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STUDIES ON THE LIFE HISTORIES OF DECAPOD
CRUSTACEA OF GEORGIA

by

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PREFACE

This is a presentation of the results of works conducted by the present author during his stay as a research associate at the University of Georgia Marine Institute for one year from February, 1969 through January, 1970. The main objective of this work was to examine the possibility of seed production of commercial shrimps for their farming in Georgia. In connection with this purpose the life histories of the commercial shrimp and crab were also studied with special reference to reproduction and larval development.

The obtained results will be presented in the following three parts.

Part I. Life histories of the commercial shrimps of Georgia

Part II. Spawning and rearing of larvae of the commercial shrimps of Georgia.

Part III. Larvae of decapod Crustacea of Georgia.

The author is well aware that the informations are still inadequate, and the various aspects of the presented results need much more discussions and verifications by further studies. For the present time, however, all that is possible for the author is for want of time to present the obtained informations as in detail and precisely as possible.

Acknowledgement is gratefully extended to various individuals who aided this study. Dr. Vernon J. Henry, Jr., Director of the University of Georgia Marine Institute and Dr. A. G. Greene, Jr., Assistant Director, invited me to the Institute and thereby gave me an opportunity to work on the present project.

Mr. Bobby A. Palmer assisted me in both field and laboratory works throughout the study period. The field work was conducted with the cooperation of Mr. Benjamin J. Rouse, Mr. James Gault, Mr. Richard W. Zinker, Mr. Lawrence D. Sawyer, Mr. Tracy Walker, and Mr. Benny Johnson.

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● of Miami provided me useful informations on the rearing of commercial shrimps in the United States.

Mr. Richard W. Heard, III provided at my disposal many of the berried females of caridean shrimp and crab, and thereby saved me much time in the collection of necessary materials. Some of the berried females were also supplied by Dr. Robert Reimold, Mr. Kenneth L. Smith and Mr. C. Westerfield.

● Dr. Frederick C. Marland critically read the manuscript of the first two parts ^{PRIOR TO FINAL TYPING.} A

Mrs. Peggy Sessoms and Mrs. Wanda Loper typed the manuscript.

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PART III

LARVAE OF DECAPOD CRUSTACEA OF GEORGIA

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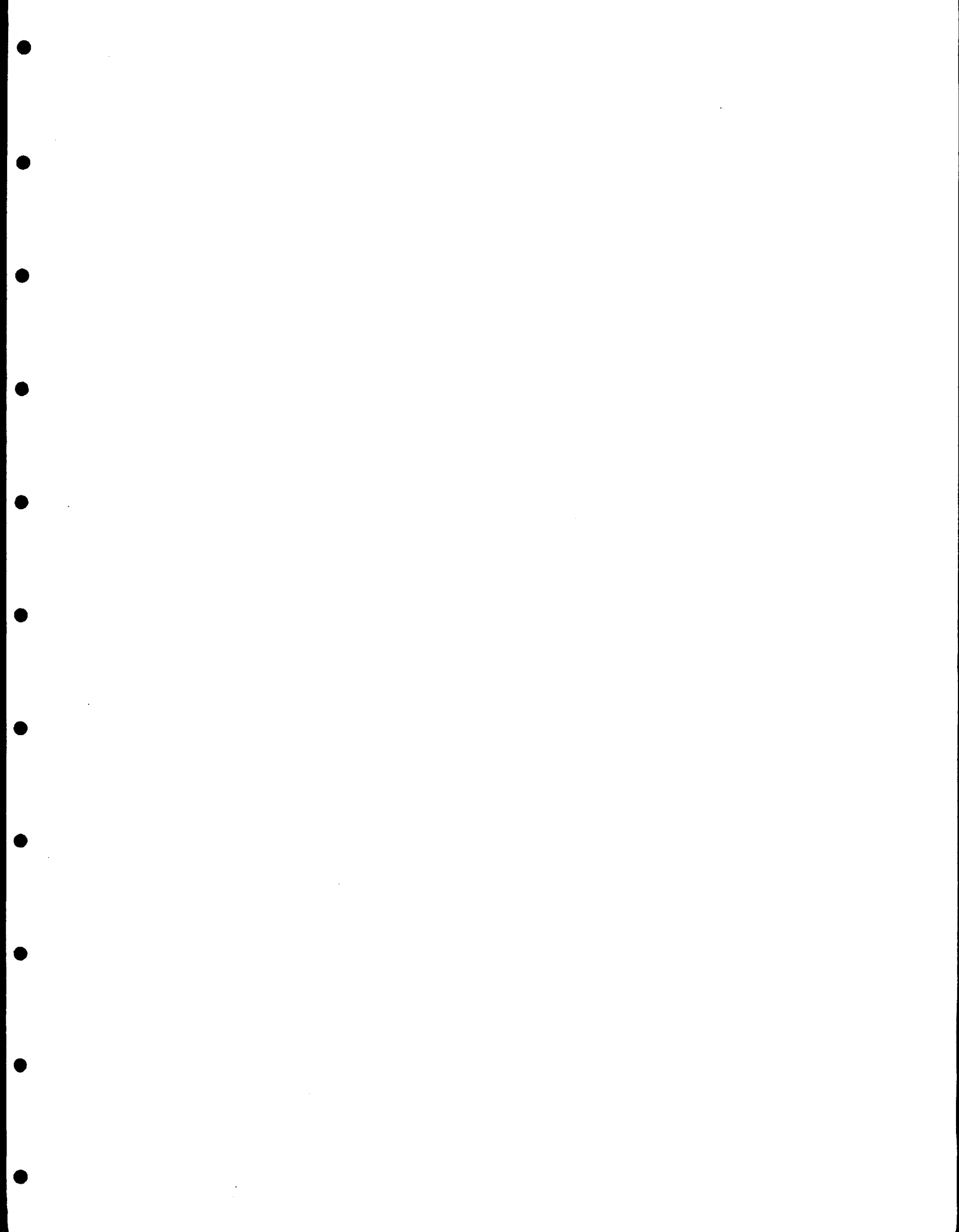
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INTRODUCTION

Larvae of decapod Crustacea have not been described in the past years from Georgia waters, except Pearson who reported in 1939 the larval development of Penaeus setiferus based on plankton tows along the Gulf of Mexico and Atlantic coasts of the U. S. including Georgia. A considerable amount of informations on decapod larvae has been made available in North Carolina (Hyman, 1920, 1924a, b, 1925; Costlow and Bookhout, 1959, 1960, 1961a, b, 1962 a, b, 1966a, b, c, 1967, 1968a, b; Costlow and Fagetti, 1967; Porter, 1960, etc.) and in Florida (Provenzano, 1962 a, b, 1967, 1968a, b; Rice and Provenzano, 1965; Yang, 1968; Robertson, 1968), where many of the crustacean fauna are in common to those in Georgia. However, the number of species the larvae are unknown in still far greater than those known and much remained to be studied.

On the other hand, a great deal of informations are now available about the adult crustacean fauna in the Carolinian Province to which the entire Georgia coast belongs. Almost all the available knowledges including their ecology were recently summarized by Williams (1965). Commercial shrimps, Genus Penaeus, were fully revised by Farfante (1969). According to Williams (1965) and Williams, McCloskey and Gray (1968), 17 species of penaeid shrimps, 38 species of caridean shrimps, 5 species of lobsters, 39 species of anomurans and 149 species of crabs are so far known to occur in the Carolinas.

This report presents descriptions of all the decapod larvae that were hatched in the laboratory of the University of Georgia Marine Institute, and some of those obtained from the plankton tows taken in the coastal off shore waters in the vicinity of Sapelo Island, Georgia in 1968 and 1969. Certain species of shrimps and crabs captured in Florida in 1969 were also included. When it is not otherwise stated, collection of berried females and subsequent rearing of the larvae were made by myself.

METHODS

Most of the described larvae have been hatched from the eggs. Berried females were kept until the eggs hatched out in an aquarium tanks containing filtered sea water which is aerated through an air diffuser stone. Whenever possible salinity of the water was assimilated to that of the sea water where the females were captured. Newly hatched larvae were pipetted off into a finger bowl and fed with rotifer, Brachionus sp., or newly hatched nauplii or juveniles of Artemia salina according to the size of the larvae. Megalopa and young were fed with juveniles of Artemia or chopped meats of hard clam or of anchovy. The range of temperature of the rearing water was from 25-27°C.

No attempts were made to secure the prezoeae. Color of the larvae was observed of the first zoea while it is still alive. When the first zoea was not available a later stage was substituted. Drawings were made of the specimens preserved in 5% formalin with an aid of a camera lucida. Exuviae were also used for the detailed observations of body parts and appendages. Exuviae were, however, useless for the observation of pleopods in most cases.

In Caridea, Thalassinidea and Anomura, carapace length was taken from the tip of rostrum to the posterior mid-dorsal extremity of carapace. In Brachyura, however, the distance from spine to spine was substituted, which denote the distance from the tip of rostral spine to the tip of dorsal spine. When the rostral spine is absent it is taken from the anterior mid-dorsal extremity of the carapace to the tip of dorsal spine.

Segments of appendages were numbered from the proximal to the distal, and spines on telson from outside or anterior to inside or posterior. Arrangement of setae on appendages was expressed by addition of number of setae on each segment or lobe from the proximal to the distal ones. For example, when the endopod of maxilla is of 3 segments bearing 2, 3 and 4 setae on basal, intermediate and terminal segment or lobe respectively,

the setation is expressed as 2+3+4. The following abbreviations were used for the body sizes; C.L., carapace length; C. W., carapace width; B.L., body length; B.W., body width; B.H., body height; T.L., total length.

TERMINOLOGY OF THE LARVAL PHASES

There has been much confusion in the terminology of the larval phases of decapod crustaceans. Many different names were attributed to various developmental phases or stages in different groups of decapods without regarding the correspondence with each other. Since we have now adequate informations about the equivalence of various decapod larvae, it is highly preferable to simplify the complicated terminology so that the equivalence of developmental phases can easily be understood throughout the order Decapoda. In the present report the following terminology were applied throughout the decapods.

NAUPLIUS The crustacean larvae in which the only three pairs of appendages (antennule, antenna and mandible) are functional. Posterior appendages may develop in later stages as rudiments but never become functional.

ZOEAE The decapod larvae in which exopod of thoracic appendages are functional as locomotory organs, regardless the number of functional appendages.

MEGALOPA The decapod larvae in which the pleopods are setose and functional as locomotory organs. In Natantia this phase may not always clearly be recognized and may merge into the adult without definable stages. But the first post-zoeal stage is commonly different from all the subsequent stages in the fact that it generally retains the vestiges of exopods on legs, or there may be degeneration or retention of zoeal

characters in certain of the mouth parts. In Reptantia the immediate post-zoeal phase is usually distinct and different both from zoea and adult and may be regarded as larva rather than adult.

YOUNG This is essentially adult in all respects and there will be no further change in morphology except minor modifications of body proportions and development of secondary sex characters.

It is not uncommon that the characters of previous phase merge into the early stages of the following phase. Thus, In Penaeidea, it is well known that the first three stages of zoea still retain large antennule and antenna which function as locomotory organs. In some Penaeidea the setose exopods on legs may be retained in megalopa and even in early stages of young. Therefore, the terminology defined above is applied to a stage when the characters of the later phase appeared regardless of the retention of characters of the previous phase. Thus, for example, the post-nauplius stage of Penaeidea is called "zoea", though the first three stages as a whole may be referred to as protozoea. The term "mysis stage" was dropped and not used in this report (cf. Gurney, 1942).

DESCRIPTION

Suborder NATANTIA

Section PENAIDEA

The eggs are not carried on the pleopods of the females but are deposited in the water, except in Lucifer in which the eggs are carried on the last two pairs of legs adhering in a mass. The larva usually hatches as nauplius.

Family Penaeidae

Subfamily Penaeinae

1. Penaeus duorarum Burkenroad
Dobkin, 1961

A single specimen of first nauplius, 5 first and 1 last zoeae and 1 megalopa

were obtained from the plankton. All of these are attributed to P. duorarum.

NAUPLIUS

The nauplius is distinctly larger than corresponding stage of other described penaeid larvae, and has no dorsal tubercle. These two characters have already been pointed out by Cook (1967) as serving to distinguish nauplii of genus Penaeus. The nauplius closely agrees with that of P. duorarum described by Dobkin (1961) in all respects, and differs from that of P. setiferus described by Pearson (1939) in the following respects.

1. Antennule has 2 apical and 1 subapical setae instead of 3 apical setae as in P. setiferus.
2. Furcal spines are about 1/3 as long as the body, whereas in P. setiferus they are half as long as the body.

Stage 1. (Pl. 1) T.L.: 0.37 mm.

There is a pair of furcal spines. Antennal exopod has 5 long setae. Setae and spines are smooth and not plumose.

EARLY ZOEAL (or protozoea)

First furcal spine is seated somewhat dorsally. Labrum has an anterior spine. Basal segment of antennule is distinctly subdivided into 5 articles, and has an inner setae at the distal end, middle segment somewhat longer than the basal segment bearing an inner seta each at about half way up and at distal end, terminal segment bearing 1 long and 1 medium apical setae beside hairs and aesthetes. Antenna is subequal to antennule in length, exopod slightly longer than endopod. There is an inner seta at distal end of protopod, endopod bearing 1 + 2 inner setae and 4 long and 1 short apical setae. Endopod of maxillule is of 3 segments, and that of maxilla is of 4, of which the third is bilobed on inner edge showing two fused segments. There are no rudiments of

maxilliped 3 in stage 1.

Stage 1. (Pl. 2) C.L.: 0.50 mm., T.L.: 1.0 mm.

Eyes are sessile. Abdomen is not segmented.

LATTER ZOEAL (or mysis)

Rostrum is slender and somewhat longer than the eyes. Carapace has a pair of supraorbital, branchiostegal and hepatic spines, but no antennae. Abdomen has a dorso-median spine on somites 3-6, and a pair of lateral spines on somite 5. Abdominal somite 6 is slender and much longer than the telson, with a pair of lateral and ventro-lateral spines, in addition to a dorso-median spine; at the hind end. Anal spine is large. Antennal scale is slender and widened distally with an apical spine not reaching the tip of lamella.

Stage 26 (Pl. 3; A, C, E) C.L.: 1.34 mm., T.L.: 4.2 mm.

There is a dorsal spine near the base of rostrum. Telson is somewhat narrower behind, with 3 pairs of lateral and 5 pairs of terminal spines, its width at the hind end is slightly more than 1/4 the length. The central notch on the hind margin is small but distinct, reaching anteriorly the level of insertions of the third pair of lateral spines. Antennal endopod is a little less than 2/3 as long as the scale with a basal articulation. Endopods of legs are longer than their exopods, and those of legs 1-3 are chelate. Pleopod buds are long and segmented but have no setae nor endopods.

MEGALOPA (Pl. 3; B, D, F) C.L.: 1.46 mm., T.L.: 4.8 mm.

