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Authors

Boden, Brian P
Johnson, Martin W
Brinton, Edward

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**THE EUPHAUSIACEA
(CRUSTACEA)
OF THE NORTH PACIFIC**

BY
BRIAN P. BODEN, MARTIN W. JOHNSON, AND
EDWARD BRINTON

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THE EUPHAUSIACEA (CRUSTACEA) OF THE NORTH PACIFIC

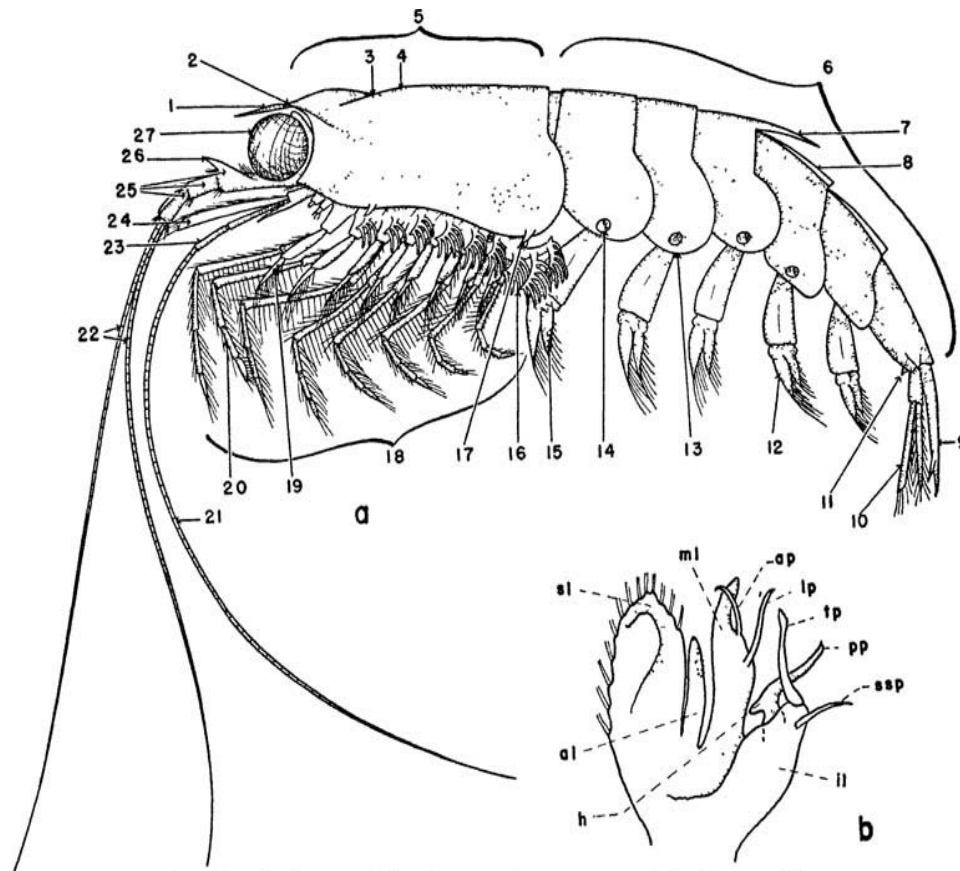
BY

BRIAN P. BODEN, MARTIN W. JOHNSON, AND EDWARD BRINTON

INTRODUCTION

AS A PART of the Marine Life Research Program of the Scripps Institution of Oceanography (a member of the California Coöperative Oceanic Fisheries Investigations) an increased effort is being made to describe and evaluate the various organic factors that are important in the biological economy of the sea.

In attacking the problem, the most expedient procedure is to study in detail the various components of the plankton, for it is well known that these components in varying degrees of importance provide directly the basic food for the



The abbreviations used in the text figures are explained on p. 398.

Fig. 1. Diagram of euphausiid, illustrating terminology. *a*. Habit: (1) rostrum, (2) frontal plate, (3) cervical groove, (4) carapace, (5) cephalothorax, (6) abdomen, (7) dorsal tooth (spine), (8) dorsal keel, (9) telson, (10) uropod, (11) preanal spine of sixth abdominal segment, (12) pleopod, one of 5 pairs, (13) pleuron, (14) luminescent organ, (15) male copulatory organ, (16) gills, (17) lateral denticle (spine), (18) thoracic appendage, (19) exopodite of first thoracic appendage, (20) endopodite (thoracic leg) of second thoracic appendage, (21) flagellum of second antenna, (22) flagella of first antenna, (23) peduncle of second antenna, (24) scale or squama, (25) peduncle of first antenna, (26) lappet on first segment of peduncle, (27) eye. *b*. Male copulatory organ.

plankton-feeding fishes, such as the sardine, and also directly or indirectly for larger but less abundant pelagic fishes, as well as benthonic life.

