Infestation | | | | | |
|----------------|--------------------------|---------------|--------|-------|-------------|-----|--------|------|-------|------|
| | | Male | Female | Ratio | Male | % | Female | % | Total | % |
| Jul/02 | 85 | 28 | 57 | 1:2.0 | 0 | 0 | 10 | 11.8 | 10 | 11.8 |
| Aug/02 | 94 | 31 | 63 | 1:2.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep/02 | 80 | 33 | 47 | 1:1.4 | 0 | 0 | 1 | 1.25 | 1 | 1.25 |
| Oct/02 | 19 | 13 | 6 | 1:0.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nov/02 | 64 | 9 | 55 | 1:6.1 | 4 | 6.3 | 43 | 67.1 | 47 | 73.4 |
| Dec/02 | 113 | 19 | 94 | 1:5.0 | 4 | 3.5 | 79 | 70 | 83 | 73.5 |
| Jan/03 | 65 | 23 | 42 | 1:1.8 | 4 | 6.2 | 37 | 56.9 | 41 | 63.1 |
| Feb/03 | 48 | 8 | 40 | 1:5.0 | 2 | 4.1 | 35 | 73 | 37 | 77.1 |
| Mar/03 | 38 | 29 | 9 | 1:0.3 | 3 | 7.9 | 7 | 18.4 | 10 | 26.3 |
| Apr/03 | 14 | 10 | 4 | 1:0.4 | 1 | 7.1 | 2 | 14.3 | 3 | 21.4 |
| May/03 | 47 | 29 | 18 | 1:0.6 | 0 | 0 | 2 | 4.26 | 2 | 4.26 |
| Jun/03 | 83 | 22 | 61 | 1:2.7 | 2 | 2.4 | 10 | 12.1 | 12 | 14.5 |
| Jul/03 | 41 | 18 | 23 | 1:1.3 | 0 | 0 | 3 | 7.32 | 3 | 7.32 |
| Total | 791 | 272 | 519 | 1:1.9 | 20 | 2.5 | 229 | 29 | 249 | 31.5 |

Table 10 provides the data on monthwise, sexwise infestation as well as sex ratio of *M. idella* of the Perumbavoor station. The result

indicates that *M. idella* was available throughout the period in this station but with lesser quantities during February 2003 to May 2003. During the breeding season from July 2002 to January 2003 the sex ratio of prawns was in favour of females. It is quite interesting to note that the parasitic infestation was during all months and maximum during November 2002 to March 2003. It is represented in the Fig. 7.

Table 11. Monthwise bopyrid infestation on *Macrobrachium idella* (sexwise, sidewise) at Perumbavoor station during July 2002 to July 2003.

| Month/ Year | Sexwise, Sidewise | | | | | | | | Total Infested | | | |
|----------------|-------------------|------|---|------|--------|------|-----|------|----------------|------|-------|------|
| | Male | | | | Female | | | | Left | | Right | |
| | L | % | R | % | L | % | R | % | No | % | No | % |
| Jul/02 | 0 | 0 | 0 | 0 | 5.0 | 50 | 5.0 | 50 | 5.0 | 50 | 5.0 | 50 |
| Aug/02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep/02 | 0 | 0 | 0 | 0 | 1.0 | 100 | 0 | 0 | 1.0 | 100 | 0 | 0 |
| Oct/02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nov/02 | 1 | 25.0 | 3 | 75.0 | 27 | 62.8 | 16 | 37.2 | 28 | 59.6 | 19 | 40.4 |
| Dec/02 | 4 | 100 | 0 | 0 | 40 | 50.6 | 39 | 49.4 | 44 | 53 | 39 | 47 |
| Jan/03 | 3 | 75.0 | 1 | 25.0 | 20 | 54.1 | 17 | 45.9 | 23 | 56.1 | 18 | 43.9 |
| Feb/03 | 2 | 100 | 0 | 0 | 15 | 42.9 | 20 | 57.1 | 17 | 46 | 20 | 54 |
| Mar/03 | 2 | 66.7 | 1 | 33.3 | 5.0 | 71.4 | 2.0 | 28.6 | 7.0 | 70 | 3.0 | 30 |
| Apr/03 | 1 | 100 | 0 | 0 | 1.0 | 50.0 | 1.0 | 50 | 2.0 | 66.7 | 1.0 | 33.3 |
| May/03 | 0 | 0 | 0 | 0 | 2.0 | 100 | 0 | 0 | 2.0 | 100 | 0 | 0 |
| Jun/03 | 0 | 0 | 2 | 100 | 4.0 | 40.0 | 6.0 | 60 | 4.0 | 33.3 | 8.0 | 66.7 |
| Jul/03 | 0 | 0 | 0 | 0 | 0 | 0 | 3.0 | 100 | 0 | 0 | 3.0 | 100 |
| Total | 13 | 65.0 | 7 | 35.0 | 120 | 52.4 | 109 | 47.6 | 133 | 53.4 | 116 | 46.6 |

In order to assess the attachment preference of bopyrids on *M. idella*, data on the sidewise and sexwise infestation is presented in Table 11. The result shows that the infestation is prevalent in females than on males (Fig. 8). Among the males and females of *M. idella* left side infestation was more when compared to right side (Fig 9). Monthwise analysis of infestation reveals that in almost all months female prawns were infested more than males.

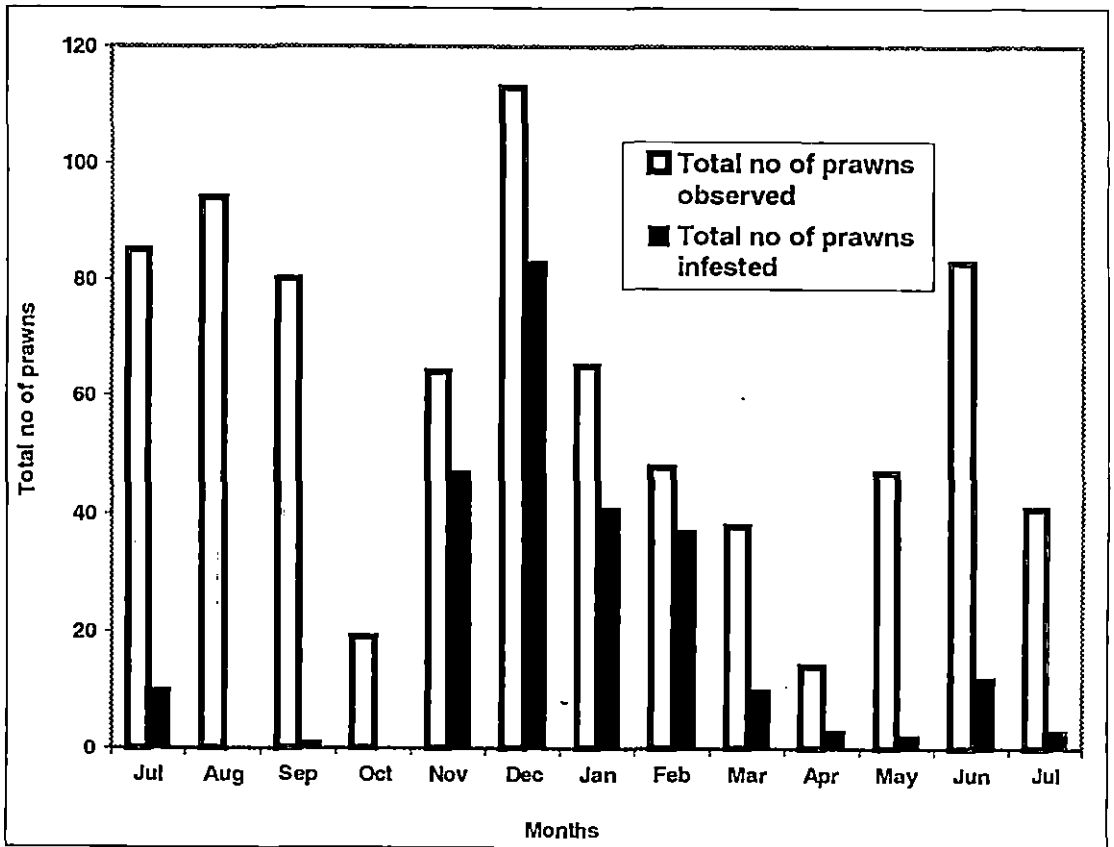


Fig. 7. Histogram showing monthly variation of infestation (July 2002 to July 2003) of *Palaegyge alcocki* on *Macrobrachium idella* at Perumbavoor station.

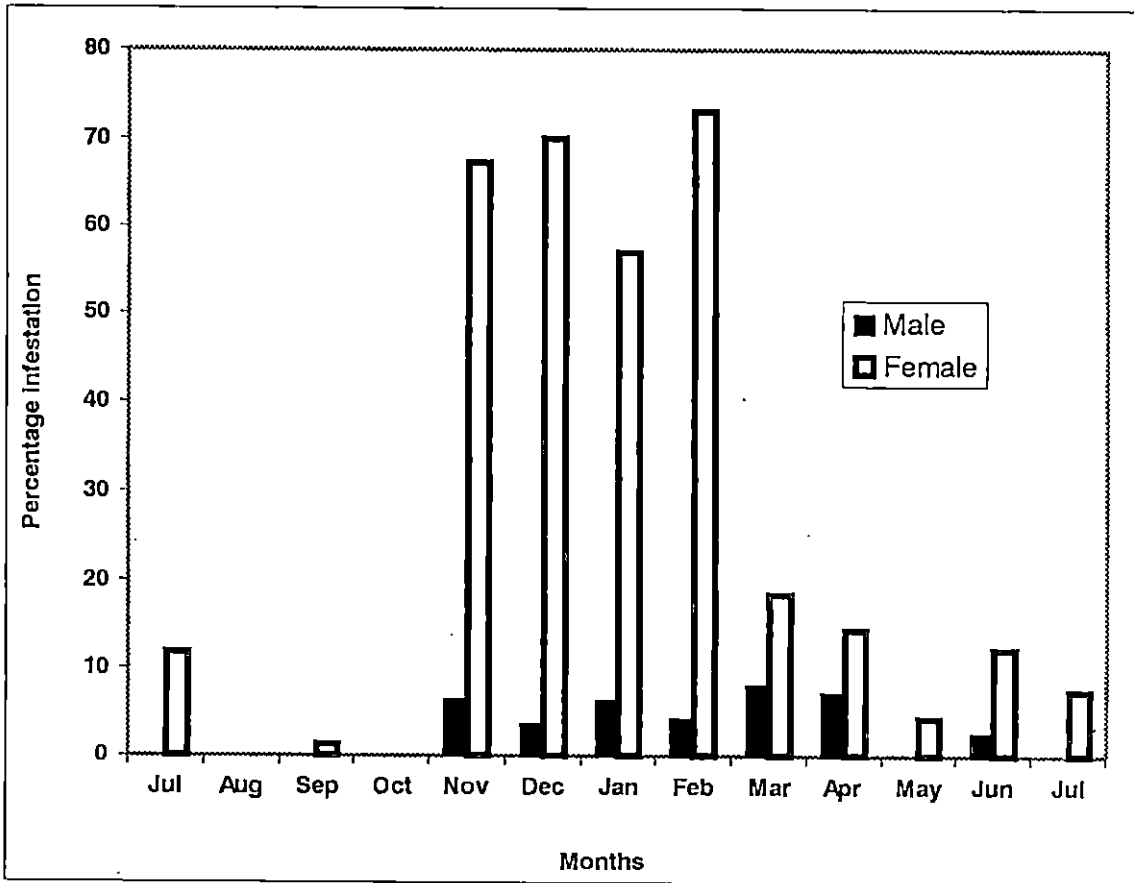


Fig. 8. Monthwise bopyrid infestation on *M. idella* (sexwise) Perumbavoor station during July 2002- July 2003.

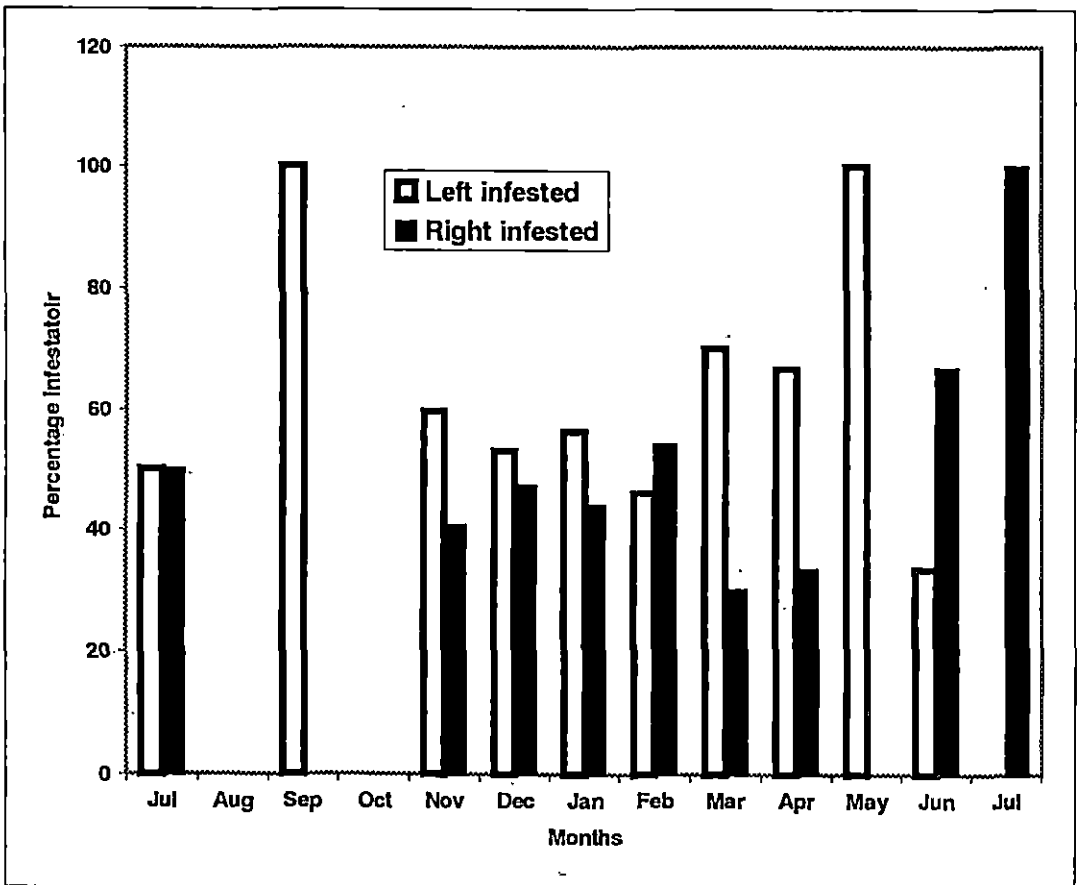


Fig. 9. Sidewise infestation of bopyrid parasites on *M. idella* at Perumbavoor station during July 2002 to July 2003.

Table 12. *Palaegyge alcocki* infestation in different length groups of *Macrobrachium idella* at Perumbavoor station during July 2002 to July 2003 (E- Examined, I- Infested)

| Months | Size range (cm) | | | | | | | | | | | |
|------------------|-----------------|---|---------|---|---------|----|---------|-----|---------|----|-----------------------|---|
| | 2.0-2.9 | | 3.0-3.9 | | 4.0-4.9 | | 5.0-5.9 | | 6.0-6.9 | | 7.0-7.9 to 9.0-9.9 | |
| | E | I | E | I | E | I | E | I | E | I | E | I |
| Jul/02 | 0 | 0 | 12 | 1 | 32 | 9 | 15 | 0 | 5 | 0 | 21 | 0 |
| Aug/02 | 0 | 0 | 0 | 0 | 21 | 0 | 25 | 0 | 25 | 0 | 23 | 0 |
| Sep/02 | 0 | 0 | 1 | 0 | 19 | 1 | 14 | 0 | 27 | 0 | 19 | 0 |
| Oct/02 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 11 | 0 | 4 | 0 |
| Nov/02 | 1 | 1 | 0 | 0 | 23 | 13 | 36 | 32 | 5 | 2 | 0 | 0 |
| Dec/02 | 1 | 1 | 1 | 0 | 42 | 37 | 59 | 43 | 7 | 2 | 3 | 0 |
| Jan/03 | 0 | 0 | 2 | 1 | 12 | 6 | 45 | 29 | 6 | 4 | 2 | 0 |
| Feb/03 | 0 | 0 | 0 | 0 | 4 | 3 | 35 | 27 | 9 | 7 | 0 | 0 |
| Mar/03 | 0 | 0 | 0 | 0 | 11 | 0 | 26 | 10 | 1 | 0 | 0 | 0 |
| Apr/03 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 0 | 6 | 2 | 4 | 0 |
| May/03 | 0 | 0 | 1 | 0 | 17 | 0 | 22 | 1 | 7 | 1 | 0 | 0 |
| Jun/03 | 0 | 0 | 0 | 0 | 43 | 7 | 28 | 4 | 5 | 1 | 7 | 0 |
| Jul/03 | 0 | 0 | 1 | 1 | 20 | 1 | 11 | 0 | 7 | 1 | 2 | 0 |
| Total | 2 | 2 | 19 | 3 | 245 | 78 | 323 | 146 | 121 | 20 | 83 | 0 |
| % Infestation | 0.8 | | 1.21 | | 31.3 | | 58.6 | | 8 | | 0 | |

Table 12 reveals that *P. alcocki* infests *M. idella* from the size range of 2.0-2.9 to 6.0-6.9 cm. No infestation was found lower than 2.0-2.9 cm and higher than 7.0-7.9 cm. The minimum size of infestation was 2.5 cm and the maximum size of infestation was 6.2 cm. The size group from 5.0-5.9 cm found to be highly infested followed by 4.0-4.9 cm than the other size groups observed. The size wise intensity of infestation was 58.6% (5.0-5.9 cm); 31.3% (4.0-4.9 cm) and 8% (6.0-6.9 cm).

Table 13. Summary of *Palaegyge alcocki* infestation in different length groups of *Macrobrachium idella* of both male and female during July`02 to July`03 (Perumbavoor) I- Infested; NI- Not infested

| Size range(cm) | Total | | Males | | Females | | TL Sex wise | |
|----------------|-------|-----|-------|-----|---------|-----|-------------|--------|
| | I | NI | I | NI | I | NI | Male | Female |
| 1.0-1.9 | - | - | - | - | - | - | - | - |
| 2.0-2.9 | 2 | - | - | - | 2 | - | - | 2 |
| 3.0-3.9 | 3 | 14 | - | 4 | 3 | 10 | 4 | 13 |
| 4.0-4.9 | 78 | 167 | 7 | 45 | 71 | 122 | 52 | 193 |
| 5.0-5.9 | 146 | 177 | 10 | 66 | 136 | 111 | 76 | 247 |
| 6.0-6.9 | 20 | 101 | 3 | 60 | 17 | 41 | 63 | 58 |
| 7.0-7.9 | - | 44 | - | 40 | - | 4 | 40 | 4 |
| 8.0-8.9 | - | 34 | - | 32 | - | 2 | 32 | 2 |
| 9.0-9.9 | - | 5 | - | 5 | - | - | 5 | - |
| Total | 249 | 542 | 20 | 252 | 229 | 290 | 272 | 519 |

The size of normal males of *M. idella* range from 3.0-3.9 to 9.0-9.9 cm and for females 2.0-2.9 to 9.0-9.9 cm. But the infestation was seen in the size group of 4.0-4.9 to 6.0-6.9 cm for males and 2.0-2.9 to 6.0-6.9 cm. The size range 5.0-5.9 cm shows maximum infestation. Among sexwise, on both males and females the size range 5.0-5.9 cm found to be maximum compared to other size groups. Prawns beyond of total length 6.0-6.9 cm were not found infested with parasite.