Rostrum is somewhat shorter than the eyes. Carapace has a dorsal spine on rostrum and a pair of hepatic spines, but neither supraorbitals

nor branchistegals. Telson has 3 pairs of lateral and 5 pairs of terminal spines. The central notch on the hind margin is still distinct and ends about half way up from the hind margin to the level of insertions of the third pair of lateral spines. There is a ventral spine on the last two thoracic somites. Labrum has no spine. Antennal scale is slender, widened distally and somewhat acutely rounded at apex, with an apical spine ending far behind the tip of lamella. Endopod is about $4/5$ as long as the scale with 4-5 distal articulations. Endopod and exopod of maxilliped 1 are regenerated to unsegmented stumps which are bare of setae. Terminal 2 segments of maxilliped 2 are more or less bent upon proximal two segments with sparse setae. There are vestiges of exopods on maxillipeds 2 and 3 and on legs. Pleopods bear long setae on exopods but have no endopods.

2. Xiphopeneus kroyeri (Heller)
Renfro and Cook, 1963

All the larval and postlarval stages were obtained from eggs spawned by females kept in aquarium tanks in the laboratory (cf. Part II). A few specimens of later nauplius were obtained also from plankton. All the descriptions and measurements were made of reared specimen except when otherwise stated.

EGG

Diameter of egg membrane is 0.23-0.24 mm. Perivitelline space is narrow. Egg membrane reflects under a microscope a small amount of bright green tinge at periphery, and no other colors. Embryo reflects blueish white. Some of the representative stages of embryonic development are illustrated in plate 4.

NAUPLIUS

Body is slightly compressed laterally, and about $1 \frac{1}{4}$ times higher than wide. There is a dorsal tubercle. Antennule is slightly less than $\frac{2}{3}$ as long as the body, with 3 inner setae on ventro-lateral margin, of which the first (proximal) one becomes very long and plumose in later stages. Antenna is slightly longer in early stages, but becomes slightly shorter in later stages, then the antennule. Endopod is much shorter than the exopod. The fourth long setae on the inner margin of exopod is bifid at tip except in stage 1. There are no outer setae on exopod. Mandible is about half as long as the antenna.

Stage 1 (Pl. 5; A, B: Pl. 6; E) B.L.: 0.22 mm., B.W.: 0.13 mm.,
B.H.: 0.16 mm.

There is one pair of furcal spines, which are about $\frac{1}{4}$ as long as the body. Antennule ends in 2 long and 1 short, rudimental setae. There is a long subapical outer seta, which is as long as the long apical setae. The first inner seta is shorter than the second and third. Antennal endopod has 2 short inner and 2 long apical setae, exopod bearing 5 long setae. All the setae and spines are simple.

Stage 2. (Pl. 5; C: Pl. 6F) B.L.: 0.23 mm., B.W.: 0.13 mm.

Number of furcal spine is still $1 + 1$, but they are now armed with fine spinules, and about $\frac{1}{3}$ as long as the body. Antennule ends in 1 long plumose and 1 short simple setae. There are 2 aesthetes but no long setae on the outer edge. Antennal endopod ends in 2 long plumose and 1 short simple setae, exopod bearing 5 long and 1 short setae.

Stage 3. (Pl. 6; A, G) B.L.: 0.23 mm., B.W.: 0.12 mm.

Number of furcal spines is $2 + 2$. Antennal exopod bears 7 setae including short one at apex. Rudiments of posterior appendages are seen under the cuticle.

Stage 4. (Pl. 6; B, H) B.L.: 0.24 mm., B.W.: 0.12 mm.

Number of furcal spines is 3 + 3. The hind end of body is concaved between the furcal spines. The first inner seta of antennule is much longer than the distal 2 setae. Antennal exopod bears 8 setae including proximal and apical short ones. Endopod ends in 2 long and 1 medium setae. Rudiments of posterior appendages are free.

Stage 5. (Pl. 6; C, I) B.L.: 2.9 mm., B.W.: 0.14 mm.

The hind end of body is distinctly divided into 2 lobes by a central notch. Number of furcal spines is 5 + 5. All the spines on each lobe are closely apposed with each other at the hind margin. The longest (fourth) spine is a little more than half as long as the body. Antennal exopod bears 9 setae including vestigial proximal and apical ones. Endopod has 1 + 2 short inner setae. Basal swelling appears on mandible.

Stage 6. (Pl. 6; D, J) B.L.: 0.30-0.32 mm. (wild specimens, 0.35 mm.)

Number of furcal spines is 6 + 6, of which the first is seated on the lateral margin, being remote from the others. Rudiments of labium and 4 pairs of posterior appendages are large but bare of setae. Antennal endopod ends in 3 long and 1 short setae. Setation of exopod is as in stage 5. There is a small ventral prominence near the posterior end of body just between the insertions of the first pair of furcal spines, sometimes ending in a small spine.

Stage 7. (Pl. 6; K; Pl. 7) B.L.: 0.31-0.33 mm. (wild specimens, 0.40 mm.)

Number of furcal spines is 7 + 7. Rami of mandible are more or less atrophied and empty. Rudiments of posterior appendages bear short setae. Posterior end of labrum is slightly notched in the center.

EARLY ZOEAL

Carapace has a dorsal tubercle, and is rather deeply notched behind.

The last 5 thoracic somites are exposed. All the telson spines are marginal. Labrum has an anterior spine. Eye papillae are small but distinct. Antennule is slightly shorter than carapace (less rostrum), with 1 long and 1 medium apical setae in addition to hairs and aesthetes. The first inner seta is shorter than the second and third. The basal segment is subdivided into 5 articles of which the proximal 3 are more or less fused together.

Antenna is about $3/4$ as long as the antennule. Exopod is a little more than $1\frac{1}{4}$ times longer than the endopod and divided into 10 segments with 10 setae on inner and apical margins and 2 outer setae on the fourth and sixth segments. None of these setae are bifid. Endopod is of 2 segments with 2 pairs of inner setae on proximal segment, and 4 long plumose setae and 1 short hair at apex. There are no setae on protopod.

Mandible has no palp. Endopod of maxillule is of 3 segments, of which the proximal 2 are partly fused, with $3 + 1 + 3$ setae. Exopod bears 4 long plumose setae. Maxilla has 4 well developed endites. Endopod is of 5 segments, of which the third and fourth are fused together but divided on inner edge, with $3 + 2 + 1 + 2 + 3$ setae. Exopod is small and bears 5 setae.

Maxillipeds 1 and 2 are functional from stage 1 with setose exopods and segmented endopods. Maxilliped 3 and legs are rudimentary. There is no anal spine.

Stage 1. (Pl. 8: Pl. 9; A: Pl. 11; A-E, H-J) C.L.: 0.30-0.35 mm.,

T.L.; 0.61-0.78 mm.

Eyes are sessile. Carapace has no rostrum. Abdomen is unsegmented.

Telson bears 7 + 7 spines. The fourth telson spine is longer than the carapace. Exopod of maxillipeds 1 and 2 each has 6 setae. Maxilliped 3 is very small, biramous but unsegmented, with 2 setae on exopod. Later larva is larger than the earlier one.

Stage 2. (Pl. 9; B, C: Pl. 11; F) C.L.: 0.51 mm., T.L.: 0.66-1.00 mm.

Eyes are stalked. Carapace has a rostrum which is about $1/4$ as long as the rest of carapace. Abdomen is segmented and is of 5 somites plus telson. Exopod of maxillipeds 1 and 2 has 7 and 6 setae respectively. Maxilliped 3 has 3 setae on exopod. Rudiments of legs are absent in earlier larva, but are seen in the later larva under the cuticle. In the later larva abdomen is considerably longer than in the earlier larva.

Stage 3. (Pl. 10: Pl. 11; G) C.L.: 0.62 mm., T. L.: 1.78 mm.

Abdominal somite 6 is segmented off from the telson and is about $1 \frac{1}{5}$ times longer than the latter. There is a dorso-median spine on somites 1-5, a pair of lateral spines on somite 5, and a pair of dorso-lateral and ventro-lateral spines on somite 6. Telson is somewhat wider than long with 8 + 8 spines. Uropods are free but not segmented with a few setae on exopods.

Antennule is consisted of a peduncle of 3 segments and an unsegmented flagellum. The first peduncular segment is not subdivided. Exopod of maxillipeds 1 and 2 has 9 and 7 setae respectively. Maxilliped 3 is large but endopod is not segmented, both endopod and exopod bearing 4 apical setae. There are biramous rudiments of legs.

LATTER ZOEAL

Carapace has a pair of supraorbital, antennal (from stage 5) and branchiostegal spines. Rostrum is slightly shorter than eyes. All the thoracic somites are fused together. Eye pailles are small but distinct.

Abdomen has a dorso-median spine on somites 4-6 and a pair of lateral spines on somite 5. Somite 3 has a dorso-median spine in all the stage 4 zoea but does not in most of the stage 6 and later zoea, though it may be retained in some zoeae as late as megalopa as is shown in the following table. There is an anal spine. Labrum has an anterior spine.

Dorsal spine on somite 3	Zoea						Megalopa
	IV	V	VI	VII	VIII	IX	
Present	48	32	12	9	2	1	1
Absent	0	30	93	65	40	38	36
Total	48	62	105	74	42	39	37

Antennular peduncles are widely separated from each other. Antennal scale has an apical spine from stage 5, which is exceeded by the tip of lamella. Mandible has a palp from stage 5 and become large and divided into 2 segments in later stages. Endopod of maxillule is present in stage 4 but absent in stage 5 and later. Mouth parts are, otherwise, as in the protozoa. Endopod of maxilliped 1 is of 4 segments, that of maxilliped 2 is of 4 (in stage 4) or 5 (from stage 5) segments, and that of maxilliped 3 is of 5 segments. Endopod of maxillipeds is more or less longer than respective exopod. Setation on exopod tends to confine distally except in maxilliped 1, in which the exopod has 1 or more setae on the proximal outer margin. Maxilliped 3 is longer than maxillipeds 1 and 2. All the legs have setose exopod and segmented endopod. Pleopods develop all together, with endopods larger in posterior than in anterior pleopods.

Stage 4. (Pl. 12; A, D, G) C.L.: 0.61 mm., T.L.: 2.0 mm.

Carapace does not cover the thoracic somites. There are no antennal spines on carapace. Telson is wider behind with a deep central notch on the hind margin, reaching about the level of the insertion of the first telson spine.

Antennal scale has one outer seta instead of apical spine. Endopod has vestiges of inner and apical setae. Endopods of legs are much shorter than their exopods, and not segmented. Legs 1-3 are not chelate.

Stage 5. (Pl. 12; B, E, H) C.L.: 0.81 mm., T.L.: 2.6 mm.

Carapace covers all the thoracic somites, and has a pair of antennal spines and one dorsal spine on rostrum. Telson is slightly wider behind. The central notch is small reaching the level of insertion of the second telson spine. Antennal scale has an apical spine, endopod is a simple rod without setae and is about 1/3 as long as the scale. Mandible has a small unsegmented palp.

Stage 6. (Pl. 12; C, F, I) C.L.: 0.93 mm., T.L.: 3.1 mm.

Carapace has 2 dorsal spines on rostrum. Telson is somewhat narrower behind with a slightly indicated central notch on the hind margin. Antennal endopod is a little less than half as long as the scale. Endopods of legs are indistinctly segmented. Chelae are beginning. There are very small pleopod buds.

Stage 7. (Pl. 13; A, D) C.L.: 1.1 mm., T.L.: 3.7 mm.

Carapace has an epigastric spine. Telson is rounded behind without trace of notch. Antennal endopod is about half as long as the scale, with 2 basal, but no distal, articulations. Chelae are formed. Pleopod buds are moderately long, but has no traces of setae, their lengths are

distinctly less than the height of respective somite. There are rudiments of gills as are shown in the following table.

	Maxilliped			Leg				
	1	2	3	1	2	3	4	5
Pleurobranch	0	0	1	1	1	1	1	0
Arthrobranch	0	1	1	1	1	1	1	0
Podobranch	1	1	0	0	0	0	0	0

Stage 8. (Pl. 13; B, E) C.L.: 1.3 mm., T.L.: 4.0 mm.

Antennal endopod is somewhat shorter than or about as long as the scale with a few distal articulations. Mandibular palp is large and divided into 2 segments. Endopod of leg 1 is shorter, but that of leg 5 is longer, than their exopods. Pleopod buds bear traces of setae on apical margin of exopod. Length of pleopods are about equal to the height of respective somite.

Stage 9. (Pl. 13; C, F; Pl. 14, Z) C.L.: 1.4 mm., T.L.: 4.7 mm.

There are 3 dorsal spines on rostrum. Antennal endopod is longer than the scale with 6-8 distal articulations, but does not reach to the tip of antennule. The inner antennular flagellum is of 3 segments. Pleopod buds are very long and bear many traces of setae, but no long setae, their lengths are distinctly greater than the height of corresponding somites. Endopod of leg 1 is longer than exopod.

MEGALOPA (Pl. 14; M; Pl. 15; A, E) C.L.: 1.5 mm., T.L.: 5.0 mm.

The larva rather gradually assumes adult characters and distinction between the last zoea and megalopa is by no means clear. However, the characters of megalopa which are different from those of zoea are seen in,

1. the presence of a pair of hepatic spines,
2. the development of numerous setae on coxae and basis of maxilliped 1 and flattening of its exopod, and
3. the presence of long setae on pleopods.

The megalopa also differs from the following young phase mainly in the form of mouth parts and in the rigidity of legs. Thus the endopods of maxillule, maxilla and maxilliped 1 are still segmented as in the zoea, while in the young endopods of these appendages are no longer segmented. Endopod of maxilliped 2 is not bent upon its self as in the young and adult and not provided with a thick fringe of setae. Endopods of legs are still more or less rudimentary and not yet well calcified, while in the young the legs become by far rigid and firm than in the megalopa. Another difference of megalopa from the young is in the retention of a pair of supraorbital and branchiostegal spines on carapace which are absent in the young.

So far as I am aware, megalopa phase has never been established in the larval development of any species of penaeid shrimps. Immediate post zoeal stage is always referred to the first postlarva. In X. kroyeri, however, and probably in many other species of penaeids also, this stage is more or less different both from the zoea and all the subsequent stages, and may well be recognized as megalopa which is equivalent with the same stage in most Caridea, Anomura and Brachyura. The megalopa is in many respects larval rather than postlarval.

There was only one stage in the megalopa of X. kroyeri. The inner antennular flagellum is of 4 segments. Antennal flagellum is about 1.5 times longer than the scale with about 10 distal articulations, it extends

somewhat beyond the tip of antennule. Lateral spines on somite 5 are still distinct. Endopod of leg 1 is longer than the exopod by its fingers. Exopod of leg 5 reaches about middle of carpus of endopod. Exopods of pelopods bear long setae distally and short ones proximally. Endopods of pleopods 1-3 are very small and bare of setae, while those of pleopods 4 and 5 are of considerable length and more or less setose.

