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by Hwa Ting-ke

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Studies of the life history of a fish-louse (Caligus Orientalis Gussev)

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The oriental fish-lice (Caligus orientalis Gussev 1951) widely spread in many areas. According to what we know at the present time, they have been found in the Sea of Japan, the Yellow Sea, the East China Sea and the Po Hai (Gulf of Chihli). The adults generally lodge at different parts of the surface of the bodies of the salt water fish. Nevertheless, they may leave the host and swim freely for short periods. It has never been reported before either in our country or abroad that the fish lice caused any mass destruction of fish. However, between November 1961 and January 1962, in several sea-side fish ponds of Amoy Fishery Research Institute, the phenomenon of wholesale perishing was twice found, which, after close examination, was determined to have been caused by large amount of lodging oriental fish-lice. The occasion of the death of the mouth brooders (Tilapia Mossambica) offered us an excellent opportunity to undertake an extensive research of the life history of the fish louse and the possible preventive measures against this parasite. This essay will report on our findings of the life history of the fish louse.

In the process of experiments and writing of this essay, the writer received the assistance of comrade Ni Cheng-chuan who provided with the necessary materials; comrade Wu Ting-hu who assisted in experiments and comrade Wu Ting-hu who assisted in experiments and comrade Liao Fei-fan who photographed. The writer would like to take this opportunity to express his gratitude to all three of them.

Material and Method

All the materials needed were gathered from various spots of the

surface of the bodies of the Tilapia mosaumbica (Peters) which weighed between 19.5 gr. and 107 gr. The freely swimming young larvae were obtained from cultivating the eggs in short periods, or gathered direct from the water in the ponds infested with fish lice. The color of the surface of the body and the structure of the eyes, etc. were hand-drawn according to live specimens. Some others were drawn with reflecto-microscope after the specimens were fixed and treated with PVA.

A Brief History of Study

There have been more than twenty people who have done research work on the life history of the Caligidae. The person who first discovered the fish lice at their larva stage was Burmeister (1823). He treated them as an independent genus. He was followed by Kröyer (1837), Goodsir (1842), and Baird (1850) who observed the nauplius larvae. However, they still considered the chalimus larvae as an independent genus. Having made a detail observation of the development of the parasite found on the skin of the Baltic fish Leuciscus rutilus , Müller (1852) became the first one to ascertain that the chalimus was actually only one of the larva stages of the parasite. This conclusion was later proved by Nordmann (1864) and the term chalimus was referred by him exclusively to the general chalimus larvae of the caligus.

Later, studies on this field included those of Hesse (1858), Claus (1868), Olsson (1869), Hesse (1877), and Leidy (1890). But none of them fully reported the parasite's entire developmental process.

Scott (1901) studied the developmental stages of Lecacophtheirus nectoralis, (?) of which he described the first Nanplius stage, the first cyclopoid stage and the third Chalimus stage (one of which possibly belonged to a different species).

In the thirty years that followed, we saw the works of following scholars who studied the family of fish-lice. Wilson (1905), (1907), (1908), Brian (1912), Scott (1913), Russell (1925), Argilas (1931), (1932) Markewitsch (1933), Gurney (1933), (1934), Bere (1936). Here we shall mention the work of the more outstanding ones:

Wilson (1905) made detail description of the development of Caligus rapaz and C. bonito. He recorded the first stage of Nauplius and the Metanauplius (which actually is the Copepodius stage .. writer), and believed that the Metanauplius would have one or two moultings. He also recorded the fourth Chalimus stage and believed that the Chalimus would undergo at least five moultings.

Gurney (1934) made some careful observations on the development of Caligus centrodonti and C. labracis. He described the second Nauplius stage, first copepodius stage and the fourth Chalimus stage. The contribution he made was rather important and it was a big step forward from the work of his predecessors.

In the past decade, not much work has been done in this special field. Those who published their findings were: Kurien (1954), Carter (1954), Mapkeb.. (1956) and Cameron (1956). They respectively described the larvae stage of the family of Caligus. However, none of them contributed more than their predecessors did.

Life History

The Ovum.... The eggs which are in the uterus are tightly packed and their sizes are smaller. The ovum in the egg sac are surprisingly three times the size of those inside the uterus. The first and the last ovum in the sac appear to be hemispherical while the rest are all

rectangular-shaped (lateral view). Their sizes vary in the range of 45 mm - 76 mm x 180 mm - 382 mm. They are piled together in an orderly, even manner (Plate I, 1). However, due to the uneven force they received when being excreted, the two sides of some of the eggs do not appear to be symmetrical. When the sac is pierced, the eggs that flow out appear to have the shape of a moon cake (a moon cake is moulded like an asprin tablet... translator), rectangular in lateral view, spherical in medial view. The embryo is situated in the central part (Plate I, 2a, b). In the very beginning, the eggs are not transparent. They become semi-transparent when nearly hatched. At this time, the eggs discharged from the ovary are elliptical. Their size ranges are: 381 mm - 450 mm x 286 mm - 375 mm. The embryonic naupliu larva can be clearly seen through the translucent egg membrane (Plate I, 3). The young embryo squirms incessantly inside the egg membrane until it breaks through the membrane to come out. The mature eggs exude one by one through the wall of the ovary. When all the eggs are hatched, the emptied ovary is still hung on the maternal body. Later it is slowly dropped off.

The Nauplius Stage .. This can be sub-divided into two periods: Nauplius and Metanauplius.

Nauplius: When the young embryo in the egg breaks through the membrane to come out, it becomes nauplius. The newly hatched nauplius larva is either egg-shaped or elliptical (Plate I, 4). Size range: 270 mm - 405 mm x 165 mm - 285 mm. The body does not have segments. It can swim freely. All nauplius are photostactic and tend to be drawn to the brighter surface.

The nauplius larva has three pairs of appendages. In the front is the first pair of appendage. On the lateral sides are the second and

third pairs of appendages. The first pair of appendage is uniramous, at the end of which are three setae: two long and one short. The long ones are plume-like bristles. On the outer corner of the base there are two small spines and in the inner corner of the base there is one small spine. The second and third pairs of appendages (Plate I, 6, 7) are all biramous. The second pair of appendage has a robust base. The exopodite is divided into four segments. Each segment has a long, plume-like seta. The endopodite is short and lacks segments. At its end there is a big, blunt spine, a small sharp spine and two long, plume-like setae. The structure of the outer limb of the third pair of appendage is similar to that of the second pair; the inner limb lacks segments, and in the middle of its inner side there is a small setae, while at its end there are two long plume-like setae. These three pairs of appendages are all locomotory organs. They enable the nauplius larva to swim swiftly.

In the middle of the anterior of the nauplius there is a median eye. Its ventral surface has a chitinous labrum, and an unopened alimentary tube which is often covered by yolk granules. The posterior of the nauplius has a pair of tails which tends to extend to two sides. The tail is not segmented and it does not move; its basal portion appears to be cylindrical while its last portion (uropod) is flattened, therefore the whole limb looks somewhat like a long spoon used to stir medicine. Its size ranges are: 60 mm - 72 mm x 4.8 mm - 7.2 mm.

Metanauplius: As soon as the nauplius larva has undergone molting, it becomes a metanauplius. It looks similar to the nauplius but is bigger; measures 342 mm - 475 mm x 160 mm - 280 mm. It still has three pairs of appendages, and one pair of branching tails at the posterior. The median eye has now become bigger and it is still in the middle of the anterior.

There are vertical lines on its body and creases on two lateral sides of the posterior. Through the ectoderm one is able to see that in the posterior of the body there is the appearance of the division of segments. Also the basic foundation of the structure of the next stage (Copepodid stage) is present.

