STUDIES ON THE LARVAE OF CRABS OF THE FAMILY XANTHIDAE[1]

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The larval stages of the Xanthidae are better known than those of any other family of the Brachyura. This doubtless is due to the fact that the adults habitually are found in shallow water near the shore and usually are very abundant. Ovigerous females may be taken without trouble, and thus the early zoeal stages may be known with certainty.

The family is well represented at Beaufort, N. C., and the writer is able to incorporate in these pages descriptions of the larvae of five genera based upon material collected there. Most of the known Xanthid larvae hatch with the prezoeal cuticle still intact. This is shed, however, within a few minutes. The first zoeal stage is characterized by the presence of dorsal, lateral, and rostral spines on the carapace and usually long and robust antennae.

The known zoeas of the family are separable into two groups. Those of *Panopeus* and *Xantho* have extremely minute exopodites on the antennae. Those of the remaining genera so far known have a well-developed exopodite. When arranged in a series, the zoea of *Panopeus* is found to be most highly specialized, while that of *Pilumnus* is least so.

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[1] This is the third of a series of studies on the larval stages of crabs. The first, Studies on larvae of crabs of the Family Pinnotheridae was published in the Proceedings of the U. S. National Museum (vol. 64, art. 7, pp. 1–9, pls. 1–6), and the second, Studies upon larvae of crabs of the Family Grapsidae, in the same serial, vol. 65, art. 10, pp. 1–8, pls. 1–2. A further study on the Development of Gelasimus [Uca] after hatching, is cited in the accompanying bibliography.

KEY TO KNOWN ZOEAS

a.[1] Exopodite of antenna minute.
b.[1] Distal third of antenna smooth---------- **Neopanope texana sayi.**
b.[2] Distal third of antenna hairy.
c.[1] Antennule bearing pigment spot distally.
Eurypanopeus depressus.
c.[2] Antennule without pigment.
d.[1] Third maxilliped distally bifurcated---------- **Xantho.**
d.[2] Third maxilliped not distally bifurcated.
Panopeus herbstii.
a.[2] Exopodite of antenna a distinct segment.
b.[1] Antenna longer than rostral spine---------- **Pilumnus.**
b.[2] Antenna shorter than rostral spine.
c.[1] Tip of rostral spine hairy---------- **Trapezia.**
c.[2] Tip of rostral spine smooth.
d.[1] Antenna one-half as long as rostral spine
Menippe mercenaria.
d.[2] Antenna two-thirds as long as rostral spine.
Eriphia spinifrons.

PIGMENTATION

Although the pigmentation of the zoeas of each species is a constant feature and is often of diagnostic value, the older papers do not describe it except in the most general terms. The following table is based upon the material collected at Beaufort. The pigment color varies from black to brown.

Table showing position of chromatophores of zoeas

	Neopanope	*Eurypanopeus*	*Panopeus*	*Hexapanopeus*	*Menippe*
Anterior rostral	+	+	+	+	+
Interorbital	+	+	+	+	+
Supracardiac	+	+	+	+	+
Dorsal carapace spine					+
Lateral to first abdominal segment					
Postero-ventral lobe	+	+	+	+	+
Labrum					+
Mandible	++	+	++	+	+
Antennule		+			
Sternal	+	+	+	+	+
Base of antenna					+
Basipodite first maxilliped	++	++	+	+	+
Basipodite second maxilliped	++	++	+	++	+
Dorso-lateral first abdominal segment	+	+	+	+	+
Ventral firs tabdominal segment					
Ventro-lateral second abdominal segment	+	+	+	+	+
Ventro-lateral third abdominal segment	+	+	+	+	+
Ventro-lateral fourth abdominal segment	+	+	+	+	+
Ventro-lateral fifth abdominal segment	+	+	+	+	+
Telson	+	+	+	+	+

METAMORPHOSIS

The complete larval history of *Neopanope* has been described while a nearly complete description has been given for *Xantho*, *Pilumnus*, and *Eriphia*. Only the prezoeal and first zoeal forms are known for the other genera.

In *Neopanope* the prezoea is followed by four zoeal stages and at least two megalops stages. The juvenile history of the crab stages has not been reported.

NEOPANOPE TEXANA SAYI (Smith)

Plate 1, figs. 1, 3, 7, 11, 13, 17; plate 2, figs. 23, 27, 31; plates 3–8

The larval history of this species has been reported very fully by Birge. The writer has checked over the development on material secured at Beaufort, where the species is abundant. The following description varies from that of Birge in a number of details.

PREZOEA (fig. 1)

The larva hatches with the embryonic cuticle still intact. It is generally sluggish at first but becomes more active and—under laboratory conditions—sheds the cuticle in a few hours.

Cephalothorax.—The cuticle covering the cephalothorax is smooth and without processes, but the processes of the first zoeal stage may be seen folded beneath it. The dorsal spine is bent forward. It is telescoped upon itself and is quite wrinkled. The lateral spines are quite difficult to see but are present, folded against the side of the body. The rostral spine is wrinkled and telescoped like the dorsal spine. It is folded posteriorly and ventrally, lying between the bases of the appendages.

Cephalic appendages.—The antennular process (fig. 3) of the embryonic cuticle is greatly prolonged. It is bifurcated distally. One ramus is much longer and is sparsely hairy while the other is short, blunt, and smooth. The antennule of the first zoea extends out into the process, reaching to the point of bifurcation. At its tip it bears several sensory hairs that are partially invaginated.

The prezoeal antennal process (fig. 7) is also entirely different in shape from the zoeal antenna that it incloses. The prozoeal antenna is biramous. One ramus is a simple, smooth, blunt process into which the great spine of the zoeal antenna extends. The other ramus carries three sparsely hairy spines that are digitately arranged. A fourth spine is present as a minute, smooth process. The antenna of the zoea is seen within the cuticle. It is wrinkled and its distal two-thirds is telescoped on itself.

The mandibles (fig. 11), the maxillules (fig. 13), and the maxillae (fig. 17) are inclosed in simple sac-like prolongations of the cuticle. Each is typically brachyuran except that the hairs are invaginated.

Thoracic appendages.—Four pairs of thoracic appendages are recognizable, three pairs of maxillipeds and the chelipeds. Each is inclosed in a closely fitting, unsegmented sac of the embryonic

cuticle. The first and second maxillipeds (figs. 23 and 27) are well developed. The endopodite of the first shows five segments and that of the second three. All of the hairs are invaginated. The third maxillipeds and the chelipeds appear as buds.

Abdomen.—The five segments and telson are clearly defined. The segments are closely invested by the embryonic cuticle, which is, however, not segmented. The cuticle covering the telson (fig. 31) is bifurcated. Each ramus bears seven large spines. Of these, the median three are sparsely hairy, elongated, and tapering. The middle spine is short, blunt, and smooth. Two of the lateral group are sparsely hairy and tapering, while the most lateral spine again is short and smooth. The zoeal telson nearly fills the cuticle. The tips of its cornua are invaginated. They extend out into the middle blunt spine. The hairs of the telson are only slightly invaginated. They extend out into the remaining spines.

FIRST ZOEA (figs. 35 and 36)

After a few hours the embryonic cuticle is shed and the striking first zoea emerges. The elongated spines and antennae give the larva an awkward appearance, but it is quite active and swims well.

Cephalothorax.—Among the most striking features of the zoea are the dorsal and rostral spines. The dorsal spine rises from a slightly swollen base and sweeps upward and backward as a long, tapering process. It is almost straight. The rostral spine is longer and more slender than the dorsal. It extends ventrally and slightly anteriorly. The lateral spines are short and slender.

Cephalic appendages.—The antennae (fig. 59) are noteworthy. The spine is tremendously elongated, extending even beyond the rostral spine of the carapace. It is smooth to its tip. The minute exopodite is scarcely discernible where it is attached to the spine near its base. The other cephalic appendages are typical.

Thoracic appendages.—The first and second maxillipeds (figs. 63 and 67) show the usual four swimming hairs on the exopodites. The proximal segments of the endopodites are developed as masticating organs while the distal segments bear sensory hairs. The remaining thoracic appendages are discernible as minute buds.

Abdomen.—It is characteristic that the posterior lateral border of each segment is produced posteriorly as a spinous process. These are not very pronounced in this early stage. The cornua of the telson (fig. 72) are slender and greatly elongated. In addition to the usual three hairs on the median margin of each cornu, there are three minute spines placed laterally and dorsally.

SECOND ZOEA (figs. 45 and 46)

According to Birge, the zoea molts a large number of times before it reaches the condition designated as the second zoeal stage. While my observations are not numerous enough to justify a dogmatic statement, I have not found this to be the case. Each of the first zoeas under my observation became transformed into a second-stage zoea at the first molt.

Cephalothorax.—The dorsal and rostral spines are longer and more slender. The eyes are movable.

Cephalic appendages.—The antennae (fig. 60) are longer and more slender. The maxillae (fig. 56) show changes in the scaphognathite, which is now a flattened plate with hairs along its border.

Thoracic appendages.—The number of swimming hairs on the first and second maxillipeds (figs. 64 and 68) is now six or seven. The third maxillipeds are larger and, at their distal ends, cleft into exopodite and endopodite. The chelipeds also show cleft extremities. The buds of the remaining pereiopods are easily identified.

Abdomen.—The lateral spinous processes on the segments are somewhat more pronounced. The anlagen of the abdominal appendages are visible beneath the cuticle but do not yet form protrusions. The cornua of the telson (fig. 73) are further elongated.

THIRD ZOEA (figs. 47 and 49)

Again Birge states that several molts occur before the third zoeal stage is reached but my observations indicate that the second zoea becomes a third-stage zoea at the first molt.

While the earlier zoeas are taken in large numbers at the surface of the water, the third-stage form is rather rare. It is taken in small numbers both from the surface and from near the bottom. It doubtless has difficulty in maintaining itself at the surface on account of its increased weight.

Cephalothorax.—The dorsal and rostral spines are again longer and relatively more slender. The eyes are more freely movable and are relatively larger.

