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Systematic Studies of the Plankton Organisms Occurring
in Iwayama Bay, Palao

VI. On Brachyuran Larvae from the Palao Islands
(South Sea Islands)

By

Hiroaki AIKAWA

INVERT
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Crustacea

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**Systematic Studies of the Plankton Organisms Occurring
in Iwayama Bay, Palao**

**VI. On Brachyuran Larvae from the Palao Islands
(South Sea Islands)***

By

Hiroaki AIKAWA

Imperial Fisheries Experimental Station, Tôkyô

(With 18 Text-figures)

Brachyuran larvae are grouped by the type of 2nd antenna and telson into 10 forms as below :

1. *Lithozoea* : 2nd antenna E-type and telson G-type.
2. *Leucozoea* : 2nd antenna D-type and telson E-type. Leucosiidae.
3. *Hymenozoea* : 2nd antenna D-type and telson D-type. Hymenosomidae.
4. *Dissodactylozoea* : 2nd antenna D-type and telson B-type. } Pinnotheridae.
5. *Pinnozoea* : 2nd antenna D-type and telson F-type. }
6. *Ethuzozoea* : 2nd antenna A-type and telson C-type. Dorippidae.
7. *Grapsizoea* : 2nd antenna B-type and telson A-type. Calappidae, Majidae, Atelecyclidae, Parthenopidae, Portunidae, Carcinidae, Oziidae, Cancridae, Trapeziidae.
8. *Grapsizoea* : 2nd antenna B-type and telson B-type. Grapsidae, Ocypodidae.
9. *Inachizoea* : 2nd antenna A-type and telson A-type. Inachidae, Majidae, Periceridae, Menippidae, Carcinoplacidae, Gonoplacidae.

* Contribution from the Palao Tropical Biological Station, No. 57.

10. *Xanthozoea*: 2nd antenna C-type and tel- Grapsidae, Oziidae,
son A-type. Xanthidae, Ocypodidae.

Zoeas of these main forms can be determined by either the presence or absence of the carapacial spines, the grouping of abdominal and maxillipedal chromatophores, and by the hair formula (Mode of serrations on the endopodites of both maxillae and the 2nd maxilliped (H. AIKAWA, 1937). These features are believed to be stable throughout the whole zoeal stage, marked changes occurring only at the succeeding Megalopa stages.

When all these features have been sufficiently ascertained, it is possible to establish the larval characters of families or even those of species. Nevertheless, only a few zoeas of known species have been described, while, usually, most of these descriptions being incomplete, in the case of zoas from natural collection, it is impossible to determine species to which they belong. The writer attempts to determine here only the families of zoas that were obtained from the Palao Island and its vicinity.

I. Description of Zoea

Table I. List of zoas from the island of Palao and its vicinity.

| Zoea | Carapacial spines | | | 2nd. ant. | Tel-son | Hair formula | | | Family |
|-------------------------------------------------|---------------------|---|---|----------------|----------------|--------------|----------|--------------------|---------------------------|
| | + present, - absent | | | | | 1st mx. | 2nd. mx. | 2nd. mxp. | |
| | D | R | L | | | | | | |
| <i>Leucozoea</i> (1) | - | - | - | D | E | 4 | 1-2(3) | 2 | Leucosiidae |
| <i>Leucozoea</i> (2) | + | + | - | D | E | 4 | 2-2(4) | 3 | " |
| <i>Grapsizoea</i> (1) | + | + | + | B ₅ | A ₁ | 5-1 | 5 | 5-1-0 or 6-0 | Majidae-Hyasteninae |
| <i>Inachizoea</i> (1) | + | + | + | A ₃ | A ₃ | 6-1 | 3-5(8) | 6-1-1 | Periceridae |
| <i>Grapsizoea</i> (2) | + | + | - | B ₂ | A ₂ | 6-1 | 2-4(6) | 5-1-1 | Portunidae |
| <i>Grapsizoea</i> (3) | + | + | + | B ₂ | A ₂ | 6-1 | 2-4(6) | 5-1-1 | " |
| <i>Trapezia</i> sp. (<i>Grapsizoea</i> , 4) | + | + | + | B ₂ | A ₂ | 4-1 | 2-3(5) | 3-1-0 | Trapeziidae |
| <i>Xanthozoea</i> (1) | + | + | + | C ₂ | A ₂ | 6-1 | 3-5(8) | 5-1-1 | } Oziidae- Panopaeinae |
| <i>Xanthozoea</i> (2) | + | + | + | C ₂ | A ₂ | 6-1 | 3-5(8) | 6-1-1 | |
| <i>Xanthozoea</i> (3) | + | + | + | C ₁ | A ₃ | 6-1 | 3-5(8) | 6-1-1 | |
| <i>Pinnozoea</i> (1) | - | + | + | D | F | 4-0 | 3 | 6 | Pinnotheridae |

Table I. (Continued).

| Zoea | Carapacial spines | | | 2nd. ant. | Tel-son | Hair formula | | | Family |
|----------------------------------------------|---------------------|---|---|----------------|----------------|--------------|----------|-----------|--------------------|
| | + present, - absent | | | | | 1st mx. | 2nd. mx. | 2nd. mxp. | |
| | D | R | L | | | | | | |
| <i>Pinnozoea</i> (2) | - | + | - | D | F | 4 | 5 | 4-0 | Pinnotheri- dae |
| <i>Dissodactylozoea</i> (1) | - | + | + | D | B | 4-0 | 3 | 6-5 | " |
| <i>Dissodactylozoea</i> (2) | + | + | + | D. | B | 5-1 | 2-2(4) | 5-1-0 | " |
| <i>Grapsizoea</i> (5) | + | + | + | B ₃ | A ₁ | 5-1 | 2-2(4) | 5-1-0 | Grapsidae |
| <i>Grapsizoea</i> (6) | - | + | - | B ₁ | B | 5-0 | 2-2(4) | 6-1-1 | Ocypodidae |
| <i>Uca dubia</i> (<i>Grapsizoea</i> , 7) | + | + | - | B ₂ | B | 4-0 | 2-2(4) | 5-0-0 | " |

1. *Leucozoea* (1) First stage.

Fig. 1.

Characters: no carapacial spines present, 2nd antenna D-type, telson E-type, hair formula 4, 1-2 (3), 2.

Length of carapace 0.48 mm. and telson 0.15 mm.

Rostrum only small tubercle, far shorter than 1st. antenna, which is of usual form, bearing 2 aesthetes and 2 hairs on tip. Second antenna thickly chitinized, but reduced to a conical process, namely, D-type. Endopodite of 1st maxilla of single joint, bearing 4 hairs on tip. Endopodite of 2nd maxilla incompletely bifurcated, bearing 1 hair on one lobe and

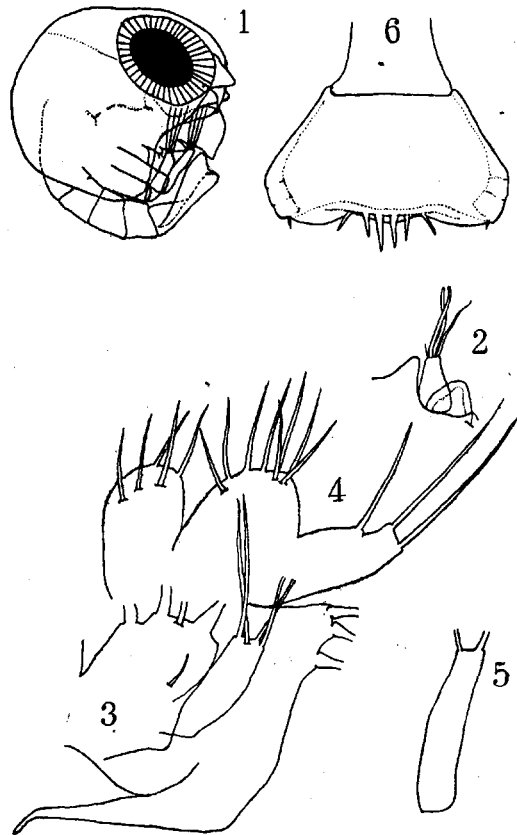


Fig. 1. *Leucozoea* (1).

1. lateral view $\times 60$, 2, rostrum and both antennae $\times 106$, 3, enp. 1st mx. $\times 377$, 4, enp. 2nd mx. $\times 377$, 5, enp. 2nd. mxp. $\times 377$, 6, telson $\times 106$.