Copepodid Stage .. When the Metanauplius larva has undergone one moulting, it immediately becomes a copepodid (Plate I, 9). The copepodid larva measures 0.57 - 0.72 mm in length. The body is segmented. It can be divided into three parts: cephalothorax, thorax and abdomen. It has the appearance of the cyclopidae, only its carapcae is wider and bigger. The length of the carapace is twice as long as that of the rear part of the body. The rostrum turns towards the surface of the abdomen. ~~The median eye has disappeared, while in the position slightly towards the front of the dorsal surface of the abdomen.~~ The median eye has disappeared, while in the position slightly towards the front of the dorsal surface, there appears a compound eye composed of a pair of single eyes. Seven paris of appendages are grown out of the ventral surface of the cephalothorax: first antenna, second antenna, first maxilla, second maxilla, mandible, first maxilliped and second maxilliped. Another appendage - first swimmeret is also found in the cephalothorax.

First antenna (Plate I, 11) consists of two segments. The outer side of the basal segment has two plume-like setae. Another plume-like seta is seen at the end of the basal segment twelve plume-like bristles of uneven length are irregularly placed on the end as well as the anterior of the terminal segment.

Second Antenna (Plate I, 12): Often protruding out from carapace to become a prehensile organ. However, it still maintains the character-

istics of the biramous appendage. The exopodite is the shorter. The basal segment has a chitinous papilla and a spine. The terminal segment looks like an awl, with its pointed end often extending to the middle of the inner side of endopodites basal segment. The second antenna has a robust inner limb with a long and robust basal segment which looks like an arm. The terminal segment appears claw-like, with the base of the claw bulging slightly. Its end is sharply pointed and the claw often curls towards the ventral surface. The claw is the instrument with which the young parasite hangs on to its host.

Mouth Apparatus: It lies on the median line behind the second antenna of the ventral surface of carapace. Its basic structure is similar to that of an image except that it is not yet fully developed. It is composed of the labrum, the labium and the mandible. Both the labrum and the labium are chitinous pieces, interwoven with vertical and horizontal chitinous sticks. The mouth part has one pair of mandibles which are two elongated parts forming a "V" shape apparatus. Each elongated part has a bulging base. Downward, it gradually becomes long and slim. There are twelve saw-teeth at the end, which however are not apparent. The setae at the end of the labium are not as well developed as those of the adult. In the lateral bulging portions of the base of the mandible, there are muscles and chitinous sticks both of which are connected with the body. The terminal part, however, is free. The mouth can, therefore, twist back and forth. Under normal circumstances, it turns towards the caudal back of the body. Nevertheless, the opposite condition is sometimes seen.

First maxilla (Plate I, 13): Situated on the lateral sides of the posterior of the mouth. It is a triangular sharp spine. The base of the spine is relatively wider. Its end points towards the back of the body.

Second maxilla (Plate I, 14): Situated on the lateral sides of the slightly receding part of the base of the mandible of the mouth. It is divided into inner and outer limbs. The exopodite has two segments, located above the endopodite. The terminal segment has the appearance of a papilla. Its end has three setae two long and one short. The endopodite is a triangular pointed spine, with its sharp end slightly leaning backward.

First maxilliped (Plate I, 15): Located on the lateral sides of the rear portion of the mouth, between the mouth and the lateral side of the carapace. It is divided into two segments. The basal segment is robust and short while the terminal segment is long and narrower. Two claw-like, robust spines are seen on the end. The spines have filters fromed by bristles. The outer claw-like spine is longer than the inner claw-like spine. The usefulness of the first maxilliped is probably cleansing of the mouth. Through the function of the filter, the dye is washed away.

Second maxilliped (Plate I, 16): Situated behind the first maxilliped, near the median line of the body. It is divided into two segments. The basal segment is long and big and has the appearance of an arm. A spine-like seta is in the center of the inner side. The last part of the terminal segment is a strong..... (several lines indistinguishable) ..... which is 2/3 of the anterior of the inner laterial side of the terminal segment.

On the median line of the entral surface of the cephalothorax, there is a chitinons rod which extends from the anterior to a place immediately past the mouth. The chitinous rod (Plate I, 10) is whip-like, the first pair of which is erect while the second half convoluted. It is a bundle of thread-like fibers formed by the secretion of the frontal head gland. Being a tube wrapped by a chitinous capsule, it is therefore called the chitinous rod. Sometimes it is seen projecting out of the apex of the

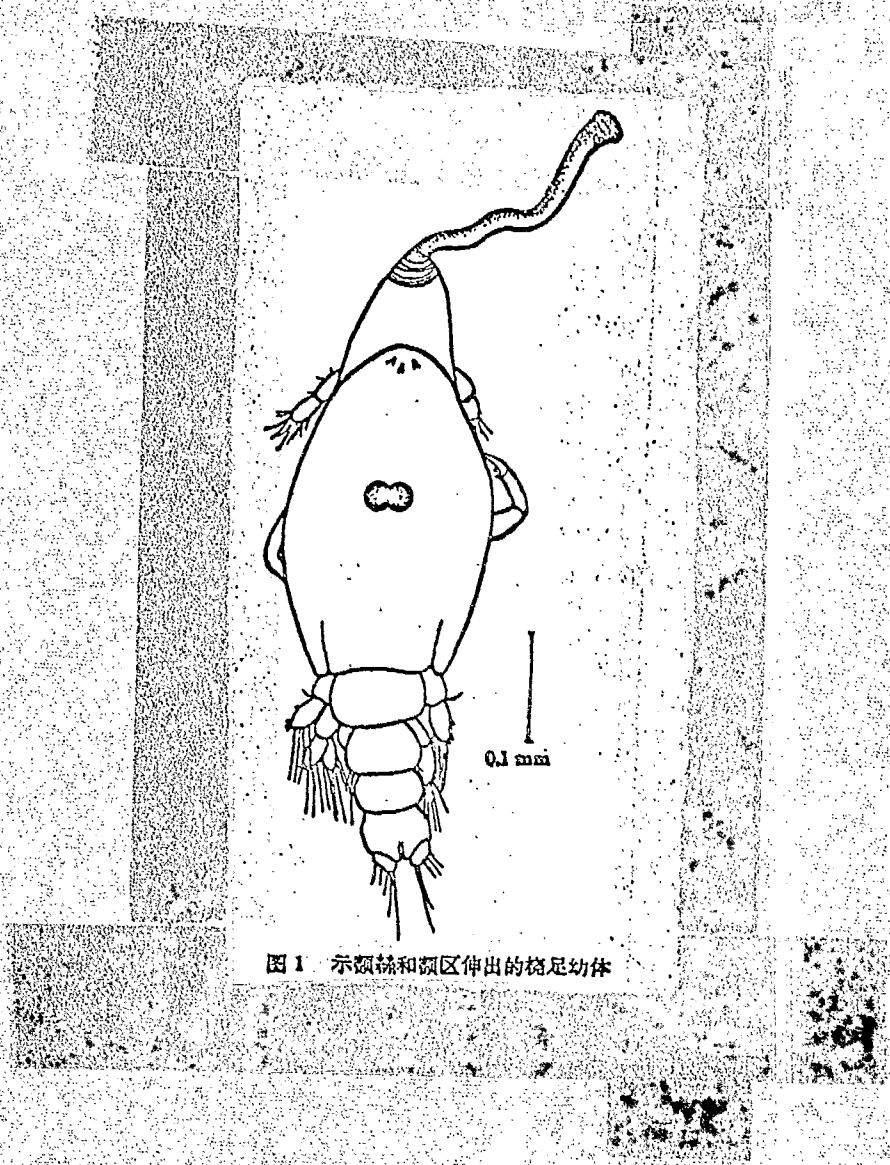


图 1 示额棘和额区伸出的桡足幼体

Figure I. Showing the chitinous rod and its region of the copepodid larva.

head of the parasite. In most cases, however, the chitinous rod and its region are carried and folded in the ventral surface of the parasite, and will not be projected out until the parasite has attached itself to a host. The surface of the projected rod shows some circular marks. Its base meets the frontal portion of the apex of the carapace, and on its end there is a trumpet-like sucker.