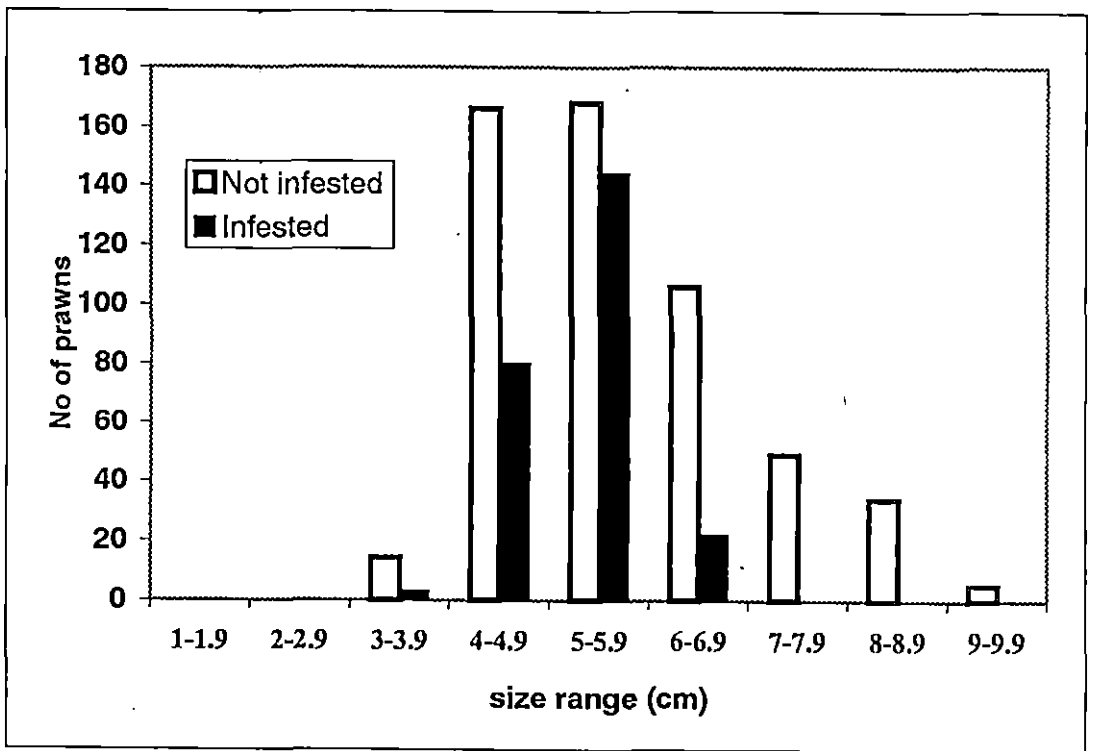


Fig. 10. Size wise infestation of *P. alcocki* on *M. idella* recorded from Perumbavoor station (July 2002 to July 2003).

4.3.2 Panangad station (Vembanand Lake).

Monthly data collected during the period from July 2002 to July 2003 have been consolidated and presented in Table 14.

Table 14. Nature, sex wise incidence and intensity of infestation of *Palaegyge alcocki* on *Macrobrachium idella* at Panangad station (period July 2002 to July 2003)

| Incidence and Intensity of infestation | Male | | Female | | Total | |
|--|------|------|--------|------|-------|-----|
| | No | % | No | % | No | % |
| Total no of prawns observed | 194 | 64.7 | 106 | 35.3 | 300 | 100 |
| Total no of prawns infested | 1 | 25 | 3 | 75 | 4 | 100 |
| Total no of prawns with parasites | 0 | 0 | 3 | 100 | 3 | 100 |
| Total no of prawns with the swelling of branchiostegite, but without parasites | 1 | 100 | 0 | 0 | 1 | 100 |
| Infestation on left side of prawn | 0 | 0 | 3 | 100 | 3 | 100 |
| Infestation on right side of prawn | 1 | 100 | 0 | 0 | 1 | 100 |
| Prawns with parasites on both the sides | 0 | 0 | 0 | 0 | 0 | 0 |
| Intensity of infestation in percentage | - | - | - | - | 4 | 1.3 |
| Sex wise infestation in percentage | 1 | 0.3 | 3 | 1 | - | - |
| Indication of infestation in percentage | 1 | 0.3 | 0 | 0 | 1 | 0.3 |

Monthly collections were taken from Panangad station of the Vembanad Lake for the period from July 2002 to July 2003. The data are presented in Tables 14 to 18 and Figs 11 to 14. Table 14 is consolidated data of the total prawns collected and nature, incidence and intensity of *Palaegyge alcocki* Chopra, 1923 on *Macrobrachium idella* Hilgendorf, 1898. It can be seen that the percentage infestation of the parasite was 1.3 (1 female; 0.3 male). Among the infested prawns, the females were infested the maximum (75%) when compared to males (25%). There was a lower incidence of 0.3 % of prawns in which the host showed swelling of the branchiostegite but parasite was not found. It was of interest to note that the parasite infestation was slightly more on the left side than on the right side. None of the host was infested with parasites on both sides.

Table 15. Monthwise and sexwise infestation (July 2002 to July 2003) of *Palaegyge alcocki* on *Macrobrachium idella* as well as sex ratio of prawn at Panangad station.

| Month/ Year | Total no of prawns | Sex and ratio | | | Infestation | | | | | |
|----------------|--------------------------|---------------|--------|-------|-------------|------|--------|-----|-------|------|
| | | Male | Female | Ratio | Male | % | Female | % | Total | % |
| Jul/02 | 50 | 42 | 8 | 1:0.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug/02 | 22 | 20 | 2 | 1:0.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep/02 | 45 | 29 | 16 | 1:0.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oct/02 | 29 | 20 | 9 | 1:0.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nov/02 | 29 | 19 | 10 | 1:0.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dec/02 | 37 | 25 | 12 | 1:0.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jan/03 | 54 | 21 | 33 | 1:1.6 | 1 | 1.9 | 3 | 5.6 | 4 | 7.4 |
| Feb/03 | 3 | 2 | 1 | 1:0.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mar/03 | 4 | 1 | 3 | 1:3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr/03 | 0 | 0 | 0 | 0:0 | 0 | 0 | 0 | 0 | 0 | 0 |
| May/03 | 1 | 0 | 1 | 0:0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun/03 | 5 | 4 | 1 | 1:0.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul/03 | 21 | 11 | 10 | 1:0.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 300 | 194 | 106 | 1:0.5 | 1 | 0.33 | 3 | 1 | 4 | 1.33 |

Table 15 provides the data on monthwise and sexwise infestation as well as sex ratio of *M. idella* of the Panangad station. The result indicates that *M. idella* was available through out the period but with lesser quantities during February to June 2003. During the breeding season from July 2002 to January 2003 the sex ratio of prawns was in favour of males. The parasite infestation was observed only during January 2003. It is presented in Fig.11.

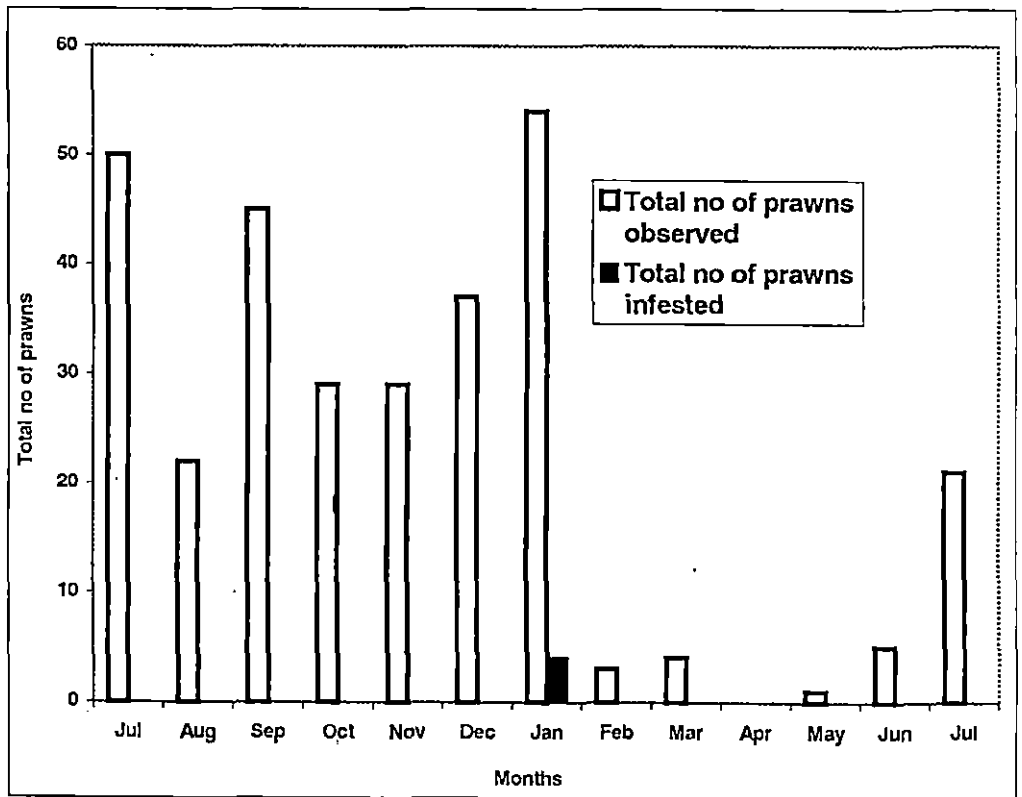


Fig 11. Histogram showing monthly variation of infestation (July 2002 to July 2003) of *Palaegyge alcocki* on *Macrobrachium idella* at Panangad station.

Table 16. Monthwise bopyrid infestation on *Macrobrachium idella* (sex wise, side wise) at Panangad station during July 2002 to July 2003.

| Month/ Year | Sexwise, Sidewise | | | | | | | | Total Infested | | | |
|----------------|-------------------|-----|---|---|--------|---|---|-----|----------------|----|-------|----|
| | Male | | | | Female | | | | Left | | Right | |
| | L | % | R | % | L | % | R | % | No | % | No | % |
| Jul/02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug/02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep/02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oct/02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nov/02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dec/02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jan/03 | 1 | 100 | 0 | 0 | 0 | 0 | 3 | 100 | 1 | 25 | 3 | 75 |
| Feb/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mar/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| May/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 1 | 100 | 0 | 0 | 0 | 0 | 3 | 100 | 1 | 25 | 3 | 75 |

In order to assess the attachment preference of bopyrids on *M. idella*, data on the sidewise and sexwise infestation is presented in Table 16. The result shows that the infestation is prevalent in females than on males (Fig. 12). Among the males and females of *M. idella* right side prevalence was more compared to left side (Fig.13)

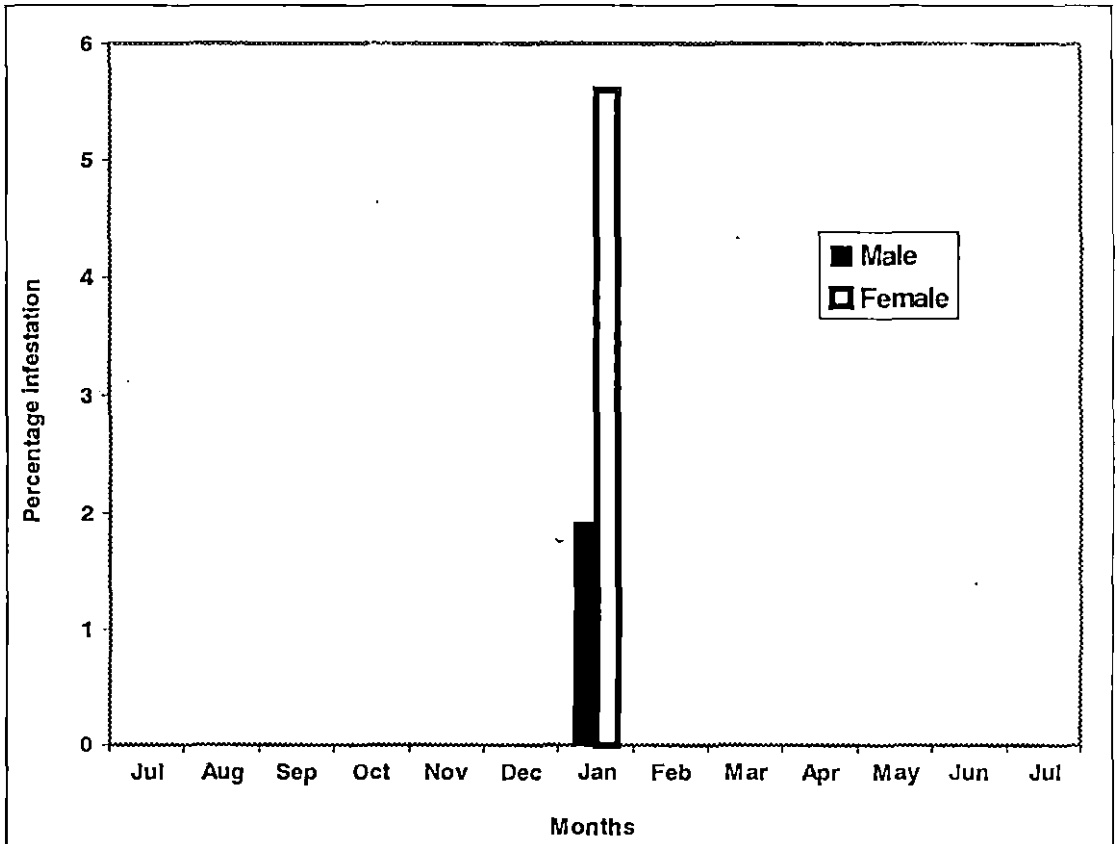


Fig. 12. Monthwise bopyrid infestation on *M. idella* (sexwise) Panangad station during July 2002- July 2003.

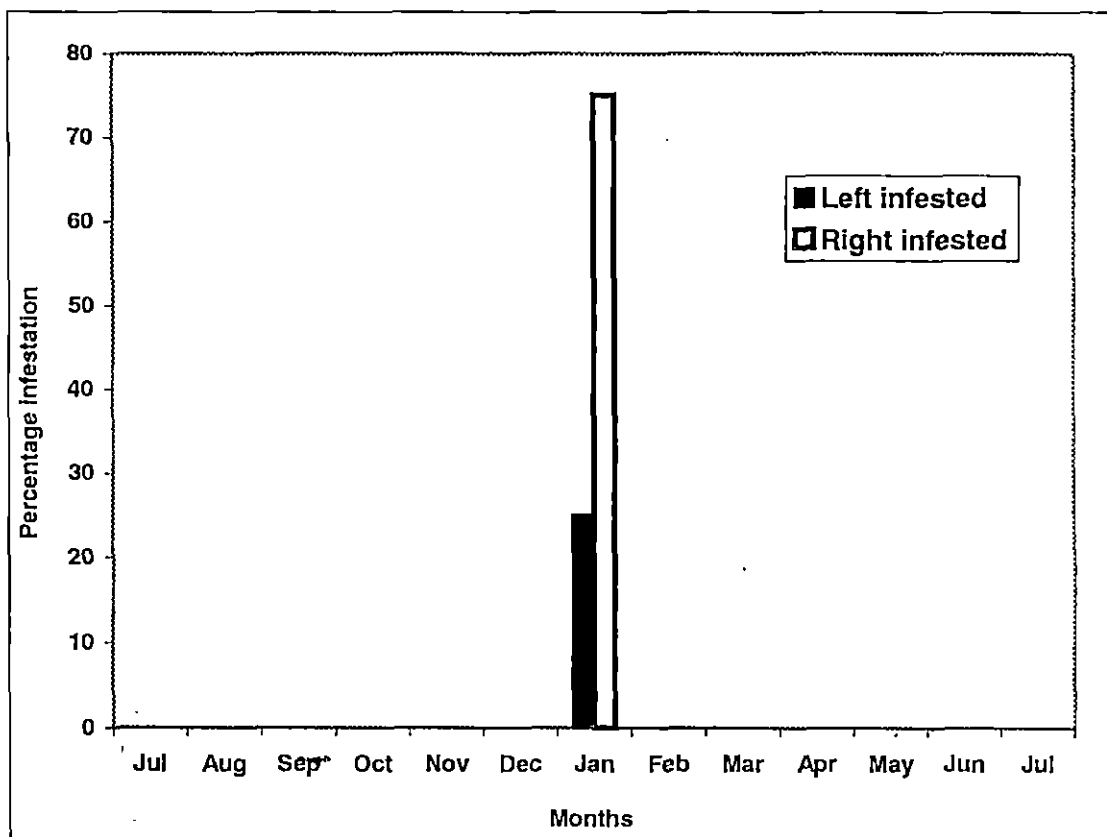


Fig. 13. Sidewise infestation of bopyrid parasites on *M. idella* at Panangad station during July 2002 to July 2003.

Table 17. *Palaegyge alcocki* infestation in different length groups of *Macrobrachium idella* at Panangad station during July 2002 to July 2003 (E- Examined, I- Infested)

| Months | Size range (cm) | | | | | | | | | | | |
|---------------|-----------------|---|---------|---|---------|---|---------|---|---------|---|--------------------|---|
| | 2.0-2.9 | | 3.0-3.9 | | 4.0-4.9 | | 5.0-5.9 | | 6.0-6.9 | | 7.0-7.9 to 9.0-9.9 | |
| | E | I | E | I | E | I | E | I | E | I | E | I |
| Jul/02 | 0 | 0 | 0 | 0 | 7 | 0 | 7 | 0 | 11 | 0 | 25 | 0 |
| Aug/02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 14 | 0 |
| Sep/02 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 17 | 0 | 25 | 0 |
| Oct/02 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 11 | 0 | 16 | 0 |
| Nov/02 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 8 | 0 | 19 | 0 |
| Dec/02 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 17 | 0 | 17 | 0 |
| Jan/03 | 0 | 0 | 0 | 0 | 5 | 1 | 13 | 2 | 16 | 1 | 17 | 0 |
| Feb/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Mar/03 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Apr/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| May/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Jun/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| Jul/03 | 0 | 0 | 2 | 0 | 11 | 0 | 3 | 0 | 5 | 0 | 0 | 0 |
| Total | 1 | 0 | 3 | 0 | 23 | 1 | 32 | 2 | 105 | 1 | 136 | 0 |
| % Infestation | 0 | | 0 | | 25 | | 75 | | 25 | | 0 | |

Table 17 reveals that *P. alcocki* infest *M. idella* from the size range of 4.0-4.9 to 6.0-6.9 cm. No infestation was found before 4.0-4.9 cm and after 6.0-6.9 cm. The minimum size of infestation was 4.0 cm and the maximum size of infestation was 6.2 cm. The size group from 5.0-5.9 cm found to be infested more than the other size groups observed. The size wise intensity of infestation was 75% (5.0-5.9 cm); 25% (4.0-4.9 cm) and 25% (6.0 to 6.9 cm).