YOUNG

This is essentially adult in all but minor respects and is accordingly considered as postlarval. The differences from the adult are seen in the short rostrum, small endopod of pleopods and absence of secondary sex characters. The setose exopod of legs, lateral spines on somite 5 and the full number of telson spines are still retained in stage 1, but degenerate in stage 2 and later. Dorso-median spine on somites 5 and 6 are always distinct, but that on somite 4 is frequently wanting. Somites 4-6 have a dorsal carina accompanied with short spinules and setae. Legs are very rigid. Distal end of dactyli of legs 4 and 5 are not pointed into spine but rounded with several sensory setae. Leg 5 is longer than any other legs but not so long as in the adult. Rostrum is rather deep and is more or less humped dorsally, ending abruptly in a pointed terminal spine.

Stage 1 (Pl. 14; Y: Pl. 15; B, C, F). C.L.: 1.6 mm., T.L.: 5.2 mm.

Rostrum is shorter than eyes, with 4 dorsal spines. Hind end of telson protrudes and bears 4 + 4 spines between the fourth (longest) pair of spines, thus the number of telson spines being 8 + 8 in all. The inner antennular flagellum is of 5 segments. Antennal flagellum is about twice as long as the scale, and about as long as the carapace. Exopods of maxillipeds 2 and 3 and of legs are still setose but much shorter than their endopods.

Stage 2. (Pl. 15; D, G) C.L.: 1.9 mm., T.L.: 5.7 mm.

Rostrum has 5 dorsal spines. Telson ends posteriorly in a pointed central spine accompanied with 3 pairs of small degenerating spines, and flanked with a pair of large terminal spines.

3. Trachypaeneus constrictus (Stimpson)

Pearson, 1939

A considerable number of egg, nauplius, zoea and megalopa were found in the offshore planktons as are shown in the following table.

Stage	Total number
Egg	28
Nauplius	4
Early Zoea	462
Latter Zoea	218
Megalopa	2
Total	714

EGG (Pl. 16; A)

Diameter of egg membrane is 0.38-0.43 mm., and that of embryonic membrane is 0.21-0.23 mm. All eggs were taken in late embryonic development, and some of them were almost ready to hatch. The egg membrane reflects under a microscope a bright blue tinge adjacent to and inside of the peripheral brilliant purplish-red color.

NAUPLIUS

There is a dorsal tubercle. The greatest height of body is somewhat less than 1.5 times the greatest width. Antennule is slightly shorter in early stages, but somewhat longer in later stages, than the

antenna. The first inner seta is shorter than the third in all stages. Exopod of antenna is much longer than the endopod and has no outer setae in all stages. No seta appears, at the distal end of protopod. Length of mandible is somewhat less than the greatest width of body, its endopod is only slightly longer than the exopod.

Stage 1. (Pl. 16; B, C, E) B.L.: 0.25 mm.

There are 1 + 1 furcal spines which are somewhat less than 1/3 as long as the body. Setae and spines are smooth and unarmed.

Stage 3. B.L.: 0.25-0.26 mm.

There are 2 + 2 furcal spines. Antennal exopod has 6 long and 1 short setae. Antennal endopod has 2 long and 1 short apical, and 2 short inner setae.

EARLY ZOEAE

The protozoaea obtained from the plankton and attributed to T. constrictus is closely similar in every detail to that of Xiphopeneus kroyeri. It is so far impossible to distinguish with certainty protozoaea of these two species obtained from plankton.

Although both Pearson (1939) and Cook (1966) did not observe the short apical hair on antennal endopod in Trachypeneus protozoaea, all the protozoaea attributed to T. constrictus in this report had this hair. It seems very unlikely that no specimen of T. constrictus early zoea are represented in these samples because its eggs, nauplius and especially latter zoea are quite abundant. On the other hand only a few nauplii and no latter zoea of Xiphopeneus were found in the plankton.

Stage 1. (Pl. 17; A, D) C.L.: 0.30-0.38 mm., T.L.: 0.64-0.94 mm.

Eyes are sessile. There is no rostrum. Abdomen is not segmented.

There are 7 + 7 furcal spines. A considerable variation was observed among the zoeae of stage 1 in the length of abdomen.

Stage 2. (Pl. 17; B) C.L.: 0.46-0.51 mm., T.L.: 1.1-1.3 mm.

Eyes are stalked. Rostrum is about 1/5 as long as the rest of carapace. Abdomen is segmented and is of 5 somites plus telson. Again a considerable variation was observed in the length of abdomen.

Stage 3. (Pl. 17; C) C.L.: 0.69 mm., T.L.: 2.1 mm.

Abdomen is of 6 somites plus telson, with a dorso-median spine on somite 1-5, and a pair of lateral spines on somite 5. Telson is somewhat less than 1.5 times wider than long and bears 8 + 8 spines. There are large rudiments of maxilliped 3 and legs.

LATTER ZOEAE

Latter zoea of T. constrictus can be distinguished from Penaeus and Xiphopenaeus by the absence of distinct lateral spines on abdominal somite 5, and from Sicyonia and Parapenaeus by the absence of ventral spines on abdomen.

Rostrum reaches at or slightly beyond the distal end of eyes. There is a pair of supraorbital spines on carapace. Carapace may also have a pair of antennal and branchiostegal spines, the former appearing in stage 5 and the latter disappearing from stage 6. Labrum has an anterior spine. Mouth parts are as in the early phase, but a palp develops on mandible and exopod of maxillule disappears. Abdominal somites 4-6 has a dorso-median spine. Somite 5 may have a pair of vestigial lateral spines in early stages. Somite 6 has a pair of ventro-lateral spines at the hind end. There is a large anal spine. Telson is rather broad, more or less notched behind. All the thoracic appendages have setose exopods. Endopod of maxilliped 1 is of 4 segments, those of maxillipeds 2 and 3 are of 5 segments, while those of legs are not segmented or indistinctly segmented.

Stage 4. (Pl. 18; A, C, E) C.L.: 0.67-0.89 mm, T.L.: 2.0-2.5 mm.

There is a pair of supraorbital and branchiostegal spines on carapace, but no dorsal nor antennal spines. Telson is widened behind, about twice as long as wide and is about $3/4$ as long as the somite 6, with 8 + 8 spines. The central notch behind is deep, almost reaching the level of insertions of the first pair of spines. Exopod of antenna is not segmented and has no apical spine but has 2 outer setae instead. Endopod is of simple rod and is about half as long as the exopod. Mandible has no palp. Maxillule has an exopod. Endopods of legs are not segmented and much shorter than their exopods. There are no pleopod buds. Of the total of 84 fourth zoeae obtained from the plankton, 49 (58%) have vestigial lateral spines on somite 5, while the remaining 35 (42%) have not, in which the posterior margin of somite 5 is either angled or rounded.

Stage 5. (Pl. 18; B, D, F) C.L.: 0.83 mm., T.L.: 2.6-3.5 mm.

Carapace has a small dorsal spine near the base of rostrum, and a pair of antennal spines. Telson is almost parallel sided, and a little less than 2.5 times as long as wide. The central notch behind is small and ends at about the level of insertions of the second pair of spines. Antennal exopod has an apical spine, ending somewhat behind the tip of the lamella. Endopod is about $1/3$ as long as the exopod. Mandible has a small palp. There is no exopod on maxillule. Chelae are beginning. Of the total of 49 fifth zoeae obtained from the plankton, 7 (14%) still retained vestigial lateral spines on somite 5.

Stage 6. (Pl. 19; A, E) C.L.: 0.96-1.12 mm., T.L.: 3.1-3.6 mm.

Carapace has no branchiostegal spines and the angles are rounded. Telson is a little more than 2.5 times as long as wide. The central notch ends behind the level of insertions of the second pair of spines.

Antennal endopod is a little more than half as long as the exopod. There are small pelopod buds. In all the sixth zoeae obtained from the plankton the posterior lateral margin of somite 5 are rounded.

Stage 7. (Pl. 19; B, F) C.L.: 1.3 mm., T. L.: 4.1 mm.

Carapace has 3 dorsal spines of which the anterior 2 are on the rostrum. Telson is narrower behind, its length is slightly more than 3.5 times the width at the hind end. The central notch is only slightly indicated, ending far behind the level of insertions of the second pair of spines. Endopod of legs are more or less segmented and about as long as or slightly longer than their exopods. Antennal endopod is about as long as the exopod with 2 basal and 3 distal articulations. Pleopod buds are moderately long and segmented, but has not setae.

Stage 8. (Pl. 19; C, G) C.L.: 1.3 mm., T.L.: 4.3 mm.

Hind margin of telson is almost straight without central notch. Antennal endopod is longer than the scale with 4-6 distal articulations. The length of pleopods are about equal to the height of respective somite. There are vestigial setae around tip of pleopods.

MEGALOPA (Pl. 19; D, H, I) C.L.: 1.3 mm., T.L.: 4.2 mm.

Rostrum is somewhat shorter than the eyes, and is moderately decurved. There is an epigastric spine, and 4 dorsal spines on rostrum. Carapace has a pair of antennal and hepatic spines but no supraorbitals. Anterior lateral angles are rounded. Abdomen has a dorso-median spine on somite 6 only. Telson has a median spine on somewhat protruded hind end, beside the 2 pairs of lateral and 6 pairs of terminal spines. Antennal scale is rather broad, and is about a little more than $2/5$ as wide as long. The apical

spine hardly reaches the distal end of the lamella. Antennal flagellum is somewhat longer than the carapace. Mouth parts are modified as in the adult but not provided with thick fringes of setae as in the latter. Legs are fully segmented and rigid. Legs 1-3 are chelate. There are vestiges of exopods on maxillipeds 2 and 3 and on legs. Pleopods are setose and functional, but has no endopods.

Subfamily Sicyoninae

4. Sicyonia brevirostris Stimpson

Eggs, nauplii and zoeae of a sicyonine shrimp were fairly common in the offshore planktons (cf. Part I). These are attributed to S. brevirostris largely because it is only one species of the genus which was commonly taken within the range of study area.

EGG (Pl. 20; A)

Diameter of egg membrane is 0.29-0.32 mm., and that of embryo is 0.24-0.26 mm. The egg membrane reflects under a microscope bright green color, in addition to a peripheral brilliant purplish-red. The former occurs inside to the latter as a separate band. All the eggs were late in embryonic development.

NAUPLIUS

Very like T. constrictus. But in later stages antennal protopod has an inner seta at the distal end and endopod has 2 pairs of inner setae. Exopod has an outer seta but no bifid setae. Early stages may be distinguished from T. constrictus by a combination of number of setae on antennal exopod and number of furcal spines (Pearson 1939; Fig. 39).

Stage 2. (Pl. 20; B-D) T.L.: 0.24 mm.

There are 2 + 2 furcal spines. Antennal exopod has 5 long setae. Long setae and spines are plumose.

Stage 76 (Pl. 20; E) T.L.: 0.47 mm.

There are 7 + 7 furcal spines. Antennal exopod is indistinctly segmented with 9 setae around the inner and apical margins. There are large rudiments of posterior appendages.

EARLY ZOEAL

Carapace has a very short rostrum from stage 2, but no other spines. Free thoracic terga and abdomen are slender and very long, when combined they are about twice (stage 1) or three times (stage 3) as long as the carapace. The first telson spine is located dorsally rather than laterally. Labrum has no spine. There is a small anterior papilla on each side between the base of antennule and the outer edge of the epistome. Mandible has no palp. Maxillule and maxilla have exopods. Endopod of maxillule is of 3 segments, and that of maxilla is of 4 segments of which the third is bilobed on the inner edge showing the two fused segments.

Antennule is much longer than antenna, and is about 1.5 times longer than the carapace. The terminal segment has 3 long apical setae. Antenna has an inner setae at distal end of protopod, and 2 + 3 inner setae on endopod, which ends in 4 long and 1 short setae. Endopod and exopod are subequal in length.

Stage 1. (Pl. 21; A, D) C. L.: 0.32 mm., T.L.: 0.95 mm.

Eyes are sessile. There is no rostrum. Abdomen is not segmented. Basal segment of antennule is subdivided.

Stage 2. (Pl. 21; B) C.L.: 0.40 mm., T.L.: 1.26 mm.

Eyes are stalked. There is a very small, blunt rostrum. Abdomen is segmented and is of 5 somites plus telson.

Stage 3 (Pl. 21; C) C.L.: 0.50 mm., T.L.: 2.0 mm.

Abdominal somite 6 is segmented off from the telson and is about 1.3 times longer than the latter, with a pair of lateral and ventro-lateral spines. Telson is about as long as wide. There is a dorso-median spine on somites 1-5, and a pair of lateral spines on somite 5. Antennule is consisted of a peduncle of 3 segments and an outer flagellum, basal segment of peduncle no longer subdivided.

LATTER ZOEAL

There is a short rostrum hardly reaching the cornea of eyes. Carapace has a pair of supraorbital, antennal and branchiostegal spines. As many as 2 dorsal spines appear on carapace of which the anterior one is on the rostrum. Abdomen has a dorso-median spine on somite 6 only, and a ventro-median spine on somites 1-5. Telson is slender and long, about as long as or longer than somite 6, with 7 + 7 spines in all stages. Exopod of maxilliped 2 is distinctly reduced in size.

Stage 4 (Pl. 22; A, C, E) C.L.: 0.72 mm., T.L.: 2.6 mm.

There are no dorsal spines on carapace. Telson is somewhat narrower behind, its length is a little more than 3 times width of the hind end, and is about as long as the somite 6. Hind margin is divided into two lobes by a deep central notch, which reaches anteriorly well beyond the level of the insertions of second pair of furcal spines. There is no anal spine.

Antennal exopod has no apical spine, and has an outer setae instead. Endopod is somewhat more than $\frac{2}{3}$ as long as the exopod and not segmented. Mandible has no palp. Maxillule has an exopod. Endopods of legs are much shorter than their exopods and are not segmented. There are no pleopod buds.

Stage 5 (Pl. 22; B, D, F) C.L.: 0.80 mm., T.L.: 2.7 mm.

There are 2 dorsal spines on carapace. The central notch on the hind

margin of telson ends anteriorly at or somewhat behind the level of insertions of the second pair of furcal spines. There is a small anal spine. Antennal exopod has an apical spine which is by far exceeded by the distal end of lamella. Mandible has a small palp. There is no exopod on maxillule. Legs 1-3 has developing chelae. There are small pleopod buds.

Stage 6 (Pl. 23; A, C, E) C.L.: 0.94 mm., T.L.: 3.2 mm.

The width of hind end of telson is about $1/5$ the length, central notch on the hind margin ending far behind the level of insertions of the second pair of spines. Antennal endopod is about as long as the exopod and has a basal articulation. Mandible has a large palp of 2 segments. Endopods of legs are as long as or longer than their exopods. Pleopod buds are moderately long and segmented.

MEGALOPA No specimens were obtained.

YOUNG

Carapace has a pair of antennal spines but no supraorbital nor branchiostegals. Hepatic spines are present. Abdominal somites 1-6 have dorsal carina, that of somite 6 is rounded behind. Telson has 2 pairs of dorsal and 5 pairs of lateral spines, all very small, and is fringed posteriorly with long setae. Exopod of uropod is somewhat truncated at apex without apical spine. Protopod has no ventral spine. Antennal scale is truncated triangular with a small apical spine.