The thorax consists of three thoracic segments, the biggest of which being the one immediately underneath the carapace. The cephalothorax and the first two free thoracic segments each has one pair of swimmerets; the first two pairs of swimmerets are biramous, and the last pair uniranmous. The first pair of swimmerets (Plate I, 17) is situated on the median line of the rear ventral surface of the cephalothorax, connected by a connexivum (or connecting plate). The two ends of the connexivum project out and thicken. The basal segment of the first pair of swimmerets is short and robust. A plume-like bristle is seen on the outer lateral angle. The inner limb and the outer limb each has one segment only. The second pair of swimmerets (Plate I, 18) is located on the first free thoracic segment. Its short and small connexivum is composed of two pieces of heart-shaped plates which inclined towards each other. The protopodite of the second pair of swimmerets are short and robust. Its outer lateral angle has a plume-like seta. The inner ramus and the outer ramus each has one segment only.

The formulae for the spines and setae of the above two pairs of pleopods (swimmerets) are as follows:

	Exopodite	Endopodite
First pair of pleopods	IV - 4;	I - 6.
Second pair of pleopods	III - 4;	I - 6.

The third pair of pleopods (Plate I, 19) is located on the bulging portions of the two outer lateral angles of the movable thoracic segments. It is not consisted of ramuses or divided segments. This pair of swimmerets is formed by two setae: a short one and a long one.

The abdomen is roughly square in shape. The uropods are short... their length is smaller than their width. The posterior of the uropods has five setae; the second one from inward is the longest (according to Figure I, the first one from inward is the longest - translator) and it is a plume-like bristle. The outer lateral edge of the last one from outward has feather-like hair which its inner lateral lacks.

The copepodid larva swims freely in water. As soon as it finds a host, it attaches itself, with its second antenna, either on the skin or the fin of the fish. Having undergone another molting, it enters the chalimus stage.

Chalimus Stage... This stage is divisible into five periods. Each of these five periods sees that the parasite goes through molting and growth. During the molting process, the chitinous rod which the young parasite uses to tie and suck itself on the body of the fish does not drop off. Therefore, one more "vasal mark" is added onto the basal region of the chitinous rod after each molting. This may also serve as the indication of the number of molting as well as its developmental stage. The chitinous rod sucks either on the anterior field of the scale of the fish body or right through the epithelium of the fin, deeply drawn itself to the fin ray. The sucking is always tight and is unlikely to come off. If force is applied to separate the sucking, usually the chitinous rod would snap either in the middle or in the part where it connects the carapace. The latter case is especially common.

Figure II. Showing chalimus larvae of various stages sucked on the fin of a mossambique mouth brooder (Tilapia mossambica, Peters).

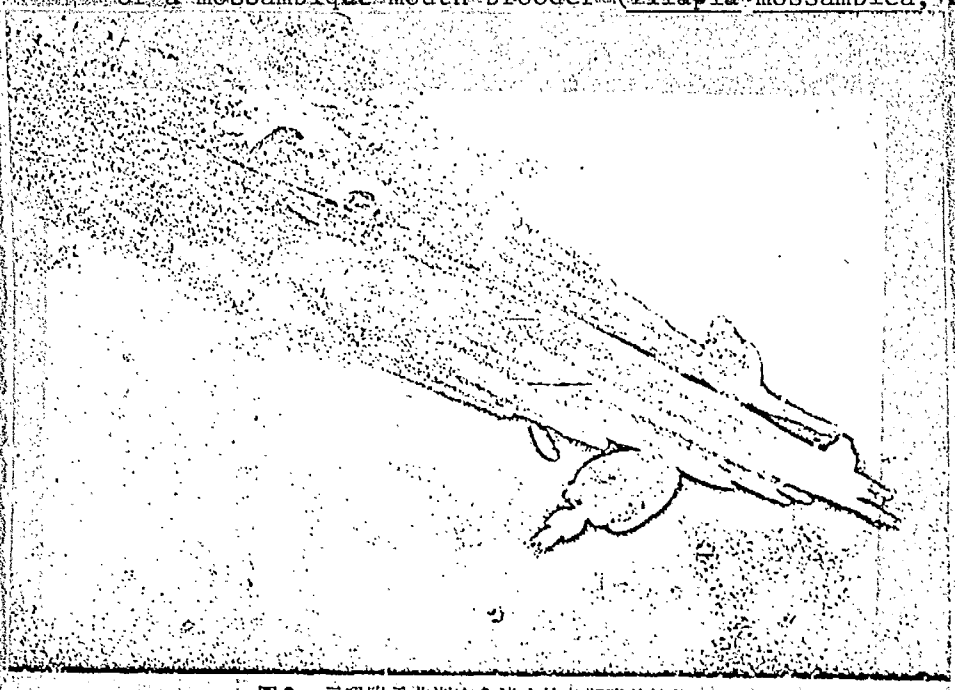


图2 示吸附于非洲的鱼鳍上的各期附着幼体

First Period of the Chatinous Stage: Length: 0.81 cm - 0.93 cm

Having undergone molting, the copepod larva would let out its chitinous rod and suck itself on the surface of the body of the fish. In the meantime, it would release its original apparatus of attachment - the second antenna. The young larva now hangs itself on the body of the fish with the chitinous rod only.

The size of the body has grown markedly (Plate II, 20). The carapace appears to be oval-shaped, its posterior is flatter. Its length is about twice as long as that of the rear part of the body. The compound eyes are situated in the centre of dorsal surface of the carapace, which gradually moves forward as later moltings and development take place, until they reach their final place at adult stage.

The setae of both the first antenna (Plate III, 27) and the three pairs of swimmerets have degenerated and reduced in size. The endopodite

of the second antenna (Plate III, 32) is robust and short; it looks cylindrical. On its end there is a big spine as well as one long and one short spine-like setae. The exopodite is not apparent.

The buccal apparatus (Plate III, 46) has attained the shape of that of the adult. It has one pair of mandibles which forms a "U" contour; at the end of which the twelve saw-teeth can be clearly seen.

The endopodite of the second maxilla (Plate III, 46) has changed to become oval-shaped. It has a small spine. The second maxilliped (Plate IV, 58) has become stronger than when it appeared at its previous stage; the bristle which was seen in the centre of the inner lateral side of the protopodite has now disappeared, while the triangular spine which was in the inner lateral side of the claw of the terminal segment has become a long plume-like seta.

The width and size of the three movable thoracic appendages of the thorax reduce in gradual order. The first movable thoracic segment has already partially connected with the cephalothorax. The distance between the left side and the right side of the first and second pair of pleopods has widened. The connexivum is not apparent. Their protopodites are strong and short and each of their outer lateral angles has a seta. Both the exopodite and endopodite are of single segment. The third pair of swimmerets (Plate IV, 77) appears to be biramus. The endopodite is a bulging. It does not have spines or bristles. The formulae for the spines and setae of the above three pairs of swimmerets are as follows:

	Expodite	Endopodite
First pair of swimmerets	IV - 4;	0 - 2.
Second pair of swimmerets	III - 4;	1 - 6.
Third pair of swimmerets	0 - 2;	0 - 0.

The length and width of the abdomen are about the same. The five setae at the posterior of the uropod have relatively reduced in size. Also between the second and the fourth (inward wise) setae, a small and indistinct seta has appeared.

Second Period of the Chalimus Stage: Length: 1.18 cm - 1.41 cm

The carapace appears to be oval-shaped (Plate II, 21). A lunule is seen at the anterior. The two lateral sides in the rear coils somewhat orderly and shows a ear-lobe shape. The first movable thoracic segment has quite obviously closed up with the cephalothorax. The second movable thoracic segment ... the fourth thoracic segment, has become a short but wide segment. The third movable thoracic segment has become wider than when it appeared in the previous stage.

The relatively remarkable change in this stage is found in the first maxilla (Plate III, 40). The triangular spine which originally was seen beneath the vaccal funnel has now been obliterated, while below the first antenna, near the edge of the carapace above the second maxilla, there appears a chitinous, semi-circular arc; or sometimes a small papilla is seen on the semi-circular arc. This is the first maxilla.