Cephalic appendages.—The antennules (fig. 39) are appreciably larger and are superficially constricted near the base. The antennae (fig. 61) are longer and more slender. Each shows now the anlage of the flagellum of the permanent antenna. This appears as a bud between the exopodite and the spine. The maxillule (fig. 53) shows a minute but significant change—a single epipodal hair appears on the basipodite.

Thoracic appendages.—The swimming hairs are now eight or nine. The exopodites of the first and second maxillipeds (figs. 65 and 69)

show a sharp constriction indicating a division into two segments. The endopodite of the second maxilliped is significantly enlarged. The third maxillipeds and the remaining thoracic appendages are more prominent.

Abdomen.—The telson is now divided from the sixth abdominal segment. Each segment except the first shows a pair of buds—the abdominal appendages. The lateral spines on the third, fourth, and fifth segments are further prolonged. A fourth median spine appears on each cornu of the telson (fig. 74).

FOURTH ZOEA (figs. 49 and 50)

The fourth and last zoea is larger and heavier and correspondingly clumsier. It is found most commonly on the bottom, where it swims spasmodically upward toward the light at intervals, but in the main is rolled along by the sweep of the tides.

Cephalothorax.—The body is now appreciably increased in weight while the spines are scarcely longer than in the previous stage.

Cephalic appendages.—The basal portion of the antennule (fig. 40) is now swollen and partially separated from the distal region by a deep constriction. The beginning of the statocyst appears in the swollen part. The tip of the antennule is divided into two rami. The inner ramus bears five or six sensory hairs; the outer is a short blunt bud. The flagellar bud of the antenna (fig. 63) is elongated. Its cuticle is not segmented but the internal fleshy part shows four or five segments distally. The mandible (fig. 44) now shows the anlage of its palp as a simple bud.

Thoracic appendages.—There are now twelve swimming hairs. The third maxilliped is well-developed although slender and weak in comparison with the first and second. Its exopodite carries a few hairs distally. Its endopodite shows indications of five segments. The pereiopods are large and, although they are short, all of their segments are clearly marked. A number of gill buds are distinguishable at this stage as follows: One on the third maxilliped, two on the cheliped, and one on each of the second and third pereiopods.

Abdomen.—The lateral spines and the cornua of the telson (fig. 75) now reach their maximum development. The buds of the abdominal appendages are elongated and cleft into exopodite and minute endopodite.

MEGALOPS (figs. 76 and 77)

According to Birge, there are at least four molts during the megalops stage. The changes at each molt are slight, however. The megalops is an active and powerful swimmer. It occurs most commonly at the surface, but may be taken near the bottom. As its

final molt approaches it seeks a crevice in some shell or stone near the tide line.

Cephalothorax.—An astonishing change in the form of the carapace occurs when the zoea changes to the megalops. The dorsal and lateral spines disappear completely. The frontal spine remains as a short, notched projection anteriorly. It is quite inconspicuous. The whole cephalothorax is now depressed rather than compressed.

Cephalic appendages.—The antennule (fig. 81) now acquires very nearly its permanent form. The basal part is composed of four large segments. The most proximal of these is swollen and contains the statocyst. The bud of the outer flagellum is elongated and separated from the basal segments by a joint. It carries a few hairs at its tip. The inner flagellum arises from the tip of the distal segment of the basal portion. It is composed of two or three segments, each bearing several hairs.

The antenna (fig. 83) now assumes practically the adult condition. It is composed of a basal portion of three large segments and a distal flagellum of about nine segments.

The mandible (fig. 85) is completely formed. Its palp shows three segments.

The maxillule (fig. 88) changes considerably. The two lobes of the basal portion become greatly elongated. The distal part loses its joint, becomes flattened, and is bent sharply outward.

The changes in the maxilla (fig. 91) are similar to those of the maxillule, although not so pronounced. The basal lobes are elongated and the distal part becomes a flattened plate bent slightly outward.

Thoracic appendages.—The maxillipeds all undergo profound changes. On the first maxilliped (fig. 94) there appears a large epipodite for the first time. The basipodite is produced into three or four lobes along its median margin and is much enlarged. The exopodite loses its joint, but is permanently flexed medially at that point. Its hairs are reduced to four or five and these are small. The endopodite loses its joints and becomes a flattened plate with few hairs. The appendage has lost its locomotor function and becomes an organ of mastication with, possibly, some sensory function.

The second maxilliped (fig. 97) is changed much like the first. Its epipodite appears. Its basipodite forms obscure median lobes, but is only slightly enlarged. The changes in the exopodite are like those in the first maxilliped but the retrogression is not so great. The endopodite becomes four-segmented and flattened.

The third maxilliped (fig. 100) is greatly enlarged, becoming the most robust of the three. It has a large epipodite. Its basipodite is scarcely larger. The exopodite is similar to that of the other

two. The endopodite is composed of five segments and is greatly enlarged.

At the change to the megalops, the pereiopods acquire what is practically the adult condtion. Each appendage, however, is relative longer and more slender than in the adult. There is no difference between the right and left chelae.

Abdomen.—The whole abdomen becomes depressed. The telson is greatly changed. Its long cornua are lost and it becomes a simple plate with a rounded posterior border. The abdominal appendages (figs. 103 and 104) now become the chief organs of locomotion. In each the exopodite becomes flattened and carries long swimming hairs along its distal border. There are 18 such hairs on the appendage of the second segment and 6 on that of the sixth. The endopodite in each case is a small simple bud.

FIRST CRAB (figs. 78 and 79)

After at least four molts, the megalops assumes the form of the first crab stage. The structural changes are not great. The animal now loses the power of swimming and crawls about near the tide line.

Cephalathorax.—The carapace is somewhat broadened. The last trace of the rostral spine is lost and the frontal margin of the carapace very closely resembles that of the adult. The eye is still a single segment and can not be erected.

Cephalic appendages.—The antennule assumes the adult condition. The external flagellum disappears and the internal becomes divided into six segments. The other cephalic appendages undergo very slight modifications.

Thoracic appendages.—The maxillipeds are very slightly changed. The most noticeable change is in the endopodite of the third. Its proximal two segments become enlarged to form an operculum for the mouthparts and the distal three segments appear as a palp.

Abdomen.—With the assumption of the crab form the abdomen undergoes a considerable change. It is further flattened and is permanently flexed under the sternum. Birge does not describe the abdominal appendages of the juvenile crab stages. Possibly the larval appendages of the megalops atrophy and are replaced by the permanent organs as in *Uca* (*Gelasimus*).[2]

EURYPANOPEUS DEPRESSUS (Smith)

Plate 1, figs. 2, 4, 8, 14, 18; plate 2, figs. 24, 28, 32; plate 9

This species is not uncommon at Beaufort, but it is not so abundant as *Neopanope*. Its zoeas are frequently found in the tow and

[2] Hyman, 1920, p. 499; 1922, pp. 457, 458.

they may be distinguished from those of *Neopanope* at all stages, including the megalops, by the simple fact that all stages of the zoea and megalops of *Eurypanopeus* have a pigment spot on the antennule.

Birge mentions the first zoea of this species and gives certain characters by which it may be distinguished from *sayi*. I have studied only the prezoea and first zoea in detail, but have identifed the remaining zoea and megalops stages in specimens from the tow. Superficially, the development seems to be the same as in *sayi*. The characteristic differences between the first zoeal forms hold throughout.

PREZOEA (fig. 2)

The prezoea is appreciably larger and more robust than that of *sayi*, but it agrees in structure except in certain details.

The prezoeal antennal cuticle (fig. 4) shows four large digitations on the lobe instead of three large ones and one minute one. The remaining appendages approximate those of *sayi* very closely, differing only relatively. In the telson (fig. 32) of *depressus* the spines of the prezoeal cuticle are longer than in *sayi*.

FIRST ZOEA (figs. 106 and 107)

In general the zoea shows the features that characterize *sayi*. There are differences in detail, however, that make the zoeas more easily distinguishable than the adults.

Cephalothorax.—The dorsal and rostral spines are very long and slender. The dorsal spine is strongly hooked at its extremity.

Cephalic appendages.—The antennules are of the usual type, but each bears a large pigment spot distally (fig. 108). The antennae (fig. 109) are long and slender and gently curved. They bear bristles for nearly a third of their length distally.

There is nothing about the remaining appendages or the abdomen that would distinguish this species from *sayi*.

PANOPEUS HERBSTII (Milne Edwards)

Plate 1, figs. 5, 9, 15, 19; plate 2, figs. 21, 25, 29, 33; plate 10

Panopeus herbstii is the most abundant Xanthid at Beaufort. It swarms under shells and débris all along the shores. I have studied the development up to the megalops stage, but only the prezoeal and first zoeal stages in detail. These resemble similar stages in *depressus* quite closely. The remaining zoeal stages develop as in *sayi*. The characteristics that distinguish the first zoea distinguish all subsequent zoeal stages.

PREZOEA (fig. 21)

The prezoea is large, as in *depressus*, and is quite robust. The carapace is in an unusually immature condition, extending posteriorly hardly beyond the heart. The resemblances to the prezoea of

depressus are so close that one would have great difficulty in distinguishing the two, except that in *herbstii* the antennule does not have a pigment spot.

FIRST ZOEA (figs. 116 and 117)

The resemblance of the first zoea to that of *depressus* is very close. They may be distinguished by the absence of pigment on the antennule of *herbstii* and by several relative though pronounced differences.

The dorsal and rostral spines are slender as in *depressus* and the dorsal shows a terminal hook. However, both are distinctly shorter than in *depressus*. The antennae are shorter than in *depressus* and the exopodite is much larger.

The remaining appendages and the abdomen are like those of *depressus* except in minute details.

HEXAPANOPEUS ANGUSTIFRONS (Benedict and Rathbun)

Plate 1, figs. 6, 10, 12, 16, 20; plate 2, figs. 22, 26, 30, 34

This species is rare at Beaufort. A single female was identified by Dr. W. P. Hay and presented to me in 1916. The eggs hatched but none of the prezoeas molted. None of the zoeal stages have been found in the tow.