Stage ?1 (Pl. 23; B, F, G) C.L.: 1.2 mm., T.L.: 3.4 mm.

There are no traces of exopod on legs. Carapace has an epigastric spine and two dorsal spines. There are no endopods on pleopods.

Family Sergestidae

Subfamily Sergestinae

5. Acetes americanus carolinae Hansen

A considerable number of zoea and young were obtained from the plankton but no eggs nor nauplii were found (cf. Part I).

EARLY ZOEAE

Carapace has a pair of anterior (supraorbital) and posterior lateral spines, and a posterior dorsal spine, these spines are all subequal in length. Rostrum appears in stage 2 and somewhat longer than the other carapacial spines. Last 6 thoracic somites are free from the carapace. Telson is not much wider than the rest of the abdomen, and bilobed by a deep U-shaped notch behind, with 6 + 6 spines in all stage. The sixth (inner most) spine is seated ventrally rather than marginally. Labrum has a long, pointed anterior spine. Antennule is a little longer than antenna. Antenna has 1 + 2 + 3 inner setae at distal end of protopod and on endopod. Endopod ends in 4 long and 1 short setae. Exopod is somewhat longer than the endopod, divided into 9-10 segments with 2 outer and 11 inner and apical setae. Endopod of maxillule is of 3 segments, and that of maxilla is indistinctly divided into 5 segments. Maxillipeds 1 and 2 are functional with setose exopods, which are much smaller than their endopods. Maxillipeds 3 and legs are rudimentary.

Stage 1 (Pl. 24; A, D) C.L.: 0.30 mm., T.L.: 0.48 mm.

Compound eyes are not developed. All the carapacial spines are armed with minute spinules. There is no rostrum. The basal segment of antennule is subdivided into 5 articles. All the thoracic somites are segmented, though somewhat obscure. Abdomen is not segmented.

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Stage 2 (Pl. 24; B) C.L. (less rostrum): 0.45 mm., B.L.: 0.86 mm.

A pair of compound eyes are developing, but not stalked. Rostrum is about 1/3 as long as the rest of the carapace, directing horizontally or slightly upward. All the carapacial spines are smooth without armatures.

A single zoea separated from the plankton showed an intermediate state of development between the normal second and third zoeae (Pl. 24; C). It was similar to stage 2 in size and general characters, but abdomen is more or less segmented dorsally and had small rudiments of legs. The most striking feature of this zoea is in the stalking of compound eyes. Thus the left eye is already stalked, while the right eye is still embedded under the carapace.

Stage 3 (Pl. 25; A, D) C.L. (less rostrum): 0.56 mm., B.L.: 1.1 mm.

Eyes are stalked. Rostrum is bent down. Abdomen is segmented and is of 5 somites plus telson, with a pair of ventro-lateral spines on somites 1-5, but no dorsal nor lateral spines. Somite 6 is not segmented off from the telson with a pair of long ventro-lateral spines at the posterior end, which is defined by the presence of uropods. The uropods are not segmented and bare of setae. The basal segment of antennule is no longer subdivided. There are rudiments of maxilliped 3 and of legs.

LATTER ZOEAE

Rostrum is bent down with a large dorsal spine at its base. The dorsal spine extend forward almost horizontally. A pair of long, pointed branchiostegal spines present on carapace. Supraorbital spines present in stage 4, but absent in stage 5. Abdomen is of 6 somites plus telson, with a dorso-median spine on somites 4-6, and a pair of ventro-lateral spines on somites 1-5. Telson is small, about half as long as the somite 6, with concaved lateral margins, it is divided behind into two lobes by a narrow but deep central notch, each lobe ending in a large spine

closely approximated with each other. Uropods are much longer than the telson. There are no anal spine.

Antennular peduncles are straight and parallel, and are apposed widely apart from each other, leaving a wide space between the inner edges of their bases. Antennal exopod is slender and short with several simple setae around the tip, and is much shorter than the endopod. Mandible has no palp. Maxillule has no endopod while exopod is retained bearing 4 setae as in the early phase. Endopod and coxal lobes of maxilla are greatly reduced and are rudimentary or lost, while the exopod becomes large with a few long setae on the distal and proximal margins. Endopod of maxilliped 1 is rudimentary or lost, while the exopod is retained, though much reduced. Coxa and basis are bare of setae. There are setose exopods on maxillipeds 2 and 3, and on legs 1-4. Endopods of maxillipeds 2 and 3, and of legs 1-3 are longer than their exopods, and more or less distinctly segmented. There is no endopod on leg 4. Leg 5 is absent. There are 3 pairs of pleopod buds on somites 1-3, these are uniramous.

Stage 4 (Pl. 25; B, E, G) C.L. (less rostrum): 0.60 mm., B.L.: 1.45 mm.

There is a pair of large supraorbital spines. Telson has 2 spines outside the terminal spine. Antennal flagellum is shorter than the antennule. Legs 1-3 are not chelate. There are vestiges of endopod on maxilla, and on maxilliped 1.

Stage 5 (Pl. 25; C, F, H-L) C.L. (less rostrum): 0.61 mm., B.L.: 1.63 mm.

There are no supraorbital spines. Telson has one spine outside of the terminal spine. Antennal flagellum is as long as or somewhat longer than the antennule, and has basal and distal articulations. There are no endopod on maxilla and maxilliped 1. Legs 1-3 are chelate.

MEGALOPA

No megalopa phase was recognized. It seems to be due to the earlier modification of mouth parts.

YOUNG (or Mastigopus)

Rostrum is not bent, but extends forward almost horizontally, with a small dorsal spine in early stages, it is shorter than the eyes and tends to be still shorter in later stages in proportion to the carapace. There is a pair of supraorbital, branchiostegal and hepatic spines on carapace. The branchio-stegal spines are lost in the fully grown adult.

Abdomen is as in the latter zoea, but pleopods are now setose and posterior pairs and endopods develop gradually. Ventro-lateral spines on somites 1-5 become smaller and eventually disappear in later stages. Telson has a pair of terminal spines only without a notch behind. The terminal spines gradually become smaller and eventually disappear. Antennal scale is slender, almost parallel sided, with an apical spine. Mouth parts are much the same in principal structures as in the latter zoea. There are no exopod on maxillipeds 2 and 3, and on legs. Leg 4 is lost.

Stage 1. (Pl. 26; A, I, J) C.L.: 0.83 mm., T.L.: 2.0 mm.

There are minute vestiges of exopod on legs 1-3, and of leg 4. In this characters this stage might well be considered as corresponding to megalopa in other decapods. There are 3 pairs of pleopods, without endopods. Antennal flagellum is about $\frac{2}{3}$ the total length.

Stage 2 (Pl. 26; B) C.L.: 0.93 mm., T.L.: 2.4 mm.

There are no vestiges of exopods on legs, and of leg 4. A pair of short pleopod buds are present on somite 4. Antennal flagellum is somewhat longer than the body.

Stage 3 (Pl. 26; C) C.L.: 0.96 mm., T.L.: 2.5 mm.

Pleopod 4 is long but not segmented nor setose. There are small buds of pleopod 5.

Stage 4 (Pl. 26; D, K) C.L.: 1.2 mm., T.L.: 3.2 mm.

Pleopod 4 is segmented and setose with a small endopod. Pleopod 5 is long, segmented, but not setose, or may bear a few setae on exopod. Pleopod 2 may or may not have endopod. Ventro-lateral spines on somite 5 are small or vestigial.

Stage 5 (Pl. 26; E, F) C. L.: 1.4 mm., T.L.: 3.9 mm.

Pleopod 5 is setose on exopod, but not on endopod. Endopod of pleopods 3 and 4 are usually more or less setose. Pleopod 2 has a small endopod. Carapace has no dorsal spine, or may have a vestigial one.

Stage 6 (Pl. 26; G, H, L) C.L.: 1.4 mm., T. L.: 4.0 mm.

Rostrum is much reduced in length. Ventro-lateral spines on somites 1-5 are vestigial or lost. All the endopod, as well as exopod, of pleopods are more or less setose.

SUBADULT (Pl. 26; M, N) T.L.: 11.8 mm.

Carapace has a dorsal spine. Telson tapers to a blunt distal and tipped with 4 setae. Specimens were obtained on August 27, 1969 by plankton tows at Boat House.

SECTION CARIDEA

The eggs are carried by females on the pleopods. The larvae hatches as zoea, except when the development is direct. Rostrum is cylindrical or laterally compressed. Three pairs of maxillipeds functional on hatching, maxilliped 1 with coxa and basis large, flattened, the endopod small, of four segments or unsegmented.

Maxillipeds 2 and 3 with endopods larger than that of maxilliped 1. Legs appearing in succession, except when development is abbreviated, but leg 5 may develop before leg 4 in Alpheidae, Palaemonidae and some of Hippolytidae. Endopods of legs usually segmented and setose (Gurney, 1942).

Family Pasiphaeidae

Carapace has a short, pointed rostrum, ventral margin of carapace is serrated both anteriorly and posteriorly. Abdomen has a pair of lateral spines on somite 5. Telson is somewhat oval in early stages. There is no anal spine. Antennal scale has a large apical spine from stage 1, inner distal spine on peduncle is long. Endopod of maxilliped 1 is of 4 segments. There are exopods on legs 1 and 2 in later stages. Legs 3-5 are rudimentary in the last stage. The development of pleopod on somite 1 is delayed.

6. Leptochela serratorbita Bate

Larvae of a species of pasiphaeid shrimp were obtained from the plankton taken in the offshore waters around Sapelo Island. They were fairly common in May and July and attributed to L. serratorbita, because this is the only one species of the family so far known from this district (Williams, 1965).

ZOEA

Rostrum is broad at base, ending into a pointed spine which is shorter than antennule and antenna. There are no dorsal spines. Spines on ventral margin of carapace are all small. Abdomen is a little less than twice as long as the carapace, with 1 and 2 pairs of lateral spines on somite 4 and 5, and, in later stages, ventral spines on somites 3-5. Second telson spine is much smaller than the others and disappears in later stages.

Antennular peduncles on each side approximated at base leaving a very narrow space between the inner edges. Endopod of maxillule is of 2 segments with a seta on each segment. Maxilla has 4 endites, its endopod is unsegmented but divided into 3 indistinct lobes with $3 + 1 + 2$ setae. Endopod of maxilliped 1 is of 4 segments, exopod has no outer setae.

Stage 1 (Pl. 27; A, H, N) C.L.: 0.67 mm., T.L.: 1.9 mm.

Eyes are sessile. Abdomen is of 5 somites plus telson. Telson has $7 + 7$ spines. The combined length of somite 6 and telson is about 2.5 times the width of telson. Antennal endopod is about $1/3$ as long as the scale, ending in a long apical seta and a short outer seta. Legs are not free.

Stage 2 (Pl. 27; B, I) C.L.: 0.77 mm., T.L.: 2.2 mm.

Eyes are stalked. Telson has $8 + 8$ spines. There is a biramous rudiment of leg 1.

Stage 3 (Pl. 27; C, D, J) C.L.: 0.90 mm., T.L.: 2.5 mm.

Abdominal somite 6 is segmented off from telson, and is about as long as the latter. Uropods are free but not segmented. Antennal endopod tapers to a pointed tip without setae, it is about $3/4$ as long as the scale. Leg 1 has setose exopod, its endopod is not segmented. There are no legs 2-5.

Stage 4 (Pl. 27; E, K) C.L.: 0.94 mm., T.L.: 3.0 mm.

Subocular angles of carapace on each side ends in a small spine. Telson is slightly longer than the somite 6, with $7 + 7$ spines. Hind margin is still notched behind, though very slightly. Uropods are segmented. Antennal endopod is nearly as long as the scale. There are rudiments of legs 2-5, those of leg 2 have small exopods.

Stage 5 (Pl. 27; F, L, O) C.L.: 1.2 mm., T.L.: 3.4 mm.

Telson is rounded behind without notch, it is slightly wider posteriorly

and is somewhat more than 2.5 times as long as wide. There are ventral spines on somites 3-5. Antennal endopod is somewhat longer than the scale with a basal articulation. Endopods of legs 1 and 2 are segmented and chelate. Exopod of leg 2 is rudimentary and not setose. Legs 3-5 are rudimentary and uniramous. There are large pleopods on somites 2-5, but not on somite 1.

MEGALOPA (Pl. 27; G, M, P) C.L.: 1.3 mm., T.L.: 3.8 mm.

Anterior ventral angles of carapace is rounded, its ventral margin is smooth except a few minute spinules on posterior corner. Telson is parallel sided with 7 + 7 spines. There are setose exopod on maxilliped 3, and on legs 1 and 2. Legs 1 and 2 are chelate. Chela are slender with pointed fingers. Legs 3-5 are fully segmented. There is a large spine on ischium of leg 4.

Family Palaemonidae

Subfamily Pontoninae

7. Periclimenes americanus (Kingsley)

Berried females were captured by Mr. Heard on March 21-23, 1969 at Pigeon Key, Florida and were at my disposal. None of the resulting larvae could be reared beyond stage 2.

ZOEA

Rostrum is moderately long, slightly upturned, reaching somewhat beyond the tip of eyes. Ventral margin of carapace is smooth and ends anteriorly in a spine. There is a pair of supraorbital spines from stage 2, but no antennals.

Abdomen is about 2.5 times as long as the carapace, with a pair of lateral spines on somite 5 from stage 2.

Antennular peduncles on each side are approximated at base leaving a very narrow space between their inner edges. Antennal scale is segmented and has 2 outer setae in early stages. Antennal endopod ends in a spine and a long plumose seta in stage 1. Endopod of maxillule is unsegmented with 2 short apical setae. Maxilla has 3 endites, its endopod is divided into 2 lobes, each with an apical seta. Exopods of maxillipeds bear 4 apical setae in stage 1.

Dark brown chromatophores occur on carapace at rear of the eyes, on front of the eyestalks, and on abdominal somite 3. There is a pair of large brown chromatophores at the base of antennae. Telson and thoracic appendages are colorless.

Stage 1 (Pl. 28; A, C, E-I) C.L.: 0.54 mm.; T.L.: 1.7 mm.

Eyes are sessile. Abdomen is of 5 somites plus telson. Somite 5 has a fringe of fine spinules on the hind margin. The combined length of somite and telson is about 1.5 times width of the telson. Telson has 7 + 7 spines. There are 3 pairs of setose exopod on maxillipeds 1-3, and biramous rudiments of legs 1 and 2, but no other legs.

Stage 2 (Pl. 28; B, D) C.L.: 0.54 mm., T.L.: 1.8 mm.

Eyes are stalked. The hind margin of somite 5 is smooth. Telson has 8 + 8 spines. There are 5 pairs of setose exopods. Endopod of legs 1 and 2 are segmented. Legs 3-5 are absent.