2 on the other. Exopodites of both maxillipedes bear 4 swimming hairs each. Endopodite of 2nd maxilliped of single joint, bearing only 2 hairs on tip.

Abdomen consists of 5 somites and telson. Semicircular lateral knobs present only on 2nd somite. First to 4th somites nearly cylindrical, but the last one expands posteriorly, ending in fan-shaped E-type telson. A small spinule present on the postero-lateral corner of telson. Three pairs of inner spines closely arranged.

2. *Leucozoea* (2) Second stage. Fig. 2.

Characters: dorsum and rostrum present, 2nd antenna D-type, telson E-type, and hair formula 4, 2-2 (4), 3.

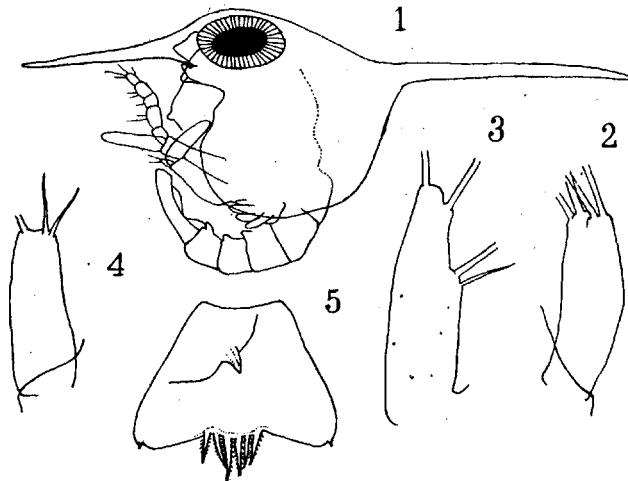


Fig. 2. *Leucozoea* (2).

1. lateral view $\times 34$, 2. enp. 1st mx. $\times 377$, 3. enp. 2nd mx. $\times 377$, 4. enp. 2nd mxp. $\times 377$, 5. telson $\times 60$.

Dorsum 0.94 mm., rostrum 0.66 mm., perpendicular distance between their tips 2.45 mm., length of carapace 0.94 mm., abdomen 0.99 mm. and telson 0.29 mm.

Dorsum and rostrum long, straight, pointed. Lateral spines absent. Both 1st and 2nd antennae greatly reduced, as in *Leucozoea* (1). Second antenna D-type. Endopodite of 1st maxilla of single joint, bearing 4

hairs on tip. Endopodite of 2nd maxilla incompletely bifurcated, each lobe bearing 2 hairs. Six swimming hairs on both maxillipedes. Endopodite of 2nd maxilliped of single joint, bearing 3 hairs on tip. Small rudiments of 3rd maxilliped and pereiopods present.

Abdomen consists of 5 somites and telson. Lateral knobs present on 2nd and 3rd somites. All somites cylindrical, similar in shape to one another. Telson E-type, a small spinule present on postero-lateral corner, its general appearance greatly resembling that of *Leucozoa* (1).

Remarks: Both *Leucozoas* (1) and (2) belong to the species of the Leucosiidae family. The writer is unable to find any zoeas that agree in all details with those larvae, since only a few zoeas of this vast family have been described.

3. *Grapsizoea* (1) First stage. Fig. 3.

Characters: all carapacial spines present, 2nd antenna B₅-type, telson A₁-type, hair formula 5-1, 5, 5-1-0 (or 6-0).

Rostrum straight and pointed. Dorsum thick and curved backward. First antenna of usual type. Second antenna B₅-type: endopodite attains to 1/2 the length of peduncle, peduncle toothed along both sides, exopodite

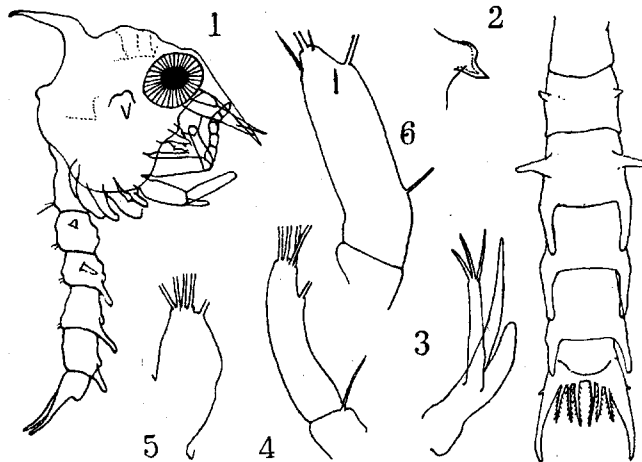


Fig. 3. *Grapsizoea* (1).

1. lateral view $\times 17$, 2. lateral spine $\times 33$, 3. 2nd ant. $\times 33$,
4. enp. 1st mx. $\times 188$, 5. enp. 2nd mx. $\times 188$, 6. enp. 2nd
mxp. $\times 188$, 7. abdomen $\times 33$.

equal to $3/4$ the length of peduncle, ending in 3 thick hairs. Second antenna resembles much that of *Chionectes opilio*. Endopodite of 1st maxilla of 2 joints, its distal joint bearing 4 hairs on tip and 1 slightly below them laterally, the basal joint with only 1 hair. Endopodite of 2nd maxilla single, bearing 5 hairs on tip. Endopodite of 2nd maxilliped of 2(?) joint, the distal joint being only incompletely segmented, bearing 5 hairs on tip and 1 laterally far below, but the basal joint without hair. Exopodites of both maxillipedes have 6 swimming hairs each. Rudiments of 3rd maxilliped and pereopods present.

Abdomen composed of 5 somites and telson. First somite smallest, becoming large posteriorly, the last 5th somite being the largest. Lateral knobs present on 2nd and 3rd somites, those of latter somite very large. Lateral ends of 3rd to 5th somites prominently projected and rounded at end. Telson A_1 -type, having small spinule laterally near base of telson-fork. Telson-fork rather thick. Three pairs of inner spines present, middle emargination shallow and narrow.

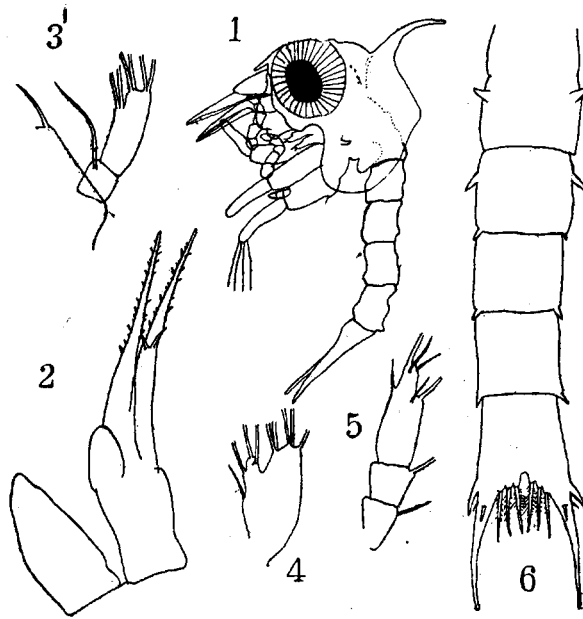
Remarks: This zoea has many features in common with the zoeas of both 2nd and 3rd groups of the family Majidae. From the presence of lateral knobs on both 2nd and 3rd somites and, judging, in addition, from the antenna of *Chionectes-type*, this zoea may belong to the subfamily Hyasteninae.

4. *Inachizoa* (1) First stage. Fig. 4.

Characters: all carapacial spines present, 2nd antenna A_3 -type, telson A_3 -type, hair formula 6-1, 3-5 (8), 6-1-1.

Dorsum 0.52 mm., rostrum 0.14 mm., perpendicular distance between their tips 1.48 mm., length of carapace 0.66 mm., abdomen 1.29 mm, and telson 0.37 mm.

Rostrum and lateral spines very short, but dorsum long, thick, curved backward. First antenna of usual type. Second antenna A_3 -type and much longer than rostrum. Peduncle and exopodite toothed along both sides. Two spines on middle part of exopodite. Endopodite attains to $2/5$ of peduncle. Endopodite of 1st maxilla of 2 joints; its distal joint has 4 hairs on tip and 2 laterally, basal joint also 1. Endopodite of 2nd

Fig. 4. *Inachizoea* (1).