Table 18. Summary of *Palaegyge alcocki* infestation in different length groups of *Macrobrachium idella* of both male and female during July`02 to July`03 (Panangad).

| Size range | Total | | Total sexwise | | Males | | Females | |
|------------|-------|-----|---------------|-----|-------|-----|---------|-----|
| | I | NI | M | F | I | NI | I | NI |
| 1-1.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2-2.9 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| 3-3.9 | 0 | 3 | 1 | 2 | 0 | 1 | 0 | 2 |
| 4-4.9 | 1 | 22 | 7 | 16 | 0 | 7 | 1 | 15 |
| 5-5.9 | 2 | 30 | 11 | 21 | 0 | 11 | 2 | 19 |
| 6-6.9 | 1 | 104 | 44 | 61 | 1 | 44 | 0 | 61 |
| 7-7.9 | 0 | 78 | 73 | 5 | 0 | 73 | 0 | 5 |
| 8-8.9 | 0 | 46 | 46 | 0 | 0 | 46 | 0 | 0 |
| 9-9.9 | 0 | 12 | 12 | 0 | 0 | 12 | 0 | 0 |
| Total | 4 | 296 | 194 | 106 | 1 | 193 | 3 | 103 |

The size of normal males of *M. idella* ranges from 3.0-3.9 to 9.0-9.9 cm and for females from 2.0-2.9 to 7.0-7.9 cm. But the infestation was seen in the size group of 6.0-6.9 cm for males and 4.0-4.9 and 5.0-5.9 cm. The size range 5.0-5.9 cm shows a maximum infestation. Among sexwise infestation, on both males and females the size range 5.0-5.9 cm found to be maximum compared to other size groups. Prawns beyond total length 6.0-6.9 cm were not found infested with parasite.

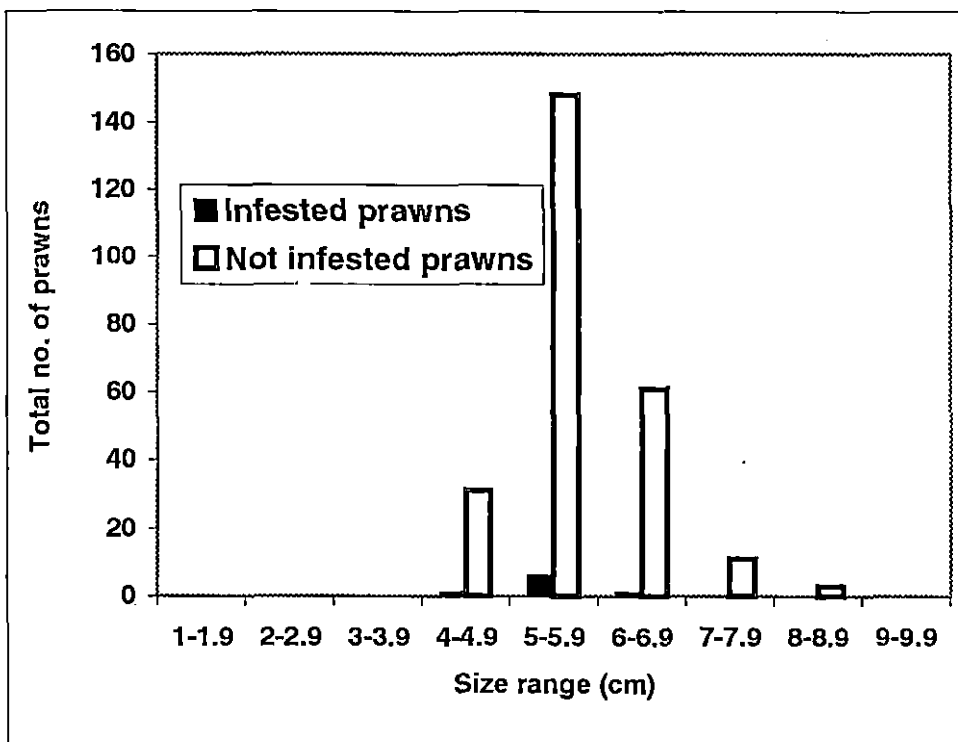


Fig. 14. Size-wise infestation of *P. alcocki* on *M. idella* recorded from Panangad station (July 2002 to July 2003).

4.3.3 Reports of Nature, Incidence and Intensity of infestation from Champakkara region.

Monthly collected data during the period from October 2003 to September 2004 have been consolidated and presented in Table 9.

Table 19. Nature, sexwise incidence and intensity of infestation of *Palaegyge alcocki* on *Macrobrachium idella* at Champakkara station. (period October 2003 to September 2004)

| Incidence and Intensity of infestation | Male | | Female | | Total | |
|---|------|------|--------|------|-------|-----|
| | No | % | No | % | No | % |
| Total No. of prawns observed | 74 | 28.2 | 188 | 71.8 | 262 | 100 |
| Total No. of prawns infested | 4 | 50 | 4 | 50 | 8 | 100 |
| Total No. of prawns with parasites | 4 | 57 | 3 | 43 | 7 | 100 |
| Total No. of prawns with the swelling of branchiostegite, but without parasites | 0 | 0 | 1 | 100 | 1 | 100 |
| Infestation on left side of prawn | 2 | 50 | 2 | 50 | 4 | 100 |
| Infestation on right side of prawn | 2 | 50 | 2 | 50 | 4 | 100 |
| Prawns with parasites on both the sides | 0 | 0 | 0 | 0 | 0 | 0 |
| Intensity of infestation in percentage | - | - | - | - | 8 | 3.1 |
| Sex wise infestation in percentage | 4 | 1.5 | 4 | 1.5 | - | - |
| Indication of infestation in percentage | 0 | 0 | 1 | 0.4 | 1 | 0.4 |

Monthly collections were taken from Champakkara region of the Vembanad Lake for the period from October 2003 to September 2004. The data are presented in Tables 19 to 23 and Figs 15 to 18. Table 19 is consolidated data of the total prawns collected and nature, incidence and intensity of *Palaegyge alcocki* Chopra, 1923 on *Macrobrachium idella* Hilgendorf, 1898. It can be seen that the percentage infestation of the parasite was 3.1 (1.5 female; 1.5 male). Among the infested prawns, the number of females and males were the same (50%). There was a lower incidence of 0.4 % of prawns in which the host showed swelling of the branchiostegite but parasite were not found. Here the parasite infestation was equal on the left side (50%) and on the right side (50%). None of the host was infested with parasites on both sides.

Table 20. Monthwise and sexwise infestation (Oct 2003 to Oct 2004) of *Palaegyge alcocki* on *Macrobrachium idella* at Champakkara station.

| Month/Y ear | Total no of prawns | Sex and ratio | | | Infestation | | | | | |
|-------------|--------------------|---------------|--------|-------|-------------|------|--------|------|-------|------|
| | | Male | Female | Ratio | Male | % | Female | % | Total | % |
| Oct/03 | 32 | 13 | 19 | 1:1.5 | 3 | 23.1 | 3 | 15.8 | 6 | 18.8 |
| Nov/03 | 58 | 20 | 38 | 1:1.9 | 1 | 5 | 1 | 2.63 | 2 | 3.4 |
| Dec/03 | 56 | 16 | 40 | 1:2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jan/04 | 25 | 3 | 22 | 1:7.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Feb/04 | 0 | 0 | 0 | 0:0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mar/04 | 0 | 0 | 0 | 0:0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr/04 | 0 | 0 | 0 | 0:0 | 0 | 0 | 0 | 0 | 0 | 0 |
| May/04 | 20 | 4 | 16 | 1:4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun/04 | 25 | 6 | 19 | 1:3.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul/04 | 15 | 2 | 13 | 1:6.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug/04 | 20 | 8 | 12 | 1:1.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep/04 | 11 | 2 | 9 | 1:4.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 262 | 74 | 188 | 1:2.5 | 4 | 5.4 | 4 | 2.13 | 8 | 3.1 |

Table 20 provides the data on monthwise and sexwise infestation as well as sex ratio of *M. idella* of the Champakkara station. The result indicates that *M. idella* was available through out the period except February to April 2004. During the breeding season from May 2004 to September 2004 the sex ratio of prawns was in favour of females. It is quite interesting to note that the parasitic infestation was only during October 2003 and November 2003 (Fig. 15).

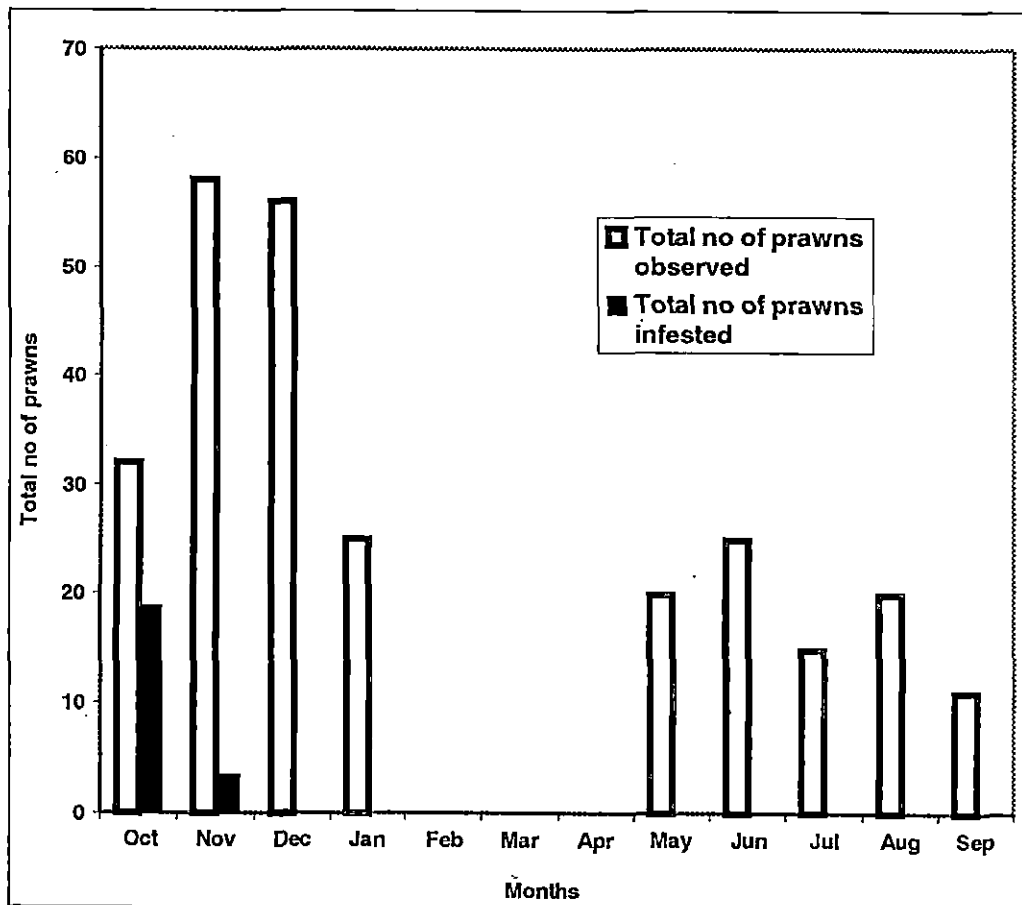


Fig. 15. Histogram showing monthly variation of infestation (October 2003 to September 2004) of *Palaegyge alcocki* on *Macrobrachium idella* at Champakkara station.

Table 21. Monthwise bopyrid infestation on *Macrobrachium idella* (sexwise, sidewise) at Champakkara station during October 2003 to September 2004.

| Month/ Year | Sexwise, Sidewise | | | | | | | | Total Infested | | | |
|----------------|-------------------|------|---|------|--------|------|---|------|----------------|----|-------|----|
| | Male | | | | Female | | | | Left | | Right | |
| | L | % | R | % | L | % | R | % | No | % | No | % |
| Oct/03 | 1 | 33.3 | 2 | 66.7 | 2 | 66.7 | 1 | 33.3 | 3 | 50 | 3 | 50 |
| Nov/03 | 1 | 100 | 0 | 0 | 0 | 0 | 1 | 100 | 1 | 50 | 1 | 50 |
| Dec/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jan/04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Feb/04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mar/04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr/04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| May/04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun/04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul/04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug/04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sep/04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 2 | 50 | 2 | 50 | 2 | 50 | 2 | 50 | 4 | 50 | 4 | 50 |

In order to assess the attachment preference of bopyrids on *M. idella*, data on the sidewise and sexwise infestation was collected from October 2003 to September 2004 and presented in Table 21. The result shows that the infestation is more prevalent in females than on males (Fig. 16). Among the males and females of *M. idella* left side prevalence was more compared to right side (Fig. 17)

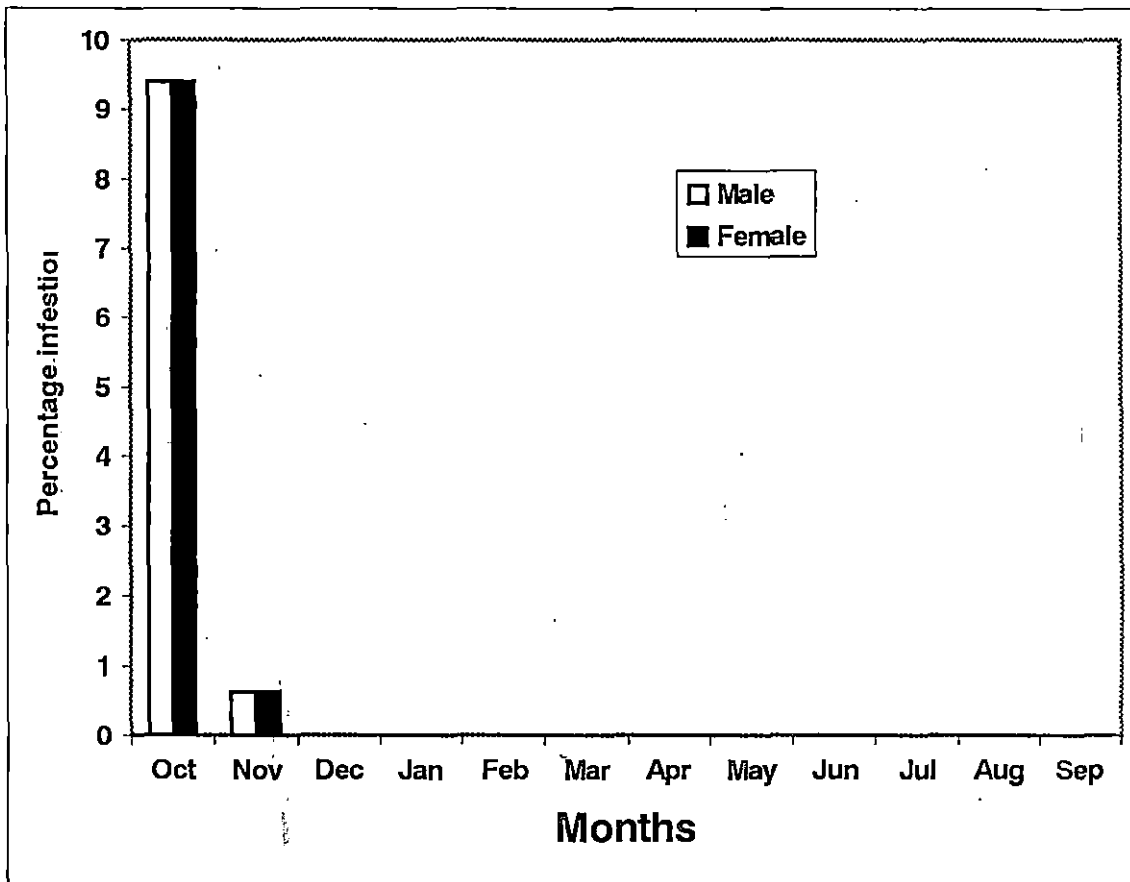


Fig. 16. Month wise bopyrid infestation on *M. idella* (sex wise)
Champakkara station during October 2003 to September 2004.

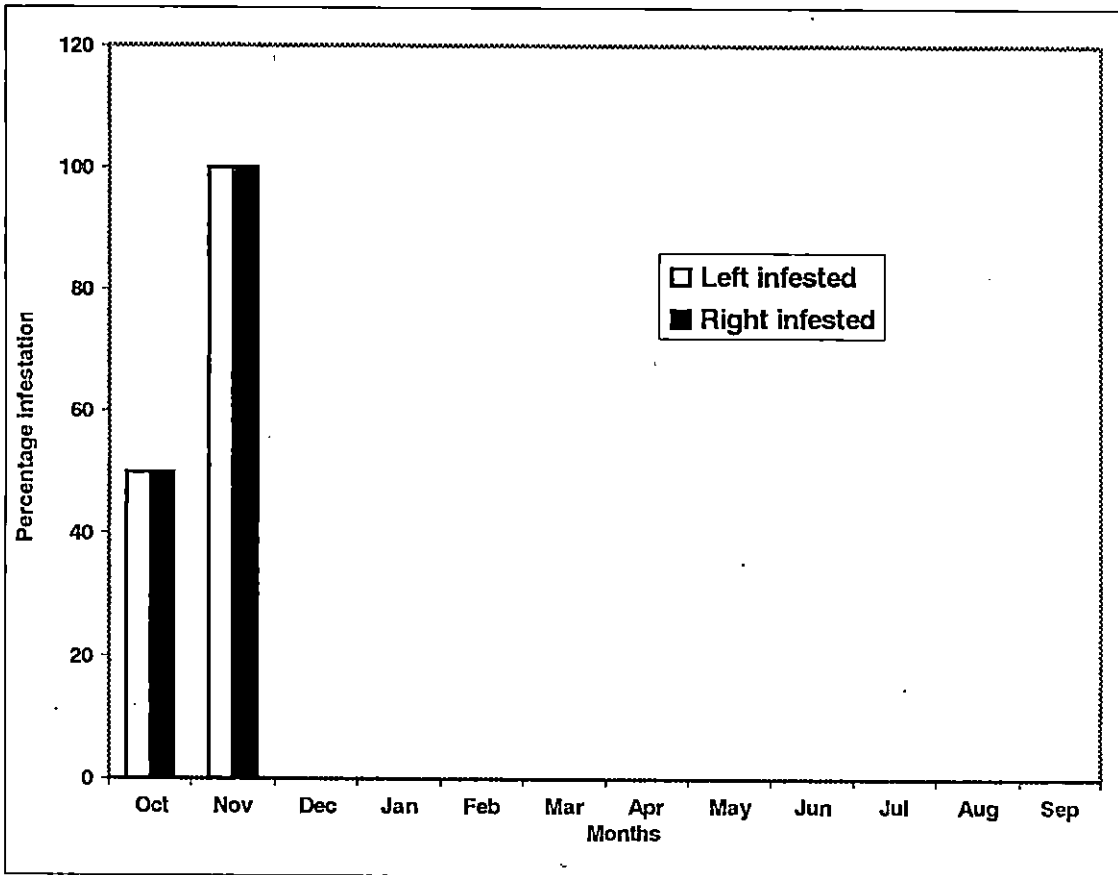


Fig. 17. Sidewise infestation of bopyrid parasites on *M. idella* at Champakkara station during October 2003 to September 2004.