The setae on the pleopods have been very much degenerated. They have become short and appeared spine-like. The first pair of swimmerets (Plate IV, 68), has robust protopodites. A seta is seen on the outer lateral angle. There is another seta on the inner lateral near the basal portion. The exopodite is elongated, which begins to divide into two

segments. The size of the endopodite is reduced; its two bristles appear to be short spine-like. The second and third pairs of swimmerets (Plate IV, 73, 78): a seta is seen or each of the outer lateral angles of their protopodites; the exopodite as well as the endopodite shortly will be divided into segments. Right now however the division line is not apparent. In this period, there appears the fourth pair of swimmeret (Plate IV) which is uniramous. On the outer lateral side of its end there are two spine-like setae. The formulae for the spines and setae of the three pairs of pleopods are as follows:

	Expodite	Endopodite
First pair of swimmerets	I - 0, III - 4;	0 - 2.
Second pair of swimmerets	I - 0, II - 6;	0 - 1, 1 - 6.
Third pair of swimmerets	I - 0, II - 5;	0 - 1, 0 - 4.

The length of the abdomen is about half of its width. Of the six tail-setae at the rear of the uropod, the second (inward wise) is the longest while the third is the shortest.

Third Period of the Chalimous Stage: Length: 1.37 cm - 2.25 cm

The carapace has expanded and looks like a shield (Plate II, 22). The first movable thoracic segment has left only rudimentary trace. The width of the second movable thoracic segment is about 1/3 of the width of the carapace. The third movable thoracic segment is obviously bulging and elliptical; its width is about 1/2.5 of that of the carapace. It has become the reproductive segment.

First antenna (Plate III, 29) is divided into three segments. The protopodite joins the lunule and the two together forms a frontal plate. The outer lateral side of the second segment has more setae. The second

(Plate III, 34) is markedly divided into two ramuses: the endopodite and the exopodite. The endopodite is long and stout, with a pointed spine on its end; the exopodite is short and has a small chitinous bulging point.

The first maxilla (Plate III, 41) is expanded, its bulging portion resembles the sharp point of a sword. The second maxilla (Plate III, 48) has an endopodite resembling a bag-like spine. An indistinct, small spine is seen at the rear part of the inner lateral side of the claw-like spine on the terminal segment of the first maxilliped (Plate III, 55).

The exopodite of the first pair of swimmerets (Plate IV, 69) is divisible into two segments. The size of the endopodite is further reduced. The exopodite of the second pair of swimmerets (Plate IV, 74) is divided into three segments; while the endopodite is consisted of two segments without distinct divisional marks. The protopodite of the third pair of swimmerets is large and plate-like; its outer lateral angle as well as the center part of the inner lateral side each has a bristle. A regular distance separates the exopodite and the endopodite. The basal segment of the exopodite has a hook-like spine. The division mark that separates the first and second segment of the exopodite is not distinct. The basal segment of the endopodite has now joined the protopodite to form a lunule which is located between the endopodite and exopodite. The fourth pair of swimmerets (Plate IV, 83) is uniramus. It has two segment. The outer lateral side of the terminal segment has a spine, on top of which there are three setae, two of which are long, and one short. The formulae for the spines and setae of the firs three pairs of swimmerets are as follows:

	Exopodite	Endopodite
First pair of swimmerets	I - 0, III - 4;	0 - 2

con't...	Exopodite	Endopodite
Second pair of swimmerets	I - 0, I - 0, III -6;	0 - 1, I - 8.
Third pair of swimmerets	I - 0, III - 7;	0 - 6.

The fifth and sixth pairs of swimmerets appear on the ventral surface of the rear lateral sides of the reproductive segment. The fifth pair of swimmerets is a papilla on which there is a plume-like seta. The sixth pair of swimmerets has one long and one short plume-like setae which are seen on the more prominent part of the bulging portion.

In this period, on the median line of the ventral surface above the first pair of swimmerets, two chitinous pieces resembling the shape of a new moon appear (Plate IV, 61). These are the developing "thoracic forks".

Fourth Period of the Chalimus Stage: Length of the female body: 2.35 cm - 2.51 cm; Length of the male body: 2.51 cm - 2.75 cm

The outward appearance of the carapace is already similar to that of the adult. It is either shield-like or elliptical. (Plate II, 23). A developing sucker is seen on the frontal plate. The chitinous bulging lines on the dorsal surface of the carapace, called back ribs, markedly form an "H" shape, from the place where the level rib in the "H" runs across, there is another lateral rib stretching backward to both sides. The reproductive segment is broad, its width being 1/2 of that of the carapace. In this period appears the different sexes of male and female. Strongly elliptical spermary can be seen below the mouth funnel of the male body. From the spermary, a long spermduct reaches the seminal vesicle in the reproductive segment. The seminal vesicle is an expansive, twisting tube. Also, in the male body, behind the reproductive segment, there appears another ventral segment, hence there are now two

segments in the abdomen. Some other changes have also taken place in the appendages. The reproductive organ of the female body is not distinctly developed. Its abdomen still has only one segment.

The number of setae on the outer lateral side of the second segment of the first antenna (Plate III, 30) have now increased. There are 15 uneven, long and robust plume like bristles projecting to the outer lateral; and then on its edge ther is a file of uneven, short, plume-like setae, extending toward the posterior. On the tip of the terminal segment and its inner lateral side, there are still twelve bristles disorderly arrayed. Second antenna (Plate III, 35, 36)... The endopodite of the male is divided into three segments. The basal segment is robust. The terminal segment is short and small with a brunt spine on its end. Fine thread marks are seen on both the basal and the second segments. The endopodite of the female has two segments; a stout basal segment and a terminal segment which is a big spine. The spine is relatively smooth and straight, which has a spine-like seta on the rear edge of its sharp end. The exopodites of both sexes are basically similar to each other. The bulging portions on their basal segments both appear to form and "U"shape, except that the basal segment of the male is comparatively bigger and longer and that it has fine thread marks.

First maxilla (Plate III, 42, 43)... Its basal segment is expansive and almost circular in shape. Its terminal segment is a triangular spine which slightly bends towards the ventral surface. The endopodite and exopodite is small circular in shape, from center of which stretch out three bristles, the middle one being the biggest, while the one protruding out from the base of the big bristle the smallest. The endopodite is a broad capsulated spine; that of the male body has fine thread marks.

Thoracic fork (Plate IV, 62) ... Basal portion arc-like or circular. The two short branching limbs form a "U" shape.

The setae of the swimmerets are longer that those of the previous period. The first segment of the exopodite of the first pair of swimmerets (Plate IV, 70) is slender; the terminal segment is short. The protopodite has a papilla. The protopodite of the second pair of pleopods (Plate IV, 75) is stout. Both the exopodites and endopodites are divided into three segments. The segmentation of the exopodite is not distinct. The third spine on the outer lateral angle of the terminal segment of the exopodite has setae on both edges. Third pair of pleopods (Plate IV, 80): the ventral side of the basal portion of the outer ramus has a small seta and a big hook-like spine. The sharp end of the spine does not reach the tip of the first segment of the outer ramous. The protopodite is expansive. The fourth pair of pleopods (Plate IV, 84) has three segments, the second being the shortest and smallest. The outer angle has a small seta. On the tip of the last segment there are three setae. The formulae for the first three pairs of swimmerets are as follows:

	Exopodite	Endopodite
First pair of pleipods	I - 0, III - 4;	0 - 0.
Second pair of pleopods	I - 0, I - 1, III - 5;	0 - 1, 0 - 2, 0 - 6.
Third pair of pleopods	I - 1, III 0 4;	0 - 6.

Fifth Period of the Chalimus Stage:

Length of the female body: 2.87 cm - 2.94 cm

Length of the male body: 3.43 cm - 4.44 cm

As this period is very close to the adult stage, its exterior shape and the structure of the appendages are both fully developed. The male has gone through metamorphosis and become mature, but the female is not

completely mature yet. The carapace appear to be more rounded in shape compared with that of last period; its width almost equals its length, or the width is greater than the length. The edge of the carapace distinctly shows a cover of thin and transparent membrane which runs from below the first antenna, backward along the edge of the carapace to the two lateral "leaves".