1. lateral view $\times 33$, 2. antennae $\times 108$, 3. emp. 1st mx. $\times 188$, 4. emp. 2nd mx. $\times 188$, 5. emp. 2nd mxp. $\times 188$, 6. abdomen $\times 61$.

maxilla bifurcated, bearing 3 and 5 hairs on lobes respectively. Exopodites of both maxillipedes bear 4 swimming hairs each. Endopodite of 2nd maxilliped of 3 joints; its distal joint provided with 6 hairs, and the remaining two with 1 each. Small rudiments of 3rd maxilliped and pereopods present.

Abdomen consists of 5 somites and telson. Lateral knobs present on 2nd and 3rd somites. Lateral ends of 3rd to 5th somites slightly pointed. Telson A_3 -type, possessing 2 spines laterally, 1 dorsally near base of telson-fork. Three pairs of inner spines present. Middle emargination narrow, but deep.

Remarks: This zoea has many features in common with the larvae of the family Periceridae, especially those *Tiarinia cornigera* (H. AIKAWA, 1937) and *Lissa* sp. (CANO, 1893).

5. *Grapsizoea* (2) First stage. Fig. 5.

Characters: dorsum and rostrum present, but lateral spines absent, 2nd antenna B_2 -type, telson A_2 -type, hair formula 6-1, 2-4 (6), 5-1-1.

Dorsum 0.18 mm., rostrum 0.14 mm., perpendicular distance between their tips 0.72 mm., length of carapace 0.44 mm., abdomen 0.80 mm, and telson 0.26 mm.

Dorsum and rostrum rather short, but pointed. A conspicuous tooth on the lower margin of carapace. First antenna of usual type, bearing 2 aesthetes and 2 hairs on tip. Second antenna B₂-type; peduncle slender, pointed, and toothed on both sides, exopodite small, attaining to 1/4 the length of peduncle, ending in a slender hair of moderate length, in addition to which, a small hair present near the base. Endopodite of 1st maxilla 2-jointed, its distal joint, bearing 4 hairs on tip and 2 laterally, the basal joint also 1 hair. Endopodite of 2nd maxilla slightly bifurcated, the two lobes bearing 2 and 3 hairs respectively. Endopodite of 2nd maxilliped of 3 joints; the distal joint provided with 5 hairs and the remaining two joint with 1 each.

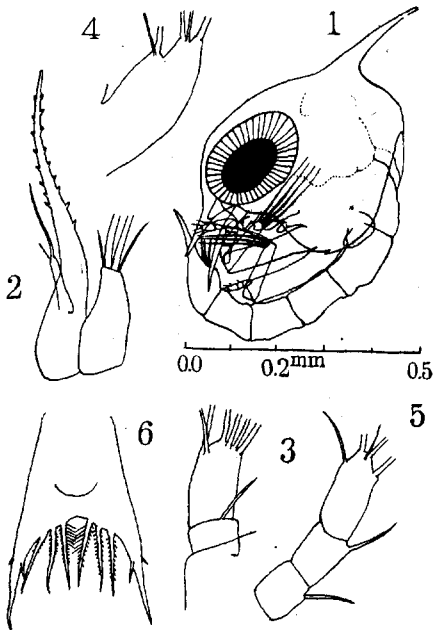


Fig. 5. *Grapsizoea* (2).

1. lateral view $\times 59$, 2. antennae $\times 187$, 3. enp. 1st. mx. $\times 374$, 4. enp. 2nd mx. $\times 375$, 5. enp. 2nd mxp. $\times 374$, 6. telson $\times 108$.

Rudiments of 3rd maxilliped and pereopods present.

Abdomen composed of 5 somites and telson. Lateral knobs present on 2nd and 3rd somites. Lateral ends of 2nd to 4th somites projected. Telson A₂-type, possessing a large spine on inside and a small one outside of middle part of telson-fork. Telson-fork slender, pointed. Three pairs of inner spines present, its inner 3rd spine with 6 or 7 long hairs among the short ones along the inner side.

Remarks: This zoea has many features in common with larvae of the Partunidae and Majidae families. From the presence of rudiments of 3rd maxilliped and pereopods at so early a stage as when there are

only 4 swimming hairs, it seems to belong the Majidae family, although in general appearance and mode of serration it closely resembles the larvae of the family Portunidae.

6. *Grapsizoea* (3) Fourth stage. Fig. 6.

Characters: all carapacial spines present, 2nd antenna B₂-type, telson A₁-type, hair formula 6-1, 2-4 (6), 5-1-1.

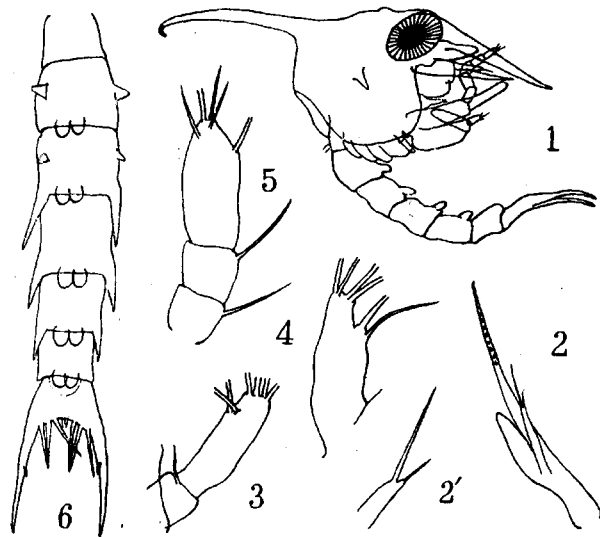


Fig. 6. *Grapsizoea* (3).

1. lateral view $\times 19$, 2. 2nd ant. $\times 59$, 2. exp. 2nd ant. $\times 108$,
3. enp. 1st mx. $\times 188$, 4. enp. 2nd mx. $\times 188$, 5. enp. 2nd.
mxp. $\times 188$, 6. abdomen $\times 33$.

Dorsum 0.90 mm., rostrum 0.99 mm., perpendicular distance between their tips 2.82 mm., lateral spine 0.21 mm., length of carapace 1.80 mm., abdomen 2.06 mm., and telson 0.62 mm.

Rostrum straight and pointed, but dorsum long and hooked at end. Lateral spine very short. First antenna of usual type. Second antenna B₂-type, greatly resembling that of *Grapsizoea* (2). Endopodites of both maxillae and 2nd maxilliped similar in construction and in mode of serration to those of *Grapsizoea* (2). Rudiments of 3rd maxilliped and pereopods very large.

Abdomen composed of 6 somites and telson. Lateral knobs present on 2nd and 3rd somites. Lateral ends of 3rd to 5th somites very prominent. Telson of A_1 -type has spine on middle of telson-fork. Telson-fork slender and pointed.

Remarks: This zoea shows many characteristics of the larvae of the family Portunidae.

7. *Trapezia* sp. (*Grapsizoea*, 4) First stage. Fig. 7.

Characters: all carapacial spines present, 2nd antenna B_5 -type, telson A_2 -type, hair formula 4-1, 2-3 (5), 3-1-0.

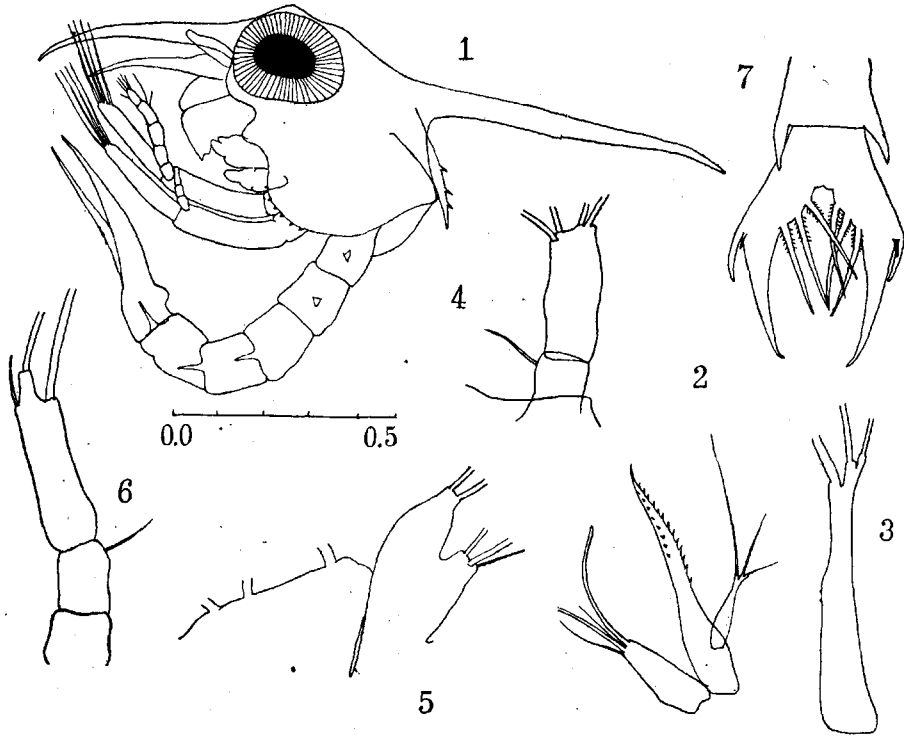


Fig. 7. *Trapezia* species (*Grapsizoea*).