PREZOEA (fig. 22)

The prezoea resembles that of *sayi* quite closely in size and general appearance. It may be distinguished by details of structure. The lobe of the prezoeal cuticle of the antenna (fig. 6) has four large digitations instead of three. The telson (fig. 34) is bicornuate, but prezoeal cuticle of either ramus carries six hairs or processes instead of seven.

Genus XANTHO

Plate 11; plate 12, figs. 141–151

The development of *Xantho* has been studied by Couch, Gourret, and Cano. Cano has given the most nearly complete description of its metamorphosis. He studied *X. rivulosus*, *X. floridus*, and *X. tuberculatus* but did not distinguish between the larval stages of the different species.

The zoeas of *Xantho* resemble those of *Neopanope* quite closely. They have the same type of carapace spines and of antennae.

FIRST ZOEA (fig. 125)

Cephalothorax.—The rostral and dorsal spines are long and slender. The lateral spines are short and slender.

Cephalic appendages.—The antennules (fig. 138) have the typical conical form. The antennae (fig. 133) are as long as the rostral

spine and are hairy along their distal two-thirds. The exopodite is minute. The remaining appendages are typical.

Thoracic appendages.—These are typical, except that the third maxilliped is unusually far advanced. Its bud already shows a distal bifurcation.

Abdomen.—The telson (fig. 150) is bicornuate. Each cornu bears three large spines medially, one minute hair dorsally, and two small hairs laterally.

SECOND ZOEA

This stage has not been described. It seems to have been overlooked by Cano.

THIRD ZOEA (figs. 126 and 127)

This stage is characterized by the increase in the number of swimming hairs to 9 or 10, and the presence of abdominal appendages as finger-shaped buds.

Cephalothorax.—The dorsal and rostral spines are still further elongated. The eye stalks are differentiated and the eyes are movable although the stalks can not be lifted from the orbits.

Cephalic appendages.—The antennule (fig. 126) shows a superficial differentiation into proximal and distal portions. The proximal portion is slightly enlarged. On the antenna (fig. 126) the anlage of the future flagellum appears as a finger-shaped bud between the exopodite and the spine.

Thoracic appendages.—The swimming hairs are now 9 or 10. The third maxilliped and the remaining thoracic appendages are long, finger-shaped buds and their points are indicated by superficial annulations.

Abdomen.—The telson is separated from the sixth abdominal segment by a joint. Each segment except the first bears a pair of finger-shaped buds—the abdominal appendages. The lateral spines on the third, fourth, and fifth segments are longer.

FOURTH ZOEA (fig. 128)

In the last zoeal stage the body is increased in size and weight without a corresponding increase in the size of the carapace spine or the appendages.

Cephalic appendages.—The proximal portion of the antennule (fig. 134) is composed of two enlarged segments. The distal of these bears two rami, an inner of a single segment bearing sensory hairs and an outer that is a simple bud.

The flagellum of the antenna (fig. 134) is considerably elongated. The mandible (fig. 137) shows the bud of the future palp. The maxillule and the maxilla (fig. 142) reach their maximum differentiation.

Thoracic appendages.—There are now 11 or 12 swimming hairs. All of the thoracic appendages are developed and the segments of each are evident. Gill buds appear on the third maxilliped and the first and second pereiopods.

Abdomen.—The lateral spines of the third, fourth, and fifth segments are greatly elongated. The abdominal appendages are elongated and biramous.

FIRST MEGALOPS (fig. 129)

After the molt from the last zoeal stage, the form of the carapace is almost completely changed. The dorsal and lateral spines are lost. The rostral spine has disappeared and two small frontal spines protrude from the anterior border of the carapace. The pereiopods are fully developed and the abdominal appendages are powerful swimming organs. The sense organs are all well developed in consonance with the more independent habits of the megalops.

Cephalic appendages.—The antennule (fig. 135) is now well formed. Its basal segment is greatly enlarged and contains the statocyst. Distally its two rami appear as short flagella that carry numerous sensory hairs.

The antenna (fig. 135) assumes what is practically the adult condition. The tremendous spine of the zoea disappears completely as does also the minute exopodite. The endopodite remains as a slender, many jointed flagellum that is sparsely hairy at the joints.

The mandible (fig. 138) also assumes the adult condition. The palp is divided into three segments, each of which bears a few hairs.

The maxillule (fig. 140 and the maxilla (fig. 143) begin to degenerate at this stage. Their endopodites begin to lose their joints and hairs.

Thoracic appendages.—The maxillipeds undergo a very striking transformation. They are no longer swimming organs, but are changed into masticatory appendages with sensory palps.

The first maxilliped (fig. 145) shows these typical changes. The exopodite becomes relatively smaller and permanently flexed near its middle. Its distal portion becomes a short flagellum and it carries several small hairs at its tip. The endopodite loses its joints and becomes adapted for mastication. The lobes of the basipodite are enlarged and adapted for mastication. A large epipodite is present.

The second maxilliped (fig. 146) has an exopodite like the first. The endopodite shows five segments. The basipodite carries a small epipodite and a gill bud.

The third maxilliped now becomes the largest of the three. Its exopodite is like that of the first and second. The endopodite is greatly enlarged and consists of six segments. The proximal three are large and flattened and form an operculum, while the distal three

form a sensory palp. The basipodite carries an epipodite and two gills.

The pereiopods assume practically the adult condition (fig. 149). The cheliped shows the characteristic spine on the third segment.

Abdomen.—The abdomen is broadened and depressed. Each segment, beginning with the second, bears a well-developed appendage. Each typically consists of a proximal segment bearing a flattened exopodite and a minute endopodite. The exopodite carries long, plumose swimming hairs along its border. The hairs of the endopodite are small and curled inward as hooks. The appendages of the last segment do not have endopodites.

SECOND MEGALOPS (fig. 130)

The second megalops stage differs only slightly from the first. The front of the carapace is altered and the whole carapace somewhat broadened in outline.

FIRST CRAB (fig. 131)

The carapace is further depressed and its front is gently rounded. The outline of the carapace dorsally is almost circular. The appendages have undergone minor changes only.

ERIPHIA SPINIFRONS (Herbst)

Plate 12, figs. 152–161

Cano has described the development of *Eriphia* and compared it with *Xantho*. The two show close agreement in many particulars, but *Eriphia* belongs with *Menippe*, *Trapezia*, and *Pilumnus* in having smaller antennae with well-developed exopodites.

FIRST ZOEA (fig. 152)

The first zoea is sharply distinguished from those of *Panopeus* and *Xantho* by the relatively inconspicuous antenna. The dorsal spine is long and robust, as is also the rostral, although neither is as long as in the above-mentioned forms. The lateral spines are slender.

Cephalic appendages.—The antennule (fig. 155) is typical. The antenna (fig. 155) has a short spine that is hairy along its distal three-fourths. The spine is approximately half as long as the frontal spine of the carapace. The exopodite is composed of a single fingerlike segment that bears two or three hairs distally. It is two-thirds as long as the spine. The other cephalic appendages are typical.

Thoracic appendages.—These all have the typical brachyuran form.

Abdomen.—The telson (fig. 159) has three median spines and two minute lateral spines on each cornu.

THIRD (SECOND?) ZOEA (fig. 153)

It is difficult to decide from Cano's description and figures whether his second zoeal stage should arise directly from his first or whether he has overlooked a stage between the two. Figure 153 seems to be that of a second zoea. There are only five abdominal segments. The pleopods are not protruding as is typically the case in the third zoea. The swimming hairs number six. On the other hand the antenna (fig. 156) shows the bud of the endopodite, a characteristic of the third zoeal stage, and the telson (fig. 160) shows four pairs of medial spines that also characterize the third zoea.

It may be that *Eriphia* has only three zoeal stages or it may be that Cano has failed to distinguish the second stage from the third and thus has described the appendages of the third stage as belonging to the second.

FOURTH ZOEA (fig. 154)

The last zoeal stage described by Cano agrees very closely with the fourth zoeal stage of *Panopeus* and *Xantho*. The swimming hairs number 12 to 14. The endopodite of the antenna is elongated and the pleopods are elongated and biramous.

Cephalic appendages.—The antennule (fig. 157) shows a proximal portion composed of three enlarged segments. The first of these contains the developing statocyst. Distally the inner ramus of the antennule shows evidence of two or three joints, while the outer is a simple bud.

The endopodite of the antenna (fig. 157) is almost as long as the spine and shows the outlines of its future joints.

Thoracic appendages.—The pereiopods are all well formed and their gill buds are prominent. The first and second maxillipeds are the only thoracic appendages that are functional as yet however.

Abdomen.—The telson is now separated from the sixth abdominal segment by a joint. The pleopods are elongated and biramous, although none of them bear hairs as yet. The telson (fig. 161) has four pairs of median spines.

MENIPPE MERCENARIA (Say)

Plate 13

Menippe mercenaria is quite abundant at Beaufort and its zoeas are frequently taken in towing. However, only the prezoeal and first zoeal stages are known. *Menippe* differs from many other Brachyura in that its eggs do not always hatch at dusk or at night. They seem to hatch at any hour of day or night.

PREZOEA (fig. 163)

The prezoea sheds its cuticle in a few minutes after leaving the egg. It differs from that of *Panopeus* in details only. The cuticle

of the prezoeal antennule (fig. 164) shows two broad spines of unequal lengths. The antenna (fig. 165) terminates in a blunt point. It bears a lateral ramus near its tip that is prolonged into four subequal hairy digitations. The telson (fig. 166) carries seven spines on each cornu. The middle spine is short and smooth, the others long and hairy.

FIRST ZOEA (figs. 167 and 168)

The zoea of *Menippe* differs strikingly from that of *Panopeus* and *Xantho*, but resembles that of *Eriphia* closely. The carapace spines are all robust. The antenna is scarcely as long as the rostral spine and its exopodite is as long as the antennal spine. The pigmentation along the anterior surface of the dorsal carapace spine is helpful in identifying this zoea.