Female... Second antenna (Plate III, 37): its endopodite has two segments. The basal segment is big and appear to be an unsymmetrical trapeziod. The terminal segment is hook-like, its tip often bend toward the ventral surface, like a bird's beak. A spine-like seta is seen at a place near the basal portion of the terminal segment; and another spine-like seta is seen in the concave part in the center of the outer edge of the terminal segment. The "U" shaped bulging portion on the basal segment of the outer ramus has become a small knife-like spine.

First maxilla (Plate III, 44): protopodite elliptical. Its inner lateral edge has two circular bulgings. From each bulging three setae (two long and one short) protrude out. Usually the small one can not easily be seen. The terminal segment is a hook-like spine slightly bending towards the ventral surface. On the ventral surface of the first maxilla, there are another two small circular bulgings each of which has two long setae. The second maxilla (Plate III, 51): its inner ramus is a triangular spine, the basal part of which has an attached piece with its sharp end pointing at the tip of the spine in the exopodite of the second antenna. First maxilliped (cf. Plate III, 57): The spine near the end of the slender terminal segment would, at first glance, appear like a plume-like seta; actually it is an attached leaf-like piece surrounded with tiny setae.

Thoracic fork (Plate IV, 63): looks like an up-side-down letter "U". The end of each arm of the "fork" is rounded. The basal portion takes the shape of a piece of Chinese tile, covering the upper portion of the fork.

First pair of swimmerets: the first segment of the exopodite is even thinner and longer. There are two spines, each situated at a place 1/3 towards the anterior of the inner edge of the base of the two claw-like spines which are on the inner edge of the end of the terminal segment. Tiny feather-like hair is seen only on the outer edge of the seta situated in the inner lateral angle of the terminal segment. Second pair of swimmerets: the outer edge of the terminal segment of the exopodite has three spines. The first one is the smallest; the inner edge of the second one has small toothed spines; and the third one is plume-like. The third pair of swimmerets: the outer edge of the protopodite is richly covered with tiny setae which appear like a layer of membrane. The outer edges of both the exopodite and the endopodite are also covered with tiny setae. The fourth pair of swimmerets are divided into three segments. In the terminal segment, besides the three spine-like setae, there is on the inner edge a "leaf" which is surrounded by 6 - 8 "teeth" (Plate IV, 85).

The formulae for the spines and setae of the first three pairs of pleopods are as follows:

	Exopodite	Endopodite
First pair of swimmerets	I - 0, III - 4;	0 - 0.
Second pair of swimmerets	I - 1, I - 1, III - 5;	0 - 1, 0 - 2, 0 - 6.
Third pair of swimmerets	I - 1, III - 4;	0 - 6.

Male (Plate II, 24).. Second antenna (Plate III, 38): its exopodite is a long and big one. The inner ramus is divided into three segments. The basal segment is robust, the second segment short and small while the terminal segment often curled up on the ventral surface. Both the dorsal and ventral surfaces of the base of the terminal segment have a spine-like seta. However, a small seta is also seen on the dorsal surface. The end of the terminal segment has four claw-like spines. Behind these spines there are two small brunt teeth. The spines often are curled together and are difficult to be distinguished. On the outer ramus, the basal segment as well as the second segment of the inner ramus, fine linear marks are seen. The middle segment of the inner ramus has crooked linear marks, one of which bulging out creating a triangular form.

Second maxilla (Plate III, 52): Basically similar to that of the female. The only difference is that in the center of the inner ramus there are fine linear marks. In some of the specimens, their inner edge has a spine. The second maxilliped (Plate IV, 60) is more robust than that of the female: especially the basal segment which appears to be particularly broad. The center of the inner edge of the basal segment has a brunt spine which often sticks up like a nipple. Immediately behind the spine, there are two brunt teeth. On the edge of the end of the basal segment, there is a spine-like seta. The terminal segment is hook-like; the seta on its inner edge is comparatively long.

Fourth swimmeret (Plate IV, 86): the "leaf" in the inner angle bulge out; it has 7 - 8 "teeth". The basal bulging portion of the sixth pair of swimmerets triangular-like.

There are 11 -12 tube-like bulgings (under low-power microscope, they look like brunt-teeth) on each lateral edge of the reproductive segment.

A small seta sticks out from the hole of each tube. Two of them are situated between the fifth and the sixth swimmerets; one below the fifth swimmeret, and one on the bulging part of the sixth swimmeret. In this period, in the reproductive segment, the structures such as the sperm-filled seminal vesicle, rounded spermatophore and the secretion gland can all be seen. The abdomen has two segments. In the center of the outer lateral edge of the second segment, there is a tub-like projection. A small seta stick out from the tube.

Stage of Image .. Length of female: 2.22 cm - 3.39 cm

Length of male: 3.72 cm - 4.56 cm

(There are cases where some small ones measure only 2.03 cm)

Then the chalimus larva of the fifth period has undergone the process of molting, it immediately becomes an adult. The chitinous rod is separated from the central base of the frontal plate, whereby it leaves a mark on the frontal plate and completes its life of attachment. The male and female copulate. From now on they either live a parasitic life or for a short time they may swim freely in order to seek a host. Therefore it is not unusual to find both sexes of the parasites on the same fish body, and sometimes both sexes can be obtained by the seaside.

Female (Plate II, 25): The carapace is heart-shape or shield-shape. The middle of its rear part is rounded. Its two lateral sides are of ear-lobe shape. Its length is slightly greater than its width. Excluding the frontal plate, its length will roughly equate its width. The widest part is its rear portion.

The structure of different pair of appendages is basically similar to that of the female of last stage.

The width of the reproductive segment is greater than its length. It slightly resembles a square. Within the segment, the broad, convoluted uterus can be seen. The eggs are arranged in the uterus in level manner. A cylindrical secretion gland, wiht its rather translucent gland proper containing a file of flat cells, is connected to the oviduct. At the joining of the gland proper and the oviduct, the "mouth" of the uterous is also located here. Sometimes a pair of rounded spermatophores can also be seen hanging on the uterous mouth.

The length of the egg sac varies. sometimes even the length and the number of eggs of two egg sacs in the same body may vary greatly. Every egg is orderly placed in the sac. The number of eggs ranges 19 - 43. The length of the abdomen approximately equals its width, sometimes its width may slightly exceed the length.

Male: Most male bodies are bigger than the female bodies. Its basic structure is similar to that in the previous stage.

Concerning the ratio of both sexes, 260 fish lice are studied. Of this number, 127 are female, and 133 are male. The ratio is close to 1:1.

Discussion

(1) If Burmeister (1823) is taken into consideration, the study of the life history of the fish louse has been a fairly long one. Just as we have mentioned at the beginning of this paper, many famous scientists have already undertaken research work in this field and made important contribution. To conclude, the developmental stages of the fish louse are divisible into the following: nauplius stage 1 - 2, copepodid stage 1 - 2, and chalimus stage 3 - 4. The result of this writer's observation of the life history of the oriental fish louse is markedly different from

what was recorded by the above mentioned scientists. In the aspect of the nauplius stage, the writer's finding is different from that of Scott (1901), Wilson (1905), Russell (1925), and Gurney (1933). However, it agrees with Gurney's observation in 1934 in that the nauplius development is divided into stages 1 and 2. In the aspect of copepodid stage, the writer's finding is different from that of Wilson (1905) and Russell (1925), and agrees with the observation of Gurney(1933), (1934) on only one of the two stages. Having studied 17 copepodid specimens, the writer found that they were different from the observation of Gurney in as far as the size of the body, and the length and width of the carapace is concerned, but there is not much variance concerning the structure of the appendages. In the aspect of the chalimus development, the writer's view differs from that of the previous scientists in that he finds the chalimus goes through four molting processes and that the chalimus stage is sub-divisible into five periods.