1. lateral view $\times 60$, 2. antennae $\times 108$, 3. exp. 2nd ant. $\times 374$.
4. exp. 1st mx. $\times 374$, 5. exp. 2nd mx. $\times 374$, 6. exp. 2nd mxp.
 $\times 374$, 7. telson $\times 60$.

Dorsum 0.64 mm., rostrum 0.44 mm., perpendicular distance between their tips 2.06 mm., lateral spine 0.26 mm., length of carapace 0.56 mm., abdomen 1.03 mm., and telson 0.46 mm.

Dorsum nearly straight, but rostrum curved. Both pointed and smooth. Lateral spine toothed along upper side. Lower margin of carapace coarsely toothed. First antenna of usual type, showing 2 aesthetes and 2 hairs on tip. Second antenna B_5 -type; exopodite attains to $1/3$ the length of peduncle, ending in 3 hairs on tip; peduncle thick, pointed, and armed with teeth along both sides. Endopodite of 1st maxilla has 2 joints: its distal joint bears 4 hairs, the basal joint only 1. Endopodite of 2nd maxilla deeply bifurcated, the two lobes bearing 2 and 3 hairs. Endopodite of 2nd maxilliped of 3 joints, its distal joint provided with 3 hairs, 2nd joint with 1 hair, but basal one with none.

Abdomen composed of 5 somites and telson. Lateral knobs present on 2nd and 3rd somites. Lateral ends of 3rd to 5th somite prominently projected. Telson A_2 -type, with unequal spinules on base of telson-fork. Telson-fork thick, pointed, and smooth. Three pairs of inner spines present.

Remarks: This *Trapezia* larva has many features in common with the larvae of group B of Xanthini, although it differs in details from the *Trapezia* larva described by O. W. HYMAN (1925).

8. *Xanthozoea* (1) First stage. Fig. 8.

Characters: all carapacial spines present, 2nd antenna C_2 -type, telson A_2 -type, hair formula 6-1, 3-5 (8), 5-1-1.

Dorsum 0.49 mm., rostrum 0.39 mm., perpendicular distance between their tips 1.30 mm., lateral spine very short, length of carapace 0.54 mm., orbital distance 0.48 mm., abdomen 1.12 mm., and telson 0.35 mm.

Rostrum straight, but dorsum hooked at end. Lateral spine very short. First antenna of usual type. Second antenna C_2 -type; single toothed peduncle, much longer than rostrum. Endopodite of 1st maxilla has 2 joints; its distal joint bearing 6 hairs, the basal joint only 1. Endopodite of 2nd maxilla bifurcated, two lobes bearing 3 and 5 hairs respectively. Endopodite of 1st maxilliped of 5 joints, its distal joint bearing 5 hairs. Endopodite of 2nd maxilliped of 3 joints; its distal joint provided with 5 hairs, and the remaining two joints with 1 hair each. Exopodite of both maxillipedes bear only 4 swimming hairs each,

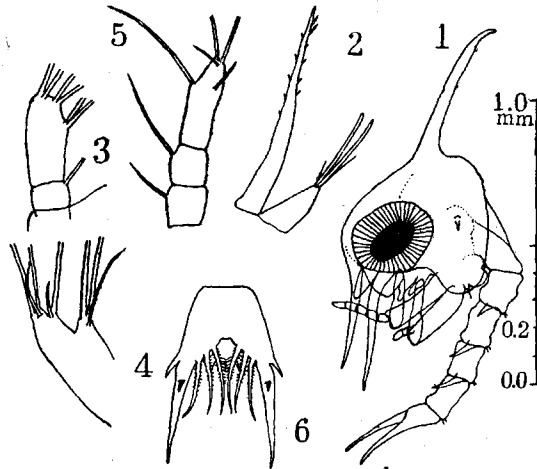


Fig. 8. *Xanthozoea* (1).

1. lateral view $\times 38$, 2. antennae $\times 61$, 3. enp. 1st mx. $\times 251$,
4. enp. 2nd mx. $\times 251$, 5. enp. 2nd mxp. $\times 251$, 6. telson $\times 61$.

but slightly jointed. In addition, small rudiments of 3rd maxilliped and pereopods occur, so that the zoea may be in a more advanced stage of growth than the 1st stage.

Abdomen consists of 5 somites and telson. Lateral knobs present on 2nd and 3rd somites, but those on 3rd somite very rudimentary. Lateral ends of 3rd to 5th somites pointed. Telson A_2 -type, with large spine laterally and small one dorsally. Three pairs of inner spines present, the spine having 4 or 5 long hairs among the short ones along inner side and 1 or 2 along outer. Middle emargination of medium depth. Telson-fork straight, pointed, smooth.

9. *Xanthozoea* (2) Third stage. Fig. 9.

Characters: all carapacial spines present, 2nd antenna C_2 -type, telson A_2 -type, hair formula 6-1, 3-5 (8), 5-1-1.

Dorsum 2.40 mm., rostrum 1.60 mm., perpendicular distance between their tips 4.72 mm., lateral spine 0.30 mm., length of carapace 0.94 mm., abdomen 2.83 mm., and telson 1.25 mm.

Dorsum and rostrum long, slender, straight. Lateral spine short, but thick. 1st antenna of usual type. Second antenna C_2 -type; single long

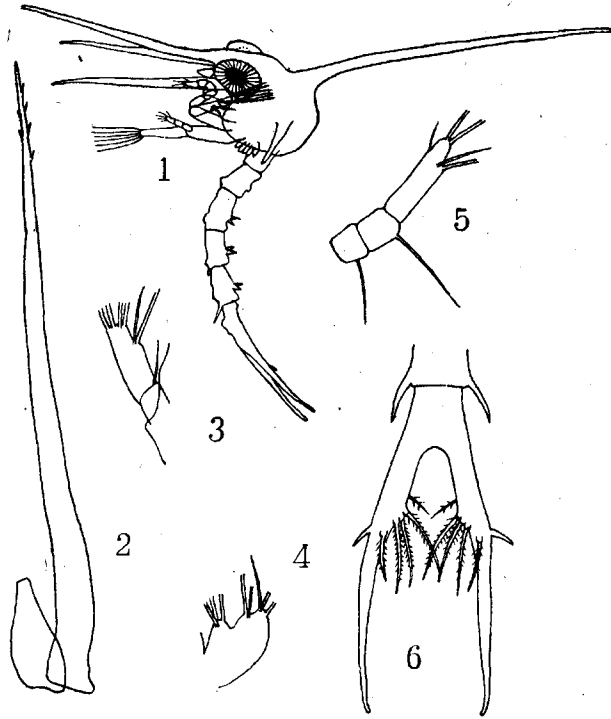


Fig. 9. *Xanthozoea* (2).

1. lateral view $\times 17$, 2. antennae $\times 59$, 3. enp. 1st. mx. $\times 108$,
4. enp. 2nd mx. $\times 108$, 5. enp. 2nd mxp. $\times 108$, 6. telson $\times 33$.

peduncle coarsely toothed only at its distal part. Endopodite not yet developed. Endopodites of both maxillae and 2nd maxilliped very similar in construction and also in mode of serration to those of *Xanthozoea* (1). Endopodite of 1st maxilliped of 5 joints; its distal joint bearing 6 hairs on tip. Rudiments of 3rd maxilliped and pereiopods present.

Abdomen consists of 5 somites and telson. Lateral knobs present only on 2nd somite. Two large dorsal spines present on 3rd to 5th somites. Lateral ends of 3rd to 5th somites projected, those of last 5th somite most prominent. Telson A_2 -type, having large lateral spine near base of telson-fork and resembling greatly C (*Ethusozoaea*)-type of telson. A long plumose hair, which grows dorsally on middle part of telson-fork, is probably identical with the usual spine, differing from the inner spines, whence the telson is regarded as of A_2 -type. Three pairs of inner spines and 2 extra-hairs present. Middle emargination wide and deep.