Table 22. *Palaegyge alcocki* infestation in different length groups of *Macrobrachium idella* at Champakkara station during October 2003 to September 2004
(E- Examined, I- Infested)

| Months | Size range | | | | | | | | | | | |
|------------------|------------|---|---------|---|---------|---|---------|---|---------|---|-----------------------|---|
| | 2.0-2.9 | | 3.0-3.9 | | 4.0-4.9 | | 5.0-5.9 | | 6.0-6.9 | | 7.0-7.9 to 9.0-9.9 | |
| | E | I | E | I | E | I | E | I | E | I | E | I |
| Jul/02 | 0 | 0 | 0 | 0 | 6 | 1 | 10 | 6 | 13 | 1 | 3 | 0 |
| Aug/02 | 0 | 0 | 0 | 0 | 4 | 0 | 31 | 0 | 19 | 0 | 4 | 0 |
| Sep/02 | 0 | 0 | 0 | 0 | 10 | 0 | 33 | 0 | 10 | 0 | 3 | 0 |
| Oct/02 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 0 | 7 | 0 | 0 | 0 |
| Nov/02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dec/02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jan/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Feb/03 | 0 | 0 | 0 | 0 | 2 | 0 | 16 | 0 | 2 | 0 | 0 | 0 |
| Mar/03 | 0 | 0 | 0 | 0 | 4 | 0 | 15 | 0 | 4 | 0 | 0 | 0 |
| Apr/03 | 0 | 0 | 0 | 0 | 2 | 0 | 11 | 0 | 2 | 0 | 0 | 0 |
| May/03 | 0 | 0 | 0 | 0 | 4 | 0 | 15 | 0 | 1 | 0 | 0 | 0 |
| Jun/03 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 4 | 0 | 0 | 0 |
| Jul/03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 0 | 0 | 32 | 1 | 154 | 6 | 62 | 1 | 0 | 0 |
| % infestation | 0 | | 0 | | 12.5 | | 75 | | 12.5 | | 0 | |

Table 22 reveals that *P. alcocki* infest *M. idella* of the size range of 4.0-4.9 to 6.0-6.9 cm. No infestation was found before 4.0-4.9 cm and after 6.0-6.9 cm. The minimum size of infestation was 4.0 cm and the maximum size of infestation was 6.1 cm. The size group from 5.0-5.9 cm was found to be infested more than the other size groups observed. The sizewise intensity of infestation was 75% (5.0-5.9 cm); 12.5% (4.0-4.9 cm) and 12.5% (6.0-6.9 cm).

Table 23. Summary of *Palaegyge alcocki* infestation in different length groups of *Macrobrachium idella* both male and female (Champakkara).

| Size range | Total | | Total sexwise | | Males | | Females | |
|------------|-------|-----|---------------|-----|-------|----|---------|-----|
| | I | NI | M | F | I | NI | I | NI |
| 1-1.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2-2.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3-3.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4-4.9 | 1 | 31 | 8 | 24 | 0 | 8 | 1 | 23 |
| 5-5.9 | 6 | 148 | 49 | 105 | 3 | 46 | 3 | 102 |
| 6-6.9 | 1 | 61 | 16 | 46 | 1 | 15 | 0 | 46 |
| 7-7.9 | 0 | 11 | 1 | 10 | 0 | 1 | 0 | 10 |
| 8-8.9 | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 3 |
| 9-9.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 8 | 254 | 74 | 188 | 4 | 70 | 4 | 184 |

The size of normal males of *M. idella* ranges from 4.0-4.9 to 7.0-7.9 cm and for females 4.0-4.9 to 8.0-8.9. But the infestation was seen in the size group of 5.0-5.9 and 6.0-6.9 cm for males and for females 4.0-4.9 and 5.0-5.9 cm. The size range 5.0-5.9 cm shows maximum infestation. Among sexwise, on both males and females the size range 5.0-5.9 cm was found to be maximum compared to other size groups. Prawns beyond total length 6.0-6.9 cm were not found infested with parasite.

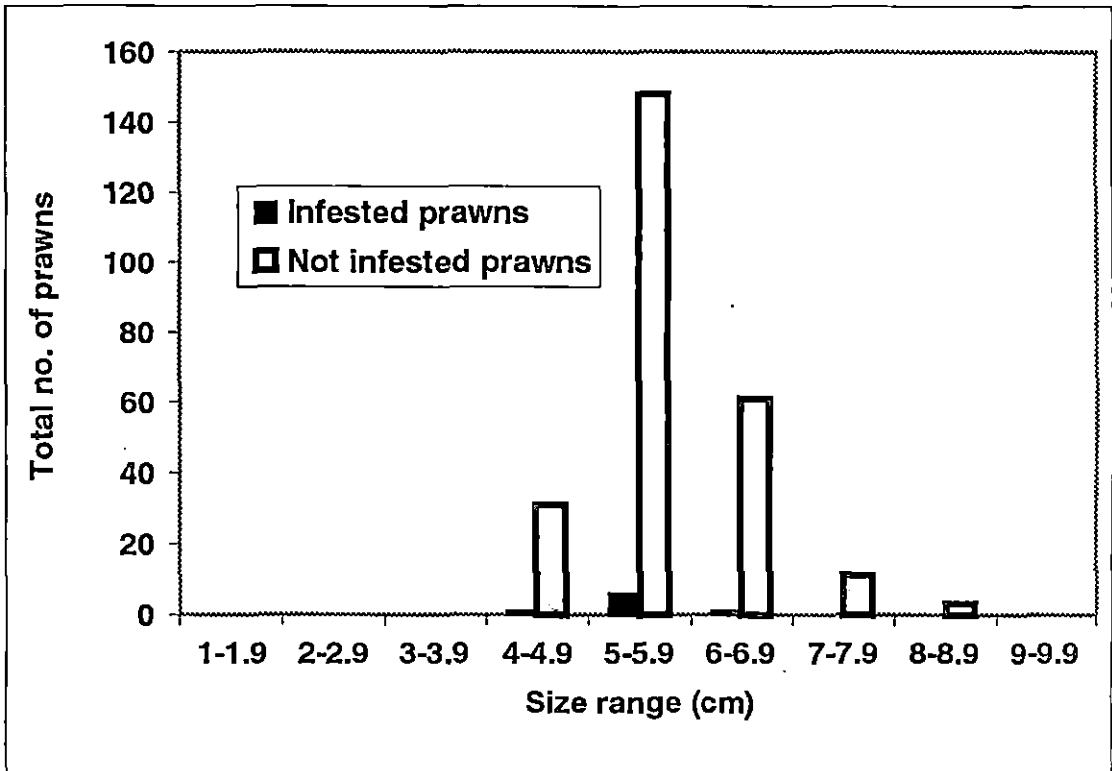


Fig. 18. Sizewise infestation of *P. alcocki* on *M. idella* recorded from Champakkara station (October 2003 to September 2004).

4.3.4 Consolidated data from three stations: Perumbavoor, Panangad, Champakkara of Cochin region.

The data collected from the three selected centres are consolidated below (Table.24).

Table 24. Consolidated data on the sexwise incidence and intensity of infestation of *Palaegyge alcocki* on *Macrobrachium idella* at Perumbavoor, Panangad and Champakkara station of Cochin region.

| Incidence and intensity of infestation | Male | | Female | | Total | |
|---|------|------|--------|------|-------|------|
| | No | % | No | % | No | % |
| Total No. of prawns observed | 540 | 39.9 | 813 | 60.1 | 1353 | 100 |
| Total No. of prawns infested | 25 | 9.6 | 236 | 90.4 | 261 | 100 |
| Total No. of prawns with parasites | 20 | 8.1 | 228 | 91.9 | 248 | 100 |
| Total No. of prawns with the swelling of branchiostegite, but without parasites | 5 | 38.5 | 8 | 60.5 | 13 | 100 |
| Infestation on left side of prawn | 15 | 10.7 | 125 | 89.3 | 140 | 100 |
| Infestation on right side of prawn | 10 | 8.3 | 111 | 91.7 | 121 | 100 |
| Prawns with parasites on both the sides | 0 | 0 | 0 | 0 | 0 | 0 |
| Intensity of infestation in percentage | - | - | - | - | 261 | 19.2 |
| Sex wise infestation in percentage | 25 | 1.8 | 236 | 17.4 | - | - |
| Indication of infestation in percentage | 5 | 0.4 | 8 | 0.6 | 13 | 1 |

Table 25. Comparison of data on the incidence and intensity of infestation of *Palaegyge alcocki* on *Macrobrachium idella* at Perumbavoor, Panangad and Champakkara station of Cochin region.

| No | Characters | Perumbavoor | Panangad | Champakkara | Consolidated data |
|----|---|--|----------------------|------------------------------------|---|
| 1 | Total No. of prawns examined | 791 | 300 | 262 | 1353 |
| 2 | Total No. of prawns infested | 249 | 4 | 8 | 261 |
| 3 | Total No. of prawns with parasites | 238 | 3 | 7 | 248 |
| 4 | Total No. of prawns with swelling but without parasites and Indication (%) | 11 (1.4) | 1 (0.3) | 1 (0.4) | 13 (1) |
| 5 | Intensity of infestation (%) | 31.48 | 1.3 | 3.1 | 19.2 |
| 6 | Monthwise availability of parasitic infestation | Almost all months | January '03 | October and November '03 | Almost all months (freshwater regions) and less infestation (estuarine region). |
| 7 | Highest incidence of infestation | February '03 (77.1) | January '03 (7.4) | October '03 (18.75) | January and February '03 |
| 8 | Lowest incidence of infestation | September '02 (1.25) | - | November '03 (3.4) | - |
| 9 | Sexwise data for infestation of prawns (%). | Female 92 Male 8 | Female 75 Male 25 | Female 50 Male 50 | Female 91.9 Male 8.1 |
| 10 | Sexwise intensity among total prawns examined (%) | Female 29 Male 2.5 | Female 1 Male 0.3 | Female 1.5 Male 1.5 | Female 17.4 Male 1.8 |
| 11 | Sex ratio Male : Female | 1:1.9 | 1:0.5 | 1:2.5 | 1:1.6 |
| 12 | Sidewise prevalence | Left side | Very few numbers. | No preference | Left side in general |
| 13 | Sidewise preference for the attachment of parasite (%) (M- Male; F- Female; L- Left; R- Right) | M: L 65 R 35 F: L 52.4 R 47.6 | M: L 100 F: R 100 | M: L 50 R 50 F: L 50 R 50 | M: L 60 R 40 F: L 53 R 47 |
| | Male and female together | Left 53.4 Right 46.6 | Left 25 Right 75 | Left 50 Right 50 | Left 53.6 Right 46.4 |
| 14 | Size range infestation (cm) | 2.0-2.9 to 6-6.9 | 3.0-3.9 to 6-6.9 | 2.0-2.9 to 6-6.9 | 2.0-2.9 to 6-6.9 |
| 15 | Size range of prawn with maximum infestation and percentage | 5.0-5.9 (58.6) | 5.0-5.9 (75) | 5.0-5.9 (75) | 5.0-5.9 (70) |

4.4 BIOLOGY OF *PALAEGYGE ALCOCKI* CHOPRA, 1923

Out of the 238 specimens of infested prawns collected from the Perumbavoor station, a random sample of 30 specimens was sorted out and was subjected to length – weight analysis.

4.4.1 Length -Weight relationship of *P. alcocki* infested *M. idella* of Perumbavoor station.

Total length and weight of bopyrid parasite, *P. alcocki* infested *M. idella* were taken. The data was subjected to Length – weight analysis. It is found that the correlation coefficient between length and weight of *M. idella* along with *P. alcocki* has a positive value of ($r = 0.92$; $n = 30$). When 't' test was applied, value of t (12.45) was statistically significant at 1% level of significance (Fig 19).

4.4.2 Length – Weight relationship of *Palaegyge alcocki* separated from *M. idella* of Perumbavoor station.

Length-Weight relationship of *Palaegyge alcocki* separated from *M. idella* is shown in Fig 20. The values of the two constants a and b from the data by applying the method of least squares were found to be: 0.1786; -0.0748 respectively.

Thus the regression equation of the fitted curve is represented as

$$Y = 0.1786x - 0.0748$$

The correlation coefficient between length and weight of the *Palaegyge alcocki* worked out was: $r = 0.78$ ($n = 30$); 't' value of the above test was t (6.57) which is statistically significant at 1% level of significance.

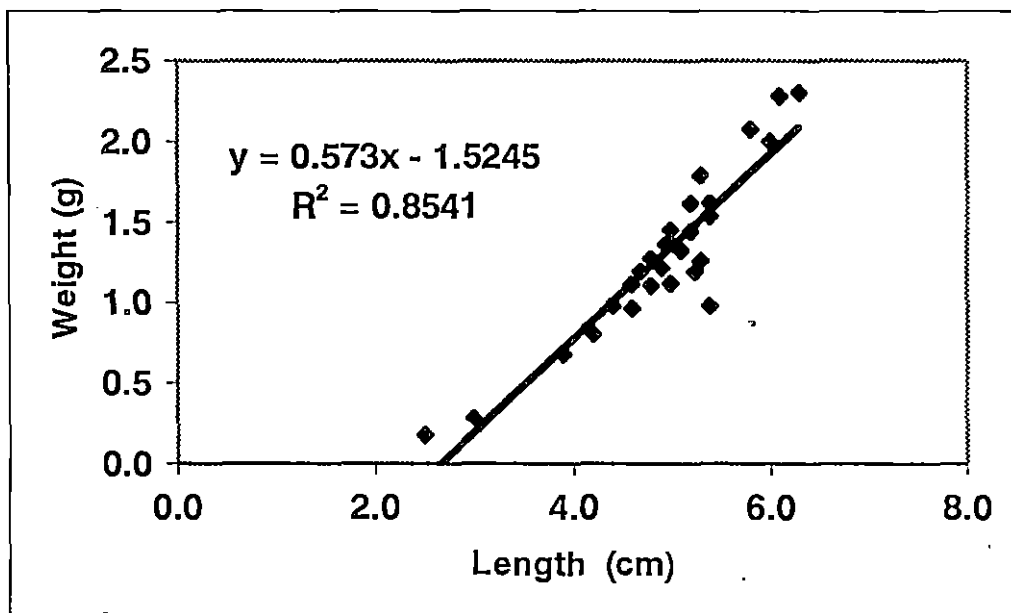


Fig. 19. Length -Weight relationship of *P. alcocki* infested *M. idella* of Perumbavoor station.

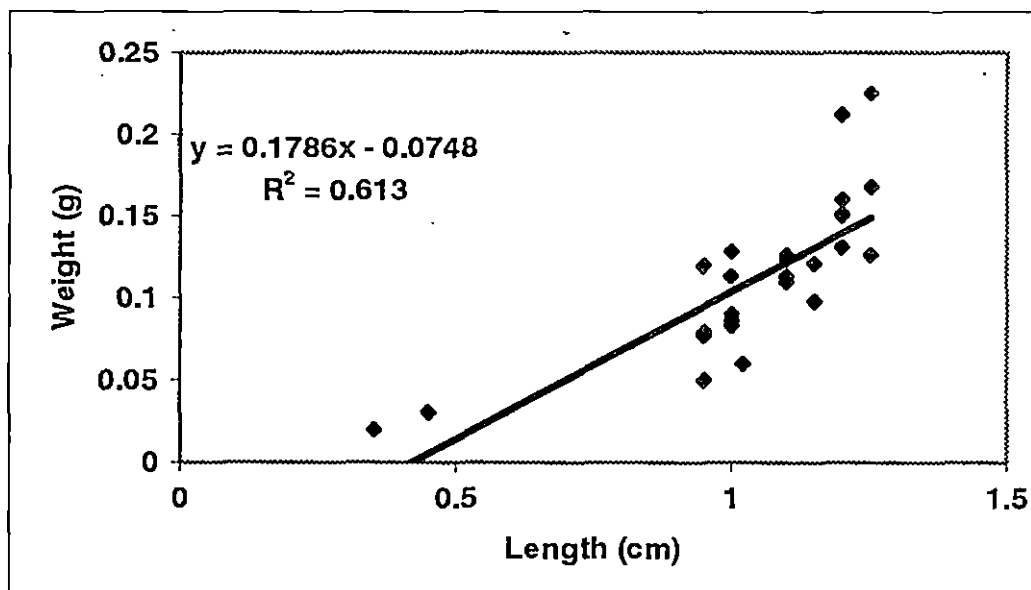


Fig. 20. Length - Weight relationship of *Palaegyge alcocki* from *M. idella* of Perumbavoor station.

4.4.3 Relationship between the total length of host and the total length of parasite.

From the Fig 21, it was found that the correlation coefficient between the total length of the host *Macrobrachium idella* and total length of the parasite *Palaegyge alcocki* ($r = 0.88$; $n = 30$) has a moderately high positive value. By 't' test, it was found that the value of t (9.8) is statistically significant at 1% level of significance.

4.4.3.1 Correlation between the carapace length of the host and total length of male and female parasite.

The parasite starts the infestation at early developmental stages in *M. idella*, which are also juvenile. So in most cases, parasite and host have concurrent development. The synchronized growing up of parasite and host was recorded for both sexes of adult isopod. There was a linear relationship between the host population carapace length and respective parasite greatest body length. Regression equations calculated for female and male parasite were $Y = 0.3268x$ ($r = 0.7003$) and $Y = 0.0773x$ ($r = 0.4191$), respectively for ($N = 27$). It is represented in the Fig 22.

4.4.4 Relationship between total length of male and female parasite

The data collected on the total length of male and female *P. alcocki* were subjected to regression analysis. It was found that the "r" was 0.45 ($n = 27$). "t" values indicated that the relationship was statistically significant at 5% level. It is represented in Fig 23.