Cephalic appendages.—The antennule (fig. 169) is simple and conical but it is longer than usual. The antenna (fig. 170) is comparatively small for a Xanthid. Its spine is slender and hairy along its distal portion. The exopodite is quite long and, with its terminal hairs, equals or exceeds the spine in length. The remaining cephalic appendages (figs. 171 and 172 and 173) have the typical brachyuran form.

Thorax and abdomen.—The thoracic appendages are typical (figs. 174 and 175). The fourth and fifth abdominal segments are characterized by short lateral spines that spring from their posterior borders. The telson (fig. 176) has the three pairs of median spines. In addition each cornu has a minute lateral spine and a minute dorsal spine.

Genus TRAPEZIA

Plate 12, fig. 162

Spence Bate has described the first zoea of *Trapezia* very briefly and given one figure. The description is confined to the enumeration of the appendages present but other details may be learned from the figure.

The dorsal spine of the carapace is slender and is curved posteriorly. The rostral spine is short and covered with spines near its tip. The antenna is nearly as long as the rostral spine. The antennal spine is hairy near its tip. Its exopodite is nearly as long as its spine. The posterior borders of the third, fourth, and fifth abdominal segments are produced laterally into long, spinous processes.

Genus PILUMNUS

Plate 14

Cano studied *Pilumnus hirtellus*, *P. villosus*, and *P. spinifer* but he did not distinguish between the species in his descriptions. Gourret states that the larvae of *P. spinifer* hatch at night but he does not

describe them. Couch simply states that *P. hirtellus* hatches as a zoea. The following descriptions are based on Cano.

FIRST ZOEA (fig. 177)

The zoea of *Pilumnus* is distinguished by its slender rostral spine and relatively large antenna. The buds of all the thoracic appendages are present and that of the third maxilliped is obviously biramous.

Cephalic appendages.—The antennule (fig. 183) has the usual conical form. The antenna (fig. 183) is nearly twice as long as the small rostral spine. The exopodite is as long as the antennal spine and bears a lateral hair near its tip. The remaining cephalic appendages are typical.

Thoracic appendages and abdomen.—The first and second maxillipeds are typical. The third maxilliped and the pereiopods are precociously developed. The buds are all large and that of the third maxilliped is biramous. The telson (fig. 192) has three median spines, two lateral spines—one very minute—and one dorsal spine on each cornu.

SECOND ZOEA (fig. 178)

The second zoea shows the usual changes. There are six swimming hairs on each maxilliped. The gill buds have appeared on the thoracic appendages. Cano does not give a detailed description of the stage.

THIRD ZOEA

Cano seems to have overlooked the third zoeal stage. His third stage apparently is the fourth zoea.

FOURTH ZOEA (fig. 179)

The fourth zoea has ten to twelve swimming hairs, six abdominal segments, and biramous pleopods.

Cephalic appendages.—The antennule (fig. 184) now has a swollen basal segment for the statocyst. The inner of the two distal rami shows several constrictions and bears several sensory hairs; the outer is a simple bud. The antenna (fig. 184) shows an endopodite that nearly equals its spine in length.

Thoracic appendages and abdomen.—The third maxilliped and pereiopods are greatly enlarged and all their segments are differentiated. The pleopods, except that of the sixth segment, are bifurcated. The telson (fig. 193) is somewhat larger than in earlier stages but otherwise is not changed.

FIRST MEGALOPS (fig. 180)

The rostral spine leaves a slight remnant. The thoracic appendages reach what is practically the adult condition. The abdominal

appendages become the organs of locomotion, each appendage being equipped with numerous long swimming hairs.

Cephalic appendages.—These are typical for the megalops.

Thoracic appendages.—The first maxilliped is relatively smaller and its endopodite and exopodite are degenerated (fig. 186). It carries a large epipodite. The second maxilliped (fig. 188) is small. Its exopodite is degenerated and its exopodite has become a palp of five segments. It carries a small epipodite and a small gill bud. The third maxilliped (fig. 189) is quite large. Its endopodite is composed of six segments. It carries an epipodite and two gills. The cheliped (fig. 191) shows the typical spine on its third segment and has two gills on the coxopodite.

SECOND MEGALOPS (fig. 182)

The carapace is further broadened and depressed. The frontal margin is broadened and somewhat bulbous. The abdomen is permanently flexed under the sternum.

The first maxilliped (fig. 187) is somewhat enlarged and has acquired its adult form. The third maxilliped (fig. 190) has reached its adult form. Both exopodite and endopodite terminate in palps. The proximal segments of the endopodite form an operculum for the other mouth parts.

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EXPLANATION OF PLATES

PLATE 1

FIG. 1. Prezoea, *Neopanope texana sayi.*
2. Prezoea, *Eurypanopeus depressus.*
3. Antennule, *Neopanope texana sayi.*
4. Antennule, *Eurypanopeus depressus.*
5. Antennule, *Panopeus herbstii.*
6. Antennule, *Hexapanopeus angustifrons.*
7. Antenna, *Neopanope texana sayi.*
8. Antenna, *Eurypanopeus depressus.*
9. Antenna, *Panopeus herbstii.*
10. Antenna, *Hexapanopeus angustifrons.*
11. Mandible, *Neopanope texana sayi.*
12. Mandible, *Hexapanopeus angustifrons.*
13. Maxillule, *Neopanope texana sayi.*
14. Maxillule, *Eurypanopeus depressus.*
15. Maxillule, *Panopeus herbstii.*
16. Maxillule, *Hexapanopeus angustifrons.*
17. Maxilla, *Neopanope texana sayi.*
18. Maxilla, *Eurypanopeus depressus.*
19. Maxilla, *Panopeus herbstii.*
20. Maxilla, *Hexapanopeus angustifrons.*

PLATE 2

FIG. 21. Prezoea, *Panopeus herbstii.*
22. Prezoea, *Hexapanopeus angustifrons.*
23. First maxilliped, *Neopanope texana sayi.*
24. First maxilliped, *Eurypanopeus depressus.*
25. First maxilliped, *Panopeus herbstii.*
26. First maxilliped, *Hexapanopeus angustifrons.*
27. Second maxilliped, *Neopanope texana sayi.*
28. Second maxilliped, *Eurypanopeus depressus.*
29. Second maxilliped, *Panopeus herbstii.*
30. Second maxilliped, *Hexapanopeus angustifrons.*
31. Telson, *Neopanope texana sayi.*
32. Telson, *Eurypanopeus depressus.*
33. Telson, *Panopeus herbstii.*
34. Telson, *Hexapanopeus angustifrons.*

PLATE 3

Neopanope texana sayi

FIG. 35. First zoea, frontal view.
36. First zoea, lateral view.
37. Antennule, first zoea.
38. Antennule, second zoea.
39. Antennule, third zoea.
40. Antennule, fourth zoea.
41. Mandible, first zoea.
42. Mandible, second zoea.
43. Mandible, third zoea.
44. Mandible, fourth zoea.

PLATE 4

Neopanope texana sayi

FIG. 45. Second zoea, frontal view.
46. Second zoea, lateral view.
47. Third zoea, lateral view.
48. Third zoea, frontal view.

PLATE 5

Neopanope texana sayi

FIG. 49. Fourth zoea, frontal view.
50. Fourth zoea, lateral view.
51. Maxillule, first zoea.
52. Maxillule, second zoea.
53. Maxillule, third zoea.
54. Maxillule, fourth zoea.
55. Maxilla, first zoea.
56. Maxilla, second zoea.
57. Maxilla, third zoea.
58. Maxilla, fourth zoea.

PLATE 6

Neopanope texana sayi

FIG. 59. Antenna, first zoea.
60. Antenna, second zoea.
61. Antenna, third zoea.
62. Antenna, fourth zoea.
63. First maxilliped, first zoea.
64. First maxilliped, second zoea.
65. First maxilliped, third zoea.
66. First maxilliped, fourth zoea.

PLATE 7

Neopanope texana sayi

FIG. 67. Second maxilliped, first zoea.
68. Second maxilliped, second zoea.
69. Second maxilliped, third zoea.
70. Second maxilliped, fourth zoea.
71. Pleopod, fourth zoea.
72. Telson, first zoea.
73. Telson, second zoea.
74. Telson, third zoea.
75. Telson, fourth zoea.

PLATE 8

Neopanope texana sayi (after Birge)

FIG. 76. First megalops, lateral view.
77. First megalops, dorsal view.
78. Carapace of first crab stage, dorsal view.
79. Carapace of first crab stage, ventral view.

FIG. 80. Carapace of adult crab, dorsal view.
81. Antennule, first megalops.
82. Antennule, adult.
83. Antenna, first megalops.
84. Antenna, adult megalops.
85. Mandible, first megalops.
86. Mandible, late megalops.
87. Mandible, adult.
88. Maxillule, first megalops.
89. Maxillule, first crab.
90. Maxillule, adult.
91. Maxilla, first megalops.
92. Maxilla, young crab.
93. Maxilla, adult.
94. First maxilliped, first megalops.
95. First maxilliped, first crab.
96. First maxilliped, adult.
97. Second maxilliped, first megalops.
98. Second maxilliped, first crab.
99. Second maxilliped, adult.
100. Third maxilliped, first megalops.
101. Third maxilliped, first crab.
102. Third maxilliped, adult.
103. Last pleopod, first megalops.
104. Third pleopod, first megalops.
105. Third pleopod, adult.

PLATE 9

Eurypanopeus depressus, first zoea

FIG. 106. First zoea, lateral view.
107. First zoea, frontal view.
108. Antennule.
109. Antenna.
110. Mandibles.
111. Maxillule.
112. Maxilla.
113. First maxilliped.
114. Second maxilliped.
115. Telson.

PLATE 10

Panopeus herbstii, first zoea

FIG. 116. First zoea, lateral view.
117. First zoea, frontal view.
118. Antennule.
119. Antenna.
120. Maxillule.
121. Maxilla.
122. First maxilliped.
123. Second maxilliped.
124. Telson.