(2) The image of the oriental fish louse was first ascertained by the Russian scientist Gussev (1951) who described and named the specimens collected form the fishes Kugil so-iuy, Limanda aspera, Kyporhamplus sajori, and Kexagrammus octogrammus from the Japan Sea. Then a scientist of our country, Shen Chia-shui (1957) discovered two new species - Caligus communis and C. laticorpus collected from the Mugil cephalus and the plankton at the mouth of the Yellow River near the city of Yen Tai. The writer carefully compared the descriptions by Shen and Gussev with the specimens discussed in this paper, and found that most of their characteristics are quite similar although there are some differences which, however, may due to the variance of individual parasites as well as the geographical difference (as comrade Shen at the time did not see Gussev's work, he had problems in ascertaining the species). The writer therefore agrees with Yun Wen-ying (1962) on the latter's classifying the Caligus

communis and C. laticorpus as the same species the Caligus orientalis Gussev (1951) but with different names. However, Yun expressed his doubt in the male specimens of the Caligus communis and argued that whether the female and male Caligus communis described by Shen were of the same species might be worth reconsideration. According to the writer's observation on the specimens studied in this paper, it is noted that the male body of Caligus communis as shown in Shen's plates of illustration are fairly frequently found its reproductive segment appears to be especially small and rounded. Minor differences in thoracic fork and the second maxilla between the specimens discussed here and the specimens described by Shen are also noted. The writer considers that this is due to the same reasons stated above. Therefore, the male Caligus communis, described by Shen still should be classed as the male Caligus orientalis Gussev.

SUMMARY

(1) From the fish bodies and from short period cultivation of mature egg sacs, specimens of various stages of the young parasites as well as adults of the oriental fish lice are obtained. The findings are as follows: Nauplius - 2 stages: copepodid - 1 stage; chalimus - 5 stages; then follows the image stage.

(2) The nauplius larva of the first stage has three pairs of appendages and one pair of branching telson. Except the first pair of appendages which is uniramus, the other two pairs are biramus. The body of the nauplius larva of the second stage has grown bigger. Inside the body, come appendages and segments of the next stage have been impregnated.

(3) During the copepodid stage, the young parasite undergoes metamorphosis. Its body is now divided into segments, and it is divisible into three parts; cephalothorax, thorax, and abdomen. Its outward appearance

is similiar to a cyclipid. The cephalothorax has the following appendages: first antenna, second antenna, mandible, first maxilla, second maxilla, first maxilliped, second maxilliped and the first pair of pleopods (swimmerets). Its thorax has three movable thoracic segments; the first two segments has one pair of appendage each, i.e., the second the third pair of swimmerets. The first and second pair of swimmerets are biramus. The third pair of swimmerets is a bulging, having two setae, one long and the other short. The chitinous rod is convoluted in the anterior of the ventral surface of the cephalothorax. The abdomen is a single segment by itself. The young parasite has also one pair of branching telson which has five tail-setae.

(4) The chalimus stage is a stage during which the parasite brings out its chitinous rod and lives by sucking itself to a host. Its carapace gradually expands. The first movable thoracic segment gradually closes up with the carapace; the second movable thoracic segment gradually reduces its size while the third movable thoracic segment gradually expands to become a reproductive segment. When the parasite reaches the fourth period of the chalimus stage, the sexual distinction appears. The reproductive organ of the male matures earlier than that of the female. The male will mature in the fifth period of the chalimus stage but the female does not attain maturity in the same period. Copulation appears after the chalimus has undergone the process of molting at the end of the fifth period. By then both the male and female parasites can either lead a parasitic life or engage in a short period of free swimming. The main areas distinguishing the two sexes are: the second antenna, the second maxilla, the second maxilliped, the reproductive segment and the abdomen.

(5) The oriental fish louse is widely spread in many areas: they have been found in the sea of Japan, the Po Hai (Gulf of Chilli), the Yellow Sea and the East China Sea. The differences between the specimens discussed in this essay and the discriptions by the earlier scientists lie in the following areas: Female - Second maxilla, first maxilliped, thoracic fork, first swimmeret, third swimmeret, fourth swimmeret, six swimmeret, and the number of eggs in the egg sac; Male - second antenna, second maxilla, thoracic fork and the reproductive segment. Nevertheless, the individual body or the geographic difference might be accounted for this structural difference.

Chinese Bibliography

Yun Wen-ying (1962); Parasitic crustaceans of fresh-water fish of the Northeast and Inner-Mongolia. Acta Hydrobiologica Sinica, 1962 (1): 11 - 12.

Shen Chia-shui (1957): The Parasitic copepods of fish in China: II Caligus, Caligidae (1). Acta Zoologica Sinica 9 (4): 351-355.

ILLUSTRATIONS

Plate I

1-S Eggs and Nauplius Stage; 9-19. Copepodid Stage.

1. Part of the egg sac, showing the manner the eggs are placed in sac.

2. Egg. 2a. lateral view; 2b. Dorsal-ventral view.

3. Eggs soon to be hatched (Dorsal view).

4. The nauplius larva, whole (Dorsal view).

5. First appendage of the nauplius larva (right).

6. Second appendage of the nauplius larva (left).

7. Third appendage of the nauplius larva (left).

8. The bifurcating telson of the nauplius larva (left).

9. The whole body (dorsal view).

10. The chitinous rod. 10a. Life specimen, showing when projecting out. 10b. Fixed specimen, showing rod in convoluted manner.

11. Frist antenna (left).

12. Second antenna (left).

13. First maxilla (left).

14. Second maxilla (left).

15. First maxilliped (right).

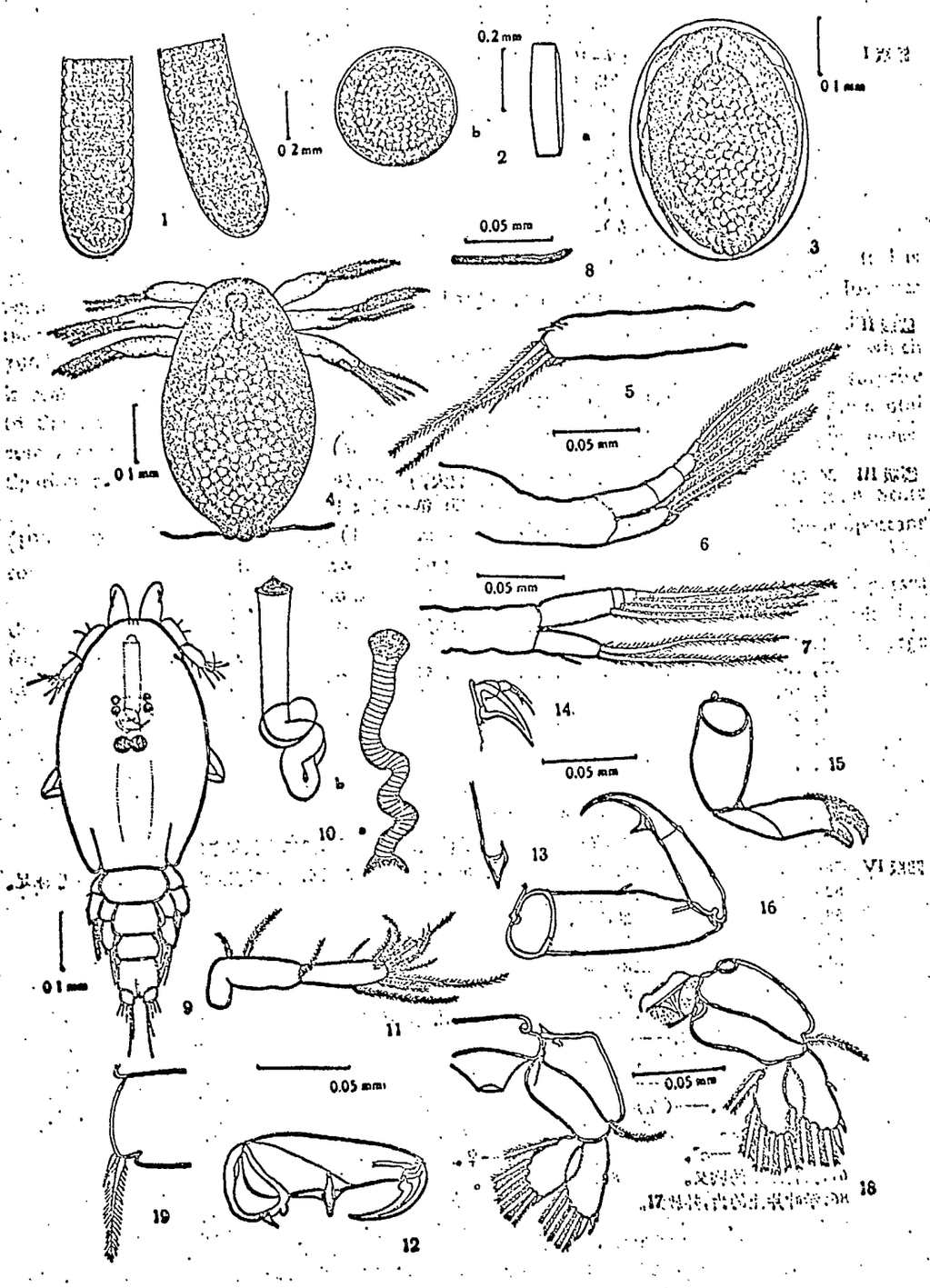
16. Second maxilliped (left).