Among the several groups of zoöplankton organisms that are being studied are the euphausiid shrimp (fig. 1). These highly pelagic crustaceans, popularly known as "krill," occur in large swarms in all oceans in both neritic and oceanic waters. They are considered second in importance only to the copepods as basic animal food in the sea but often exceed the copepods in mass and numbers, especially at greater depths.

The present report deals with the group taxonomically on a wide geographic basis. The chief purpose here is to provide an essential tool with complete descriptions and illustrations to facilitate further study of the biology of the euphausiids and their relation to the pelagic community of the Pacific. Such a study is now under way, and it is believed that application of knowledge of the various species, their geographic ranges, concentrations, and reproductive areas will yield pertinent information relative to the importance of different oceanic currents and water masses in the marine ecology of our coasts.

Among the marine animals that are known to feed upon the euphausiids are especially such fish as the herring and sardine, and also the whalebone whales whose diet is, despite their huge size, almost exclusively plankton. A literature too voluminous to review here bears this out for both the fish and mammals. The catch of baleen whales is remarkably closely correlated with the abundance and swarming of euphausiids in the Atlantic and Antarctic waters (Ruud, 1932). Locally, the California gray whale is known to feed at least in part upon *Euphausia pacifica*, the most common euphausiid off our coast (Howell and Huey, 1930). Similarly, the humpback whales of our coast were found to have fed upon "shrimp." The place of euphausiids in the diet of the California sardine and other local fishes is presently under investigation in connection with the Marine Life Research program.

The euphausiids are food not only to fish and other aquatic animals but to a lesser extent also to sea birds. The euphausiids usually live at depths beyond the range of surface-feeding animals, but during swarming, vast hoards may migrate to the very surface within reach of large flocks of birds. These swarmings may be within restricted areas as in the passages between Passamaquoddy Bay and the Bay of Fundy (Fish and Johnson, 1937). Here *Meganyctiphanes norvegica* and *Thysanoëssa* spp. rise in the turbulent water within reach of sea gulls and other birds.

On the open coast off La Jolla, California, swarms of female *Thysanoëssa spinifera* that had migrated to the upper water layers were swept ashore and stranded upon the beach. In Australian waters "rafts" of *Nyctiphanes australis*, covering an acre in extent, may occur at the surface where they are fed upon by the muttonbird (Sheard, 1953).

Finally, euphausiids may hold a place directly in the diet of man himself. Japanese fishermen sometimes catch vast numbers of these crustaceans, which periodically swarm in the deep bays of Honshu Island.

The niche occupied by the euphausiids in the food chain of the sea requires also a consideration of the food upon which they themselves subsist. Some progress

along this line has been made by various workers. Much remains to be done. Einarsson (1945) reviews briefly pertinent literature which brings evidence to show that the diet of euphausiids consists of both diatoms and microcrustaceans, but chiefly of the phytoplankton diatoms. Floating detritus is also an item of diet, but further study is needed in determining the efficiency of the feeding mechanisms in screening out the very finest particulate organic material known to be present in the sea water.