10. *Xanthozoea* (3) Last stage. Fig. 10.

Characters: all carapacial spines present, 2nd antenna C₁-type, telson A₃-type, hair formula 6-1, 3-5 (8), 6-1-1.

Dorsum 2.54 mm., rostrum 1.01 mm., perpendicular distance between

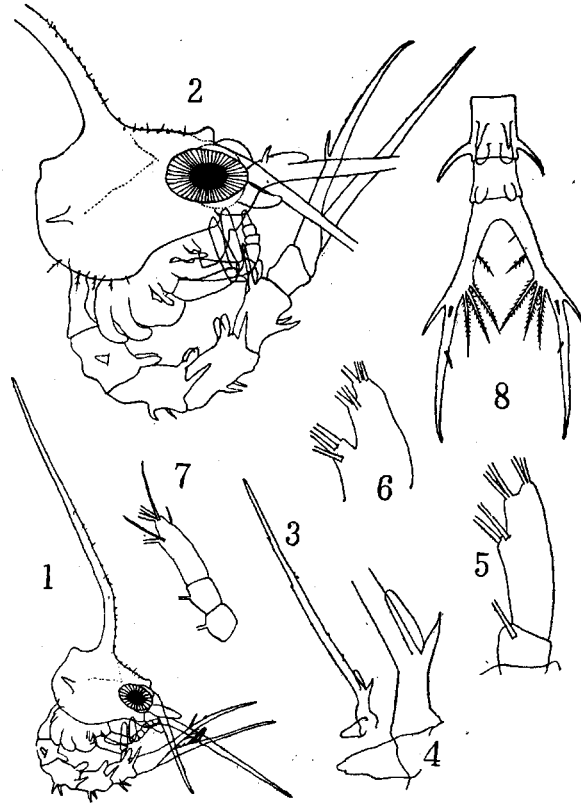


Fig. 10. *Xanthozoea* (3).

1. lateral view $\times 13$, 2. lateral view $\times 25$, 3. antenna $\times 15$, 4. exp. 2nd ant. $\times 45$, 5. enp. 1st mx. $\times 188$, 6. enp. 2nd mx. $\times 188$, 7. enp. 2nd mxp. $\times 188$, 8. telson $\times 25$.

their tips 3.28 mm., lateral spine 0.32 mm., length of carapace 1.15 mm., abdomen 1.92 mm., and telson 1.28 mm.

Dorsum long, curved backward, coarsely toothed and haired over its upper side. Rostrum nearly straight, smooth, much shorter than 2nd antenna. Lateral spine very short. A small tubercle present on front, and the carapace behind it coarsely toothed and haired, as seen on dorsum.

Posterior end of carapace slightly tuberculated. Lower margin of carapace provided with thick plumosed hairs. First antenna of usual type and incompletely 3-jointed. Second antenna C₁-type; peduncle coarsely toothed all over, having small exopodite near base. Small endopodite also occurs. Endopodites of both maxillae and 2nd maxilliped very similar in construction and in mode of serration to those of *Xanthozoeas* (1) and (2). Exopodites of both maxillipedes bear 12 swimming hairs each. Rudiments of 3rd maxilliped and pereopods present.

Abdomen consists of 6 somites and telson, being very slender. Large lateral knobs only on 2nd somite, differing from the other two *Xanthozoeas* mentioned above. Two large dorsal spines present on 3rd to 5th somites, as seen in *Xanthozoea* (2). Lateral ends of 3rd to 5th somites prominently projected. Telson of A₃-type; has 1 large lateral and 2 small dorsal spines, differing from telson of *Xanthozoea* (2), but in general appearance greatly resembling that of latter. Three pairs of inner spines and 3 extra-hairs present. Middle emargination wide and deep.

Remarks: All these *Xanthozoeas* have many features in common with larvae of the Panopaeinae subfamily of the Oziidae family, although they resemble also the larvae of the Xanthidae family. Zoeas of these families can be distinguished only by the grouping of the maxillipedal chromatophores. So far as can be assumed from the trace of the chromatophores, which easily fade in specimens preserved in formaline, they probably belong to the Panopaeinae subfamily.

11. *Pinnozoea* (1) Third stage. Fig. 11.

Characters: dorsum absent, but rostrum and lateral spines present, 2nd antenna D-type, telson F-type, hair formula 4-0, 3, 5.

Rostrum 1.38 mm., lateral spine 0.93 mm., length of carapace 0.59 mm., orbital distance 0.53 mm., abdomen 1.12 mm., and telson 0.24 mm.

Dorsum absent. Rostrum thick, straight, and rather rounded at end. Lateral spines thick. Both antennae very reduced. Endopodite of 1st maxilla of 2 joints, its distal joint bearing 4 hairs on tip. Endopodite of 2nd maxilla single, bearing 3 hairs. Endopodite of 2nd maxilliped of single joint, bearing 5 hairs on tip. Exopodites of both maxillipedes have 8

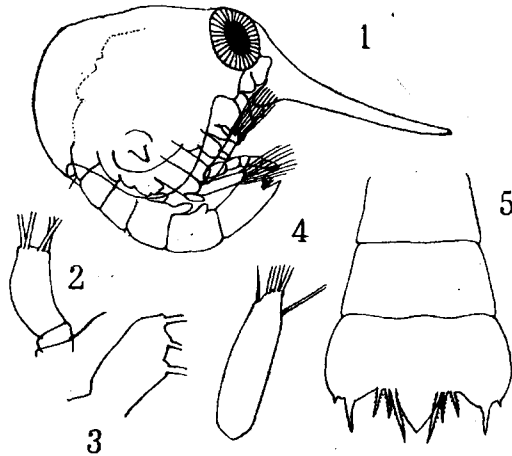


Fig. 11. *Pinnozoea* (1).

1. lateral view $\times 33$, 2. enp. 1st mx. $\times 188$, 3. enp. 2nd mx. $\times 188$, 4. enp. 2nd mxp. $\times 188$, 5. telson $\times 59$.

swimming hairs each. Rudiments of 3rd maxilliped and pereopods present.

Abdomen consists of 5 somites telson, and expanding posteriorly. Lateral knobs only on 2nd somite. Telson F-type, with large median lobe. Telson-fork short, but thick. A small spinule present outside telson-fork. Three inner spines closely arranged on each side of median lobe.

12. *Pinnozoea* (2). Fig. 12.

Characters: only short rostrum present, 2nd antenna D-type, telson F-type, hair formula 4-0, 3, 4-0.

Rostrum 0.02 mm., length of carapace 0.66 mm., abdomen 0.70 mm., and telson 0.19 mm. Rounded tubercle present dorsally and frontally, carapace between these tubercles being coarsely serrated. Carapace spherical and areolated. Rostrum depressed, nearly quadrate. Both antennae markedly reduced in size. Endopodite of 1st maxilla has 2 joints, its distal joint alone bearing 4 hairs on tip. Endopodite of 2nd maxilla single, bearing 3 hairs. Endopodite of 2nd maxilliped of 2 joints, its distal joint bearing 3 hairs on tip and 1 hair laterally. Rudiments of 3rd maxilliped and pereopods very large.

Abdomen composed of 5 somites and telson, expanding posteriorly. Lateral knobs only on 3rd somites, a chitinous membrane wrapping

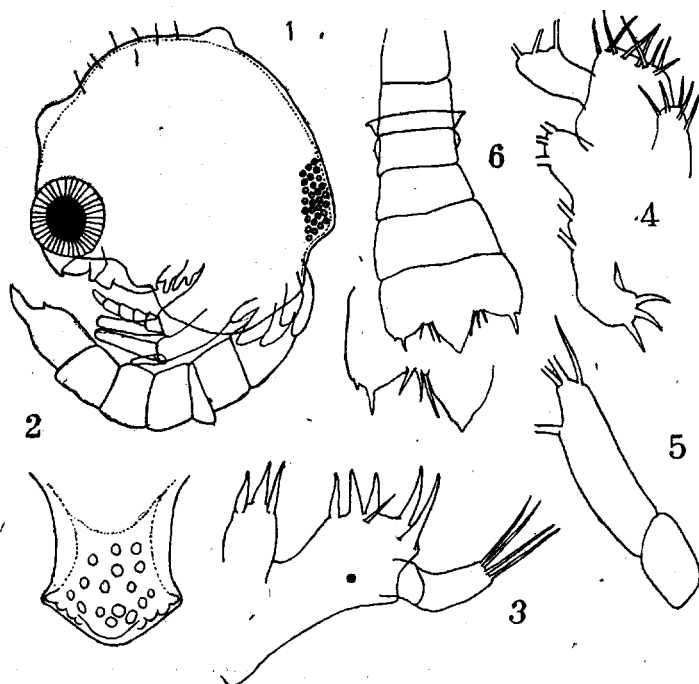


Fig. 12. *Pinnozoea* (2).