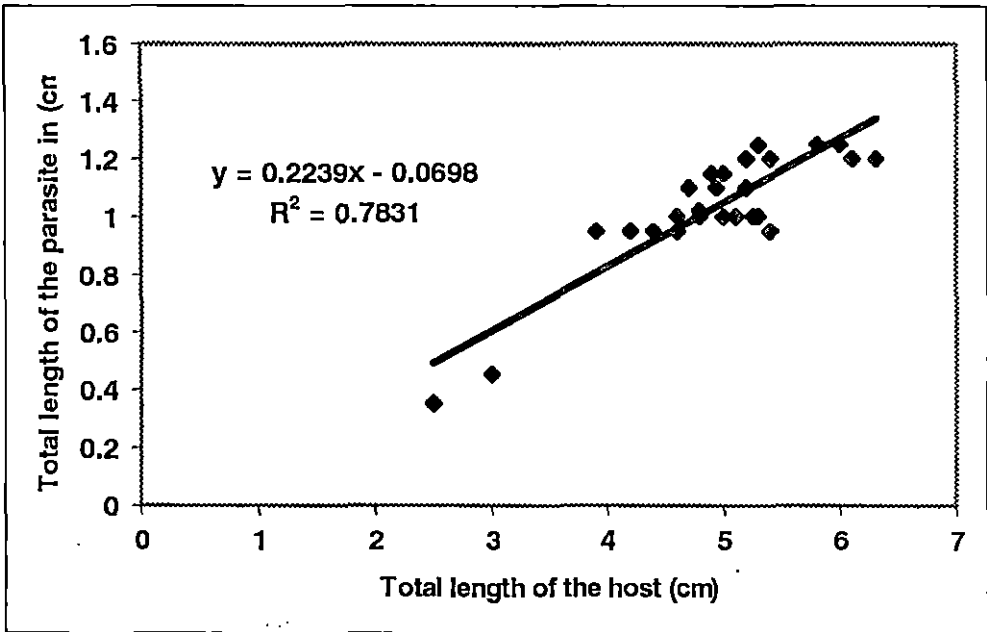


Fig. 21. Relationship between the total length of host and the total length of parasite.

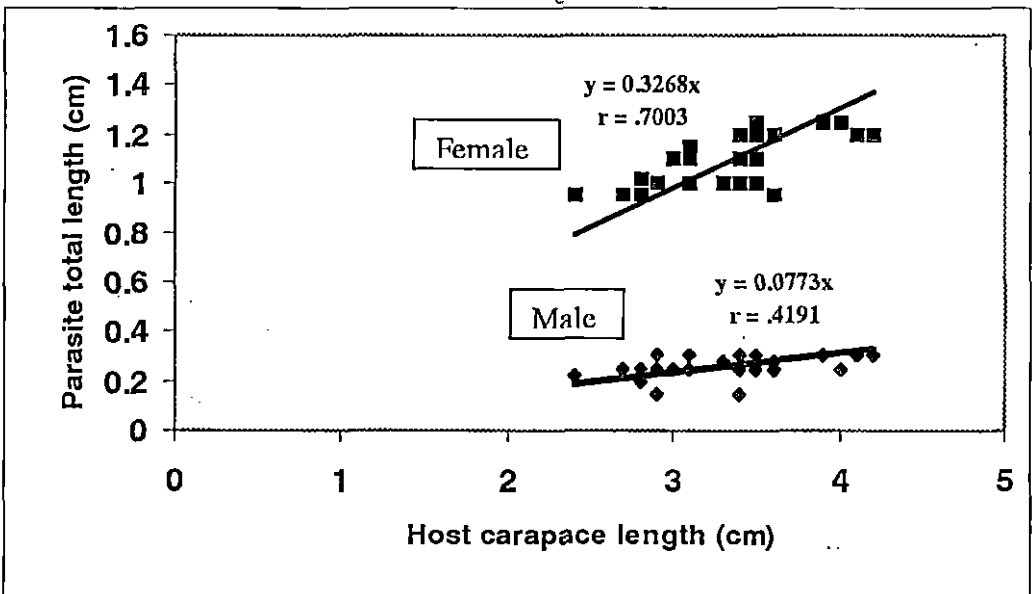


Fig. 22. Correlation between the carapace length of the host and total length of male and female parasite.

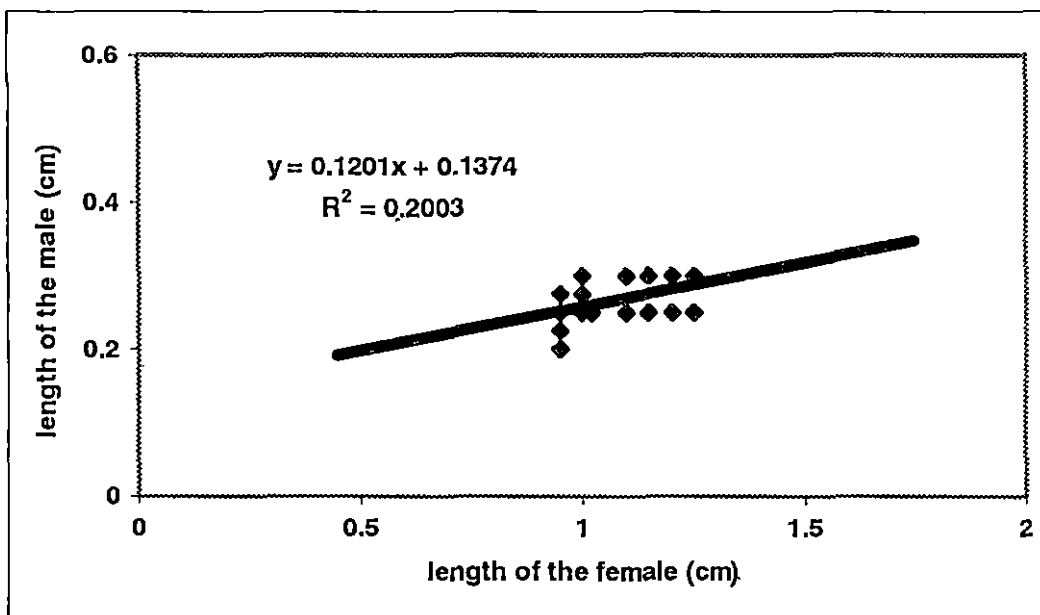


Fig. 23. Relationship between length of male and female parasite

4.5 REPRODUCTION AND LIFE CYCLE OF *PALAEGYGE* ALCOCKI CHOPRA, 1923

4.5.1 Male and female association (Plate 5 B, C)

Males and females could be identified as per the character given in the chapter on taxonomy. Both male and female parasite were found hostage on the host (*M. idella*). The female adult parasite was markedly asymmetrical and the axis was strongly turned either to right or to left depending on the size and side of the host where the parasite was attached. This intimate association of both sexes was a parasitic adaptation specially suited for fertilizing the eggs. The male parasite is diminutive and always seen residing in close association with the female at the pleopods of the female. The female bopyrid parasite was always found in juxtaposition with the gills of the host causing prominent enlargement of the carapace. There is a little space in the enlarged part

of the branchial chamber, where the parasite lives. This enables the circulation of the water for respiratory purpose.

4.5.2 Mature female (Plate. 6A, B)

The mature female could be identified based on the character given in Table 26.

4.5.3 Fecundity

The number of ova in the brood pouch varied from 8148 (1 cm TL; 0.9 cm TW; 0.12 g WT) to 29,683 (1.2 cm TL; 0.16 cm TW; 0.16 g WT); (TL- Total length; TW- Total width; WT - Weight). The number of ova per milligram body weight (Fecundity factor) ranged from 67.9 to 185.518, with an average of 126.709. In order to find out the relationship between fecundity and total length, total weight, total width and total brood weight, the data were subjected to regression analysis and the regression lines were fitted to the results by the least squares method.

4.5.3.1 Relationship between fecundity and total length of *P. alcocki*

The scatter diagram of Total length - Fecundity relationship is depicted in Fig. 24, as $Y = 17023x$. The correlation coefficient (r) computed was 0.77. The relationship between the two variables was found to be significant at 1% level ($t = 6.8$; $n = 15$).

4.5.3.2 Relationship between fecundity and total weight of *P. alcocki*

The relationship between fecundity (Y) and weight (X) of *P. alcocki* was linear (Fig. 25). The regression equation worked out was $Y = 129460x + 1293.2$ and the correlation coefficient (r) computed was 0.74. The relationship between the two variables is showed to be significant at 1% level ($t = 6.53$; $n = 15$).

4.5.3.3 Relationship between fecundity and total width of *P. alcocki*

Fig. 26 is the scatter diagram of the relationship between width of the parasite (x) and fecundity (y) and the equation worked out was $Y = 63192x - 39933$. The correlation coefficient (r) computed was 0.63. From the equation, the estimated values of fecundity were worked out and the relationship was found to be significant at 1% level ($t = 3.76$; $n = 15$).

4.5.3.4 Relationship between fecundity and total brood weight of *P. alcocki*.

The regression analysis revealed that the relationship between fecundity (y) and brood weight (x) appeared to be linear (Fig. 27). The equation obtained was $Y = 374623x + 361.2$. The correlation coefficient (r) was 0.84 and the relationship was found to be significant at 1% level ($t = 10.27$; $n = 15$).

4.5.3.5 Relationship between brood weight and the female weight of *P. alcocki*.

The linear regression equation of brood weight on female parasite weight was $Y = 0.1616x + 0.0262$ (Fig. 28). The correlation coefficient (r) computed was 0.41. The relationship was found to be not significant ($t = 1.61$; $n = 15$).

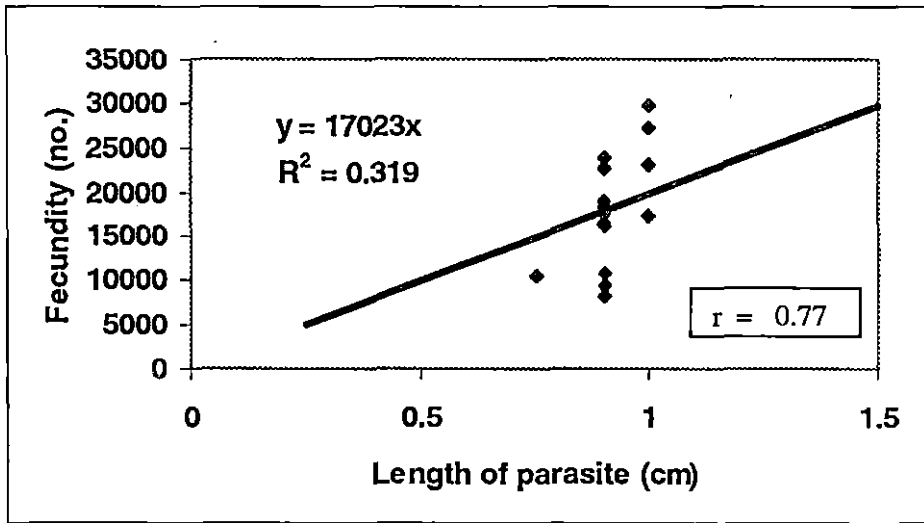


Fig. 24. Relationship between fecundity and total length of *Palaegyge alcocki*.

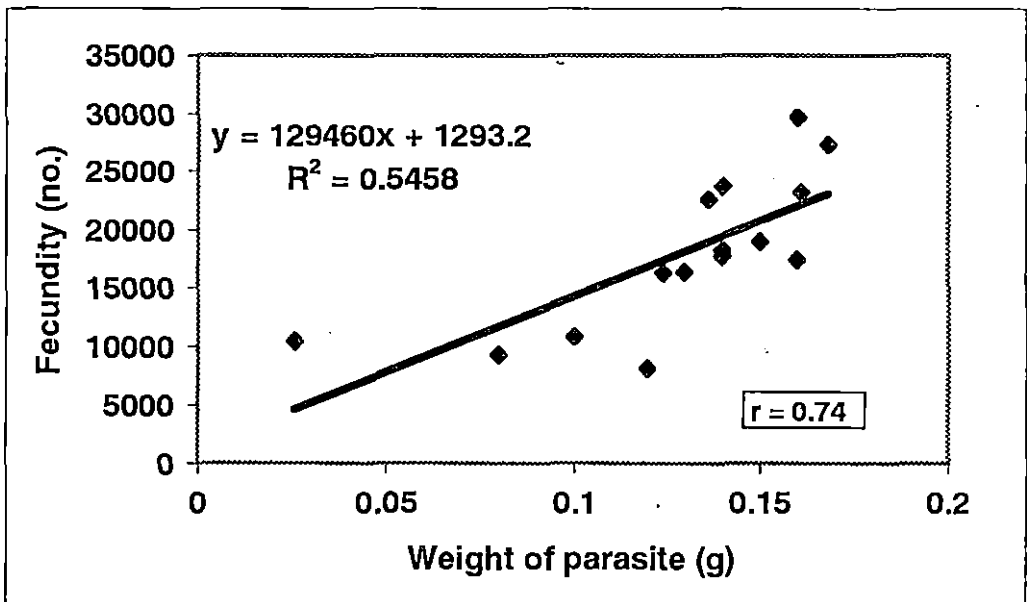


Fig. 25. Relationship between fecundity and total weight of parasite of *P. alcocki*.

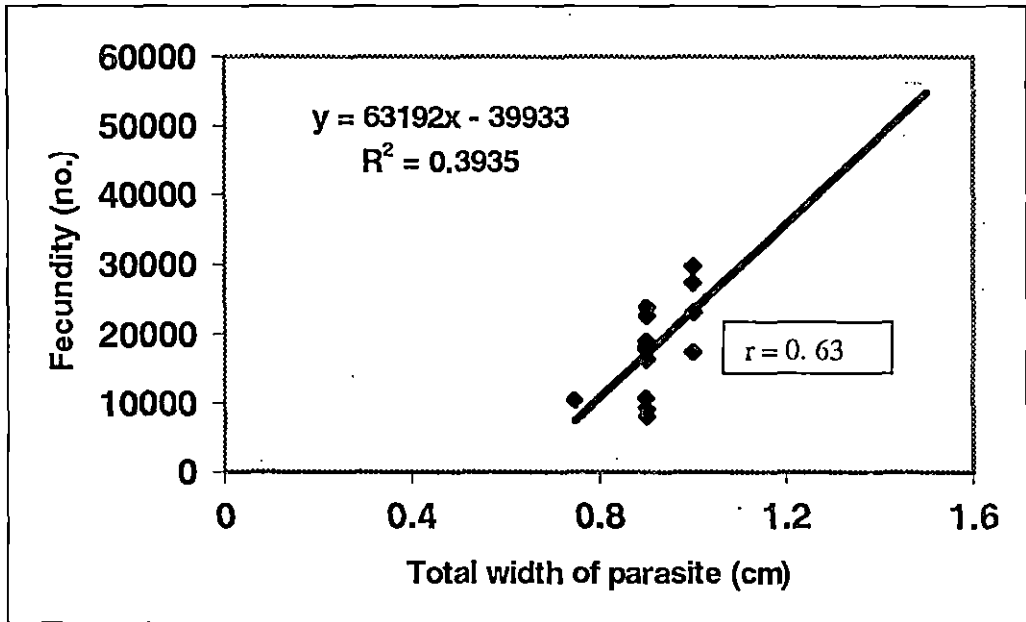


Fig. 26. Relationship between fecundity and total width.

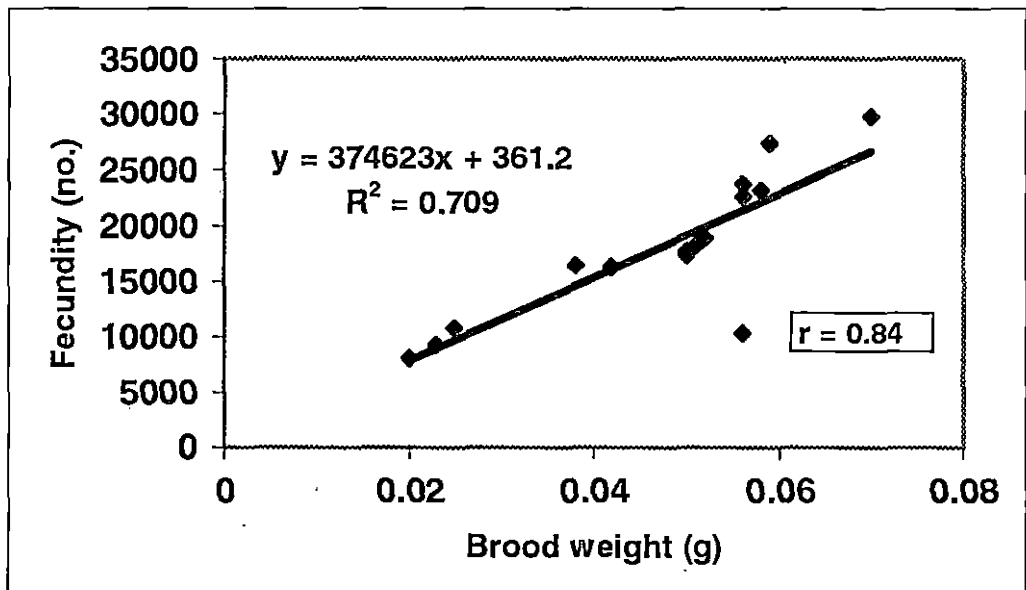


Fig. 27. Relationship between fecundity and total brood weight.

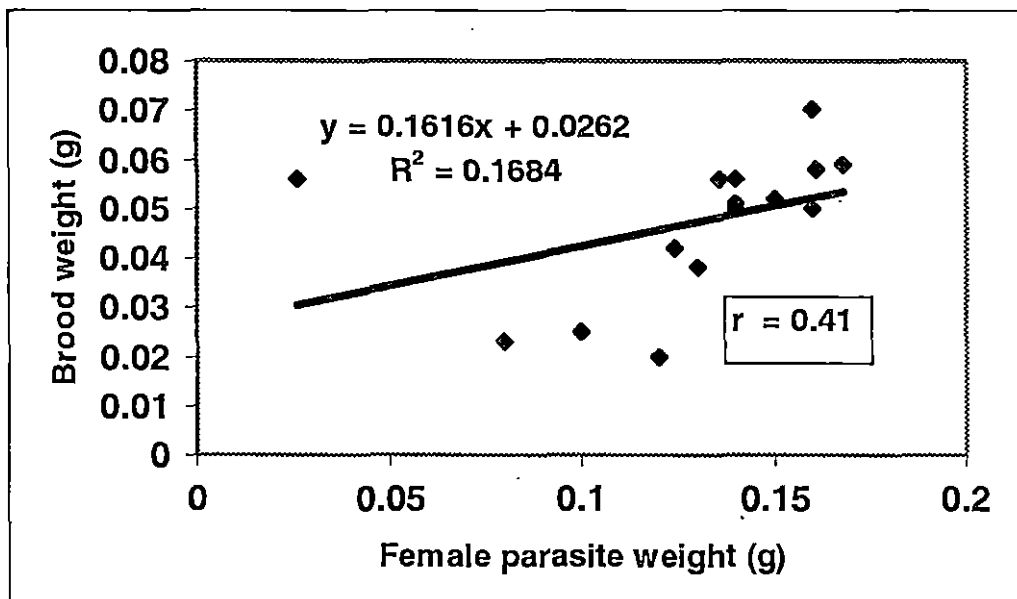


Fig. 28. Relationship between brood weight and the female weight.