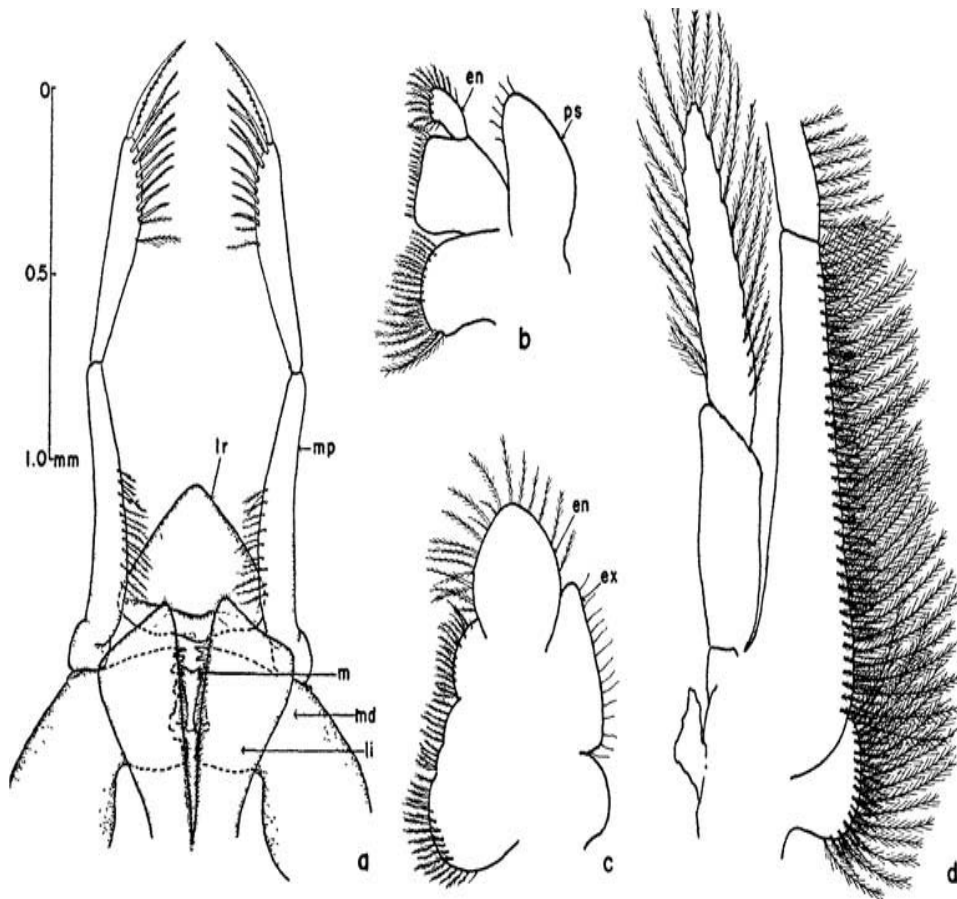


Fig. 2. Feeding structures, *Euphausia pacifica*. a. Anterior-most mouth parts dissected out to show relative position of structures. b. First maxilla. c. Second maxilla. d. Part of first thoracic leg to show setal basket on endopod.

The feeding mechanism of the euphausiids consists of a basket formed by the thoracic appendages, the inner margins of which are provided with long plumose bristles or setae (fig. 2, d). Water is strained through the bristles, and the small organisms and detritus are screened out as the animal swims through the water propelled by the swimming feet (pleopods) on the abdomen. Important also are the mouth parts which are shown in figure 2 for *Euphausia pacifica*.

The mouth parts are situated immediately in front of the thoracic appendages (fig. 1, a, and fig. 2, a-c). From anterior to posterior, they consist of labrum, mandibles (with "teeth" and palps), labia, first maxillae, and second maxillae.

There are no maxillipeds differing from the thoracic appendages (see Terminology).

The first and second maxillae are small, but they are well provided with many rather short setae and spines which are apparently used mainly in holding or transferring food particles to the labia and mandibles.

The active feeding process of euphausiids was not studied but, from consideration

of the structure of the feeding mechanisms, it appears that at least in *Euphausia pacifica* an important nonscreening device is the pair of mandibular palps.

These palps are designed to move the food particles from the basket and maxillae into reach of the labia and mandibles and doubtless to hold larger particles against the mandibles during mastication. The end segment of each palp is provided with a row of strong, curved spines along the posterior edge. In figure 2, *a*, the palps are rotated somewhat toward the mid-line to show the orientation of the spines.

In *Nematoscelis difficilis* the mandibular palps are much shorter and may therefore serve a more restricted function. In the genus the second pair of thoracic legs are enormously elongated, but it is not clear with what feeding function this modification may be associated.

Although much of the food material consists of detrital particles or organisms of very small size, this is only a fraction of the diet. Larger objects such as copepod larvae, and even adults, form a part of the food of *Meganyctiphanes norvegica* (MacDonald, 1927). The well-developed mandibles with chitinized gnathobase attest to this fact. They are each provided with a cutting incisor process and a molar process useful in crushing.

PREVIOUS STUDIES

Heretofore the euphausiids from the west coast of California have received only scant attention. Holmes (1900) included two species of the genus *Thysanoëssa* from the Pacific Coast, and Hansen's (1913b) material included only four species in two genera from California. The most applicable work is that of Esterly (1914*a*, 1914*b*) in which he gave brief accounts of the occurrence, vertical distribution, and movements of eight local species in five genera. His study was, however, confined to the San Diego region. The present work enlarges the area and contains descriptions of fifty-five species belonging to ten genera. This includes all but one (*Meganyctiphanes*) of the known genera and about two-thirds of the known species.

The euphausiids of the northeast Pacific off the coast of Washington northward to Alaska have been studied taxonomically by Banner (1949). His report proves especially useful since it deals with an area contiguous to that of the California Coöperative Oceanic Fisheries Investigations and has an essentially different euphausiid community, eleven species of which are, however, found off the coasts of California and Oregon.

Other publications touching these or adjacent areas include: Sars, 1885; Ortmann, 1905; Hansen, 1912, 1915; Schmitt, 1919; Tattersall, 1933. Since this investigation, Banner (1954) has published a brief report which lists eleven California euphausiids.