17. First swimmeret (left).

18. Second swimmeret (left).

19. Third swimmeret (right).

PLATE I



ILLUSTRATIONS

Plate II

20. First chalimus larva, whole (dorsal view).

21. Second chalimus larva, whole (dorsal view) and the enlarged view of the basal portion of the chitinous rod.

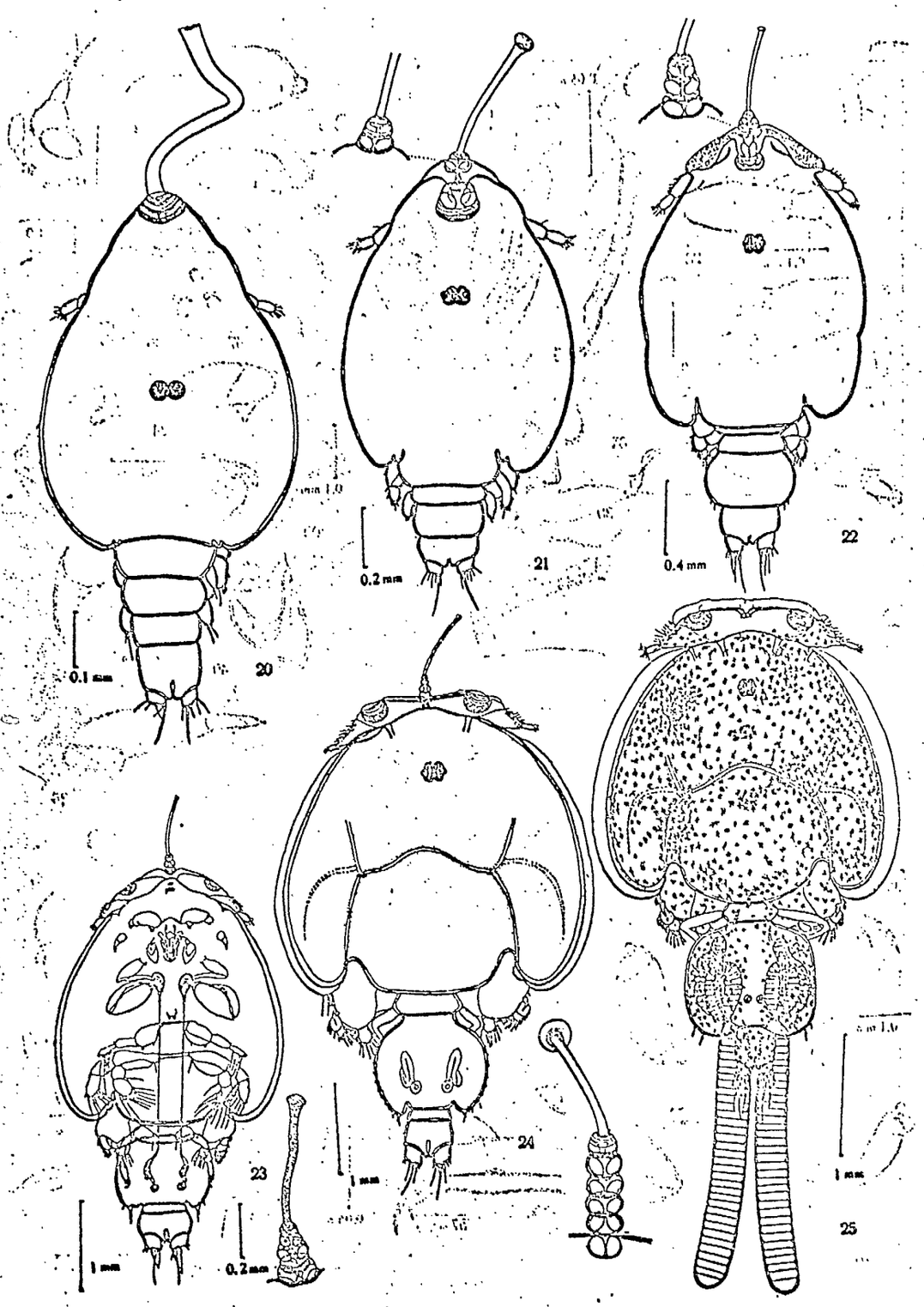
22. Third chalimus larva, whole (dorsal view) and the enlarged view of the basal portion of the chitinous rod.

23. Fourth chalimus larva, whole (ventral view) and the enlarged view of the chitinous rod.

24. Fifth chalimus larva, whole (dorsal view) and the enlarged view of the chitinous rod.

25. Image, whole (dorsal view) .

PLATE II



ILLUSTRATIONS

Plate III

26. Mouth parts of the first chalimus larva.

26a. Whole larva.

26b. Enlarged view of the mandible, showing the mandible teeth.

27-31. First antenna; 32-33. Second antenna.

39-45. First maxilla. 46-52. Second maxilla.

53-57, First maxilliped.

27, 32, 39, 46, 53. First period of the chalimus stage.

28, 33, 40, 47, 54. Second period of the chalimus stage.

29, 34, 41, 48, 55. Third period of the chalimus stage.

30, 35, 36, 42, 43, 49, 50, 56. Fourth period of the chalimus stage.

31, 37, 38, 44, 51, 52, 57. Fifth period of the chalimus stage.

27, 28, 29, 32, 34, 39, 41, 46, 48, 53, 54, 55, 56. (right)

33, 40, 45, 47. (left)

31, 35, 42, 49, 56, 57. (right)

30, 38, 45, 52. (left)

37, 43, 44, 50. (right)

36, 51. (left)

38a. Showing inner and outer ramuses.

38b. Enlarged view of the hooked spines on the terminal segment of the endopodite.