PLATE 11

Xantho (after Cano)

FIG. 125. First zoea, lateral view.
126. Third zoea, frontal view.
127. Third zoea, lateral view.
128. Fourth zoea, lateral view.
129. First megalops.
130. Second megalops.
131. First crab.
132. Older crab.
133. Antennule and antenna, first zoea.
134. Antennule and antenna, fourth zoea.
135. Antennule and antenna, first megalops.
136. Mandible, first zoea.
137. Mandible, fourth zoea.
138. Mandible, first megalops.
139. Maxillule, first zoea.
140. Maxillule, first megalops.

PLATE 12

Xantho (after Cano)

FIG. 141. Maxilla, first zoea.
142. Maxilla, fourth zoea.
143. Maxilla, first megalops.
144. Thoracic appendages, fourth zoea.
145. First maxilliped, first megalops.
146. Second maxilliped, first megalops.
147. Third maxilliped, first megalops.
148. Third maxilliped, first crab.
149. Cheliped, first megalops.
150. Telson, first zoea.
151. Telson, fourth zoea.

Eriphia spinifrons (after Cano)

FIG. 152. First zoea.
153. Second zoea.
154. Fourth zoea.
155. Antennule and antenna, first zoea.
156. Antennule and antenna, second zoea.
157. Antennule and antenna, fourth zoea.
158. Mandible, fourth zoea.
159. Telson, first zoea.
160. Telson, second zoea.
161. Telson, fourth zoea.

Trapezia (after Spence Bate)

FIG. 162. First zoea.

PLATE 13

Menippe mercenaria

Prezoea

FIG. 163. Prezoea.
164. Antennule.
165. Antenna.
166. Telson.

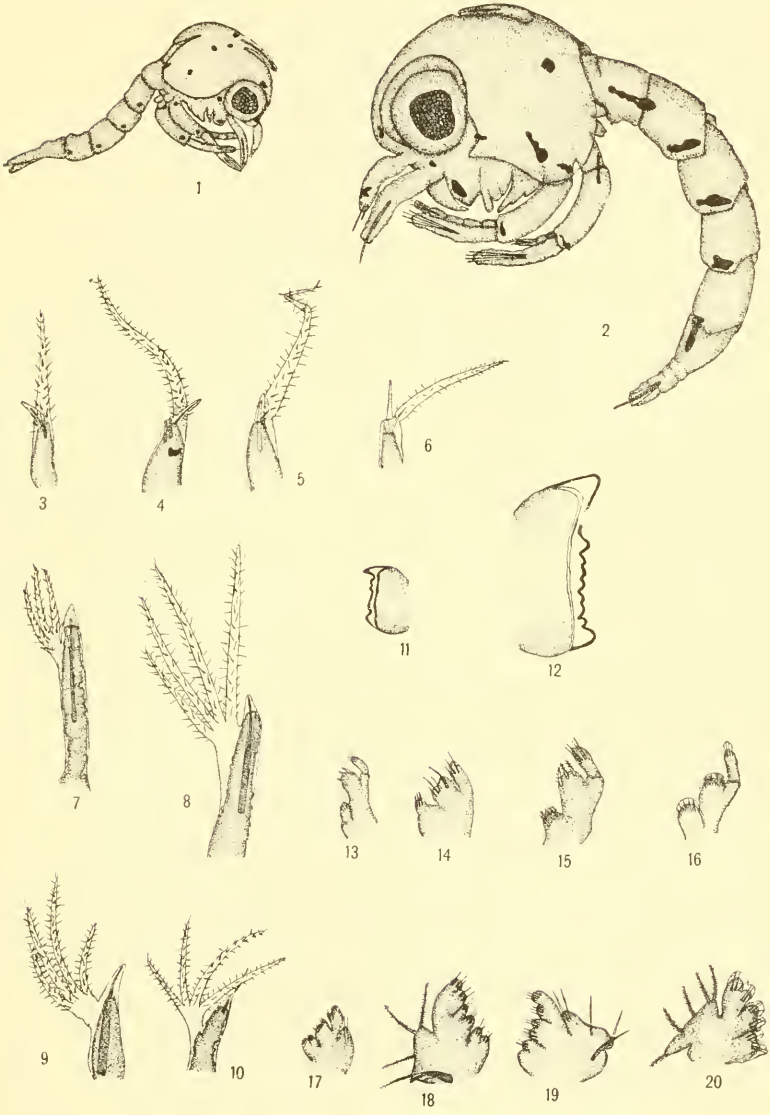
First zoea

FIG. 167. First zoea, frontal view.
168. First zoea, lateral view.
169. Antennule.
170. Antenna.
171. Mandible.
172. Maxillule.
173. Maxilla.
174. First maxilliped.
175. Second maxilliped.
176. Telson.

PLATE 14

Pilumnus (after Cano)

FIG. 177. First zoea.
178. Second zoea.
179. Fourth zoea.
180. First megalops.
181. Second megalops.
182. First crab.
183. Antennule and antenna, first zoea.
184. Antennule and antenna, fourth zoea.
185. Mandible, first zoea.
186. First maxilliped, first megalops.
187. First maxilliped, first crab.
188. Second maxilliped, first megalops.
189. Third maxilliped, first megalops.
190. Third maxilliped, first crab.
191. Cheliped, first megalops.
192. Telson, first zoea.
193. Telson, fourth zoea.



LARVAE OF CRABS OF THE FAMILY XANTHIDAE

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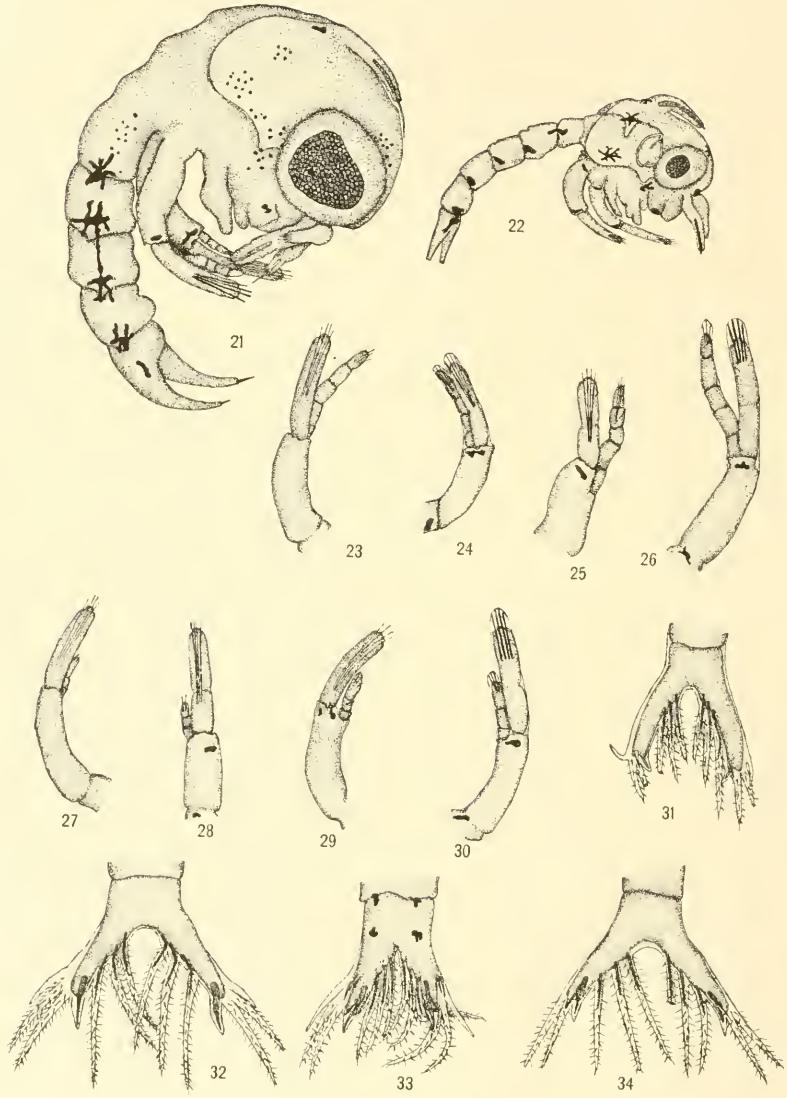

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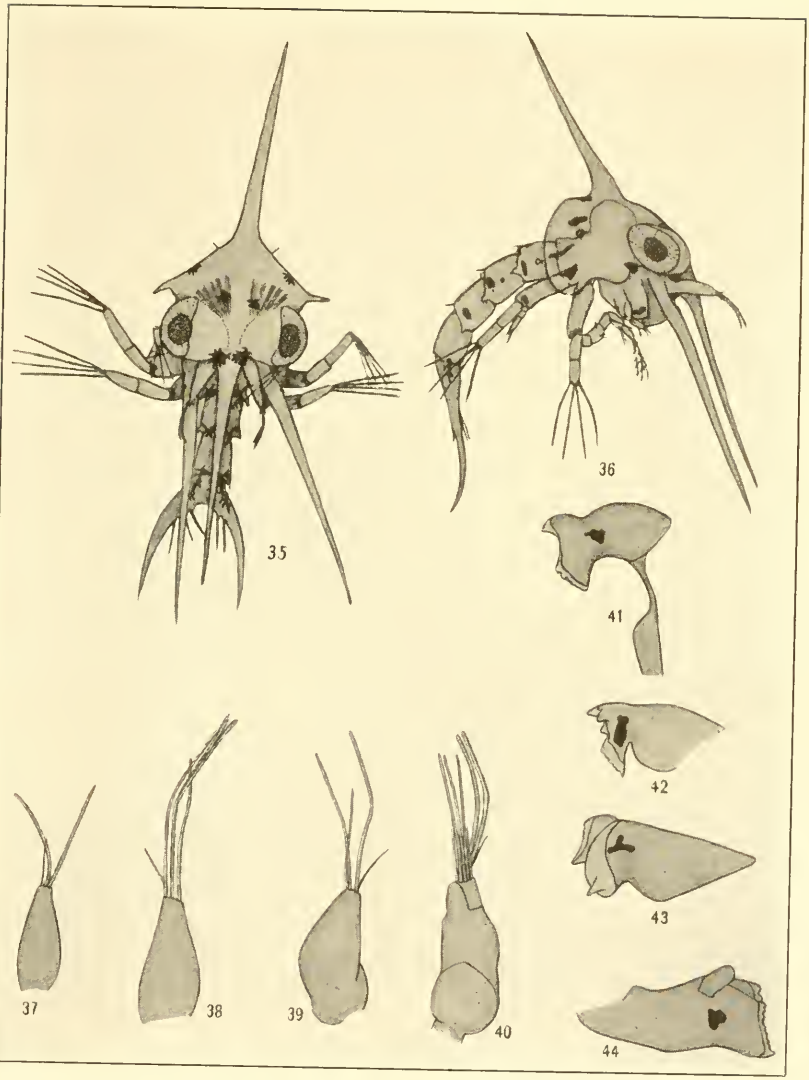