4.5.4 Marsupial brooding

Marsupium is a chamber developed for incubating eggs. It is formed by the oostegites, which are extensions of coxae of thoracic appendages. First two oostegites are comparatively small and are part of maxillipeds. The remaining five pairs arise from the pereopods. The fifth pair of oostegites has stiff hairs, which direct the flow of water.

The posterior dorsal part of the marsupium develops a membranous covering on the floor probably during the breeding season. The female isopod parasite goes through one or more preparatory moults during which oostegites first appear as small ventral protrusions on the coxal plates that become fully formed only in the mature female parasite. During breeding season the eggs are released into the brood chamber and incubated here. The marsupium protects the eggs without shedding even during the ventilatory movements of water exchange.

4.5.5 Embryonic developmental cycle (Fig. 29)

Embryonic developmental cycle is much faster in case of isopod bopyrid parasite, *Palaegyge alcocki*. It is a year round breeder. The embryonic stage starts with the release of eggs to brood chamber and ends with the larval release, which takes about 8 to 12 days (Table 27). The next ovulation takes place only after an interval of 3 to 6 days. The moulting of host usually takes place at an interval of 21 days. It has multiple broods with shorter incubation times. It has been observed that *Palaegyge alcocki* is a continuous breeder. Mature female releases the eggs to the marsupium for incubation. The eggs are released as a long string without interruption. It is quite amazing to note that the eggs are free without any attachment inside the marsupium. How this is achieved remains obscure.

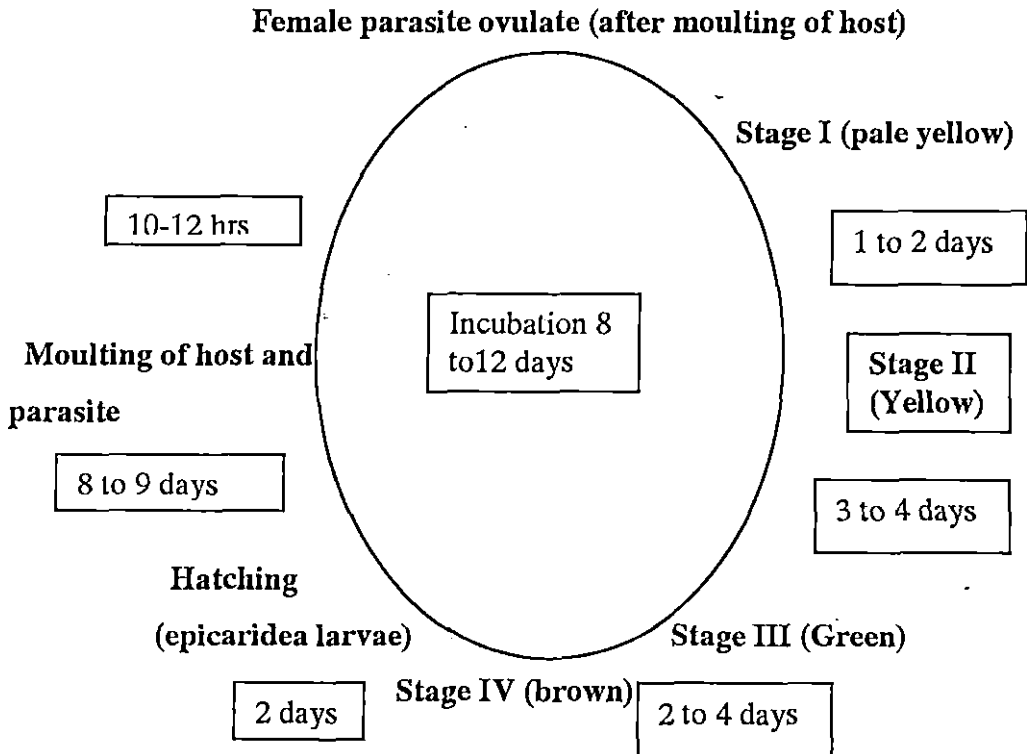


Fig. 29. Embryonic developmental cycle of *Palaegyge alcocki*

4.5.6 Pre ovulatory moult and ovulation

The female parasite's moulting coincides with that of the host. There is a pre ovulatory moult of the female parasite. Ovulation follows promptly after female's moulting. A membranous envelope encloses the deposited eggs from the ovary into the brood pouch, which prevent them from being washed away.

Males live in close association with females at maturity. During the present investigation the males could not be seen in immature female parasite. The mature female parasite can be recognized by its fully developed oostegites, which appear after the pre ovigerous moult. The breeding characteristics of 15 live specimens were observed under laboratory conditions. Generally the parasites continued ovulation and brooding for many consecutive cycles. But in one specimen an abrupt stopping of ovulation and brooding was noticed. When the parasite was examined, it was found that there was no male. Probably the female stops breeding in the absence of males. A parasite association involves a single male and a female.

4.5.6.1 Host ecdysis and ovulation of parasite

The host generally moults at an interval of 20 to 21 days. The parasite is inside the exoskeleton and exoskeleton swells to accommodate the parasite. Thus moulting of the host does not in any way affect the parasite. At the same time the parasite's moulting and breeding cycle perfectly coincide with the host's. Under laboratory conditions it was observed that incubation of eggs by the parasite completes within a period of 8 to 12 days. After the eggs are spawned, the parasite remains apparently without breeding activity, till the host moults probably for a period of 8 to 9 days or more. Immediately after host's moulting the ovulation of the parasite takes place. In some of the

exuviae of the host, oostegites of the parasites were also found and it is a clear proof that the parasite probably moults before breeding cycle.

4.5.7 Incubation (Plate 7 A, B, Plate. 8 A, B, Plate 9. A, B)

It was observed that egg deposition into marsupium occurs 10-12 hrs after the parasite moults when the cuticle is soft. The eggs of about 0.12 mm (116 μ) in size are deposited in the marsupium through female genital openings on the sixth thoracic segment. The eggs are safely incubated in the space between the ventral thoracic cuticle and the overlapping oostegites of the parasite and dorsally by the exoskeleton of the host. The embryonic stages of *P. alcocki* is given in Table 27. The eggs were filled with yolk, which forms the nutrient of developing embryo (Plate. 10 A). Eggs are found to be slightly adhesive in nature. First cleavage of the eggs was observed under the microscope and was found to be superficial (Plate. 10 B)

Table 26. Differences between mature and immature parasite.

| Sl. No | Immature | Mature |
|--------|-------------------------------------|----------------------------------|
| 1 | Smaller in size (0.35-0.45cm) | Larger in size (0.9-1 cm) |
| 2 | No pigmentation in thoracic region. | Pigmentation in thoracic region. |
| 3 | Oostegites rudimentary | Oostegites well developed. |
| 4 | Ovarian bosses not visible | Ovarian bosses visible |
| 5 | Nearly symmetrical | Asymmetrical |

Table 27. Embryonic stages of (*Palaegyge alcocki*)

| Sl. No | Egg stages | Egg size (mm) | Egg colour |
|--------|------------|---------------|-------------------------|
| 1 | Stage I | 0.12 | Pale yellow |
| 2 | Stage II | 0.13 | Yellow |
| 3 | Stage III | 0.15 | Green |
| 4 | Stage IV | 0.16 | Brown |
| 5 | Stage V | - | Spent (empty marsupium) |

4.5.8 Hatching

After 8 to 12 days of incubation an advanced larva is released called as epicaridium larva. Under laboratory conditions it was observed that regular ventilatory movements of the oostegites enhance water circulation in the tightly packed marsupium. The water current enters through the fifth oostegites and flows from posterior to anterior side of the parasite. As the water rushes in through fifth oostegites of posterior side, the epicaridium larvae are forced to move to the anterior side and the water flows out through the other posterior side. During larval release, the female parasite flexed its body so that the epicaridium larvae were freed and exposed to the respiratory system of the host swept out away through the anterior end of the branchial chamber. The release of larvae progressed from the posterior to the anterior part of the female's marsupium that is, from anterior to posterior in the host's branchial chamber.

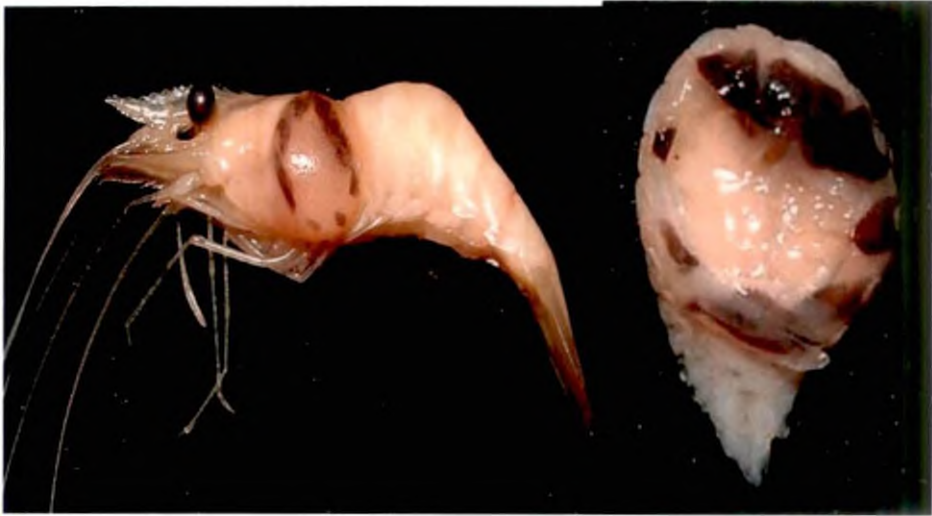
4.5.9 Epicaridea stage

In the newly released epicaridea larvae, all cephalic appendages (antennae, antennule, maxillipeds) six pairs of thoracic appendages and five pairs of abdominal appendages were seen (Plate 11 A, B, C). The miniature juvenile looks different from the adult in lacking the seventh pair of thoracic appendages and brood chamber. It is semicircular in shape in the side view.

The epicaridea larvae survived in fresh water (without salinity) for 2 or 3 days.



(A)



(B)

Plate 6. *Palaegyge alcocki*: (A) Immature parasite (B) Mature parasite



(A)



(B)

Plate 7. Embryonic stages of *Palaegyge alcocki*: (A) Stage I (B) Stage II



(A)



(B)

Plate 8. Embryonic stages of *Palaegyge alcocki*: (A) Stage III (B) Stage

IV



Plate 9. Embryonic stage V of *Palaegyge alcocki*

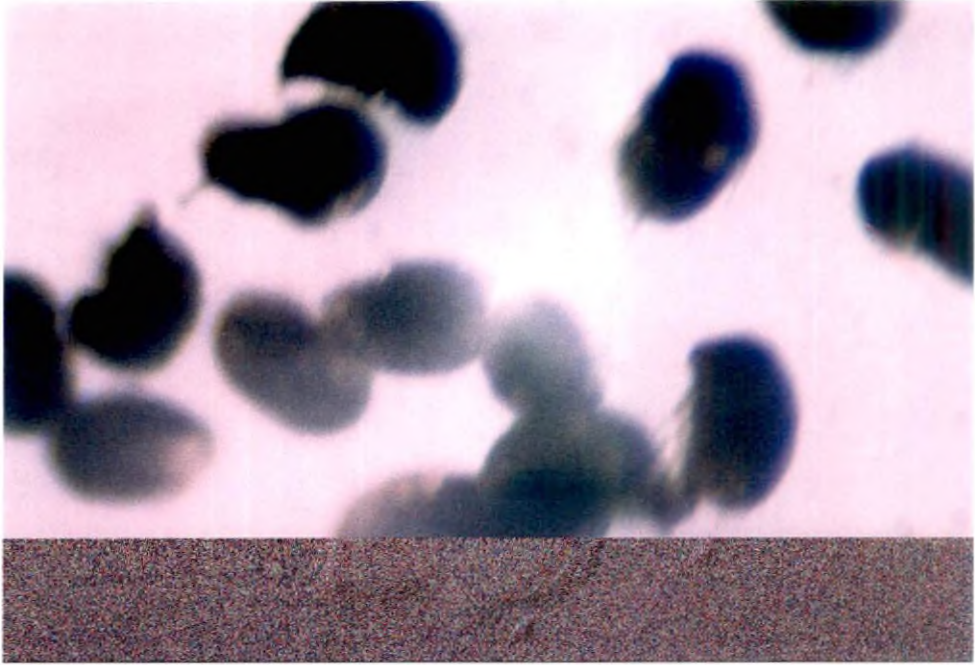


(A)

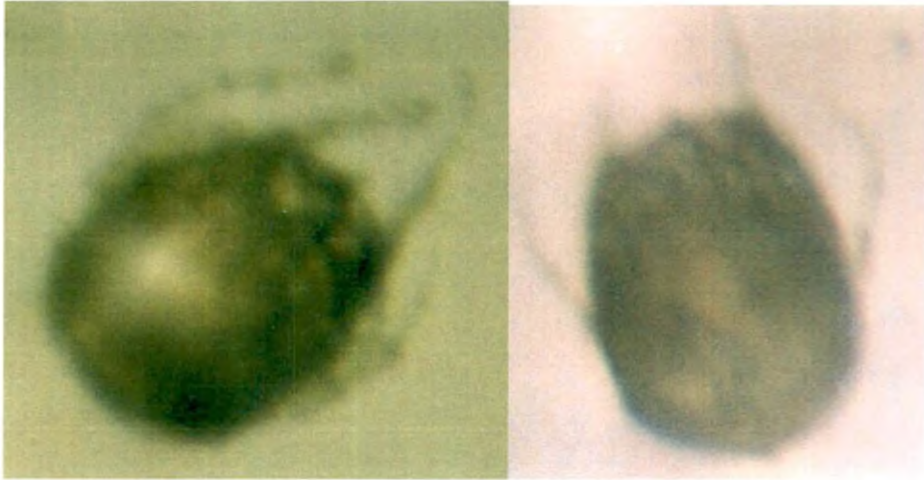


(B)

Plate 10. Development of eggs of *Palaegyge alcocki*: (A) Yolkly egg
(B) Superficial cleavage



(A)



(B)

(C)

Plate 11. Epicarideal stage of development of *Palaegyge alcocki* (A, B, C)

4.6 EFFECTS OF *PALAEGYGE ALCOCKI* ON THE SIZE, SEX AND BEHAVIOUR OF *MACROBRACHIUM IDELLA* (HILGENDORF, 1898).

Broad generalizations are made regarding parasite responses to host size, sex and behaviour.

4.6.1 Territoriality behaviour of prawns

Generally when water quality deteriorates diseases may appear and pathogenic infestation proliferates. The situation intensifies with high stocking density. The prawns will by this time be territorial in behaviour. Damage to many body parts and even mortality may be caused by fighting with the other prawns of the same genus and species and exacerbated by the poor water conditions and by the irritation of the parasite. Even though the prawns are not active due to its parasitization, but due to irritation caused by the parasite and its territoriality behaviour, *M. idella* shows its territoriality to its own species compared to its other species like *M. rosenbergii* and *M. scabriculum* stocked at the same size (Plate 12 A)

4.6.2 Secondary infections

The infestation of isopod bopyrid parasite affects the general health of prawn and it paves way for secondary infections. The infections can be by *Fusarium* sp (fungus) which cause mycelial growth, blackening of gills etc. resulting in locomotory difficulties (Plate 12 B, Plate 13A).

4.6.3 Parasitic castration

Parasitism may influence sexual processes of their hosts. Indirect parasitic castration is much more common than direct castration of the gonads. It was observed that *Palaegyge alcocki* influenced

degeneration of host gonads. Since the gonad was affected, consequently development of secondary sexual characters was arrested. This has resulted in lesser development of second pereopod and appendix masculina in males and none of the female hosts were found berried.

Table 28. Details of infected males and females of *Macrobrachium idella* during the period of July 2002 to July 2003 at Perumbavoor station.

| Month | Males | | | Females | Non Ovigerous Females | | | Ovigerous females | | Total Prawns examined |
|-------|-------|-----|----|---------|-----------------------|-----|-----|-------------------|-----|-----------------------|
| | TL | NI | I | | TL | NI | I | NI | I | |
| Jul | 28 | 28 | 0 | 57 | 32 | 10 | 15 | 0 | 85 | |
| Aug | 31 | 31 | 0 | 63 | 25 | 0 | 38 | 0 | 94 | |
| Sep | 33 | 33 | 0 | 47 | 13 | 1 | 33 | 0 | 80 | |
| Oct | 13 | 13 | 0 | 6 | 1 | 0 | 5 | 0 | 19 | |
| Nov | 9 | 5 | 4 | 55 | 3 | 42 | 10 | 0 | 64 | |
| Dec | 19 | 17 | 2 | 94 | 9 | 80 | 5 | 0 | 113 | |
| Jan | 23 | 19 | 4 | 42 | 2 | 38 | 2 | 0 | 65 | |
| Feb | 8 | 6 | 2 | 40 | 3 | 37 | 0 | 0 | 48 | |
| Mar | 29 | 26 | 3 | 9 | 2 | 7 | 0 | 0 | 38 | |
| Apr | 10 | 9 | 1 | 4 | 3 | 1 | 0 | 0 | 14 | |
| May | 29 | 29 | 0 | 18 | 15 | 2 | 1 | 0 | 47 | |
| Jun | 22 | 22 | 0 | 61 | 22 | 10 | 29 | 0 | 83 | |
| Jul | 18 | 18 | 0 | 23 | 12 | 3 | 8 | 0 | 41 | |
| Total | 272 | 256 | 16 | 519 | 142 | 231 | 146 | 0 | 791 | |

The prawns collected from the wild showed that no prawns beyond 6.2 cm were infested. Prawns were reared in the laboratory conditions and found that the growth of these prawns was adversely affected and never recorded a size beyond 6.1 cm even after 7 to 8 months in aquarium. Since gonad development was adversely affected by infestation, consequent development was also adversely affected. Consequent development of secondary sexual characters like over development of second pereopods in male was arrested. General growth

of the infected female and male host was adversely affected. None of the infected female host collected were berried (Tables 30, 31 and 32).