40. Showing various stages of development.

44. Enlarged view of the first maxilla and its exopodite.

51. Enlarged view of the second maxilla and its exopodite.

PLATE III

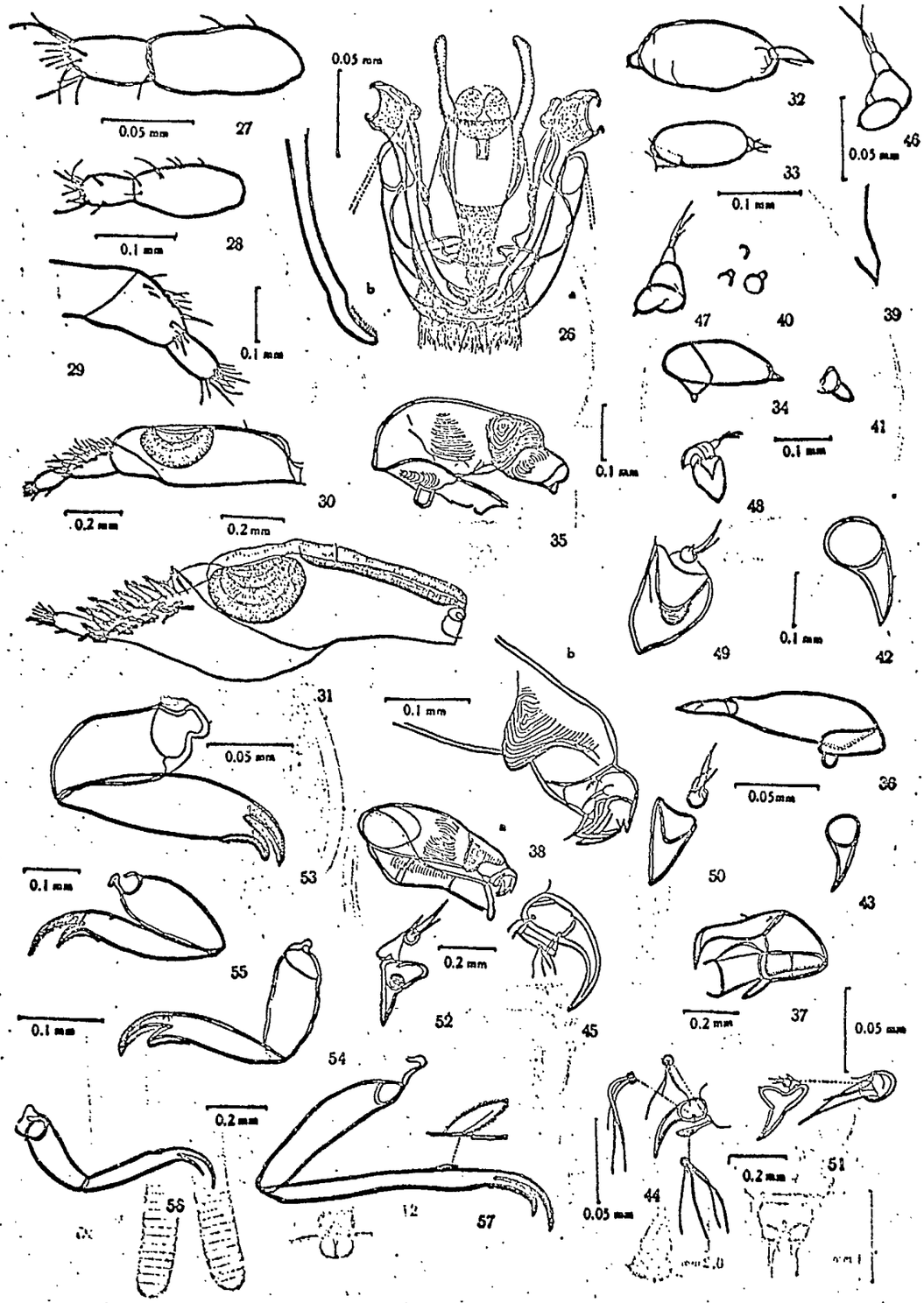

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Plate IV

58-60. Second maxilliped

61-66. Bifurcating thorax (thoracic fork).

67-71. First swimmeret.

72-76. Second swimmeret.

77-81. Third swimmeret.

82-86. Fourth swimmeret.

87. Fifth and sixth swimmerets.

58, 67, 72, 77. First period of the chalimus stage.

68, 73, 78, 82. Second period of the chalimus stage.

61, 69, 74, 79, 83. Third period of the chalimus stage.

62, 70, 75, 80, 84. Fourth period of the chalimus stage.

59, 60, 63, 64, 71, 76, 81, 85, 86, 87. Fifth period of the chalimus stage.

58, 67, 69, 77, 82. -- (left)

68, 72, 73, 74, 78, 79, 82. -- (right)

60, 71, 76, 80, 81. --(right)

70, 75, 84, 86. --(left)

87. -- (right)

59. --(left)

62, 64, 66. --

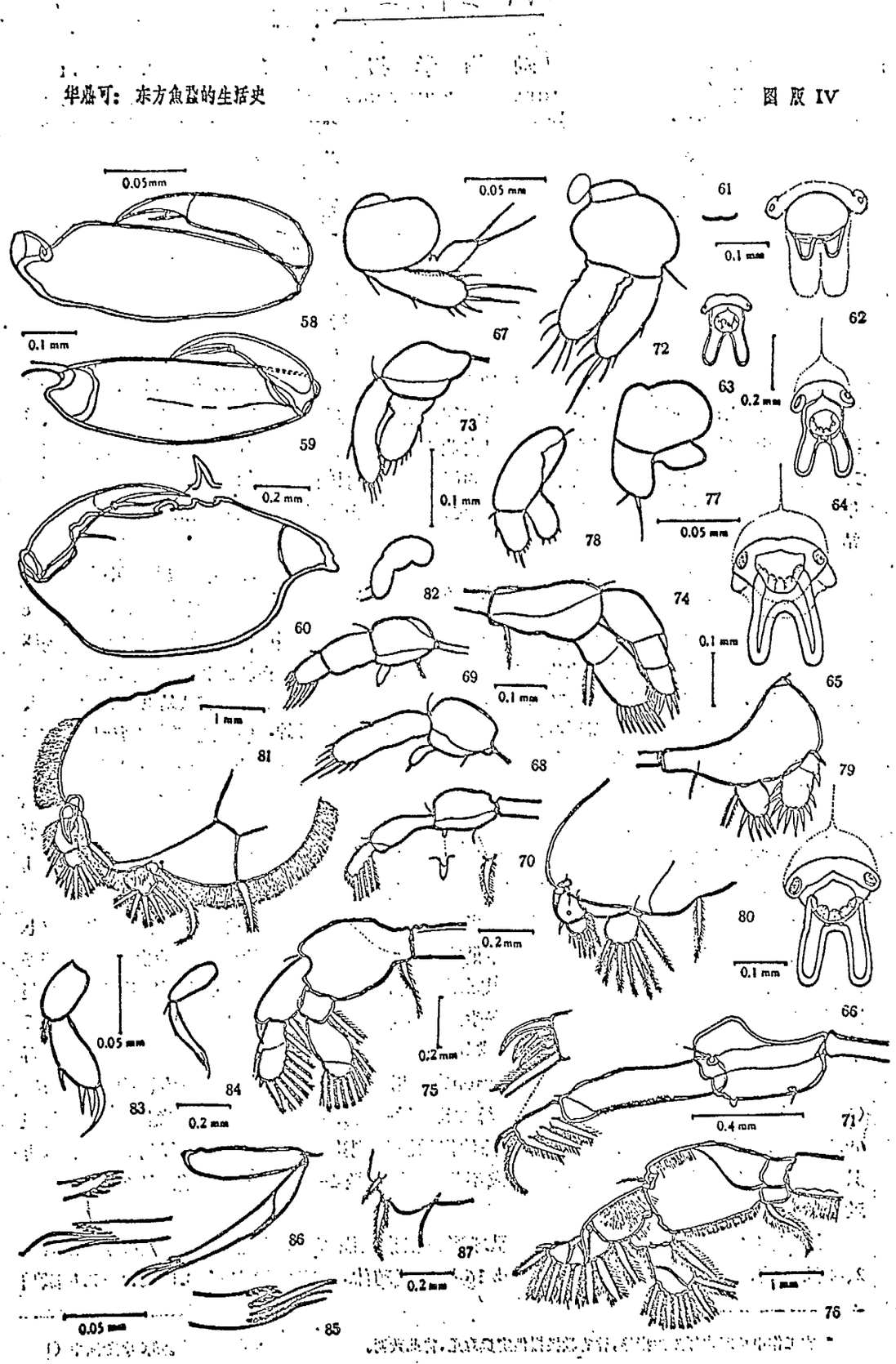
63, 65, 85. --

61. Developing bifurcating thorax.

62. Showing the teeth on the "leaf".

63. Showing the teeth on the "leaf", and the enlarged view.

PLATE IV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