Subfamily Palaemoninae

Carapace has supraorbital and one or more dorsal spines, except in stage 1. Abdominal somite 5 has a pair of lateral spines. Antennular peduncles are approximated closely leaving a narrow space between the inner edge of their bases. Ventral spine on antennular peduncle is small and

seated about middle of the first segment. Antennal scale is segmented in early stages. Endopod of maxillule is small, unsegmented with an apical seta. Maxilla has 3 endites only, the endopod is divided into 2 lobes with 2 + 1 setae. Endopod of maxilliped 1 is of 2 segments, though the articulation is somewhat obscure. Leg 4 is smaller than, and develops after, leg 5, usually with exopod. Leg 5 is uniramous.

8. Palaemon floridanus Chace

A berried female was captured by Mr. Heard on March 21-23, 1969 at Pigeon Key, Florida and was at my disposal. The first zoeae were hatched from this female and have been reared as far as stage 4. No later stages were obtained.

ZOEA

Carapace has a long rostrum, slightly longer than the rest of the carapace, with minute barbs at the terminal ventral edge. As many as 3 dorsal spines appear on carapace and the base of rostrum. Supraorbital (from stage 2), branchiostegal (from stage 3) and pterigostomian (from stage 4) spines are present on carapace.

Abdomen has no dorsal spines. Telson is triangular with an almost straight hind margin in early stages. The terminal spines of the telson are rather short and there are no great variations in their length.

Antennal endopod ends in a short spine and a long plumose seta in stage 1. There is an inner distal spine on peduncle from stage 1, but it tends to be reduced in later stages. Exopods of maxillipeds has 4 apical setae in stage 1. Legs 1-4 are biramous while leg 5 is uniramous.

There is a good deal of dark brown color at the anterior end of carapace. In addition, rather dense distribution of red chromatophores occur on antennal peduncles, along the bases of thoracic appendages and ventrally along the abdominal somites 1-5. Telson and thoracic appendages are colorless.

Stage 1 (Pl. 29; A, E, I) C.L.: 1.15 mm., T.L.: 3.3 mm.

Eyes are sessile. Abdomen is of 5 somite plus telson. Combined length of somite 6 and telson is about 1.5 times the width of the telson. Telson bears 7 + 7 terminal spines. There are 3 pairs of setose exopods on maxillipeds 1-3, and rudiments of legs 1 and 2.

Stage 2 (Pl. 29; B, F, J) C.L.: 1.28 mm., T.L.: 3.6 mm.

Eyes are stalked. There is a pair of supraorbital spines, and one dorsal spine on carapace. Telson has 8 + 8 terminal spines. The terminal segment of antennular peduncle is segmented off from the rest of the peduncle. There are 5 pairs of setose exopods. Endopods of legs 1 and 2 are segmented. There are small rudiments of legs 3-5.

Stage 3 (Pl. 29; C, G, K) C.L.: 1.44 mm., T.L.: 4.1 mm.

There are 2 dorsal spines on carapace. Abdominal somite 6 is segmented off from the telson and somewhat longer than the latter. Telson is slightly longer than wide with 7 + 7 terminal spines on slightly concaved hind margin. Uropods are free but not segmented, with endopod bare of setae. Antennal endopod has 2 basal articulations. Legs 3-5 are still rudimentary.

Stage 4 (Pl. 29; D, H, L) C.L.: 1.7 mm., T.L.: 4.4 mm.

There are 3 dorsal spines on carapace and the base of rostrum. Pterigostomian angles of carapace ends in a small spine. Telson is about twice as long as wide with 5 + 5 terminal spines. There is an anal spine. Uropods are segmented with setose endopods. Antennal scale has an apical

spine, somewhat exceeding the tip of lamella, and no traces of segmentation. There are 6 pairs of setose exopods. Endopod of leg 3 is segmented. Legs 4 and 5 are rudimentary. The rudiment of leg 5 is uniramous and longer than that of leg 4 which is biramous.

9. Palaemonetes vulgaris (Say)

Broad, 1957a

P. vulgaris is quite abundant around Sapelo Island in tidal creeks and rivers. Berried females were captured on April 13, 1969 at the Marsh Landing Dock, and were kept in the laboratory until the eggs hatched into the first zoea which has been reared as far as the megalopa.

The following table shows the chronological data of development.

Stage	Date	Days after hatching
1	4/25	0
2	4/28	3
3	5/1-3	6-8
4	5/4-5	9-10
5	5/7-8	12-13
6	5/10-11	15-16
7	5/13-15	18-20
8	5/16-18	21-22
Megalopa	5/20-23	25-28

ZOEA

The larva very like Palaemon floridanus, but distinguished from the latter by the following characters. Rostrum strongly curves at extremity except in stage 1 and 8 (the last). Pterigostomian angles are rounded in later stages. Antennal endopod ends in only a plumose seta in stage 1. Antennal scale has a poorly developed lamella distally, and gradually tapers toward a blunt apical spine in later stages. Legs 1 and 2 become functional in different stages, the one after the other. As many as 2 dorsal spines appear on carapace. Antennal peduncle has no inner distal spine.

Body is transparent and poor in coloration. Chromatophores are black and occur on carapace at the rear of eyes, on antennular and antennal peduncles, at the base of maxilliped 3, on abdominal somite 3 and around anus.

Stage 1 (Pl. 30; A, E: Pl. 32; A, K-N) C.L.: 1.04 mm., T.L.: 2.6 mm.

Combined length of somite 6 and telson is about $1 \frac{2}{3}$ times the width of telson. Telson has $7 + 7$ terminal spines. Antennal scale is segmented with 2 outer setae. There are 3 pairs of setose exopods and biramous rudiments of legs 1 and 2.

Stage 2 (Pl. 30; B, F: Pl. 32; B) C.L.: 1.07 mm., T.L.: 2.9 mm.

There is a dorsal spine on carapace, and 4 pairs of setose exopods. Endopod of leg 1 is segmented, while the whole structure of leg 2 is rudimentary. There are no rudiments of legs 3-5. Telson has $8 + 8$ spines.

Stage 3 (Pl. 30; C, G: Pl. 32; C) C.L.: 1.23 mm., T.L.: 3.3 mm.

Abdominal somite 6 is segmented off from telson, and uropods are free but not segmented with endopod bare of setae. Telson is slightly longer than wide with $7 + 7$ spines. Antennal endopod has 2 basal articulations, the apical plumose seta is replaced by simple short setae. There are 5 pairs of setose exopods. The endopod of leg 2 is segmented. Legs 3-5 are rudimentary.

Stage 4 (Pl. 30; D, H: Pl. 32; D) C.L.: 1.42 mm., T.L.: 4.0 mm.

There are 2 dorsal spines on carapace. Telson is still wider posteriorly and 2 or 3 times longer than wide, with $5 + 5$ spines. Antennal scale has no apical spine but no longer segmented. There are 6 pairs of setose exopods. Legs 4 and 5 are rudimentary.

Stage 5 (Pl. 31; A, D: Pl. 32; E) C.L.: 1.54 mm., T.L.: 4.3 mm.

Telson is parallel sided or slightly tapers toward the posterior end with $5 + 5$ spines. Leg 5 is segmented with a long apical spine, and some-

what longer than other legs, while the leg 4 is still rudimentary. There are small pleopod buds.

Stage 6 (Pl. 31; B, C: Pl. 32; F) C.L.: 1.76 mm., T.L.: 5.1 mm.

Telson distinctly tapers toward the posterior end with 5 + 5 spines. Antennal scale ends in a blunt apical spine, endopod shorter than the scale with 2 distal articulations, peduncle with an outer distal spine. There are 7 pairs of setose exopods. Chelae are beginning. Pleopod buds are moderately long but not segmented.

Stage 7 (Pl. 31; C, F: Pl. 32; G) C.L.: 1.90 mm., T.L.: 5.5 mm.

The outer flagellum of antennule has 2 groups of aesthetes. Antennal endopod is about as long as the scale. Exopods of pleopods are segmented off from the protopods, with a few short setae. There are no appendices internae.

Stage 8 (Pl. 32; H: Pl. 33; A, B) C.L.: 2.35 mm., T.L.: 6.2 mm.

Antennal endopod has 4 distal articulations and is longer than the scale. Both endopod and exopod of pleopods are segmented off from the protopod.. There are rudiments of appendices internae.

Megalopa (Pl. 33; C, D) C.L.: 2.5 mm., T.L.: 6.3 mm.

Rostrum has 7 dorsal spines, of which the posterior one is on the carapace behind the orbital angles, and 2 ventral spines. Antennal and pterigostomian spines present on carapace, but no supraorbitals. There are vestiges of exopods on legs 1-4. Abdomen has no spines. Telson ends posteriorly in a small median tooth, with 2 pairs of lateral and 2 pairs of terminal spines. Antennal scale has a well developed lamella distally.

Family Alpheidae

Carapace has no supraorbital nor dorsal spines. The rostrum is short, widened at its base. Abdominal somites have no dorsal nor lateral spines.

The fifth telson spine is shorter than the sixth. Antennular penduncles on each side is straight in dorsal view, and closely approximated with each other at base without leaving space between their inner edges. Antennal scale is segmented in early stages. Mouth parts are as in *Plaemoninae*. Endopod of maxilliped 1 is unsegmented with a basal inner lobe ending in a seta. Endopod of maxilliped 3 has a very long apical spine. Leg 5 develops before leg 4, and is much longer than the latter with a very long apical spine.

10. *Alopheus normanni* Kingsley

A berried female was captured by Mr. Heard on March 22-23, 1969 at Pigeon Key, Florida and was at my disposal. The resulting larvae were reared as far as stage 4.

ZOEA

Rostrum is about half as long as the rest of carapace, and does not reach the distal end of eye. Ventral margin of carapace is smooth and ends anteriorly in a spine. Abdomen is about 2.5 times as long as the carapace, without spines. Telson is rather slender in stage 1 with a slightly concaved hind margin. Antennal endopod ends in stage 1 in a small spine and a long plumose seta. Maxilliped 1 has 4 spines on the basis. Endopods of legs 1-4 are unsegmented, rudimentary stumps in the early phase of their development.

The zoea is almost colorless and transparent when alive, with a small amount of dark brown color in the cardiac region and around anus.

Stage 1. The specimens of this stage were missed.

Stage 2 (Pl. 34; A, C, E, -G) C.L.: 0.64 mm., T.L.: 2.4 mm

Eyes are stalked. Abdomen is of 5 scimites plus telson. The width of telson is about half length of scomite 6 and telson combined. Telson has

8 + 8 spines. Antennal scale has 4 apical segments and 2 outer setae. There are 3 pairs of setose exopods on maxillipeds 1-3. Legs 1-5 are rudimentary, leg 5 much longer than the others.

Stage 3. The specimens of this stage were missed.

Stage 4 (Pl. 34; B, D, F) C.L.: 0.69 mm., T.L.: 2.5 mm.

The somite 6 is segmented off from the telson, and is a little more than 1.5 times longer than the latter. Telson is somewhat less than twice as long as wide, with 7 + 7 spines of which the first and second are reduced. Uropods are segmented with setose endopods.

Antennal scale has a minute apical spine, which is by far exceeded by the tip of lamella. Endopod is of a simple rod and somewhat less than half as long as the scale. There are 6 pairs of setose exopods. Endopods of legs 1-3 and the whole structure of leg 4 are rudimentary. Leg 5 is segmented and very long with a long apical spine. There are no pleopod buds.

11. Alpheus sp.

A berried female was captured by Mr. Heard on March 21-23, 1969 at Pigeon Key, Florida and was at my disposal. The adult female resembles A. heterochaelis Say, but different from it in the relative length of the stylocertite and movable finger of the major chela. Dr. F. A. Chace attributed it to a new species.

ZOEA

The zoea is closely similar in structure to A. normanni, but distinctly larger in size and richer in coloration. Red chromatophores occur at distal end of antennular peduncle, on front of eyestalks, on carapace, in the cardiac region and around anus.

Stage 1. The specimens of this stage were missed.

Stage 2 (Pl. 35; A, D, G) C.L.: 0.75 mm., T.L.: 3.2 mm.

Eyes are stalked. Abdomen is of 5 somites plus telson. The combined length of somite 6 and telson is somewhat more than twice as great as the width of telson. Telson has 8 + 8 spines. Antennal scale has 3 apical segments and 2 outer setae. Endopod ends in a short spine and a plumose seta.

There are 3 pairs of setose exopods on maxillipeds 1-3. Legs 1-5 are rudimentary. Leg 5 is much longer than the others.

Stage 3 (Pl. 35; B, E, H) C.L.: 0.82 mm., T.L.: 3.1 mm.

Somite 6 is segmented off from the telson and is a little less than twice as long as the latter, with a pair of small dorso-lateral spines at the hind end. Telson is somewhat longer than wide with 8 + 8 spines. Uropods are free but not segmented, with endopod bare of setae. Antennal endopod ends in a simple spine. There are 4 hairs of exopods. Endopod of leg 1 and the whole structure of legs 2-4 are rudimentary. Leg 5 is segmented and very long with a long apical spine, almost reaching the tip of antennules.

Stage 4 (Pl. 35; C, F, I) C.L.: 0.85 mm., T.L.: 3.2 mm.

Uropods are segmented with setose endopods. Telson still has 8 + 8 spines, but the first 3 spines are greatly reduced in size. The antennal scale has a very small apical spine, being by far exceeded by the tip of lamella. There are 5 pairs of setose exopods. Legs 3 and 4 are still rudimentary. There are no pleopod buds.

Family Hippolytidae

The larvae are highly variable and it is impossible to frame any definition which will distinguish them as a whole from other Caridea (Gurney, 1942).

12. Lygmata wurdemanni (Gibbes)

A berried female was captured by Mr. Heard and was at my disposal. Larvae, hatched from this female, were reared as far as the megalopa. Chronological data of their development were shown in the following table.

Stage	Date	Days after hatching
1	5/8	0
2	5/11	3
3	5/14	6
4	5/16-17	8-9
5	5/19-22	11-14
6	5/25-28	17-20
7	6/1-3	24-26
8	6/8-13	31-36
9	6/21-26	44-49
10	6/29-30	52-53
11	7/4-6	57-59
Megalopa	7/8-10	61-63

ZOEA

Carapace has a slender, pointed rostrum which is as long as the rest of the carapace in stage 1, but is about half or somewhat less than half as long as the latter in later stages. As many as 4 dorsal spines develop on carapace, of which the anterior 3 are on the rostrum. There is a pair of supraorbital, antennal and pterigostomian spines on carapace. Ventral margin of carapace is serrated anteriorly in early stages. Eystalks are elongated in later stages but return normal in the megalopa.

Abdomen is a little more than twice as long as the carapace, with a pair of lateral spines on segment 5. These spines disappear in later stages. There is no anal spine. Hind margin of telson is distinctly indented in the center, with the fifth spine not shorter than the sixth.