XANTHID LARVAE OF THE GENUS NEOPANOPE

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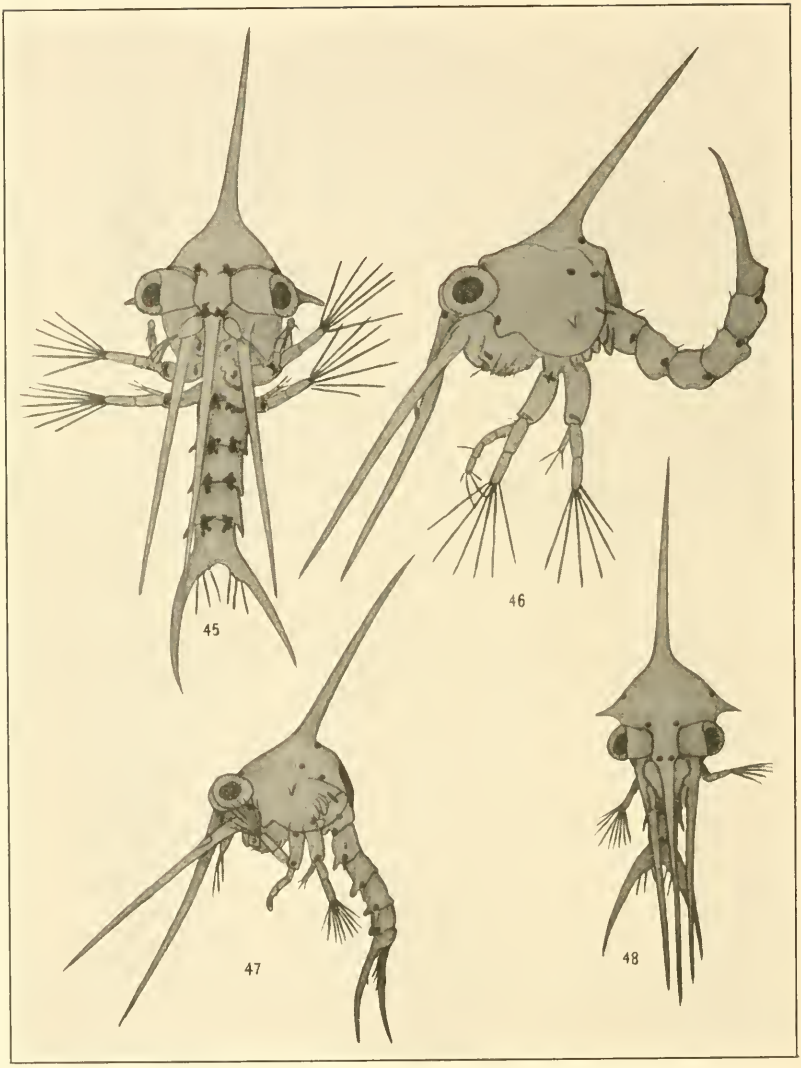

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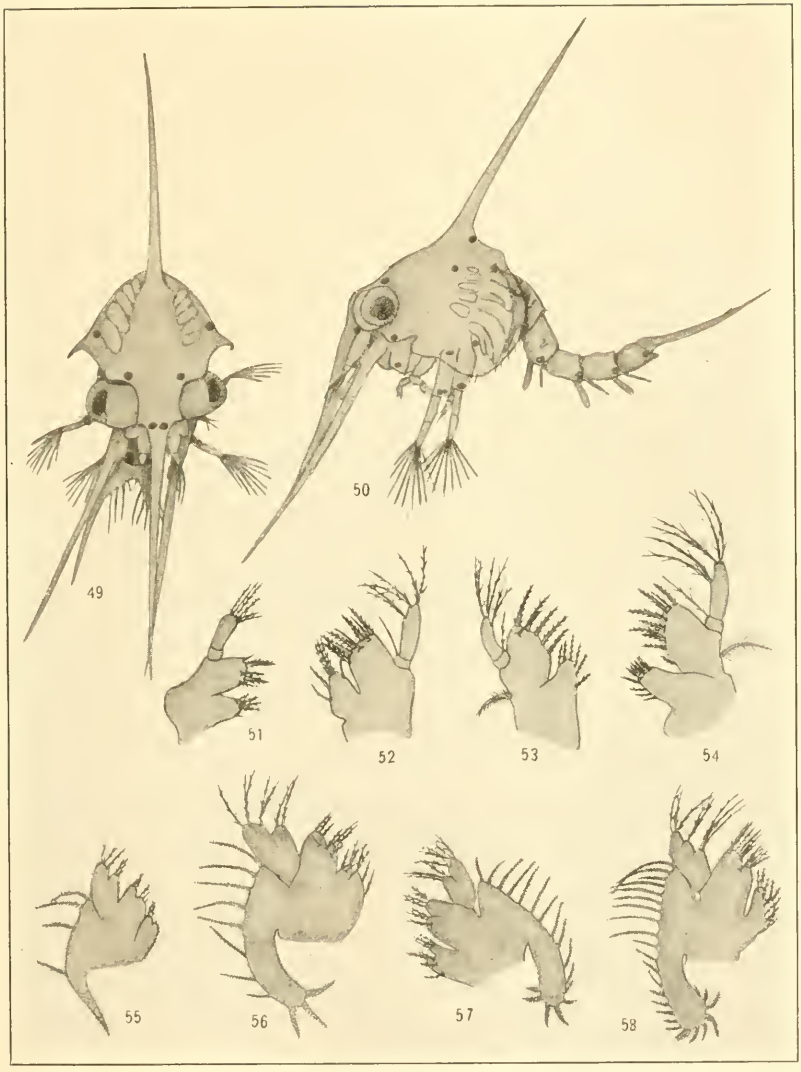

XANTHID LARVAE OF THE GENUS NEOPANOPE

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APPENDAGES OF LARVAE OF THE GENUS NEOPANOPE

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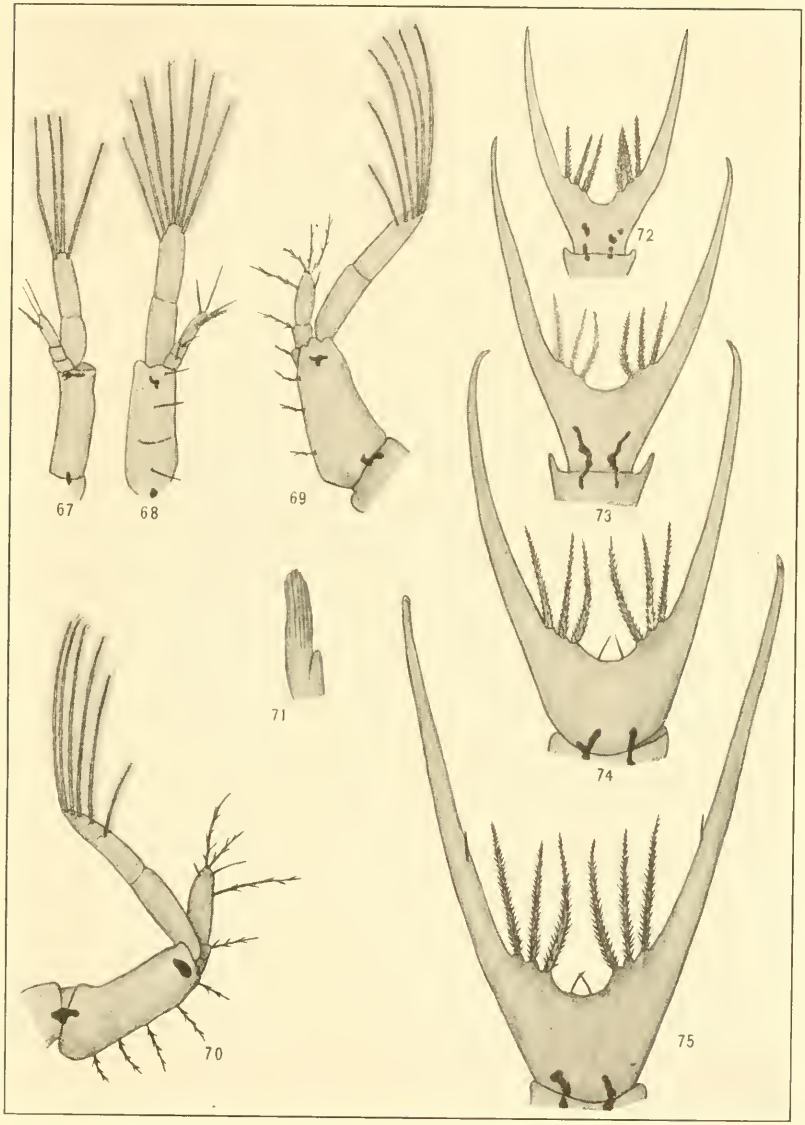