SOURCE OF MATERIAL

The material forming the basis of this report was derived mainly from plankton collections made along the west coast of America by the Scripps Institution of Oceanography since 1934, but especially during 1939 to 1941 in collaboration with the U.S. Fish and Wildlife Service and during 1949 to 1954 as a part of the California Coöperative Oceanic Fisheries Investigations involving the following

agencies: Scripps Institution of Oceanography, U.S. Fish and Wildlife Service, California Department of Fish and Game, the California Academy of Sciences, and Hopkins Marine Station. The area covered by routine sampling on these research programs has varied somewhat with season but, including all cruises, it extends

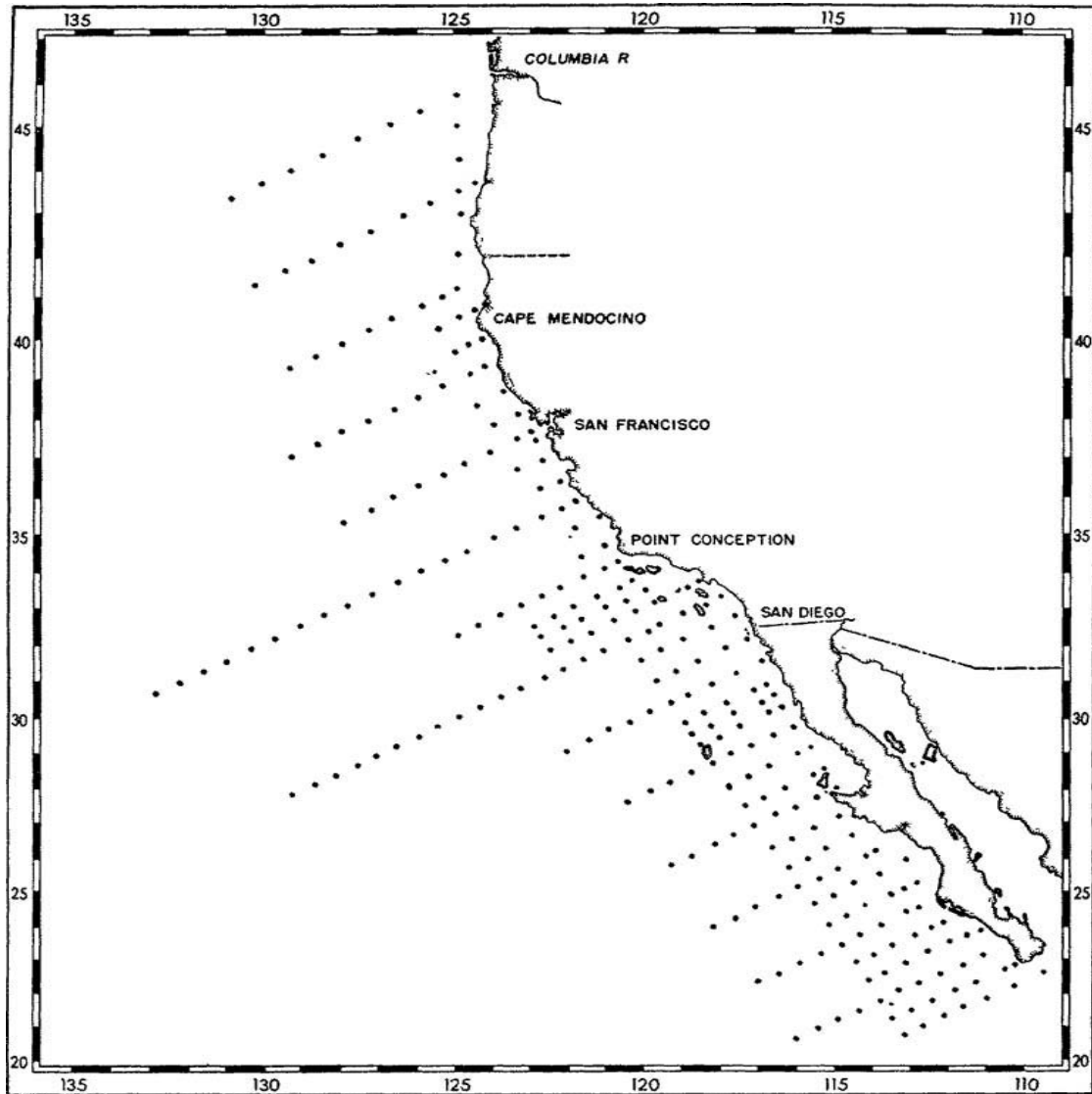


Fig. 3. Station plan for California Coöperative Oceanic Fisheries Investigations.

from the Columbia River southward to below the tip of Lower California, and seaward to 500 miles. The station pattern usually followed is shown in figure 3. In the past five years, cruises have been made simultaneously each month (with few exceptions) with three vessels. The collecting gear routinely used consisted of a one-meter net towed obliquely from depth of 140–0 meters, 400–0 meters, and 700–0 meters. Special hauls have been made with these nets or the Isaacs-Kidd mid-water trawl (Devereux and Winsett, 1953) to depths over 2,000 meters. Thus the seasonal and bathymetric distribution appears to have been adequately sampled over much of the area.