Antennular peduncle on each side is almost straight, parallel, and disposed widely apart from each other. In early stages antennal scale is segmented with an outer seta, ended ending in a plumose seta. Flagella

of antennule become very long and multiarticulated in later stages, while that of antenna remains short and simple except in the last two stages. Endopod of maxillule is unsegmented with 5 setae of 2 groups. Maxilla has 4 endites, endopod divided into 3 lobes with $3 + 2 + 3$ or 4 setae. Endopod of maxilliped 1 is of 4 segments. Exopod of maxillipeds has 3 apical setae in stage 1. Maxilliped 3 and legs, when they become functional, are very slender and long. Leg 5 develops earlier than legs 2-4 and has a greatly expanded paddle shaped propodus, which in later stages is much longer than the carapace.

Body is transparent with orange-red chromatophores on front of the eyestalks, in the cardiac region, on abdominal somites 3 and 5, around the anus, on the telson (one pair) and endopods of maxillipeds. In later stages a good deal of orange-red occur ventrally along the cephalo-thorax. Antennules and both endopod and exopod of thoracic appendages also share orange-red chromatophores mainly at or near the articulations. Paddle-shaped propodus of leg 5 and tips of uropods are also orange-red accompanied with a considerable amount of yellow. A green tinge occurs on the eyestalks in addition to the orange-red.

Stage 1. (Pl. 36; A: Pl. 37; A, L-O: Pl. 41; A) C.L.: 0.87 mm.,

T.L.: 2.7 mm.

Eyes are sessile. Abdomen is of 5 somites plus telson. Somite 5 has a fringe of fine spinules on posterior dorsal margin. Telson bears $7 + 7$ processes, its width is about $3/5$ as great as the length of somite 6 and telson combined. Endopod of antenna is somewhat less than half as long as the scale. There are 3 pairs of setose exopods on maxillipeds 1-3. Rudiment of leg 1 is present.

Stage 2 (Pl. 36; B: Pl. 37; B: Pl. 41; D) C.L.: 0.94 mm., T.L.: 3.0 mm.

Eyes are stalked. The posterior margin of somite 5 is smooth. Telson has 8 + 8 processes. Endopod of antenna is about 1/3 as long as the scale. There are biramous rudiment of leg 1 and uniramous rudiment of leg 5, but no other legs.

Stage 3 (Pl. 36; C: Pl. 37; C: Pl. 41; C) C.L.: 0.96 mm., T.L.: 3.2 mm.

Abdominal somite 6 is segmented off from the telson and is about 1 2/3 times longer than the latter, with a pair of dorso-lateral spines at the hind end. Uropods are free but not segmented with endopods bare of setae. Telson is somewhat wider than long with 8 + 8 processes, of which the first pair are reduced in size. The terminal segment of antennular peduncle is jointed off from the rest of the peduncle. There is a small conical base of the inner flagellum. Antennal endopod has no apical seta and is greatly reduced to a short spinous process at the distal end of the peduncle. Leg 1 has setose exopod and its endopod is segmented. Leg 5 is still rudimentary.

Stage 4 (Pl. 36; D: Pl. 41; D) C.L.: 0.99 mm., T.L.: 3.4 mm.

Telson is a little less than 1.5 times as long as wide, with first three pairs of spines much reduced in length. Uropods are segmented with setose endopods, which are shorter than the telson. Antennal scale has an apical spine and is no longer segmented. Leg 5 is segmented and very long, reaching, when stretched forward, well beyond the tip of antennules. There is a biramous rudiment of leg 2, but no rudiments of legs 3 and 4.

Stage 5 (Pl. 36; E: Pl. 37; E: Pl. 41; E) C.L.: 1.03 mm., T.L.: 3.8 mm.

Telson is about twice as long as wide. Rudiment of leg 2 is long but not segmented. There is a biramous rudiment of leg 3, but no leg 4.

Stage 6 (Pl. 36; F: Pl. 37; F: Pl. 41; F) C.L.: 1.08 mm., T.L.: 3.9 mm.

There is a dorsal spine on carapace just in front of the dorsal tubercle. Lateral spines on abdominal somite 5 disappear. Telson is parallel sided or slightly tapers toward the posterior end. Endopod of uropod is longer than the telson. Leg 2 is functional with setose exopod and segmented endopod. Legs 3 and 4 are rudimentary.

Stage 7 (Pl. 37; G: Pl. 38; A: Pl. 41; G) C.L.: 1.13 mm., T.L.: 3.9 mm.

Telson is distinctly narrower behind, hind margin still indented. Spine 2 seated slightly up on the lateral margin. Leg 3 is functional with setose exopod and segmented endopod. Leg 4 is still rudimentary.

Stage 8 (Pl. 37; H: Pl. 38; B: Pl. 41; H) C.L.: 1.4 mm., T.L.: 5.3 mm.

Telson strongly tapers posteriorly with straight hind margin. Number of spines is 7 + 7, but sometimes vestigial 8th pair may be retained. Antennular flagella are shorter than the peduncle. Antennal endopod is still a rudimentary stump. Leg 4 is functional.

Stage 9 (Pl. 37; I: Pl. 39; A: Pl. 41; I) C.L.: 1.5-1.7 mm., T.L.: about 5.8 mm.

There are 1-3 dorsal spines on the rostrum in addition to the one on the carapace. Carapace is divided by shallow grooves. Hind margin of telson is slightly convexed. Antennular flagella are longer than the peduncle. Antennal endopod is about half as long as the scale and has one basal articulation. Chelae are beginning in some larvae. There are small pleopod buds with or without short setae on exopods.

Stage 10 (Pl. 37; J: Pl. 39; D: Pl. 41; J) C.L.: 1.8 mm., T.L.: 6.0 mm.

Endopod of antenna is as long as the scale and has 5 distal articulations. Chelae are beginning. Exopods of pleopods are segmented off from the protopods, but endopods are not, and there are no appendices internae.

Stage 11 (Pl. 37; K: Pl. 40: Pl. 41; K) C.L.: 1.9-2.2 mm., T.L.: about 6 mm.

The inner flagellum of antennule is longer than the outer, and is about twice as long as the peduncle. Antennal endopod is much longer than the scale and multiarticulated. Both the exopod and endopod of pleopod are segmented off from the protopod bearing short setae. Appendices internae are present.

MEGALOPA (Pl. 42) C.L.: 3.3 mm., T.L.: 8.5 mm.

There are 3 dorsal spines on carapace, of which the anterior two are on the rostrum. Rostrum is about half as long as the rest of the carapace, almost reaching the distal end of the eyes. Carapace has a pair of antennal spines but no supraorbitals nor pterygostomians. Telson ends posteriorly in a small median tooth, with 2 pairs of dorso-lateral and 3 pairs of terminal spines. Antennal scale is about 3.5 times as long as wide, with a short apical spine. Carpus of leg 2 is as long as the ischium and merus combined, and divided into about 20 articulations. There are vestiges of exopods on maxilliped 3 and legs 1-4. Leg 5 like legs 3 and 4 in structure, but somewhat shorter and stouter, especially in propodus, than the latter.

13. Thor floridanus Kingsley

Broad, 1957b

A berried female was captured by Mr. Heard on March 21-23, 1969 at Pigeon Key, Florida and was at my disposal. The resulting larvae were reared as far as stage 4.

ZOEAE

The zoea is closely similar to Penaeus americanus in structure

and size, but has more red and less brown than the latter. Red chromatophores occur in fairly large amount around anus, in small amount on endopods of maxillipeds 1 and 2 in addition to the ones on carapace and on abdominal somite 3.

Stage 1 (Pl. 43; A, E, I) C.L.: 0.56 mm., T.L.: 1.7 mm.

Eyes are sessile. Abdomen is of 5 somites and telson. There are 3 pairs of setose exopods.

Stage 2 (Pl. 43; B, F) C.L.: 0.56 mm., T.L.: 1.9 mm.

Eyes are stalked. There is a pair of supraorbital spines. Abdominal somite 5 has a pair of lateral spines. There are 5 pairs of setose exopods. Endopods of legs 1 and 2 are segmented. Leg 5 is rudimentary.

Stage 3 (Pl. 43; C, G) C.L.: 0.56 mm., T.L.: 2.2 mm.

Somite 6 is segmented off from the telson, and is a little less than 1.5 times longer than the latter, with a pair of dorso-lateral spines at the hind end. Uropods are free but not segmented, with endopod bare of setae. Antennal scale is still segmented distally, with one outer setae. Endopod is a simple rod without apical setae, and is about $4/5$ as long as the scale. There are 5 pairs of setose exopods, and uniramous rudiments of legs 3-5. Leg 5 is much longer than legs 3 and 4.

Stage 4 (Pl. 43; D, H, J). C.L.: 0.56 mm., T.L.: 2.2 mm.

Telson is slightly wider behind, with 6 + 6 spines. Uropods are segmented with setose endopods. Antennal scale has an apical spine, reaching the distal end of the lamella. Leg 5 is segmented and long with a long apical spine, but not so long as in Alpheus. Legs 3 and 4 are still rudimentary. There are no pleopod buds.

14. Thor sp.

Dobkin, 1968

A berried females was captured by Mr. Heard on March 21 at Pigeon Key, Florida and was at my disposal. When checked against the identified specimens in the U. S. National Museum, the female could not be distinguished from T. floridanus, but the larvae were quite different from it as will be described below. Dr. F. A. Chace kindly called my attention to Dobkin's (1968) paper. This species probably identical with Thor sp. of which the larvae were described by Dobkin.

All the resulting larvae died before the first molt, and no later stages were obtained. The high mortality was seemed to be due to unsuitable salinity of rearing water.

ZOEAE

The zoea is robust and considerably advanced in development on hatching. Carapace has no rostrum in stage 1. Ventral margin of carapace ends anteriorly in a spine with additional two spines closely behind.

Abdomen is a little more than twice as long as the carapace, and has no spines in stage 1. The fifth telson spine is much shorter than the sixth, and as long as the seventh.

Antennular peduncle strongly curves outward, leaving a moderately wide space between the inner edges of its base on each side. Antennal scale is not segmented with two outer setae in stage 1. Endopod of maxillule is unsegmented but divided into two lobes with $1 + 3$ setae. Maxilla has 4 endites, its exopod is divided into 4 lobes with $3 + 2 + 1 + 3$ setae. Maxilliped 1 has endopod of 4 segments and exopod with an

outer seta near the proximal end in stage 1. Endopod of maxillipeds 2 and 3 each is of 5 segments. There are large rudiments of legs and pleopods from stage 1. Legs 1 and 2 are biramous, while legs 3-5 are uniramous.

The zoea is very rich in coloration, with dark brown chromatophores densely covering over the whole body.

Stage 1 (Pl. 44, A-C) C.L.: 0.91 mm., T.L.: 2.8 mm.

Eyes are sessile. Abdomen is of 5 somites plus telson. The combined length of somite 6 and telson is somewhat more than 1.5 times greater than the width of the telson. Telson bears 7 + 7 spines. There are no uropods. Antennular peduncle is unsegmented with a short outer, and a small conical base of the inner, flagella. Antennal endopod is longer than the scale, with a basal articulation. Peduncle is of 2 segments with both the inner and the outer distal spines. Exopods of maxillipeds have 3 apical setae. Pleopod buds are small.

Suborder REPTANTIA

Section MACRURA

Superfamily THALASSINIDEA

The known larvae of this group show a fundamental cleavage between the Callianassinae and Upogebiinae, which are regarded as members of one family. The genera of this group may be arranged in two groups (Gurney, 1942).

Homarine group: Axiidae and Callianassidae

Amomuran group: Laomediidae and Upogebiidae

Family Callianassidae

15. Callianassa sp.

Larvae of a species of Callianassa were quite abundant in offshore plankton taken in May and July. Williams (1965) describes two species of Callianassa from the Carolinas; C. major Say and C. atlantica Rathbun. But on Sapelo Island C. atlantica is very rare (Mr. K. L. Smith, personal communication). C. major and Callianassa sp. (not yet identified) are quite common on sandy beach. The planktonic larvae were attributed to the unidentified species of Callianassa based on the similarity of form of telson between the former and the embryonic prezoea of the latter (Pl. 45; A). The specimens of female carrying eggs of late developmental stages were provided by Mr. K. L. Smith.

When checked against the identified specimens in the U. S. National Museum, the adult of this species was found to be quite different from that of C. atlantica in size, shape of eyes, relative length and form of fingers of major chela, presence of a spine on merus of small chela, etc.

ZOEAE

Rostrum is large, cylindrical in stage 1, but depressed and fringed laterally with spinules from stage 2. It is somewhat shorter than the rest of the carapace. Ventral margin of carapace ends anteriorly in a spine and armed with several minute spinules behind the anterior spine. Posterior margin is smooth and rounded.

Abdomen is about 1.5 times longer than the carapace, with a huge dorsal spine on somite 2. Somites 3-6 has a dorsal carina, each ending posteriorly in a small spine. There are no lateral spines. Somite 6 has a pair of ventro-lateral spines from stage 3. The anal spine is large in stages 1 and 2 but disappears from stage 3. Telson is more or less wider behind in all stages. Hind margin is convexed with a large median spine. Second telson spine is reduced to a hair.

Antennular peduncle is divided into 2 segments in later stages. Antennal scale has a large apical spine, endopod ending in 1 long and 1 medium setae in early stages. Peduncle has a large outer distal spine. The inner distal spine develops in later stages and small.

Mandible has a well developed molar process. Endopod of maxillule is of 3 segments with 2 + 2 + 4 setae, and that of maxilla is of 4 segments, of which the proximal 3 are partly fused together, with 3 + 2 + 2 + 3 setae. Maxillipeds 1-3 are functional from stage 1, with setose exopods, and endopod of 4 segments. Maxilliped 1 has coxa and basis large, flattened with a thick fringe of setae on the inner edge. Endopod of maxilliped 3 is seated somewhat low on the basis, its first segment becomes greatly enlarged in the later stages. Legs 1-4 have exopods, though that of leg 4 never become setose in zoea stages. There are only 3 pairs of pleopods on somites 3-5.

Stage 1 (Pl. 45; B, G, K) C.L.: 1.1 mm., T.L.: 2.7 mm.

Eyes are sessile. Abdomen is of 5 somites plus telson. The width of telson is about $3/4$ as great as the combined length of somite 6 and telson. Telson has 7 + 7 spines besides the median spine which is somewhat shorter than the fourth (longest) spine. Antennule is not segmented. Antennal endopod is about $2/3$ as long as the exopod. Legs are not free.

Stage 2 (Pl. 45; C, F, H) C.L.: 1.25 mm., T.L.: 3.1 mm.

Eyes are stalked. Telson has 8 + 8 spines besides the median spine which is longer than any other telson spines. There are biramous rudiments of legs 1 and 2, but no legs 3-5.

Stage 3 (Pl. 45; D, I) C.L.: 1.4 mm., T.L.: 3.6 mm.

Abdominal somite 6 is segmented off from the telson, and is slightly shorter than the latter. Telson is slightly longer than wide. Uropods are free but not segmented, with endopod bare of setae. Antennal endopod is about $2/3$ as long as the exopod and has no apical setae. Legs 1 and 2 have setose exopods, their endopods are not segmented. Legs 3-5 are rudimentary. Legs 3 and 4 are biramous while leg 5 is uniramous. There are small pleopod buds.