1. lateral view $\times 62$, 2. rostrum $\times 107$, 3. enp. 1st mx. $\times 254$,
4. enp. 2nd mx. $\times 254$, 5. enp. 2nd mxp. $\times 254$, 6. abdomen
 $\times 62$, 7. telson $\times 107$.

posterior part of 2nd somite except ventral side. Telson of F-type resembles much that of *Pinnozoea* (1).

Remarks: These 2 *Pinnozoeas* belong to the family Pinnotheridae.

13. *Dissodactylozoea* (1) Fig. 13.

Characters: rostrum and lateral spines present, 2nd antenna D-type, telson B-type, hair formula 4-0, 3, 5.

Rostrum 0.55 mm., length of carapace 1.65 mm., abdomen 1.96 mm., and telson 0.53 mm. Carapace large, wrapping nearly all extremities, even abdomen. Lower margin of carapace coarsely haired. Rostral and lateral spines thick, pointed. Second antenna D-type, slender. Endopodite of 1st maxilla of 2 joints, its distal joint alone bearing 4 hairs on tip, but none on the other. Endopodite of 2nd maxilla single with 3 hairs.

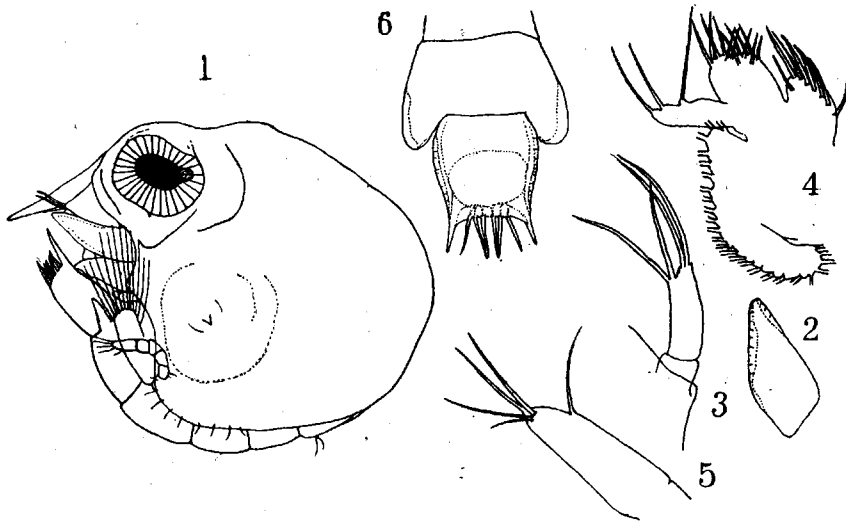


Fig. 13. *Dissodactylozoa* (1).

1. lateral view $\times 34$, 2. 2nd ant. $\times 62$, 3. enp. 1st mx. $\times 107$,
4. enp. 2nd mx. $\times 107$, 5. enp. 2nd mxp. $\times 107$, 6. telson $\times 34$.

Endopodite of 2nd maxilliped incompletely 2-jointed, having 5 hairs on tip. Exopodites of both maxillipedes have 12 swimming hairs each. Rudiments of 3rd maxilliped and pereopods very large.

Abdomen composed of 5 somites and telson. Fifth somite has, laterally, a large, flattened, and rather quadrate projection. Large lateral knobs present on 3rd somite, a chitinous membrane wrapping the posterior part of 2nd somite, except on ventral side. Abdomen very similar to that of *Pinnozoa* (2), although telson in this *Dissodactylozoa* (1) is of B-type. Lateral side of telson thickly chitinized, sharply edged. Telson-fork short, but thick.

14. *Dissodactylozoa* (2) Second stage. Fig. 14.

Characters: all carapacial spines present, 2nd antenna D-type, telson B-type, hair formula 5-1, 2-2 (4), 5-1-0.

Dorsum 0.56 mm., rostrum 0.48 mm., perpendicular distance between their tips 1.79 mm., lateral spine 0.13 mm., length of carapace 0.83 mm., abdomen 1.34 mm., telson 0.46 mm.

All carapacial spines thick, straight, pointed. Small tubercle present

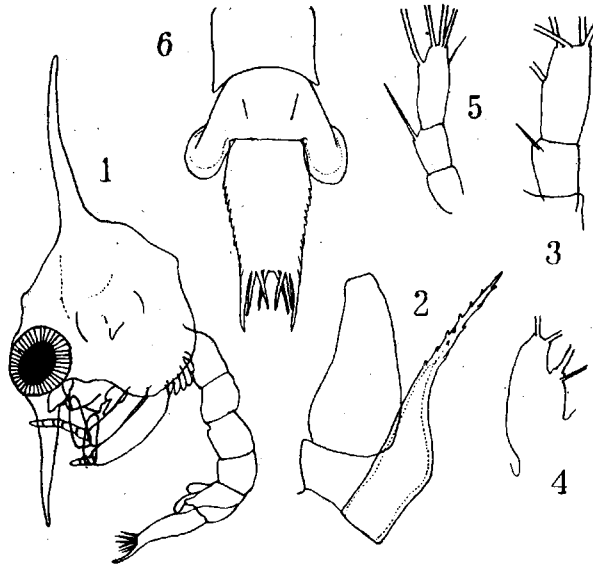


Fig. 14. *Dissodactylozoa* (2).

1. lateral view $\times 35$, 2. both antennae $\times 251$, 3. enp. 1st mx. $\times 251$, 4. enp. 2nd mx. $\times 251$, 5. enp. 2nd mxp. $\times 251$, 6. telson $\times 59$.

on front. Both antennae greatly reduced; the 2nd being slender and toothed. Endopodite of 1st, maxilla of 2 joints, its distal joint bearing 4 hairs on tip, and 1 hair laterally, and basal joint only 1 hair. Endopodite of 2nd maxilla slightly bifurcated, each lobe bearing 2 hairs. Endopodite of 2nd maxilliped of 3 joints; its distal joint provided with 5 hairs, the 2nd with 1, but the basal with none. Endopodite of 1st maxilliped of 5 joints, its distal joint bearing 5 hairs on tip. Small rudiments of 3rd maxilliped and pereopods present.

Abdomen consists of 5 somites and telson. First to 3rd somites cylindrical, 4th somite slightly pointed at lateral end, 5th somite prominently projected at lateral end. Lateral knobs present on 2nd and 3rd somites. Telson B-type, lateral side thick, toothed. Telson-fork short, but thick. Three pairs of inner spines closely arranged.

Remarks: *Dissodactylozoas* were reared from *Pinnotheres taylori*, *P. latissimus*, and *Dissodactylus mellitae* (J. F. L. HART, 1935; O. W. HYMAN, 1924; S. MIYAKE, 1935). Consequently, *Dissodactylozoa* probably belongs

to the Pinnothereidae family. Besides, *Pinnozoea* also have been described from other species of the same family. On the other hand, we meet with *Dissodactylozoea* more frequently than we do with *Pinnozoea* among the zoeas collected from nature. From the absence of uniformity in the larval characters, *Dissodactylozoea* probably comprises some other families, none of whose larvae have yet been described. *Dissodactylozoeas* (1) and (2) may belong to the family Pinnothereidae, seeing that it has single endopodite of 2nd maxilla and 2nd maxilliped, while, in addition, the abdomen is similar in construction to that of *Pinnozoea*, whereas it is not certain if *Dissodactylozoea* (2) belongs to the family Pinnothereidae.

15. *Grapsizoea* (5) First stage. Fig. 15.

Characters: all carapacial spines present, 2nd antenna B_3 -type, telson A_1 -type, hair formula 5-1, 2-2 (4), 6-1-1.