For study of greater geographic range, the material has been derived mainly from special expeditions in coöperation with the U.S. Navy as follows: (1)

“Operation Crossroads” to the North Marshall Islands, 1946; (2) the “Mid-Pacific” expedition, 1950; (3) the “Northern Holiday” expedition, 1951; (4) the “Shellback” expedition, 1952; (5) the “Capricorn” expedition, 1952–53; and (6) the “Transpacific” expedition, 1953. The tracks covered are shown in figure 4.

In discussing the distribution of species it is convenient to refer to large geographic areas of the Pacific Ocean which are analogous to the large “water masses,” as roughly outlined for the equatorial and North Pacific by

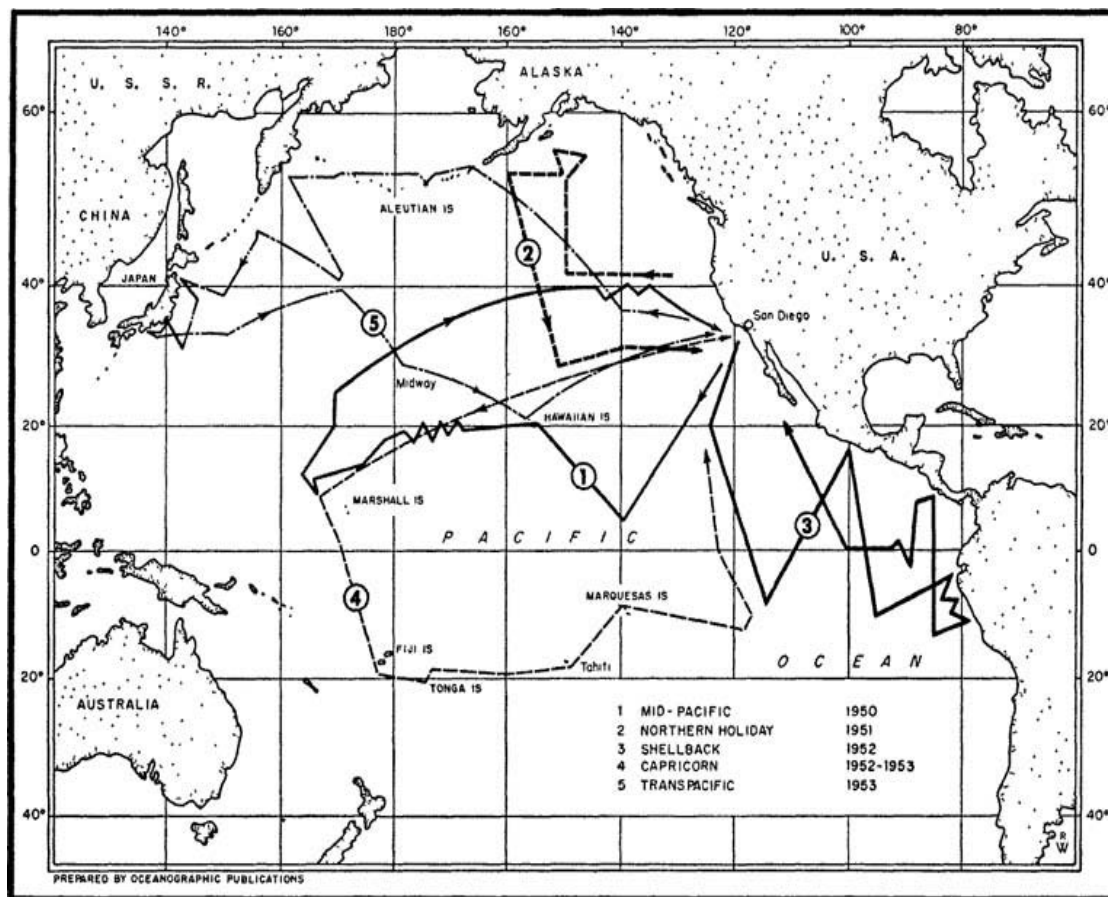


Fig. 4. Track chart of expeditions.