Table 29. Details of infected males and females of *Macrobrachium idella* during the period of July 2002 to July 2003 at Panangad station.

| Month | Males | | | Females | Non Ovigerous Females | | Ovigerous females | | Total Prawns examined |
|-------|-------|-----|---|---------|-----------------------|----|-------------------|----|-----------------------|
| | TL | NI | I | | TL | NI | I | NI | |
| Jul | 42 | 42 | 0 | 8 | 6 | 0 | 2 | 0 | 50 |
| Aug | 20 | 20 | 0 | 2 | 1 | 0 | 1 | 0 | 22 |
| Sep | 29 | 29 | 0 | 16 | 6 | 0 | 10 | 0 | 45 |
| Oct | 20 | 20 | 0 | 9 | 2 | 0 | 7 | 0 | 29 |
| Nov | 19 | 19 | 0 | 10 | 0 | 0 | 10 | 0 | 29 |
| Dec | 24 | 24 | 1 | 12 | 9 | 0 | 3 | 0 | 37 |
| Jan | 21 | 21 | 0 | 33 | 30 | 3 | 3 | 0 | 54 |
| Feb | 2 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 3 |
| Mar | 1 | 1 | 0 | 3 | 3 | 0 | 0 | 0 | 4 |
| Apr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| May | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| Jun | 4 | 4 | 0 | 1 | 1 | 0 | 0 | 0 | 5 |
| Jul | 11 | 11 | 0 | 10 | 10 | 0 | 0 | 0 | 21 |
| Total | 194 | 193 | 1 | 106 | 70 | 3 | 36 | 0 | 300 |

Table 30. Details of infected males and females of *Macrobrachium idella* during the period of October 2003 to September 2004 at Champakkara station.

| Month | Males | | | Females | Non Ovigerous Females | | Ovigerous females | | Total Prawns examined |
|-------|-------|----|---|---------|-----------------------|----|-------------------|----|-----------------------|
| | TL | NI | I | | TL | NI | I | NI | |
| Oct | 13 | 10 | 3 | 19 | 10 | 3 | 6 | 0 | 32 |
| Nov | 20 | 19 | 1 | 38 | 12 | 1 | 25 | 0 | 58 |
| Dec | 16 | 16 | 0 | 40 | 40 | 0 | 0 | 0 | 56 |
| Jan | 3 | 3 | 0 | 22 | 22 | 0 | 0 | 0 | 25 |
| Feb | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mar | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| May | 4 | 4 | 0 | 16 | 16 | 0 | 0 | 0 | 20 |
| Jun | 6 | 6 | 0 | 19 | 15 | 0 | 4 | 0 | 25 |
| Jul | 2 | 2 | 0 | 13 | 13 | 0 | 0 | 0 | 15 |
| Aug | 8 | 8 | 0 | 12 | 12 | 0 | 0 | 0 | 20 |
| Sep | 2 | 2 | 0 | 9 | 9 | 0 | 0 | 0 | 11 |
| Total | 74 | 70 | 4 | 188 | 149 | 4 | 35 | 0 | 262 |

4.6.4 Loss of gill plates and reducing respiratory efficiency

The maximum size of *Palaegyge alcocki* was 9-12 mm found in the size range of host of about 40-70 mm. The parasite having size of 6-7 mm was found infesting host of about 30-40mm. From this it is clear that the larger parasites are found on larger hosts and smaller parasites on smaller hosts. It indicates that the parasite infested the host early in life and it grows with the host. The female parasite is asymmetrical and was always found in juxtaposition with the gills of the host, causing prominent enlargement of the carapace and when it reaches its maximum size of 9-12mm, it covers 90% of the branchial chamber. The male parasite is diminutive, only 2.5-3 mm and always found between the posterior pleopods of the female.

Due to continuous association of the parasite in the branchial chamber, a number of gills and gill plates were found degenerated (Plate 13 B). The parasite made a permanent wound in the gill chamber for sucking the haemolymph. These created apparent reduction in the respiratory efficiency of the host.



(A)



(B)

Plate 12. Effect of parasitism on the host (*Palaegyge alcocki* on *Macrobrachium idella*): (A) Aggressive behaviour (B) Blackening of gills



(A)



(B)

Plate 13. Effect of parasitism on the host (*Palaegyge alcocki* on *Macrobrachium idella*): (A) Secondary infection of pleopods of host (B) Loss of gill plates.

Discussion

5. DISCUSSION

5.1 SPECIES DIVERSITY AND TAXONOMY OF BOPYRID PARASITES OF COCHIN REGION.

5.1.1 Species diversity

Prawns of the genus *Macrobrachium* Bate, 1868 contribute substantially to the fishery wealth of Kerala state. The species of commercial importance are *M. rosenbergii*, *M. idella*, *M. equidens* and *M. sulcatus*. *M. scabriculum* is of lesser importance. In Cochin region all the five species occur. These prawns were found infested by certain isopod parasites mostly belonging to the family Bopyridae. Once infested, the growth and other physiological processes of the hosts are severely affected. Therefore, the infestation causes considerable damage to the fishery. The present study on species specificity of isopod parasite infestation on prawns indicates that, out of the five species of the genus, only two species (*M. idella* and *M. scabriculum*) were found infested with the bopyrid. The bopyrid parasite of *M. idella* is identified as *Palaegyge alcocki* Chopra, 1923 whereas the isopod parasite of *M. scabriculum* is a variant of *P. alcocki* and named as *P. alcocki* var. nov. *cochinensis*. The two can be separated based on the characters given in Table 2. Even though these two forms are distinct in their morphology and host preference, further studies are necessary to confirm their species status. Jayaraj (1999) reported that *P. alcocki* infests *M. idella* in Cochin backwaters. A consolidated account on the infestation of bopyrids on other species of *Macrobrachium* is given in Table 31.

Table 31. Consolidated report of isopod bopyrid parasite infestation on species of *Macrobrachium* and *Palaemon*.

| Name of host | Name of parasite | Region | References |
|------------------------|--------------------------------|-------------------------------------|---|
| <i>M. lamarrei</i> | <i>Palaegyge prashadi</i> | Hughli delta | Chopra, 1923; 1930; Pal and Ghosh, 1975 |
| <i>M. malcolmsoni</i> | <i>Palaegyge alcocki</i> | Deltas of Ganges, Godavari, Krishna | Chopra, 1923; Ibrahim, 1962 |
| <i>M. rosenbergii</i> | <i>Palaegyge buitendijki</i> | Delta of Ganges | Chopra, 1923 |
| <i>M. mirabile</i> | <i>Palaegyge brachysoma</i> | Delta of Ganges | Chopra, 1923 |
| <i>M. rosenbergii</i> | <i>Palaegyge bengalensis</i> | Vembanad Lake, Kerala | Pillai, 1954 |
| <i>M. birmanicum</i> | <i>Palaegyge bengalensis</i> | Hooghly River, West Bengal | Pal and Ghosh, 1975 |
| <i>M. villosimanus</i> | <i>Palaegyge bengalensis</i> | Hooghly River, West Bengal | Pal and Ghosh, 1975 |
| <i>M. dayanam</i> | <i>Palaegyge prashadi</i> | Hooghly River, West Bengal | Pal and Ghosh, 1975 |
| <i>M. idella</i> | <i>Palaegyge alcocki</i> | Vembanad Lake, Kerala | Jayaraj, 1999 |
| <i>Palaemon sp</i> | <i>Palaegyge pica</i> | Travancore, Kerala | Chopra, 1930 |
| <i>Palaemon sp</i> | <i>Palaegyge abhoyai</i> | Delta of Ganges | Chopra, 1930 |
| <i>M. equidens</i> | <i>Probopyrus sp</i> | Netravati River, Karnataka | Natarajan <i>et al.</i> 1982 |
| <i>M. idella</i> | <i>Probopyrus sp</i> | Veli Lake, Trivandrum | Sree Devi, 1995 |
| <i>Palaemon sp</i> | <i>Probopyrus gangeticus</i> | Delta of Ganges | Chopra, 1923 |
| <i>M. amazonicum</i> | <i>Probopyrus pandalicola</i> | West Indies; NE South America | Markham, 1985a |
| <i>M. amazonicum</i> | <i>Probopyrus floridensis</i> | Curacao | Nierstrasz and Brender à Brandis, 1925 |
| <i>M. americanum</i> | <i>Probopyrus markhami</i> | State of Guerrero, Mexico | Contreras, 1996 |
| <i>M. tenellum</i> | <i>Probopyrus pacificensis</i> | Pacific coast of Mexico | Contreras, 1993 |

| | | | |
|-------------------------|-----------------------------------|-------------------------------------|--|
| <i>M. tenellum</i> | <i>Probopyrus pandalicola</i> | Pacific coast | Guzman and Contreras, 1983 |
| <i>M. faustinum</i> | <i>Probopyrus insularis</i> | Caribbean islands, Jamaica | Contreras and Bourdon, 2001 |
| <i>M. faustinum</i> | <i>Probopyrus pandalicola</i> | Puerto Rico | Williams <i>et al.</i> 1998 |
| <i>M. potuina</i> | <i>Probopyrus floridensis</i> | Pereque River, Southern Brazil | Masunari <i>et al.</i> , 2000 |
| <i>M. carcinus</i> | <i>Probopyrus pandalicola</i> | Panama | Markham, 1985a |
| <i>M. rosenbergii</i> | <i>Probopyrus buitendijki</i> | South East Asia | Markham, 1985c |
| <i>M. lar</i> | <i>Probopyrus borrei</i> | Guadal Canal & New Britain | Shiino, 1973 |
| <i>M. australe</i> | <i>Probopyrus borrei</i> | Guadal Canal & New Britain | Shiino, 1973 |
| <i>M. surnamicum</i> | Unidentified | Surinam | Markham, 1985a |
| <i>M. acanthurus</i> | <i>Probopyrus panamensis</i> | Pariso, canal Zone, Panama | Richardson, 1912 |
| <i>M. acanthurus</i> | <i>Probopyrus pandalicola</i> | Central America | Markham, 1985a |
| <i>M. acanthurus</i> | <i>Probopyrus meeki</i> | Panama and Canal Zone | Richardson, 1912 |
| <i>M. equidens</i> | <i>Probopyrus annandalei</i> | Thailand | Markham, 1985b |
| <i>M. lanchesteri</i> | <i>Probopyrus annandalei</i> | Thailand | Markham, 1985b |
| <i>M. olfersii</i> | <i>Probopyrus pandalicola</i> | Mexico to Surinam, Cuba; Hispaniola | Markham, 1985a |
| <i>M. ohione</i> | <i>Probopyrus pandalicola</i> | Missouri; Mississippi; Louisiana | Markham, 1985a |
| <i>M. ohione</i> | <i>Probopyrus bithynis</i> | Louisiana | Richardson, 1904 |
| <i>Macrobrachium sp</i> | <i>Probopyrus oviformis</i> | Virgin islands | Nierstrasz and Brender à Brandis, 1929 |
| <i>Macrobrachium sp</i> | <i>Probopyrus papaloapanensis</i> | Mexico | Lemos de Castro and Brasil Lima (1974) |

There are reports of 14 species of *Probopyrus* and 6 species of *Palaegyge* infesting on *Macrobrachium* (Table 31). It can be seen that these parasites are generally species specific except parasites like *Probopyrus pandalicola* (infesting *M. faustinum*, *M. acanthurus*, *M. amazonicum*, *M. carcinus*, *M. ohione*, *M. olfersii*, *M. tenellum*), *Probopyrus annandalei* (infesting *M. equidens* and *M. lanchesteri*), *Probopyrus borrei* (infesting *M. lar* and *M. australe*), *Palaegyge alcocki* (infesting *M. idella* and *M. malcomsonii*), *Palaegyge bengalensis* (infesting *M. rosenbergii*, *M. birmanicum* and *M. villosimanus*), *Palaegyge prashadi* (infesting *M. dayanam* and *M. lamarrei*). There are also exceptions like *M. rosenbergii* (infested by *Palaegyge bengalensis* and *Probopyrus buitendijki*), *M. malcomsonii* (infested by *Palaegyge bengalensis* and *P. alcocki*) and *M. faustinum* (infested by *Probopyrus pandalicola* and *Probopyrus insularis*, infested by more than one species of parasite. However the present study at the species-specificity in infestation of *Macrobrachium idella* (*Palaegyge alcocki*) and *M. scabriculum* (*Palaegyge alcocki* var. nov. *cochinensis*).

5.1.2 Taxonomy of *Palaegyge alcocki* Chopra, 1923, (Isopoda: Bopyridae)

From Table 31, it can be found that the bopyrid parasites of *Macrobrachium* belong to 2 genera, *Palaegyge* Giard and Bonnier, 1888 and *Probopyrus* Giard and Bonnier, 1888. It appears that the parasites infesting the Indian prawn are mainly *Palaegyge* whereas the parasites of *Macrobrachium* outside India are *Probopyrus*. Chopra (1930), Dale and Anderson (1982) and Markham (1985a; b, c) pointed out the difficulty in separating the two genera. It is highly confusing. However Chopra (1930) has distinguished the two genera by the characters such as:

| <i>Palaegyge</i> | <i>Probopyrus</i> |
|--|---|
| Female: | Female: |
| Form of body generally markedly asymmetrical | Form of body generally rounded |
| Lateral plates of abdominal somites generally present. | Lateral plates of abdominal somites never present. |
| Last abdominal somite cleft posteriorly. | Last abdominal somite generally entire posteriorly. |
| Rudimentary uropods generally present. | Uropods never present |
| Male: | Male: |
| Abdominal somites generally distinct. | All abdominal somites never distinct. |

Markham (1985c) disagreed with the separation of the two genera and proposed a single genus *Probopyrus*. He also pointed out that the parasites show great morphological plasticity. All these indicate the complexity within the genera and species. However the present identification is based on Chopra (1923, 1930). Hence *Palaegyge alcocki* is followed in this study. The characters exhibited by the present species agree fully with the description given for the *Palaegyge alcocki* by Chopra, 1923. However the isopod present in *M. scabriculum* is slightly different. A comparison of characters is given in Table 2 and illustrated in Fig 1. It can be seen that the two forms differ very much in the body shape and pigmentation in the uropod. Hence it may be presumed that the two forms are variants of the same species.

A comparison of characters of closely related species of *P. alcocki* namely, *P. pica* and *P. bengalensis* is given in Table 3. It reveals that the species can be easily separated mainly based on characters such as body shape, size, body colour, pigmentation, thoracic somites, last abdominal somite, oostegites, caudal lobe, pleon and uropods. It appears that *P. alcocki* closely resembles *P. bengalensis* in most of the characters. But the two species can be separated based on the structure

of the last abdominal somite, which is large and triangular in the former whereas it is narrow and deeply cleft in the latter (Chopra, 1923; 1930).

5.2 HOST- PARASITE RELATIONSHIP

5.2.1 Mode of attachment and association

Of 1353 specimens of *M. idella* collected, 248 specimens exhibited infestation on the branchial chamber and about 13 specimens showed indication of infestation but were without the parasite. A diminutive male was found on the pleon of the female in all mature parasites. Since the dorsal surface of the parasite was pressed against the gills of the host, degeneration of tissue and gills occur at the branchial chamber. In the present investigation, it was found that the bopyrid parasite *P. alcocki* infests the host *M. idella* at its early life and that it exhibits a concurrent development. A significant positive correlation between the length of the host and length of the parasite occurs and in addition there exists a positive relationship between male and female parasites (Tables 5, 6, 7 and 8). Similar observation was made by many authors (Pike, 1960; Truesdale and Mermilliod, 1977; Beck, 1980). The present study indicates that the important reproductive aspects of parasites such as spawning, incubation, hatching and liberation of larvae take place immediately before the ecdysis of the host. This has been observed by scientists like Anderson (1975), Beck (1980), Walker (1984) and Cash and Bauer (1993). After the prawn moults, two important events in the relationship of host and parasite occur. One important event is even after the moulting of the host, the parasite remains inside the branchial chamber. Another one is that the moulting of the host and spawning of the parasite occur sequentially. While the parasite is brooding embryos, host moulting never occurs. Studies of Roccatagliata and Lovrich (1999) and Hiraiwa and Sato (1939) show that after the loss of parasite, the host recovers from the inhibitory effect

on reproduction. But no studies explain about the condition of the parasite after the death of the host. The present study reveals that the parasite also dies soon after the death of the host showing a dependent relationship between the host and the parasite.

5.3 INTENSITY OF PARASITIC INFESTATION ON WILD POPULATION OF PALAEMONID PRAWNS OF COCHIN REGION

The percentage infestation of the parasite *P. alcocki* on *M. idella* at 3 stations namely Perumbavoor, Panangad and Champakkara were 31.48, 1.3 and 3.1 respectively (average 19.2). Similar studies were conducted by Chopra (1923), Kunju (1956), Thomas (1977), Kunju (1981), Deshmukh (1984) and Masunari *et al.* (2000). The infestation was more in *M. idella*, probably because of the greater population size of the species. The results reveal that the infestation is more in freshwater regions than in the estuaries.

Lower incidence of infestation was noticed during the months May to October whereas higher incidence was during the months November to April at Perumbavoor whereas at other stations only stray occurrence was noticed. Jayaraj (1999) observed a steady increase of infestation from June to October and then a decline slight in November in Cochin backwaters. Masunari *et al.* (2000) observed high incidence values in June and July followed by lower incidence lasting until May.

The infestation in relation to the size of *M. idella* was found to be maximum in the length group 5.0 – 5.9 cm. The intensity increased with increase in length of the host from 2.0 – 2.9 cm, 0.8%; 3.0 – 3.9 cm, 1.21%; 4.0 – 4.9 cm, 31.3%; 5.0 – 5.9 cm, 58.6%; 6.0 – 6.9 cm, 8.0% in Perumbavoor station, 4.0 – 4.9 cm, 25%; 5.0 – 5.9 cm, 50%; 6.0 – 6.9 cm, 25% in Panangad station, 4.0 – 4.9 cm, 12.5%; 5.0 – 5.9 cm, 75%; 6.0 – 6.9 cm, 12.5% in Champakkara station. The infestation of the

parasite on *M. idella* was in the size range of 2.5 cm – 6.2 cm and the minimum and maximum size of the parasite was 0.35 cm and 1.2 cm respectively. The smaller size groups of less than 50 mm estuarine prawn, *Nematopalaemon tenuipes* (Deshmukh, 1984) and 10 – 19.9 mm crab, *Paralomis granulosa* (Roccatagliata and Lovrich, 1999) showed significantly higher prevalence of infestation.

The infestation in relation to sex indicated that females (92%) were infested more than males (8%) and the intensity of infestation (in relation to total prawns examined) also females dominated (17.4%) than males (1.8%). During the breeding season from July to January, the sex ratio of the prawns was in favour of females. The dominance of isopod bopyrid parasites in female prawns had positive relationship with the breeding season. Similar observations are reported by Kunju (1956), Allen (1966), Thomas (1977), Natarajan *et al.*, (1982) and Jayaraj (1999). In contrast to the above, Deshmukh (1984) observed no preference to either sex.

Bopyrid parasite (*P. alcocki*) lodges only on one side of the gill chamber either left side or right side. In the present observation, the left side infestation (53.4%) is higher compared to right side (46.6%) in Perumbavoor, right side infestation (75%) is higher compared to left side (25%) in Panangad and both the sides are equally infested (50% each) in Champakkara. When the above data was consolidated it was found that left side infestation was slightly higher (53.6%) compared to right side infestation (46.4). The observations by Deshmukh (1984), Oliveira and Masunari (1998), Roccatagliata and Lovrich (1999) and Masunari *et al.* (2000) are also in this line.

Prawns infested with parasite collected from freshwater zone of the Periyar River (Perumbavoor) during July '02 to July '03 had the intensity of infestation at 31.48%. In the estuarine zone of Vembanad Lake (Panangad and Champakkara) the intensity was 1.3% and 3.1%.