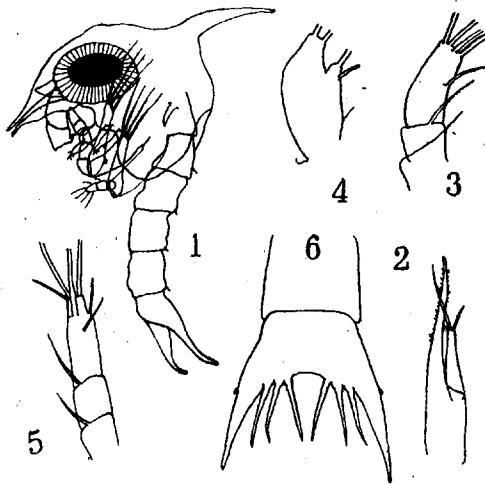


Fig. 15. *Grapsizoea* (5).

1. lateral view $\times 35$, 2nd ant. $\times 106$, 3. enp. 1st mx. $\times 187$, 4. enp. 2nd mx. $\times 187$, 5. enp. 2nd mxp. $\times 187$, 6. telson $\times 62$.

Dorsum 0.34 mm., rostrum 0.24 mm., perpendicular distance between their tips 1.18 mm., lateral spine 0.15 mm., length of carapace 0.69 mm., abdomen 1.11 mm., and telson 0.34 mm.

Dorsum and rostrum short, thick, pointed. Lateral spine also very short. Lower margin of carapace smooth. Second antenna B_3 -type: exopodite attains to $1/2$ the length of peduncle. Peduncle slender, pointed, toothed along both sides. Endopodite of 1st

maxilla has 2 joints; its distal joint bearing 4 hairs on tip and 1 hair laterally, its basal joint only 1 hair. Endopodite of 2nd maxilla bifurcated, both lobes showing 2 hairs each. Exopodites of both maxillipedes have 4 swimming hairs each. Endopodite of 1st maxilliped of 5 joints, its

distal joint bearing 5 hairs on tip. Endopodite of 2nd maxilliped of 3 joints; its distal joint provided with 6 hairs, the other two remaining joints with 1 hair each.

Abdomen consists of 5 somites and telson. Lateral knobs present on 2nd and 3rd somites. Lateral ends of 2nd to 5th somites somewhat projected. Two short dorsal hairs on each somite. Telson A₁-type, having small spinule laterally near base of telson-fork. Telson-fork thick, pointed, smooth. Three pairs of inner spines present. Third spine has 4 or 5 long hairs among the short ones along the inner side. Middle emargination shallow.

Remarks: This zoea may belong to species of the Grapsidae family, especially to species allied with *Hemigrapsus*, although the larvae of this family usually have telson of B-type. In this *Grapsizoea* (5), the lateral spine of telson rather rudimentary, and so small that the telson may be regarded as B-type. Mode of serration on the endopodites has the character of the family Grapsidae.

16. *Grapsizoea* (6) Fifth stage.

Fig. 16.

Characters: only rostral spine present, 2nd antenna B₁-type, telson B-type, hair formula 5-0, 2-2 (4), 6-1-0.

Rostrum 0.26 mm., length of carapace 0.85 mm., abdomen 1.24 mm., and telson 0.38 mm. Rostrum short, pointed. First

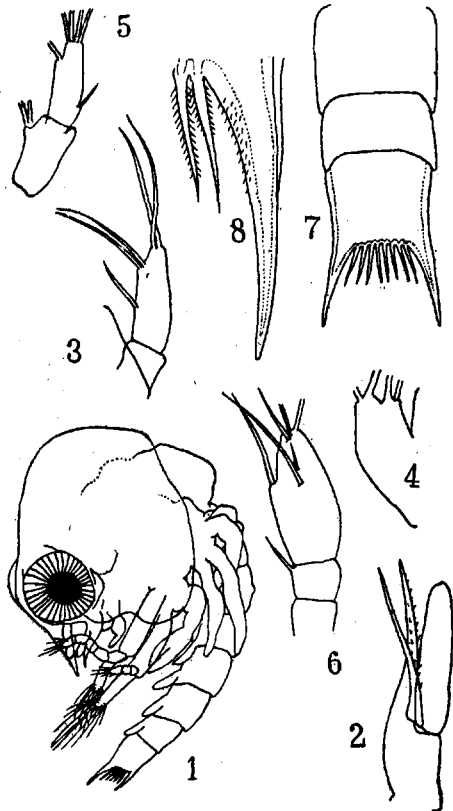


Fig. 16. *Grapsizoea* (6).

1. lateral view $\times 35$, 2. 2nd ant. $\times 187$, 3. enp. 1st mx. $\times 187$, 4. enp. 2nd mx. $\times 187$, 5. enp. 1st. mxp. $\times 187$, 6. enp. 2nd. mxp. $\times 187$, 7. telson $\times 62$, 8, telson-fork, $\times 187$.

antenna robust and bears 7 sensory hairs. Second antenna B₁-type; slender peduncle pointed and toothed on both sides, exopodite nearly equal in length to peduncle, coarsely toothed, while exopodite large, nearly equal to peduncle. Endopodite of 1st maxilla of 2 joints and its distal joint bearing 4 hairs on tip and 1 hair laterally, but basal joint none. Endopodite of both maxillipedes show 10 swimming hairs each. Endopodite of 2nd maxilliped of 3 joints; its distal joint provided with 6 hairs, the 2nd joint with 1 hair, but basal joint with none. Large rudiments of 3rd maxilliped and pereopods present.

Abdomen consists of 6 somites and telson. Lateral knobs only on 2nd somite. Telson B-type, thickly chitinized laterally. Telson-fork thick, pointed, finely haired along its inner side. Four pairs of inner spines present. Middle emargination narrow.

Remarks: From the feature of the 2nd antenna and the mode of serration of endopodites (hair formula), this zoea may belong to the Macrophthalminae subfamily of the Ocypodidae family.

17. *Uca dubia* (*Grapsizoea*, 7) First stage. Fig. 17.

Characters: both rostral and dorsal spines present, 2nd antenna B₂-type, telson B-type, hair formula 4-0, 2-2 (4), 5-0-0.

Dorsum 0.09 mm., rostrum 0.16 mm., perpendicular distance between their tips 0.61 mm., length of carapace 0.45 mm., abdomen 0.86 mm, and telson 0.23 mm.

Both dorsum and rostrum rather short, pointed. Carapace rather large. First antenna of usual type, with 2 aesthetes and 2 hairs on tip. Second antenna B₂-type: exopodite attains to 1/3 the length of peduncle, ending in slender spine, besides showing a hair on tip. Endopodite of 1st maxilla has 2 joints; its distal joint bearing 4 hairs on tip, but basal joint none. Endopodite of 2nd maxilla bifurcated, each lobe showing 2 hairs. Endopodite of 2nd maxilliped of 3 joints, only its distal joint provided with 5 hairs.

Abdomen consists of 5 somites and telson, simple in construction. Telson B-type. Middle emargination shallow. Telson-fork pointed, smooth.

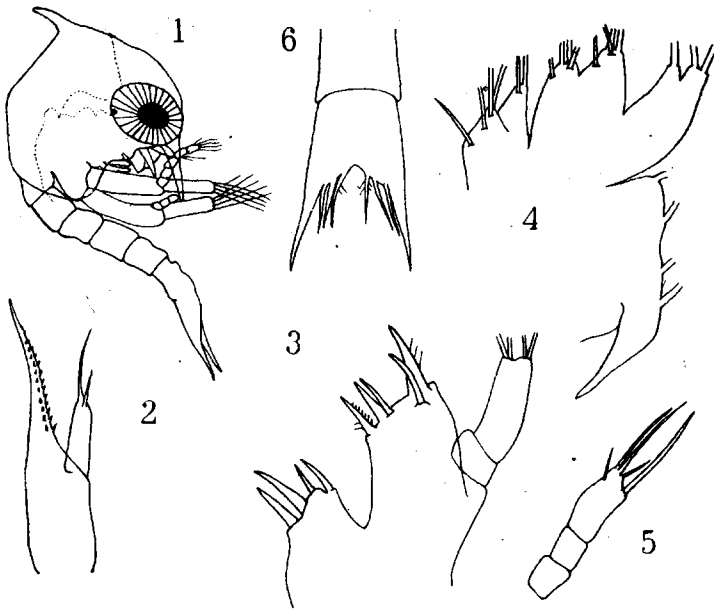


Fig. 17. *Uca dubia* (*Grapsizoela*).

1. lateral view $\times 63$, 2. 2nd ant. $\times 377$, 3. enp. 1st mx. $\times 377$,
 4. enp. 2nd mx. $\times 377$, 5. enp. 2nd mxp. $\times 377$, 6. telson $\times 107$.