Sverdrup, Johnson, and Fleming (1946). These are as follows: (1) “subarctic,” which includes waters lying mostly north of about 45° N. and bending southward along the North American continent; (2) “central Pacific,” which covers a very large area extending from the subarctic to about 20° N. but does not extend all the way across the Pacific; and (3) “equatorial Pacific,” which extends all the way across the Pacific between about 20° N. and 18° S.

The Marine Life Research cruises referred to are numbered to indicate the year and month of the cruise. The first two digits give the year, the second two the month.

TAXONOMY OF NORTH PACIFIC EUPHAUSIACEA

Owing largely to the work of Hansen (1893) and Calman (1904), the old group Schizopoda is now separated into two orders, the Euphausiacea and the Mysidacea. The Euphausiacea contain two families, the Benth euphausiidae and the Euphausiidae. One of the fifty-one species which occurred in the Scripps Institution collections

has only recently been described, i.e., *Thysanopoda spinicaudata*, Brinton (1953). Descriptions of other species are scattered throughout an extensive literature. Therefore, the descriptions of each species dealt with have been reviewed and integrated here. Where necessary, they have been modified or expanded for clarification. In their synonymy, references have been made only to the most useful previous publications.

TERMINOLOGY

Sars (1885, p. 5) gives a detailed account of the general morphology of the euphausiids; further discussions may be found also in the works of Ortmann (1893, p. 3) and Zimmer (1909, p. 1). Sars's terminology has persisted in the literature and, with few exceptions, has been adopted here. Figure 1 provides a key to the structures and terms used in the taxonomy of the Euphausiacea.

The euphausiid body is readily separable into a larger anterior part—the *cephalothorax*—and a more slender posterior part—the *abdomen* (fig. 1, *a*). The cephalothorax is covered by a carapace, the anterior dorsal part of which is usually triangular, when viewed from above, and is called the *frontal plate*. This may be produced anteriorly, over or between the eyes, as a *rostrum* of variable size and shape, although it is usually acute. Below the *eyes* are the *peduncles* of the first *antennae* (Sars's antennulae), to each of which two *flagella* are attached. The *peduncles* of the *second antennae* carry one *flagellum* each and a *scale* or squama. The mouth-parts are made up of *labrum*, *labia*, *mandibles*, and two pairs of *maxillae* (fig. 2).

The term maxilliped, used by G. O. Sars (1885, p. 67), has been abandoned here, inasmuch as the pair of appendages on the cephalothorax immediately posterior to the maxillae are not used as feeding organs in the usual sense. They are not differentiated from the succeeding pairs, and function with them in screening out small organisms and fine organic material. There are, then, eight pairs of *thoracic appendages*. This is consistent with the terminology of most modern workers who also refer to the endopodites of these appendages, which are usually long as compared with their exopodites, as *thoracic legs*.

Holt and Tattersall (1905, p. 101) discarded the term maxilliped and spoke of all of the thoracic appendages as thoracic limbs, and of their endopodites as legs. Zimmer (1909, p. 2) and Dakin and Colefax (1940, p. 136) have used the term "cormopod" in the same sense that "thoracic appendage" is presently employed. The endopodites are divided into coxal, basal, ischial, meral, carpal, propodal, and dactyl, or terminal, segments. A gill is attached to the outer side of each coxal joint which is common to both exopodite and endopodite of a given leg.

The abdominal segments may carry, dorsally, a *median keel*, which may or may not be extended in a posterior direction as a *dorsal tooth* or *process*. Laterally, the edges of the abdominal segments project as *pleura*.

The appendages of the first five abdominal segments are referred to as *pleopods*. The male copulatory organs are modifications of the endopodite of the first and second pleopods. They are of considerable taxonomic importance. In most of the illustrations in this paper, only the diagnostic characters are featured. The various parts of a typical copulatory organ are shown in figure 1, *b*. The sixth abdominal

segment terminates in the *telson*, which bears a biramous *uropod* on either side.

The length given for each of the described species is the measurement from the tip of the rostrum to the tip of the telson.

Certain of the figures presented herein also illustrate identical species reported from South Africa (Boden, 1954).

FAMILY BENTHEUPHAUSIIDAE Colosi, 1917

The endopodites of the first and second pairs of pleopods of the male are not transformed into copulatory organs, but the base of the first pair carries one to six spines. The endopodite of the first maxilla is two-jointed and that of the second is three-jointed. There is a transverse suture on the outer plates of the uropods at a point about one-quarter the distance from the distal end. There are no luminescent organs. The eyes are imperfectly developed. All eight thoracic legs are well developed.

BENTHEUPHAUSIA G. O. Sars

Bentheuphausia G. O. Sars, 1885: 108–109.