APPENDAGES OF LARVAE OF THE GENUS NEOPANOPE

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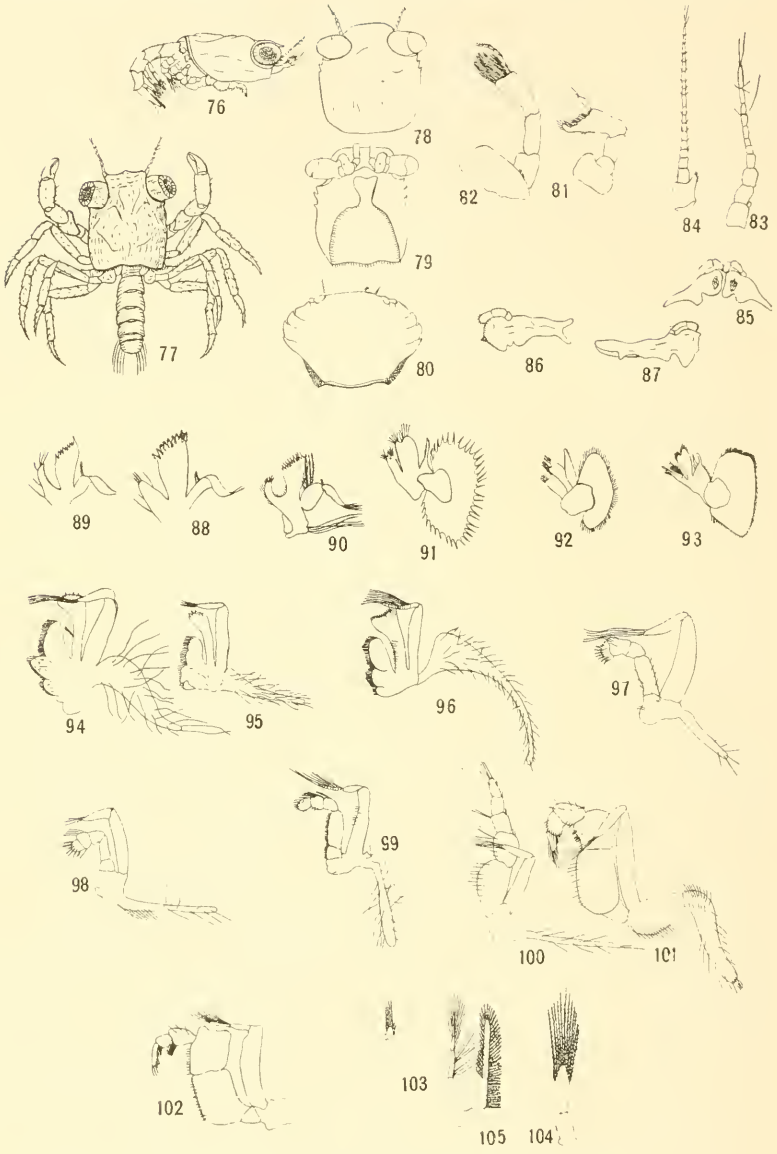

XANTHID LARVAE OF THE GENUS NEOPANOPE

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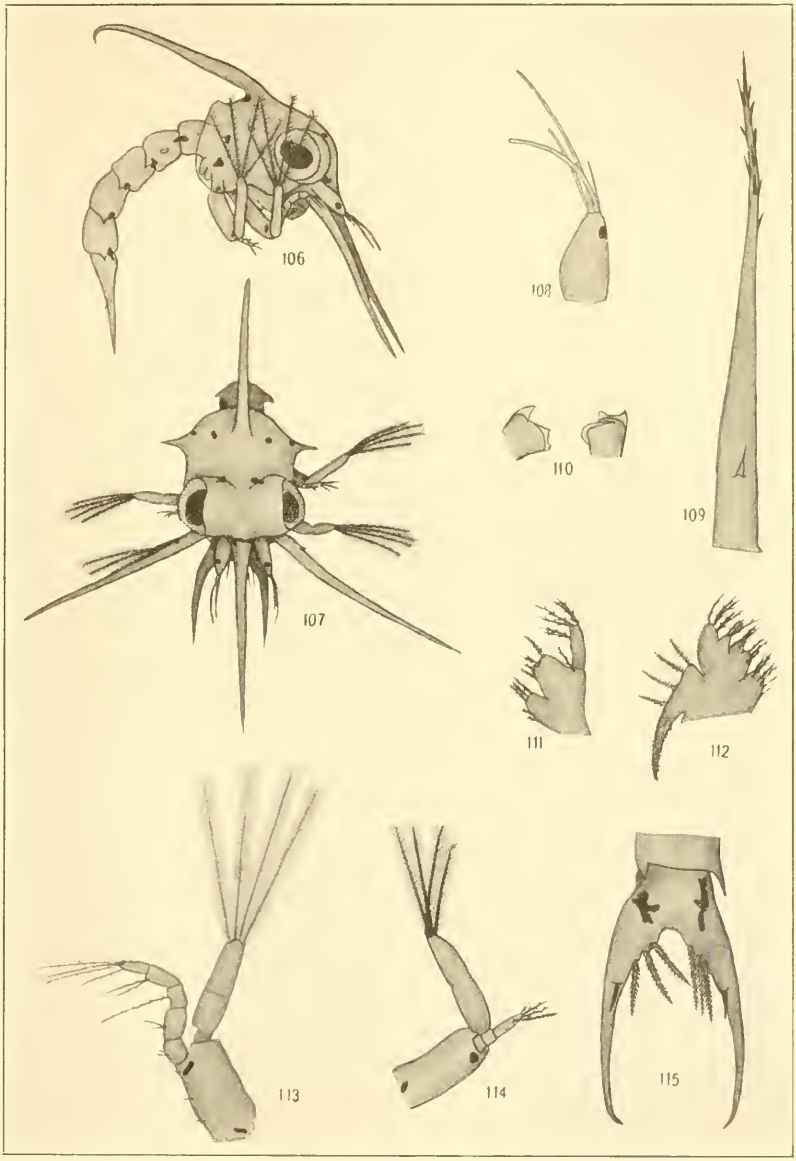

XANTHID LARVAE OF THE GENUS EURYPANOPEUS

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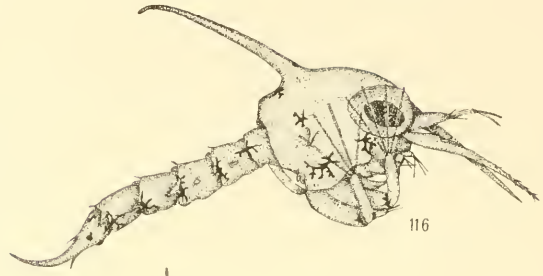

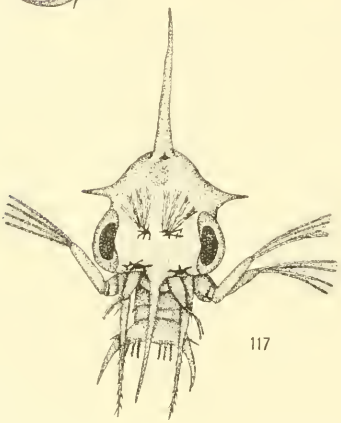

XANTHID LARVAE OF THE GENUS PANOPEUS

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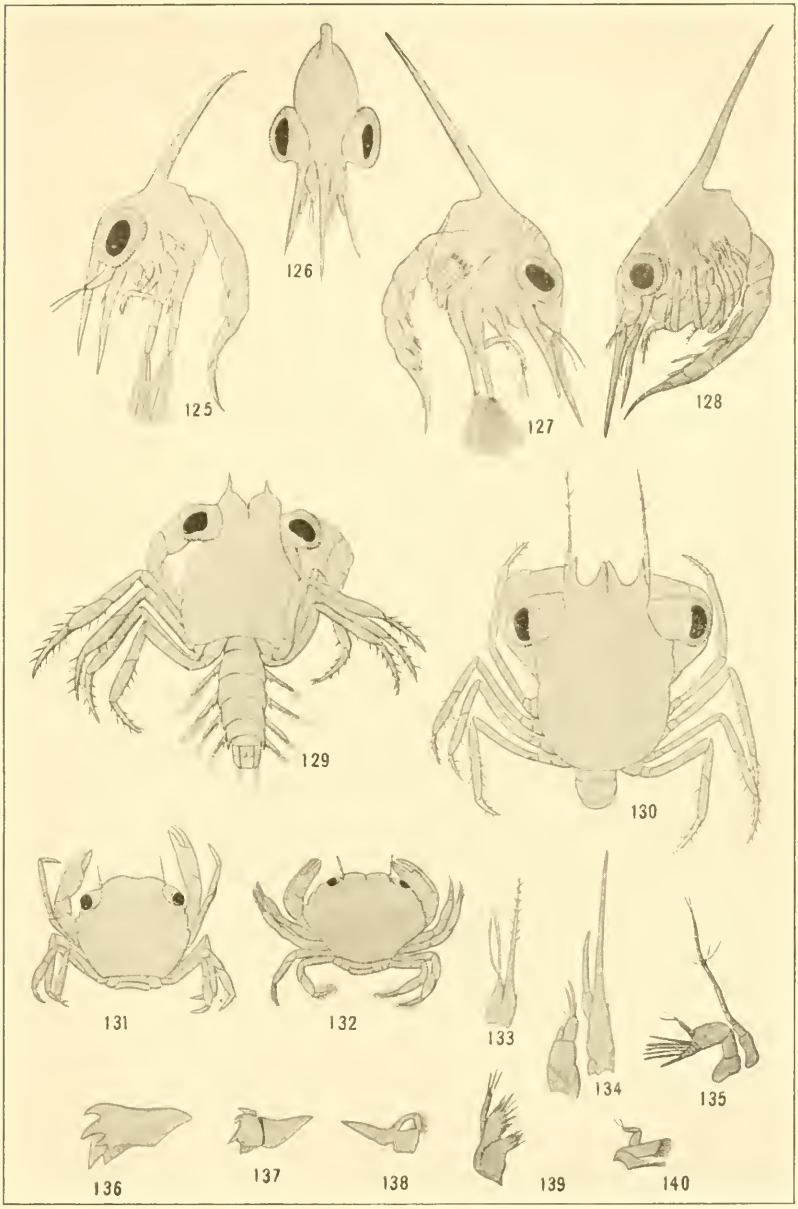