16. Callianassa major Say

No free living larvae were obtained. Embryonic prezoae were dissected out from late stage eggs carried by a female which was captured on August 4, 1969 on sandy beach of Sapelo Island.

PREZOEAE (Pl. 46; A-D). C.L.: 1.0 mm., T.L.: about 3.8 mm.

The larvae is covered by embryonic skin, and much larger in size than the first zoea of Callianassa sp. described above. Telson is concaved behind with 7 + 7 spines on each side near the corner.

The telson of the first zoea, which can be seen through the prezoal

skin, has a large spine at posterior angle on each side, and about 18 + 18 paired spines and a small median spine on the hind margin.

17. Upogebia affinis (Say)

A berried female was captured by Dr. Reimold on October 1, 1969 in Duplin River, and was at my disposal. The eggs hatched into the first zoea on October 3, but none of them survived beyond stage 2. Many later stages were obtained from the plankton taken in offshore waters. They are especially abundant in May within a few miles from shore.

ZOEA

Cephalo-thorax is distinctly narrowed anteriorly. Rostrum is short, pointed and smooth, it is about 1/3 as long as the rest of the carapace. A pair of needle-like spines are present from stage 2 at posterior-dorsal angle of orbit. Otherwise the carapace has no spines nor ridges.

Abdomen is about twice as long as the carapace, with a pair of lateral spines on somite 5 and, from stage 3, a pair of dorso-lateral spines on somite 6. A large anal spine is present from stage 2. Telson has a small median spine from stage 2, the second pair of terminal spines are reduced to hairs and the fourth become enlarged and fused to the telson from stage 3.

Antennular peduncle is not segmented in all stages. The antennal scale is not segmented, the endopod ending in 3 equally long setae in stages 1 and 2. Mandible has a small palp in the last stage. Maxillule has no outer setae, the endopod is of 2 segments with 2 + 6 setae. Maxilla has well developed 4 endites, unsegmented endopod with 5 setae, and a small exopod of which the proximal lobe bears a few setae in later stages.

Maxillipeds 1 and 2 are functional from stage 1, with bases much longer than coxae, and the endopods of 5 and 4 segments respectively.

There are many stiff, coarsely plumose setae along the inner edges of both the maxillipeds. Maxilliped 3 is rudimentary in stage 1, its exopod becomes setose from stage 2, while endopod remains rudimentary in all stages, springing from low down on the basis. Legs 1-3 have setose exopods in the last stage, and the endopods seated as in maxilliped 3. There are no pleopods on abdominal somite 1.

Stage 1 (Pl. 47; A, D: Pl. 48; B, F, G). C.L.: 0.75 mm., T.L.: 1.9 mm.

Eyes are sessile. Abdomen is of 5 somites plus telson. Telson has 7 + 7 spines, its width is about $\frac{3}{4}$ the length of somite 6 and telson combined. Antennal peduncle has an inner distal spine which is seated at the base of exopod rather than of endopod. Maxilla has no proximal lobe on exopod. Exopod of maxillipeds 1 and 2 each has 4 setae. Maxilliped 3 and legs are rudimentary.

Stage 2 (Pl. 47; B, E: Pl. 48; C) C.L.: 0.91-0.96 mm., T.L.: 2.4-2.8 mm.

Eyes are stalked. Telson has 8 + 8 paired spines and a small median spine. Antennal peduncle has a small outer distal spine. Leg 1 has a setose exopod. Legs 2-5 are rudimentary.

Stage 3 (Pl. 47; C, F: Pl. 48; D) C.L.: 1.06-1.15 mm., T.L.: 2.8-3.4 mm.

Abdomen is of 6 somites plus telson. Telson is somewhat longer than wide. The fourth spine is enlarged and fused to the telson. Uropods are free but not segmented, without setae on endopods. Antennal endopod ends in a small spine and a short hair, and is nearly as long as the exopod. There are 6 pairs of setose exopods on maxilliped 1 - leg 3, and 4 pairs of small pleopods on somites 2-5.

Stage 4 (Pl. 47; G: Pl. 48; A, E). C.L.: 1.4 mm., T.L.: 4.2 mm.

Telson is still somewhat wider behind, it is slightly less than twice as long as wide, with 8 + 8 paired and a median spine. The second pair of

telson spines, unlike in the preceding stages, and now assume the form of spine. Uropods are segmented with setose endopods. Antennal endopod is longer than the exopod. Endopods of legs and pleopod buds are large but not segmented.

Section ANOMURA

Carapace has a pair of posterior lateral spines except in Diogenidae, in which the posterior margin is rounded, these spines are either marginal or submarginal. Posterior margin is serrated in Galatheidae but smooth in other groups. Second telson process is atrophied. Antennular peduncle is never segmented. Antennal scale is more or less foliaceous with a fringe of setae except in Porcellanidae, Lepidopa and Emerita where it is reduced to a spine. Antennal peduncle has a large spine at the distal end. Proximal lobe of exopod of maxilla is bare of setae partly at least. Maxillipeds 1 and 2 with bases much longer than coxae and cylindrical. In all stages endopod of maxilliped 1 is of 5 segments, and that of maxilliped 2 is of 4 segments. There are stiff, coarsely plumose setae on these appendages in Galatheidae, Paguridae and Hippidae, but not in Porcellanidae and Diogenidae. Maxilliped 3 is rudimentary in stage 1, becomes setose from stage 2, with rudimentary endopod seated low down on the basis, but in Emerita and Lepidopa it is absent in stage 1 and the whole structure remains rudimentary and uniramous in later stages (Pike and Williamson, 1960).

Superfamily PACURIDEA

Family Paguridae

Subfamily Diogeninae

18. Clibanarius vittatus (Bosc)

The striped hermit crab is very common on the beaches and shallow

offshore areas around Sapelo Island. Berried females were trawled about one mile off the Big Hole, Sapelo Island on May 23, 1969. Eggs hatched into first zoeae which were reared as far as megalopa in the laboratory.

The following table shows the chronological data of development.

Stage	Date	Days after hatching
1	6/3	0
2	6/10-12	7-9
3	6/15	12
4	6/23-25	20-22
5	6/28-30	25-27
Megalopa	7/1-5	28-32

ZOEA

Rostrum is large, cylindrical and tapers rather abruptly into a short terminal spine, it is about as long as the rest of the carapace and well exceeds antennule and antenna. Carapace has round posterior, and smooth ventral, margins.

Abdomen has no spines. Telson is divided into two lobes by a deep notch in stage 1. Second telson process is reduced to a hair, which is by far longer than the first which is short and spinous.

Antennal scale is well developed, foliaceous and fringed with plumose setae on the outer as well as the inner and apical margin, but proximal about 3/4 of the outer margin is bare of setae, and there is no apical spine. Antennal endopod ends in early stages in 2 long and 1 medium plumose setae. Peduncle has a large inner distal spine. Mandible has an unsegmented palp in the last stage.

Endopod of maxillule is indistinctly divided into 2 segments with 1 + 2 setae, and that of maxilla is divided into two lobes with 2 + 2 setae. The proximal lobe of the maxilla has a well developed fringe of setae in later stages. There are no stiff setae on maxillipeds. Leg rudiments are

uniramous. Abdominal somite 1 has no pleopods. Uropods are large, with both exopod and endopod articulated from the protopod in the last stage.

There are red or orange-red chromatophores ventrally along the rostrum, at bases of antennule and antenna, in the mouth parts and abdominal somites 3-6.

Stage 1 (Pl. 49; A, B: Pl. 50; A) C.L.: 0.94 mm., T.L.: 1.82 mm.

Eyes are sessile. Abdomen is of 5 somites plus telson. Exopod of maxillipeds 1 and 2 each has 4 setae. Maxilliped 3 is rudimentary. Telson has 7 + 7 spines including hairlike second, its width is slightly less than the length of somite 6 and telson combined.

Stage 2 (Pl. 49; D: Pl. 50; B) C.L.: 1.15 mm., T.L.: 2.3 mm.

Eyes are stalked. Exopod of maxilliped 3 is functional with 5 setae. Exopod of maxillipeds 1 and 2 each has 6 setae. Telson has 8 + 8 spines.

Stage 3 (Pl. 50; C) C.L.: 1.54 mm., T.L.: 2.8 mm.

Abdominal somite 6 is segmented off from the telson and is about half as long as the latter. Telson is as long as wide and is deeply notched on the hind margin between the fourth processes, which are now spinous, fused to the telson and shorter than the fifth pair. Uropods are free but not segmented, with exopod large and setose and endopod small and bare of setae. Antennal endopod is shorter than the exopod ending in a short spine and a seta. Exopods of maxillipeds 1-3 each has 6 setae.

Stage 4 (Pl. 49; C, F: Pl. 50; D-G) C.L.: 2.08 mm., T.L.: 4.0 mm.

Antennal endopod is much longer than the exopod. There are pleopod buds on somites 2-5. Uropods are segmented with setose endopod. Exopod of maxillipeds 1-3 has 6, 8 and 6 setae respectively.

MEGALOPA (Pl. 51) C.L.: 1.2 mm.

Rostrum is short, blunt and bifid at tip. Eyes are a little less than twice as long as wide, cornea not wider than stalk, and there is no ocular scale.

Abdomen is about 1.7 times longer than the carapace, without spines. Telson is about as long as the somite 6 and as long as wide, bearing 9 long setae on the rounded hind margin. Uropods are symmetrical.

Antenna has a small exopod, which is about as long as the fourth peduncular segment, ending in a blunt spine. Antennal flagellum almost reaches the distal end of leg 2 stretched forward.

Chelipeds are symmetrical and much shorter than leg 2 reaching about distal 1/3 of propodus of the latter. Chela is rather slender and small, somewhat more than 1/3 as high as long, fingers slightly shorter than the palm. Dactyli of legs 2 and 3 are a little less than 4/5 the length of their propodi, with 3 and 2 ventral spines respectively. Leg 4 is subchelate and leg 5 is chelate.

Superfamily HIPPIDEA

Family Albuneidae

19. Albunea paretii Guérin

A berried female was captured by Mr. Westerfield on August 6, 1969, on sandy beach of Sapelo Island and was at my disposal. The female was kept in aerated seawater but discarded its eggs before hatching. The eggs were then placed in a glass bottle containing filtered sea water which is strongly aerated. A few first stage zoea hatched from these eggs on August 16, but none of them had survived beyond the first molt. Many larvae including later stages were obtained from the plankton taken in the coastal offshore waters around Sapelo Island.

ZOEAE

Body is heavily built. Rostrum and a pair of posterior lateral spines are present on carapace. These are comparatively short in stage 1, but

become very long in later stages. The posterior lateral spines are sub-marginal. There is a large dorsal prominence at posterior end of carapace. Anterior ventral angles of carapace end in a small spine on each side.

Abdominal somites are parallel sided, somites 4 and 5 each has a pair of small lateral spines. Telson is roughly semicircular with a convexed hind margin fringed with many spines and spinules. The first spine is much larger than the others and fused to the telson. The second spine is reduced to a hair and is hardly seen in later stages. The fourth spine never become enlarged nor fused to the telson.

Antennule has a long flagellum. Antennal exopod is foliaceous and very broad, without apical spine, it is fringed with plumose setae on apical and inner margins but not on the outer margin. Protopod has a very long inner distal spine. Endopod is absent in stage 1. Mandible has a small molar process. Endopod of maxillule is small, unsegmented with 1 long and 1 short apical setae. Maxilla has 3 vestigial endites, endopod unsegmented, bearing 4 or 5 apical setae, and exopod very large with well expanded proximal lobe which is partly bare of setae.

Maxillipeds 1 and 2 are functional from stage 1, with stiff, coarsely plumose setae. Maxilliped 3 is rudimentary in stage 1, its exopod becomes setose from stage 2, endopod appears from stage 3 and is seated low on the basis. There are no exopod on legs. Leg 5 is hidden. Abdominal somite 1 has no pleopods. Uropod has terminal spines, endopod is present in the last stage but not segmented off from the protopod.

Stage 1 (Pl. 52; A, B: Pl. 53; A, G-I) C.L.: 1.1 mm.

Eyes are sessile. Abdomen is of 5 somites plus telson. The width of

the telson is slightly less than twice the length of somite 6 and telson combined. The number of spines on the hind margin is 12 + 12 including the vestigial second. Antennule is unsegmented. Antenna has no endopod nor outer distal spine on peduncle. Exopod of maxillipeds 1 and 2 each has 4 setae. There are rudiments of gills but no legs.

Stage 2 (Pl. 52; D: Pl. 53; B) C.L.: 1.8 mm.

Eyes are stalked. A pair of spines are added to the telson at the center of the hind margin but the second disappeared, so that the number of spines remain 12 + 12 as in stage 1. There is a small endopod on antenna. Maxilliped 3 has setose exopod but no endopod, it does not reach the distal end of basis of maxilliped 2. Exopod of maxillipeds 1-3 has 6, 6 and 3 setae respectively.

Stage 3 (Pl. 52; C, E: Pl. 53; C) C.L.: 2.7 mm.

Abdomen is of 6 somites plus telson. Uropods are free but not segmented, without endopod. And another pair of spines are added to the telson and their number becomes 13 + 13 in all. There are also several intercalated spines, which are shorter than usual spines but distinctly longer than the spinules fringing the hind margin. Antennule is segmented, flagellum about as long as the peduncle. Antennal endopod is as long as the inner distal spine of the peduncle. The outer distal spine is present on peduncle. Exopod of maxillipeds 1-3 has 8, 8 and 5 setae respectively. Maxilliped 3 has a small endopod tipped with a seta. There are small rudiments of legs and moderately large gills.

Stage 4 (Pl. 52; F: Pl. 53; D) C.L.: 3.9 mm.

Antennal endopod is longer than the inner distal spine on peduncle. Exopod of maxillipeds 1-3 has 10, 10 and 7 setae respectively. Uropod is segmented with 3 spines and 11 setae on exopod, but has no endopod. The fifth spine on the hind margin of telson on each side is somewhat enlarged and becomes longer than the others except the first.

Stage 5. (Pl. 52; G: Pl. 53; E) C.L. (less rostrum, which is broken): 2.6 mm.

Antennular flagellum is longer than the peduncle with 2 groups of aesthetes. Exopod of maxillipeds 1-3 has 12, 12 and 8 or 9 setae respectively. Uropod has 4 spines and 14 or 15 setae on exopod. There are no pleopod buds.

Stage 6 (Pl. 52; H, I: Pl. 53; F) C.L. (less rostrum): 3.9 mm.

There are large pleopod buds. Uropod has a small endopod, and exopod with 6 spines and 17 setae. Telson is about as long as wide. Leg rudiments are large and more or less segmented.

20. Albunea gibbesii Stimpson

A single specimen of fourth zoea was obtained from the plankton taken on July 8, 1969 about 25 miles off Sapelo Island. The larva is closely similar to A. paretii in all but minor characters, and differs from Lepidopa and Emerita in the armature of telson, in the form of antennal scale and maxilla, and in the development of maxilliped 3. It is, therefore, attributed to A. gibbesii, the only one species of the genus other than A. paretii which is known to occur in this district (Williams, 1965).