Generic characters.—The eyes are poorly developed. The peduncles of the first antennae are short and robust, but the flagella are extremely long. The eight thoracic legs are all well developed. The genus lacks luminescent organs. The pleopods of the male are not modified as copulatory organs.

There is only one species in the entire family.

Bentheuphausia amblyops G. O. Sars

(Fig. 5, *a* and *b*)

Thysanopoda (?) *amblyops* G. O. Sars, 1883: 23; *Bentheuphausia amblyops* G. O. Sars, 1885: 109–114, text fig. 4, pl. 19; Einarsson, 1942: 283–285, text figs.

Diagnosis.—The two distal segments of the first antennal peduncle are a little thicker in the male than in the female and the third segment is a trifle shorter in the male. The basal segments are similar in both sexes. The basal segment of the first antennal flagellum is longer in the male than in the female and it bears numerous rows of sensory hairs which are separated longitudinally by a hairless zone. There are fewer rows of hairs in the female, and they are carried only on the upper side of the flagellum.

The carapace carries no lateral denticles on its inferior margin but the posterolateral margin is slightly serrated in young specimens.

Length.—Males and females up to 50 mm.; commonly 25–30 mm.

Distribution.—North Pacific. This species was caught northward to 48° 58.3' N., 157° 49.8' W., off Alaska, by the "Northern Holiday" expedition. It is reported from 53° 34' N., 136° 26' W., off British Columbia (Banner, 1949), but has not been taken in the Gulf of Alaska. The only record in the Bering Sea is east of the Komandorski (Commander) Islands at 53° 56' N., 171° 08' E. ("Transpacific" expedition). It was taken south of these islands at 47° 35.7' N., 167° 44.8' W., and at five stations off the east coast of Japan. It has been found in deep water off the California and Baja California coast, and in the basins of the southern California Continental Borderland.

Equatorial Pacific. *B. amblyops* is recorded from the western Pacific near the East Indian Archipelago (Hansen, 1910), from the equatorial mid-Pacific ("Mid-Pacific" expedition; "Capricorn" expedition), and from the eastern region explored by the "Shellback" expedition, as far east as $04^{\circ} 04' S.$, $82^{\circ} 14' W.$ off Ecuador and $14^{\circ} 01' S.$, $81^{\circ} 48' W.$ off Peru.