XANTHID LARVAE OF THE GENUS XANTHO

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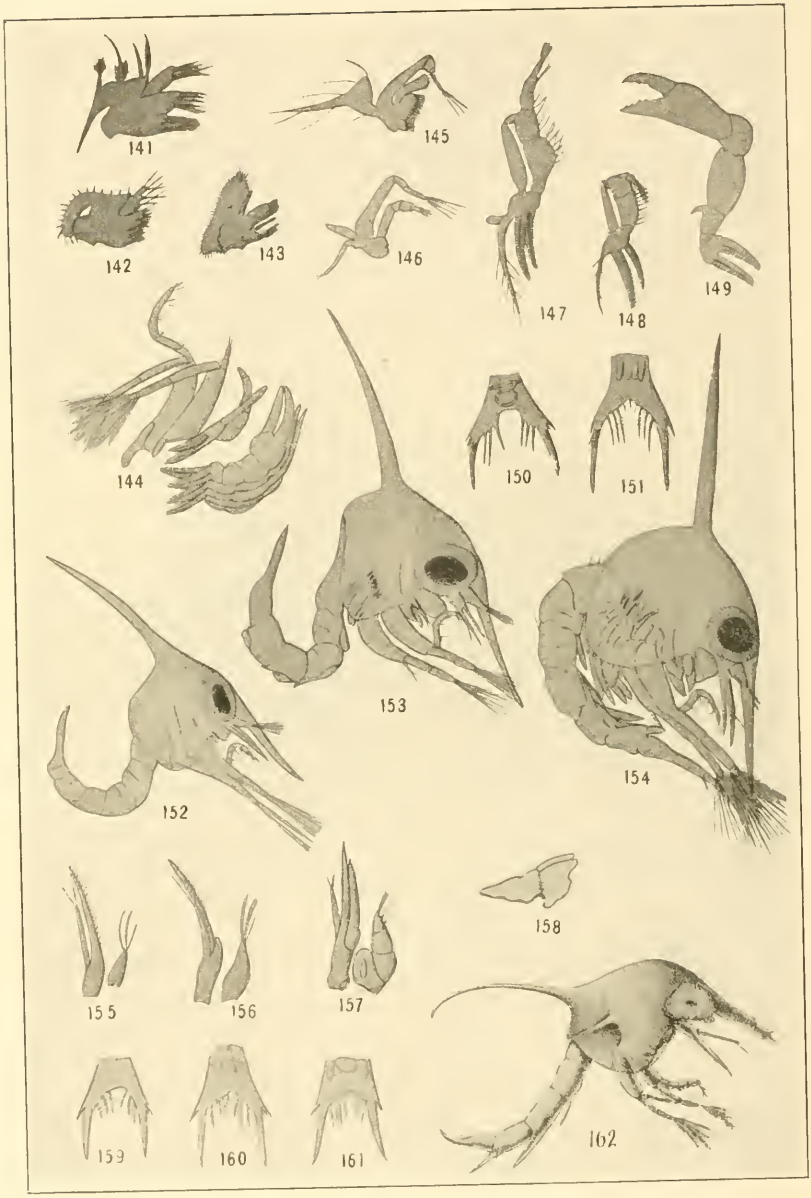

LARVAE OF CRABS OF THE FAMILY XANTHIDAE

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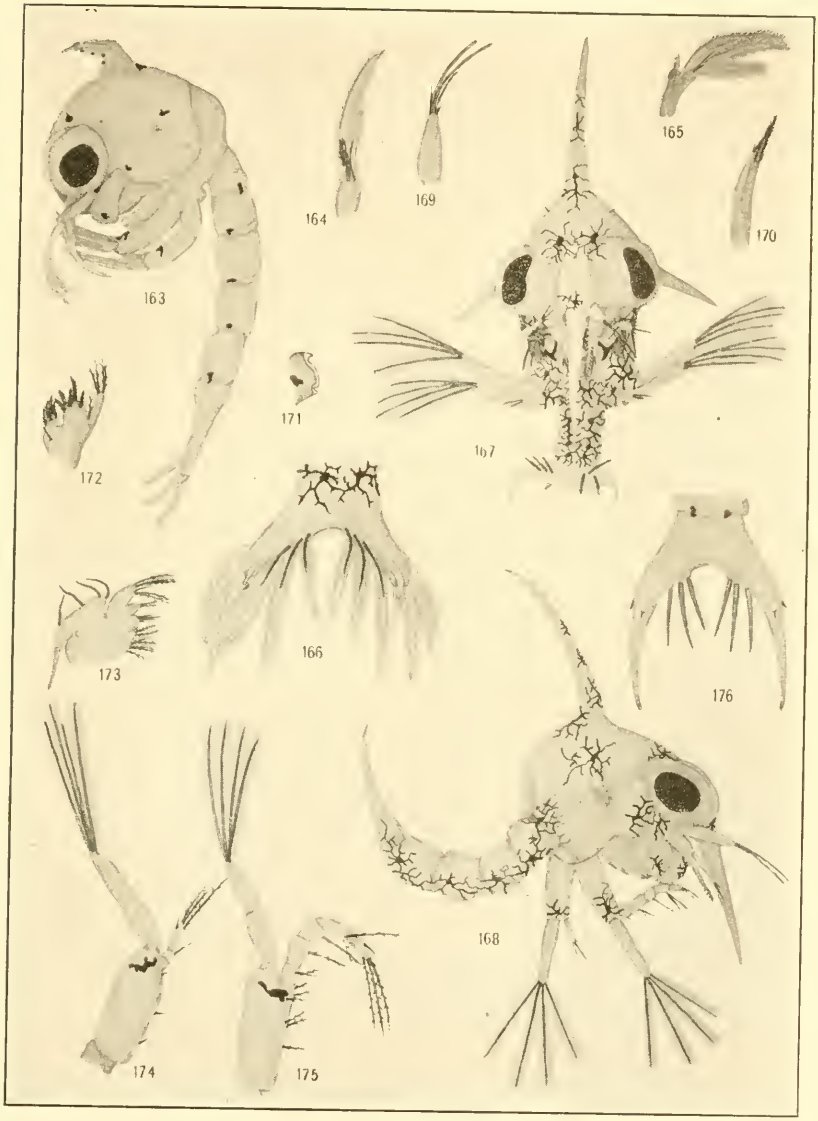

XANTHID LARVAE OF THE GENUS MENIPPE

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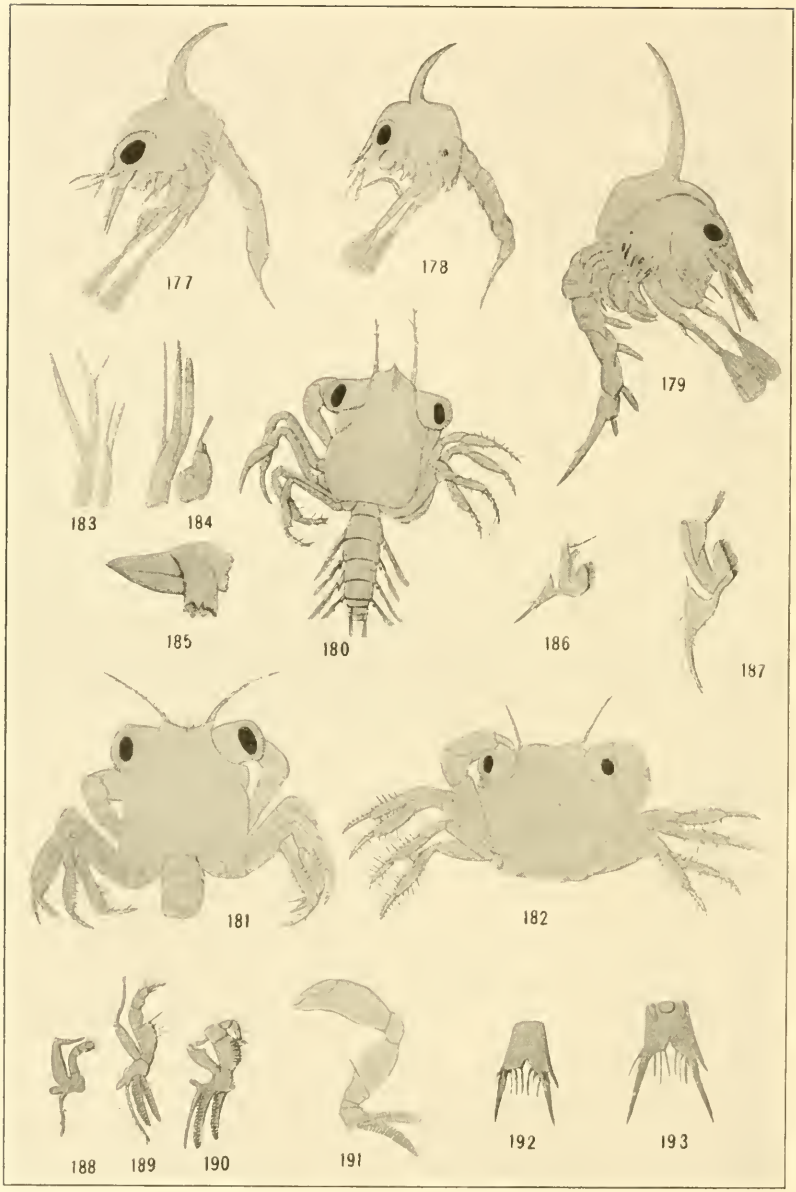

XANTHID LARVAE OF THE GENUS PILUMNUS

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