These sites showed wide range of salinity variation from 2 –35 ppt (Haridevi *et al.* 2003). The infestation is more in this region when the salinity decreases considerably due to the southwest monsoon. In the present study it was observed that infestation is more in freshwater regions (maximum at Perumbavoor and least at Panangad) indicating that low saline conditions promote the infestation. Hence even though the parasite tolerates variations in salinity, higher prevalence of infestation is at low saline areas. No studies are available in these lines.

The prawns with a bulged branchial chamber and which the parasites are considered as deparasitized prawns. Thirteen out of 1353 specimens were of this category. Such cases of infestation were found to be 1.4% at Perumbavoor; 0.3% at Panangad and 0.4% at Champakkara. The reason is loss of parasite along with moult of the host. Such cases have been reported by Pike (1960), Beck (1980), Cash and Bauer (1993) and Roccatagliata and Lovrich (1999).

5.4 BIOLOGY OF *PALAEGYGE ALCOCKI*, CHOPRA, 1923

A positive correlation existing between length and weight of the infested *M. idella*; length & weight of the parasite (separated from the host). There was a positive correlation existing between total length of host and total length of parasite; total length of female and total length of male parasites; carapace length of the host and total length of female and total length of male parasites. The regression equations calculated for these characters are:

1. Length and weight of the infested *M. idella*: $Y = 0.573x - 1.524$
2. Length and weight of the parasite (separated from the host): $Y = 0.1786x - 0.0748$
3. Total length of host and total length of parasite: $Y = 0.2239x - 0.0698$

4. Total length of female and total length of male parasites: $Y = 0.1201x + 0.1374$
5. Carapace length of the host and total length of female and total length of male parasites: $Y = 0.3268x$, $r = 0.7003$; $Y = 0.0773x$, $r = 0.4191$

Since there is a significant positive correlation exists between various characters of both the host and the parasite, it can be safely concluded that the growth of parasite is similar to that of the host. Similar studies were also made by Pal and Ghosh (1975).

5.5 REPRODUCTION AND LIFE CYCLE OF *PALAEGYGE* *ALCOCKI* CHOPRA, 1923

Practically no information on the reproductive biology of *P. alcocki* is available. But some studies were conducted on the genus *Probopyrus* ((Richardson, 1912; Shiino, 1933 -1958; Markham, 1972, 1973, 1980, 1985a, b, c, 1988, 1989, 1990; Castro and Lima, 1974; Bourdon and Bruce, 1979, 1983; Bourdon and Markham, 1980; Bourdon, 1981, 2001; Natarajan *et al.*, 1982; Cash and Bauer, 1993; Contreras, 1993, 1996; Sree Devi, 1995; Contreras and Wehrtmann, 1997; Oliveira and Masunari, 1998; Roccatagliata and Lovrich, 1999; Castagini and Oliveira, 2000; Contreras and Bourdon, 2001; Contreras and Soto, 2002).

5.5.1 Male and female association

The association of male and female of *P. alcocki* on *M. idella* is quite interesting. The diminutive male was found on the pleon of the female. Bursey, 1978; Cash and Bauer, 1993; Masunari *et al.* 2000 have also noticed males in the pleopods of females in the female adult parasite was markedly asymmetrical. The parasite which infests the right side of the branchial chamber has its body axis distorted to right side and

head displaced to left side (dextral) whereas the parasite which infests the left side has its body axis turned to left side and head displaced to right side. The chamber developed in the branchial chamber enables the animal to live inside and also helps in the circulation of water for respiration.

5.5.2 Mature female

Generally the mature female could be identified based on well-developed oostegites, asymmetrical body shape, ovarian bosses etc (Roccatagliata and Lovrich, 1999 and Masunari *et al.* 2000). In the present investigation, in addition to all these characters; the body size and pigmentation in the thoracic region are also found to be important in differentiating mature and immature female parasites. Such observations are made use of for this purpose for the first time.

5.5.3 Fecundity of *Palaegyge alcocki* (Isopoda: Bopyridae)

No information regarding the fecundity of isopod parasites was available so far. *P. alcocki* produces a large number of eggs at a time. The eggs in the brood chamber are fertilized eggs. Number of eggs in the broods of mature females varied from 8148 (1.0 cm TL; 0.9 cm TW; 0.12g WT) to 29683 (1.2 cm TL; 1.0 cm TW; 0.16g WT) and it was found that the ability of egg production varies within the species and is dependent on length, weight, width and brood weight. The estimated fecundity is useful in determining the population structure of the parasite. Johnson (1976) has stated that the relation between the total length and fecundity for all peracarids is exponential. There was significant correlation between fecundity and total length, total weight, total width and total brood weight, which are indicated by high value of correlation coefficient 'r' which was always above 0.7. A straight-line relationship existed between fecundity and length, weight, width and

brood weight. The number of egg production depended on ovary weight more closely. Hence brood weight is a better index of fecundity than the total length, total weight and total width. But the relationship between brood weight and weight of the female was found to be not significant.

5.5.4 Marsupial brooding

In the female the most striking character is the presence of ventral thoracic structure, which is the marsupium. The eggs hatched from the female marsupium (Masunari *et al.* 2000). The moult of female parasites was observed along with the host moult. The immature parasites with undeveloped oostegites or a small ventral protrusion and mature parasites with fully developed oostegites of female were observed in the host moult of the branchial chamber. Observations of Roccatagliata and Lovrich (1999) also lend support to this aspect. Hence it can be confirmed that the moulting of the female parasite coincides with that of the host.

5.5.5 Embryonic developmental cycle

P. alcocki takes a shorter incubation period of only about 8 to 12 days and the next ovulation within 3 to 6 days. Hence the parasite reproduces continuously. Oliveira and Masunari (1998) observed that the isopod bopyrid parasites are continuous breeders. However in most intertidal isopods from temperate waters, reproductive periods are restricted to warmer months, with only limited sexual development during the winter (Johnson, 1976). The embryonic developmental cycle of *P. alcocki* is shown in Fig. 24. The parasites of size group 0.9 to 1.1 cm is attached to the host of size group 4.0-4.9 to 6.0-6.9 cm. The brood with or without eggs in the brood chamber were differentiated into 5 different stages. The eggs in the brood chamber were differentiated based on shape, colour and stage of development. Stage I:

spherical, pale yellow coloured eggs with an average diameter of 0.12 mm; Stage II: spherical, yellow coloured eggs with an average diameter of 0.13 mm; Stage III: Oval, green coloured eggs with an average length (longer axis) of 0.15 mm; Stage IV: Oval, brown coloured eggs with an average length of the longer axis of 0.16 mm; Stage V: Spent stage (empty marsupium).

5.5.6 Preovulatory moult and ovulation

Moulting of the host is a critical point in the reproduction of *P. alcocki*. The female parasite also moults along with the host. Ovulation follows immediately after female parasite's moulting. When the male parasite is accidentally or naturally detached from the female, then the reproductive activity is stopped. Cash and Bauer's (1993) observation also indicates the same. These observations give strong evidence that males inseminate females prior to each spawning.

5.5.6.1 Host ecdysis and ovulation of parasite

The important characteristic feature of the reproductive cycle is that the parasite moults before ovulation and that its moulting and the breeding cycle fully related with the moulting of the host. But the host ecdysis are no way affecting the parasite. Beck (1980) and Cash and Bauer (1993) studies also reveal the same.

5.5.7 Incubation

Within 10 to 12 hours, after the female parasite moults, the eggs are deposited in the marsupium. The eggs are of about 0.12 mm size. The eggs are tightly packed in the marsupium and are seen to be adhesive in nature. The yolk of egg provides nutrition for the developing embryo. The cleavage is superficial. There are some

references of isopods having incubatory behaviour (Cash and Bauer, 1993; Oliveira and Masunari, 1998).

5.5.8 Hatching

The epicaridea larvae were freed from the brood chamber and are exposed to the respiratory system of the host, which swept away the larvae through the anterior end of the branchial chamber. During the larval release, the parasite flexed its body to free off the epicaridea larvae. The same observation was also noted by Cash and Bauer (1993).

5.5.9 Epicaridea stage

Epicaridea larvae bear all cephalic appendages (antennae, antennule, maxillipeds), six pairs of thoracic appendages and five pairs of abdominal appendages. Oliveira and Masunari (1998) described about the cryptoniscus larvae, the next larval stage of epicaridea.

5.6 EFFECTS OF *PALAEGYGE ALCOCKI* ON THE SIZE, SEX AND BEHAVIOUR OF *MACROBRACHIUM IDELLA* (HILGENDORF, 1898)

Due to the infestation of *P. alcocki*, the prawns were observed to be lean, transparent, less in consistency, poor in feeding and comparatively weak immune response. This might have paved way for the secondary infestations like *Fusarium* sp which lead to mycelial growth, blackening of gills and locomotory difficulties etc. The sex of the specimens of *M. idella* parasitized by *Palaegyge alcocki* is difficult to identify because the parasite inhibits sexual activity and prevents development of secondary sexual characters. None of the infested host became ovigerous (Tables 30; 31 and 32). The second pereopod and appendix masculina of males did not grow to normal size posing difficulties for its identification also. Ibrahim (1962) and Pal and Ghosh

(1975) also agree that parasitization inhibits reproduction. The infestation was observed between the size groups from 20 – 29 to 60 – 69 mm. According to Jayachandran (1984) minimum length at first maturity for prawns of *M. idella* was about 56 mm. Hence as a result of parasitism, the prawns fail to reproduce and hence it can be concluded that gonad development of suppressed. The parasite feeds on the haemolymph of the host, which causes lot of upsets in the physiological processes. The observations of Cameron, 1956 and Bursey, 1978) are also in these lines. Since gonad development was affected, development of secondary sexual characters also was adversely affected. As observed here, parasitic infestation and retardation of growth were observed by many (Chopra, 1923; Menon, 1953; Thomas, 1977).

The present study brought out the following: taxonomy, species diversity, length – weight relationship and reproductive biology of bopyrid parasites infesting on the genus *Macrobrachium*, Bate, 1868. The negative effects on the host due to the parasitism like aggressive behaviour of infested hosts, secondary infections (mycelial growth, blackening of gills, degeneration of pleopods etc), retarded growth of the host, degeneration of reproductive organs, loss of gills etc.

Summary

6. SUMMARY

The present study is on the taxonomy, species diversity, length and weight relationship, reproductive biology of bopyrid parasites infesting on the genus *Macrobrachium* Bate, 1868.

1. A total of 1353 specimens of *Macrobrachium idella*, 150 specimens of *M. scabriculum*, 265 specimens of *M. equidens*, 145 specimens of *M. sulcatus* and 120 specimens of *M. rosenbergii* were collected from 3 stations namely, Perumbavoor (Periyar River), Panangad and Champakkara (Vembanad Lake). Fortnightly collections for 13 months from Perumbavoor station and Panangad station during July '02 to July '03 and monthly collections for 12 months from Champakkara station during October '03 to September '04 were observed. It was found that only two species were infested with bopyrids (*M. idella* and *M. scabriculum*).

2. The bopyrid parasite of *M. idella* has been identified as *Palaegyge alcocki* Chopra, 1923. Since the parasite of *M. scabriculum* shows variation, it has been identified as a new variety of *P. alcocki* and named as *P. alcocki* var. nov. *cochinensis*.

3. The new variety is distinguished by the highly asymmetrical body shape, oval shaped cephalothorax, narrow abdomen, round and deeply cleft pleotelson and non pigmented last pleon. The diagnostic characters of *P. alcocki* is also given in the text.

4. *P. alcocki* is the typical ectoparasite of *M. idella*, and lives inside the branchial region in a swelling of the branchiostegite. The male and female live in close association. The male parasite is diminutive, seen in between the pleon of the female parasite.

5. The data suggests that the parasite enters the juvenile host at an early stage and they exhibit a concurrent development. The parasite grows along

with the host. The minimum size of the host at which the parasite enters was 25 mm (3.5 mm parasite).

6. The parasites were retained in the gill chamber even after moulting of the host. The host moulting and parasite spawning occurs sequentially. This is evidenced from the fact that the parasite's moult (oostegites) is seen along with the moult of the host.

7. The parasite could not survive after the death of the host.

8. The intensity of infestation (%) of the parasite (*P. alcocki*) on the host (*M. idella*) at 3 stations namely Perumbavoor, Panangad and Champakkara were 31.48, 1.3 and 3.1 respectively (average 19.2).

9. Monthwise infestation: At Perumbavoor station (freshwater) the prawns with bopyrid infestation were collected in all the months (except Oct 2002). Lower incidence of infestation was noticed during the months May to October whereas higher incidence during the months November to April. At other stations only stray occurrence was noticed. This shows that the bopyrid parasite infestation on *M. idella* is more prevalent in freshwater region than in estuarine regions.

10. Sizewise infestation: The infestation was found to be maximum in the length group 5.0-5.9 cm (58.6% - Perumbavoor, 75% - Panangad and 75% - Chamapakkara). The parasite in between the size range of 0.35 cm – 1.2 cm was found to infest *M. idella* in the size range of 2.5 – 6.2 cm in total length.

11. Sexwise infestation: Females (92%) were found infested more than males (8%). The intensity of infestation (in relation to total prawns examined) in females (17.4%) was more than males (1.8%). The sex ratio of the prawns was also in favour of females (1:1.9)

12. Sidewise infestation: *Palaegyge alcocki* harbours only on one side of the gill chamber either left or right side. There was not much preference for side for infestation (Left : right = 53.4 : 46.6 %).

13. Thirteen specimens of prawns, which had swelling, but without parasites in the branchial chamber are considered as deparasitized prawns. This gives the possibility of the parasite being removed along with the moult of the host

14. A positive relationship was observed between length and weight of parasite infested *M. idella* ($Y = 0.573x - 1.5245$, $R^2 = 0.8541$) and also between length and weight of the parasite, which was separated from the host ($Y = 0.1786x - 0.0748$, $R^2 = 0.613$)

15. A positive relationship was observed between the total length of host and the total length of parasite ($Y = 0.2239x + 0.0698$, $R^2 = 0.7831$) and between the carapace length of the host and total length of male as well as female parasite ($Y = 0.0773x$, $r = 0.4191$; $Y = 0.3268x$, $r = 0.7003$). The relationship between total length of male and female parasite was significant ($Y = 0.1201x + 0.1374$; $R^2 = 0.2003$).

16. The female adult parasite was markedly asymmetrical and the axis was strongly turned either to right or to left depending on the size and side of the host.

17. The mature female parasite was identified from the immature female based on the characters like size, shape, pigmentation in the thoracic region, extent of oostegites and development of ovary.

18. The number of ova in the brood pouch varied from 8148 (1 cm TL, 0.9 cm TW, 0.12g WT) to 29, 683 (1.2 cm TL, 1.0cm TW, 0.16 g WT) (TL – Total length, TW – Total width, WT – Total weight,). The number of ova per milligram body weight (fecundity factor) ranged from 67.9 to 185.518,

with an average of 126. 709. The relationship between fecundity and total length, total weight, total width and total brood weight were all positive.

19. The fifth pair of the oostegites in the marsupium has stiff hairs, which direct the flow of water.

20. The posterior dorsal part of the marsupium develops a membranous covering on the floor during the breeding season. The female isopod parasite goes through one or more preparatory moults during which oostegites first appear as small ventral protrusions on the coxal plates that become fully formed only in the mature female parasite.

21. Under laboratory conditions it was found that the *P. alcocki* breeds through out the year.

22. The embryonic development starts with the release of eggs to brood chamber and ends with the larval release, which takes about 8 to 12 days. The next ovulation takes place only at an interval of 3 to 6 days. The moulting of the host usually takes place at an interval of 21 days.

23. The eggs are released as a long string without interruption. Eggs are free in the marsupium without any attachment. The eggs of about 0.12 mm in size are deposited in the marsupium. The eggs were filled with yolk, which forms the nutrient of developing embryo. They are adhesive. First cleavage of eggs was observed to be superficial.

24. The female parasite's moulting coincides with the host moult. Ovulation takes place after female's moulting.

25. The female stops breeding in the absence of males.

26. The embryonic stages are classified into five: Stage I- Pale yellow coloured eggs; Stage II - Yellow coloured eggs; Stage III - Green coloured eggs; Stage IV - Brown coloured eggs; Stage V - Empty marsupial chamber.

27. Post-embryonic stage, epicaridea, has been illustrated.

28. There are so many negative effects on the host due to parasitism like aggressive behaviour, secondary infections (mycelial growth, blackening of gills, degeneration of pleopods), retarded growth, degeneration of reproductive organs and loss of gills.

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**INFESTATION OF ISOPOD PARASITES ON PRAWNS OF THE
GENUS *MACROBRACHIUM* BATE, 1868 (PALAEMONIDAE) OF
COCHIN REGION.**

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ABSTRACT OF THESIS

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ABSTRACT

The major objective of the research work is to study the taxonomy, species diversity, host specificity, intensity of infestation, length – weight relationship and reproductive biology of bopyrid parasite infesting the genus *Macrobrachium* Bate, 1868 of the Cochin region. Collections were taken from 3 stations Perumbavoor (Periyar River) and Panangad (Vembanad lake) for a period of 13 months (July 2002 to July 2003) and Champakkara (Vembanad lake) for a period of one year (October 2003 to September 2004). The study revealed that of the five species of *Macrobrachium* inhabiting water bodies of Cochin region, only two species were found infested with bopyrids. *Macrobrachium idella* was infested with *Palaegyge alcocki* whereas *M. scabriculum* with a new variety, *P. alcocki* var. nov. *cochinensis*. This shows that bopyrid infestation is species specific. Diagnostic characters of both the parasite species are given in the text. Regarding the intensity of infestation, prawns from the Perumbavoor region of Periyar River had maximum infestation in comparison with other regions (Panangad and Champakkara). The infestation during different months also revealed the same trend. It indicates that infestation is more at the freshwater region than at the estuarine region.

Relationships between length and weight of infested *M. idella*, *P. alcocki* separated from the host, total length of host and parasite, total length of male and female parasite, carapace length of the host and total length of male as well as female parasite are all statistically significant.

The study has brought out the ways of association of male and female parasites as well as attachment of female parasite to the host. Mature female parasite has been distinguished from the immature. Fecundity studies revealed that the number of eggs produced by the parasite ranges from 8148 (1 cm total length, 0.9 cm total width, 0.12 g

total weight) to 29,683 (1.2 cm total length, 1.0 cm total width, 0.168 g total weight). Number of ova per milligram body weight ranged from 67.9 to 185.518 (126.709 average). Relationships between fecundity and total length, total weight, total width and total weight of brood of the parasite are all significant.

The chapter on reproductive biology reveals important observations on marsupial brooding, ovulation, embryonic development and incubation, hatching and epicaridea stage of *P. alcocki*. The last chapter is on the effect of parasitism on the host. Here the aggressive behaviour of infested host, parasitic castration, degeneration of gills and secondary infections are dealt with in some detail.