ZOEAE

Rostrum is shorter than the rest of the carapace in stage 4. Carapace has no dorsal prominences. Abdomen is of 6 somites plus telson in later stages, with small lateral spines on somites 4 and 5. Telson is like in A. paretii. Antennal scale has a small apical spine. Mouth parts and thoracic appendages are like A. paretii, but maxilliped 2 has no stiff setae.

Stage 4 (Pl. 54; A-F). C.L.: 3.3 mm.

Eyes are stalked. Abdomen is of 6 somites plus telson. Telson bears 15 + 15 spines, in addition to minute spinules and small intercalated spines

on the hind margin. The fourteenth spine on each side is somewhat longer than the others except the first. Uropod is segmented with 2 spines and 11 setae on exopod, but has no endopod. Antennal endopod is longer than the inner distal spine of peduncle. Exopod of maxillipeds 1-3 has 10, 10 and 7 setae respectively. There are small rudiments of legs and of large gills, but no pleopod buds.

21. Lepidopa websteri Benedict

A berried female was captured on July 6, 1969 on the beach of Sapelo Island at low tide. The eggs hatched on July 16, but none of the larvae survived beyond the first molt. Several larvae including the later stages were obtained from plankton taken in the coastal offshore waters of Sapelo Island. One megalopa was obtained by rearing the last zoea separated from the plankton.

ZOEA

There is a rostrum and a pair of posterior lateral spines on carapace, these spines are enormously long. Rostrum is smooth, cylindrical and almost 3 times as long as the rest of the carapace in stage 1, but tends to be shorter in proportion to the latter in later stages. The posterior lateral spines are about $2/3$ as long as the rostrum in stage 1, but tends to be longer in proportion to the latter in later stages and is about 1.5 times longer than the rostrum in the last stage. The anterior ventral angles of carapace on each side end in a small spine from stage 2.

Abdomen is about twice as long as the carapace (less rostrum), with a pair of lateral spines on somites 3-5, those on somite 5 are very long and curved. Telson is robust, more or less wider than long, with many spines on the hind margin, of which the first and the fourth are very large

and fused to the telson and the second is more or less reduced. The hind margin is convexed with a central emargination. There is no median spine.

Antennule has a long flagellum in later stages. Antennal exopod is spinous and has no setae. Peduncle has a large inner distal spine, which is $3/4$ or $2/3$ as long as the exopod and armed with spinules. There is no endopod in stage 1. Endopod of maxillule is unsegmented with 1 long and 1 short apical setae. Maxilla has 4 endites, small endopod tipped with 4 or 5 simple setae, and a large exopod with well expanded proximal lobe which is partly bare of setae. Endopod of maxilliped 1 is of 5 segments and that of maxilliped 2 is of 4 segments, both with a few stiff setae. Maxilliped 3 and legs are rudimentary in all stages. There are no exopods on legs. Leg 5 is hidden.

Stage 1 (Pl. 55; A-F; Pl. 56; A, B) C.L.: 3.8 mm.

Eyes are sessile. Abdomen is of 5 somites plus telson. The number of telson spines between the fourth is 15 or 16 on each side, of these the 10th is somewhat longer than others. Antennules are not segmented. Antenna has no endopod. Exopod of maxillipeds 1 and 2 each has 4 setae. There are no rudiments of maxilliped 3 and legs.

Stage 2 (Pl. 55; G) C.L.: 6.0 mm.

Eyes are stalked. There is a small antennal endopod. Rudiments of maxilliped 3 and legs are present. Exopod of maxillipeds 1 and 2 each has 10 setae.

Stage 4 (Pl. 55; H; Pl. 56; C) C.L.: 5.8 mm.

Abdomen is of 6 somites plus telson. Uropods are free and segmented but have no endopod. The number of telson spines between the fourth are 5 + 15, of these the 9th is somewhat longer than the others. Antennal

endopod is about half as long as the spinous process. Exopod of maxillipeds 1 and 2 has 12 and 13 setae respectively.

Stage ?6 (Pl. 55; I: Pl. 56; D) C.L.: 5.2 mm.

Uropod has small endopod, which is segmented off from the protopod but has no setae. Antennal endopod is longer than the spinous process. Exopod of maxillipeds 1 and 2 has 13 and 15 setae respectively.

MEGALOPA (Pl. 56; E) C.L.: 2.9 mm.

Carapace has a fairly long rostrum and a pair of about equally long posterior lateral spines. The rostrum is about $2/5$ as long as the rest of the carapace. Abdomen is flattened dorso-ventrally and somewhat shorter than the carapace, with expanded pleura on somites 2-5. Telson is transversely oval with a small notch on each side at the posterior lateral margins, and is fringed with 7 long setae on each side anterior to the notch and about 30 medium setae on the hind margin between the notches. Uropod is large with elongated oval exopod and endopod fringed with many setae.

Eyes are cylindrical. Antennular outer flagellum is thick, long and multiarticulated with 4 aesthetes of 2 groups near the tip, while the inner flagellum is represented by a small stump at the distal end of peduncle. Antenna is much shorter than the antennule and about as long as the rostrum, peduncle is of 5 segments, stout, flagellum is of 7 segments and about as long as the peduncle, exopod is reduced to a small stump and much smaller than the terminal segment of peduncle.

Maxilliped 3 has a small setose exopod, its carpus is produced distally at the distal outer end reaching the distal end of propodus. Legs 1-4 are more or less flattened. Leg 1 is subchelate. Legs 2-4 have bifurcated dactyli, their carpus are more or less produced distally as in maxilliped 3.

Leg 5 is very small, folded and chelate.

There are well developed pleopods on somites 2-5, with long peduncles, comparatively short setose exopod and rudimentary endopods.

Family Hippidae

22. Emerita talpoida (Say)

Rees, 1959

A single specimen of fourth zoea was obtained from plankton taken on July 8, 1969 about 5 miles off Sapelo Island, and attributed to this species according to Rees (1959).

ZOEA

Carapace has a large rostrum and, except in stage 1, a pair of posterior lateral spines, but no dorsal prominences. Abdomen is of 5 somites plus telson in all stages, without spines. Somites 4 and 5 are widened behind. Telson is roughly oval, with short spines and minute spinules on the roundly convexed hind margin. Uropod has a small endopod and a few setae on exopod, and are seated near the base of the telson.

Antenna is greatly reduced in size and structure, and is shorter than the antennule, it is composed of a curved peduncle with a large outer and a minute inner distal spines, and a short spinous exopod. Endopod develops in later stages. Molar process of mandible is composed of sharp spines. Endopod of maxillule is very small, unsegmented with an apical seta. Maxilla is a simple, undivided plate with only 3 simple apical setae, endopod absent, exopod very large with a well expanded proximal lobe which is partly bare of setae. Maxillipeds 1 and 2 bear a few stiff setae, their endopod each is of 4 segments. Maxilliped 3 remains rudimentary in later stages. There are no exopods on legs. Leg 5 is hidden. Gills are smaller and fewer in number than in Albunea and Lepidopa.

Stage 4 (Pl. 57; A-G) C.L. (less rostrum): 1.5 mm.

Eyes are stalked. Abdomen is of 5 somites plus telson. Telson is slightly longer than wide, with 14 or 15 spines including the fused first on each side of the hind margin. The 9th spine is somewhat longer than the others except the first. Uropod has 4 setae on exopod, endopod is very small and bare of setae. Antennal endopod is shorter than the exopod. Maxillipeds 1 and 2 each bears 10 setae on exopod. Maxilliped 3 and legs are rudimentary.

Section BRACHYURA

With the exception of Dromiacea, the great majority of Brachyura have a typical zoea larva provided with well developed rostral, dorsal and a pair of lateral spines on the carapace, slender, flap-like, curved abdomen, and forked telson. Some or all of the carapacial spines may be wanting. Abdomen has a pair of lateral hooks on somite 2. Further pairs of hooks may also occur on somite 3, 4 and 5. Telson is of triangular plate in Leucosiidae, three lobed in some of Pinnotheridae, and produced into a pair of extremely long, prickly forks in Dorippidae.

Antennule is simple and unsegmented in all but the last zoea stages. Antennal exopod is reduced to a spine, small rod or hairs, except in Raninidae in which it is well developed and foliaceous. Distal spine on peduncle develops into a large spinous process. The whole structure of antenna is rudimentary in Leucosiidae and many of Pinnotheridae.

Maxillipeds 1 and 2 are principally like those in Anomura, but endopod of maxilliped 2 is more reduced than in Anomura and is never of more than 3 segments. Maxilliped 3 is biramous but never becomes functional during zoea stages. Legs have no exopods and are rudimentary in the last zoea stage. There are no pleopods on somite 1. Uropod is very small and

has no endopod, it is setose only in the megalopa.

Subsection GYMNOPLEURA

Family Raninidae

23. Ranilia muricata H. Milne Edwards

The early stage zoeae of a species of raninid crab were obtained from the plankton taken in July and October, 15-45 miles off Sapelo Island. They were attributed to R. muricata, since this is the only species of the family so far known from this district (Williams, 1965).

ZOEA

Carapace, eyestalks, and abdomen are covered by many short, stiff setae. There is a long rostral, dorsal and a pair of very short lateral spines on carapace. Rostral and dorsal spines are armed both dorsally and ventrally with many spines and stiff setae. Anterior and posterior dorsal tubercles are distinct and prominent. There is a fringe of a moderately large spine and small spines on each side of the posterior dorso-lateral margin of carapace.

Abdomen is spiny, and about half as long as the distance from spine to spine. Somite 2 has a pair of lateral hooks, which curves forward and sharply pointed. There is a pair of lateral spines on somites 2-5, 1, 2 and 3 pairs of dorso-lateral spines on somite 1, 2 and 3-5 respectively, and a dorso-median spine on somites 1 and 5. In addition, there is a ventro-median spine on somites 2-5. The number and arrangement of dorsal spines are somewhat irregular.

Telson is widely divided into two lobes. Lateral margin on each side is armed with 5 pointed, immovable teeth. The fourth telson spine is much larger than the others and fused to the telson, thus resembling the telson fork in typical brachyuran zoea. Second spine is reduced to a hair. The number of internal spines between the fourth pair is 3 + 3 in stage 1, but

greatly increases in later stages.

Antennal exopod is foliaceous and fringed with long setae along the outer as well as the apical and inner margins. Endopod ends in 2 long plumose setae in stage 1. There is no long spine on distal end of peduncle. Endopod of maxillule is of 2 segments with 1 + 5 setae, and that of maxilla is unsegmented with 5 apical, and 1 outer setae. Endopod of maxilliped 2 is of 3 segments with 2 + 2 + 6 setae.

Stage 1 (Pl. 58; A, B, D, F-H) From spine to spine: 3.0 mm.

Eyes are sessile. Abdomen is of 5 somites plus telson. Exopod of maxillipeds 1 and 2 each has 4 setae. Antennal endopod is about 1/4 as long as the exopod. The exopod is fringed with 6 setae around the apical margin. There are minute rudiments of legs.

Stage 2 (Pl. 58; C, E) From spine to spine: 4.1 mm.

Telson has 8 + 8 internal processes between the fourth pair of spines. Antennal endopod ends in a short spine and a seta. Exopod is fringed with many setae on the outer as well as the apical and inner margins. Peduncle has a small outer-distal spine. Rudiments of gills are as large as those of legs. Exopod of maxillipeds 1 and 2 has 11 and 13 setae respectively.

Subsection DROMIACEA

So far as concern the larval forms, Dromiacea is totally different from the rest of Brachyura, and the writer agrees with Gurney (1942) that it should be excluded altogether from the latter. The most striking and fundamental differences are seen in the form and armature of telson and antenna. It also differs from the typical Anomura in the presence of setae on the outer margin of antennal exopod, and of exopods on legs.

Family Dromiidae

24. Dromidia antillensis Stimpson

A berried female was captured by Mr. Heard on September 2, 1969 at the

Sponge Reef off Sapelo Island, and was at my disposal. The first zoea obtained from this female were reared as far as megalopa. The following table shows the chronological data of development of the larvae.

Stage	Date	Days after hatching
1	9/7	0
2	9/9-10	2-3
3	9/12-15	5-8
4	9/16-18	9-11
5	9/20-23	13-16
6	9/24-26	17-19
Megalopa	9/26-29	19-22

No young were obtained, though the megalopa had survived for about 2 weeks.

ZOEA

Rostrum is broad at base and ends in the center into a short rostral spine which is about $1/4$ as long as the rest of the carapace, angles of rostrum on each side ending, from stage 2, in a supraocular spine just in front of eyes. There is a short longitudinal dorsal ridge extending from the base of rostral spine to the dorsal tubercle behind eyes. Cervical, hepatic and branchial grooves present on carapace, though somewhat obscure in early stages. The branchial groove reaches ventral margin of carapace. Posterior margin of carapace is rounded and fringed with small spinules. Carapace and eyestalks are covered with numerous fine longitudinal ridges. There are large eye papillae.

Abdomen is somewhat longer than carapace, with a pair of dorso-lateral prominences on somites 2-5. Somite 6 has a pair of longitudinal dorso-lateral ridges. In stage 1 telson is triangular with almost straight hind margin which is indented in the center. Telson spines are in the form of setae except the first, which is short, spinous and fused to the telson. The second process is hairlike and about half as long as the third.

Antennular peduncle is segmented in the last stage. Antenna has a well developed foliaceous exopod fringed with many plumose setae on both inner and outer margins. Endopod ends in 3 long setae in stage 1 and 2, with an accessory seta on the inner edge at about distal 1/4. Protopod has an inner distal spine from stage 1, while the outer distal spine appears in later stage. In addition to the distal spines, there appear 2-3 ventral spines on protopod in later stages. Mandible has a palp in later stages. Endopod of maxillule is of 2 segments with 2 + 6 setae. There are no setae on the outer margin of maxillule. Maxilla has well developed 4 endites, a large exopod (scaphognathite) with well expanded proximal lobe fringed with setae, and endopod of 2 segments with 3 + 6 setae.

Endopod of maxilliped 1 is of 5 segments and that of maxilliped 2 of 4 segments. There are no stiff setae on these maxillipeds. Basis of maxilliped 2 is produced proximally into a blunt tooth tipped with a seta. Maxilliped 3 is rudimentary in stage 1, its exopod becomes setose from stage 2, while endopod remains rudimentary in all stages, springing from low down on the basis. Leg 1 has a setose exopod from stage 2, endopod seated low on the basis like in maxilliped 3. Legs 2-5 are uniramous and rudimentary in all stages. Leg 5 is exposed. The numbers of swimming setae on exopods of maxillipeds and leg 1 at each larval stage are summarized in the following table.

Stage	Mxp. 1	Mxp. 2	Mxp. 3	Leg 1
1	4	4	0	0
2	6	6	5	4
3	7	8	7	5
4	9	10	8	6
5	11	12	10	6
6	12	14	12-13	8

There is a dense distribution of orange-red chromatophores ventrally