Remarks: The zoea were described from *Uca pugnax*, *U. pugilator*, and *U. minax* (O. W. HYMAN, 1920). The zoea of *Uca dubia* is quite similar in construction to these larvae, except the number of hairs on the endopodite of 2nd maxilliped, namely 5 in *Uca dubia*, while it is 4 in the other 3 forms.

II. Occurrence

Zoea. The zoeal community observed in Iwayama Bay in the Palao atoll during the period from May to October, 1940, showed the following composition.

| Species | Early stage | Advanced stage | Percentage frequency |
|-------------------------------------------------|-------------|----------------|----------------------|
| 1. <i>Leucozoea</i> (1) | — | 4 | 0.6 % |
| 2. <i>Leucozoea</i> (2) | — | 2 | 0.3 „ |
| 3. <i>Grapsizoea</i> (1) | — | 1 | 0.1 „ |
| 4. <i>Inachizoea</i> (1) | — | 4 | 0.6 „ |
| 5. <i>Grapsizoea</i> (2) | — | 1 | 0.1 „ |
| 6. <i>Grapsizoea</i> (3) | 63 | 1 | 9.2 „ |
| 7. <i>Trapezia</i> sp. (<i>Grapsizoea</i> , 4) | — | 6 | 0.9 „ |
| 8. <i>Xanthozoea</i> (1) | 21 | 1 | 3.1 „ |
| 9. <i>Xanthozoea</i> (2) | — | 1 | 0.1 „ |
| 10. <i>Xanthozoea</i> (3) | 42 | 5 | 6.7 „ |
| 11. <i>Pinnozoea</i> (1) | — | 9 | 1.3 „ |
| 12. <i>Pinnozoea</i> (2) | 42 | 5 | 6.7 „ |
| 13. <i>Dissodactylozoea</i> (1) | — | 54 | 7.7 „ |
| 14. <i>Dissodactylozoea</i> (2) | — | 10 | 1.4 „ |
| 15. <i>Grapsizoea</i> (5) | — | 1 | 0.1 „ |
| 16. <i>Grapsizoea</i> (6) | 84 | 4 | 12.6 „ |
| 17. <i>Uca dubia</i> (<i>Grapsizoea</i> , 7) | 315 | 3 | 45.8 „ |
| 18. Macruran larvae | 21 | — | 3.0 „ |
| Total | 588 | 110 | 100.0 „ |

Of early larvae, the 1st and 3rd zoeas of *Uca dubia* prevailed, whereas, of developed larvae, *Dissodactylozoea* (1) was most abundant. Zoeas of *Trapezia* sp. were rather scarce.

Appendix

18. Porcellana larva (Family Porcellanidae). Fig. 18.

Characters: long rostral spine and 2 short posterior spines present, 2nd antenna of Anomuran type, telson of Porcellana-type, hair formula 3, 9, 7-3-3-3.

First stage. Fig. 18; 10-3, 5, 11.

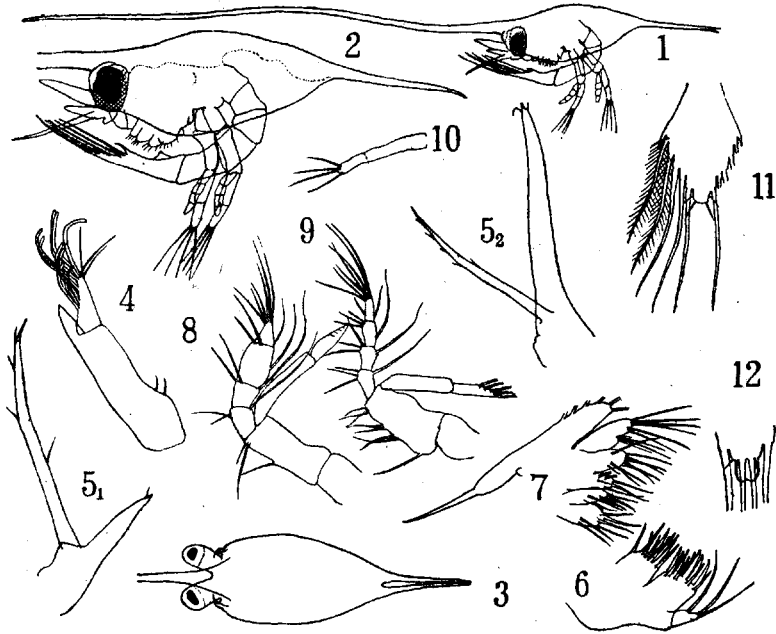


Fig. 18. *Porcellana larva* (Family Porcellanidae) 1st and 4th stages.

1. total view $\times 20$, 2. lateral view $\times 30$, 3. dorsal view $\times 20$, 4. 1st antenna (4th stage) $\times 46$, 5₁. 2nd antenna $\times 65$, 5₂. 2nd antenna (4th stage) $\times 46$, 6. 1st maxilla (4th stage) $\times 65$, 7. 2nd maxilla (4th stage) $\times 65$, 8. 1st maxilliped (4th stage) $\times 36$, 9. 2nd maxilliped (4th stage) $\times 35$, 10. 3rd maxilliped (4th stage) $\times 36$, 11. telson $\times 46$, 12. posterior projection of telson (4th stage) $\times 46$.

Carapace elliptical, greatly resembling *Ethusozoeca*. Rostral spine remarkably long, serrated on its distal part. Carapace ends posteriorly in two short smooth spines. Eye stalked already at this early stage, with small spine near base. First antenna slender, bearing 3 aesthetes and 3 hairs on tip. Second antenna of Anomuran type, consisting of endopodite and exopodite, but lacks peduncle. Endopodite of slender plate bears small tubercle and one fine hair on tip. Exopodite pointed and coarsely serrated. Second antenna, as a whole, resembles much that *Porcellana platycheles*, but differs from those *Porcellana longicornis* and *Petroliithes japonica*.

Both maxillae greatly resemble those of the usual brachyuran larvae. Endopodite of 1st maxilla of single joint, with 2 hairs on tip and 1 on side. Basi- and coxopodidites of 2nd maxilla deeply bifurcated, but endo-

podite simple, having 4 hairs on tip, 2 slightly below them, and, in addition, 3 long and 1 short hairs far below them. Scaphognathite rather narrow.

Exopodites of maxillipedes 2-jointed, with 4 swimming hairs on tip. Endopodites of both maxillipedes 4-jointed. The distal joint of 2nd maxilliped provided with 7 hairs and the remaining 3 joints with 3 hairs each.

Abdomen consists of 5 somites and telson. Telson of usual *Porcellana*-type and provided with 1 stout spine and 5 plumosed hairs along the postero-lateral margin. Posterior corner somewhat quadrate, showing 4 fine hairs.

Fourth stage. Fig. 18; 4, 5₂, 6-10, 12.

General appearance remains unchanged. Rostral spine serrated all over, the 2 posterior spines also coarsely toothed along outer side of its basal part. First antenna segmented, showing 6 aesthetes on side in addition to 3 aesthetes and 3 hairs on tip at 1st stage. Small projection of endopodite also present. Second antenna shows no distinct change in construction from that at 1st stage, except endopodite, which grows longer than exopodite. Mode of serration on both maxillae and 2nd maxilliped also remains unchanged. Third maxilliped and 5 pairs of pereopods well developed.

Posterior quadrate projection of telson has 2 long plumose hairs in addition to previous 4 fine hairs.

Remarks: The *Porcellana* larvae of *Porcella longicornis* (H. C. WILLIAMSON, 1915, Figs. 488-493), *Porcellana platycheles* (do, figs. 494-499), and *Petrolisthes japonica* (H. AIKAWA, 1927) were previously described. The present *Porcellana* larva has also many features in common with the larvae of the three species just mentioned. It differs from the larva *Petrolisthes*, however, in the shorter posterior spines, in the number of plumosed hairs along the postero-lateral margin of telson, and also in the shape of the posterior projection. Second antenna of this larva resembles that of *Porcellana platycheles*, but differs from that of *P. longicornis*. In the ratio of the long rostral spine to the short posterior spines, this larva resembles *P. longicornis* rather than *P. platycheles*. All the spines

of the latter two forms are wholly serrated, while in this larva it is only partially so. Judging from these points, this larva must belong to the Porcellanidae family, probably to *Genus Porcellana* rather than *Genus Petrolisthes*.

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