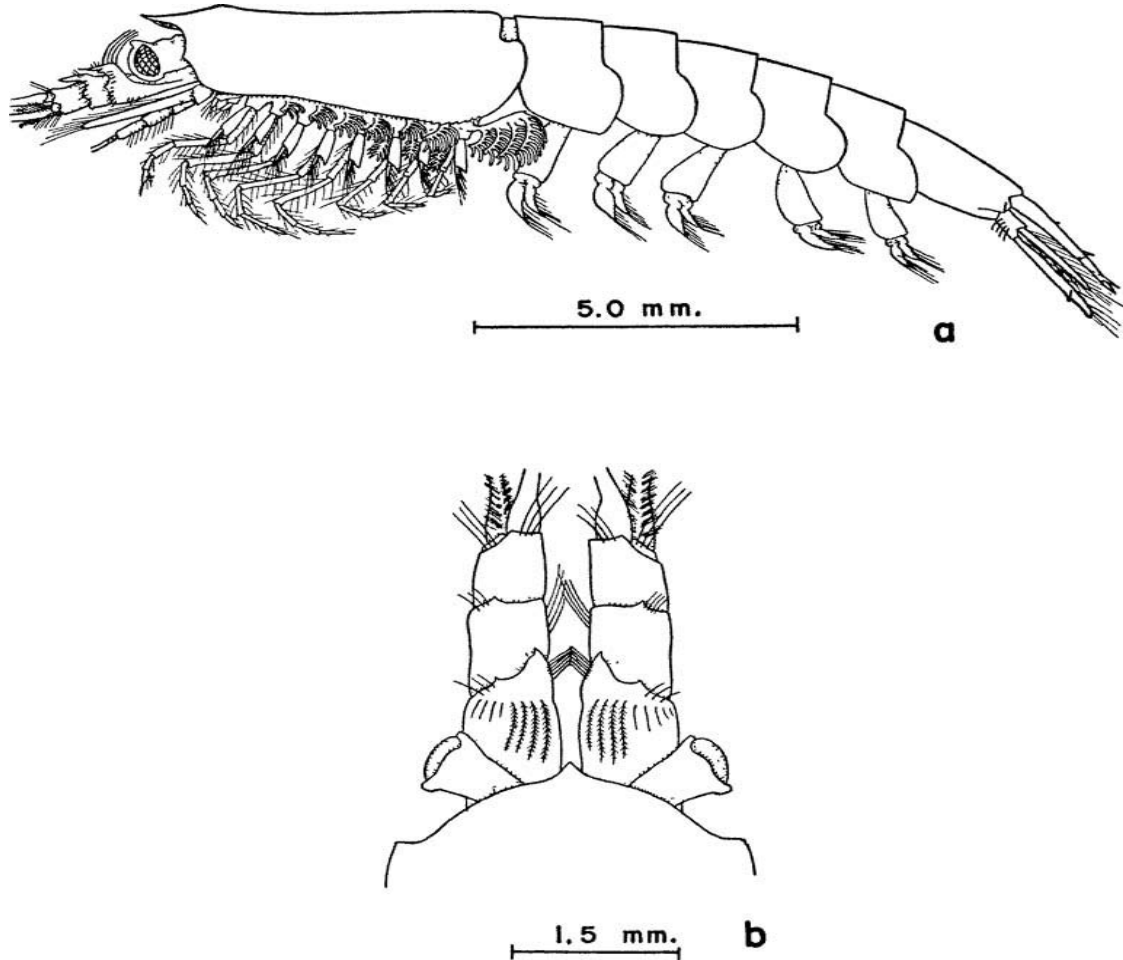


Fig. 5. *Bentheuphausia amblyops* G. O. Sars. *a.* Young male (17 mm.). *b.* Front part of carapace and first antennal peduncles from above.

South Pacific. The most southern record from the eastern Pacific is $20^{\circ} 2.4' S.$, $91^{\circ} 52.5' W.$ (Hansen, 1912). From the southwestern Pacific, Sars (1885) records Willemoes-Suhm's specimen from $50^{\circ} 01' S.$, $123^{\circ} 04' E.$, off South Australia.

Elsewhere. This species occurs also in the Indian Ocean and the Atlantic.

Depth.—Adults and larvae, below 600 meters.

FAMILY EUPHAUSIIDAE Holt and Tattersall, 1905

(Partly from Esterly, 1914a: 2-3)

The gills are not covered by the carapace. There are two subapical spines anterior to the tip of the telson. The inferior margin of the carapace is smooth or carries

one or two small denticles. The seventh and eighth thoracic legs (particularly the eighth) are nearly always more or less reduced. The second to eighth thoracic legs carry gills which are retained on the last pair irrespective of the amount of reduction undergone by these appendages. The gills on the anterior thoracic legs have but one main branch, whereas the posterior ones have several. The pleopods, well developed in both sexes, serve as swimming feet, and the inner rami of the first and second pairs function in the males as copulatory organs. These structures are of great systematic importance, and Hansen (1911) gives detailed accounts of them (see also fig. 9). Lens-shaped luminescent organs are normally found, one on each eyestalk, a pair on the base of the second and seventh thoracic appendages and one under each of the first four segments of the abdomen.

KEY TO NORTH PACIFIC GENERA OF THE EUPHAUSIIDAE

(Altered from Sars, 1885)

- 1a Thoracic legs nearly uniform in structure (fig. 1)
- 2a Eighth pair rudimentary (fig. 6)
- 3a Seventh pair of same appearance as preceding (fig. 6)
Thysanopoda Milne-Edwards, p. 297
- 3b Seventh pair with distal three segments of endopod confluent (fig. 18)
Nyotiphanes G. O. Sars, p. 317
- 2b Seventh and eighth pairs quite rudimentary
- 4a Distal three segments of sixth thoracic leg greatly reduced *Pseud-
uphausia* Hansen, p. 320
- 4b Sixth thoracic leg similar in appearance to fifth.....*Euphausia* Dana,
p. 322
- 1b Thoracic legs unequally developed, one or two of the anterior pairs being
greatly elongate (fig.32)
- First and second pair of thoracic legs greatly produced (fig. 40)
Tessarabrachion Hansen, p. 361
- 5b Second pair of thoracic legs greatly produced
- 6a Second pair of thoracic legs rather strong, the last two segments armed
with spiniform bristles on both margins (fig. 34).....*Thysanoëssa* Brandt,
p. 349
- 6b Second pair of thoracic legs very slender, filiform, naked, with only a
tuft of apical bristles (fig. 41).....*Nematoscelis* G. O. Sars, p. 363
- 5c Third pair of thoracic legs greatly produced
- 7a Third pair of thoracic legs slender, naked, with tuft of serrated apical
bristles (fig. 45)*Nematobrachion* Calman, p. 373
- 7b Third pair of thoracic legs with penultimate segment dilated, and
forming, together with the last one, a kind of prehensile hand (fig. 48)
Stylocheiron G. O. Sars, p. 379

THYSANOPODA Milne-Edwards

Thysanopoda Milne-Edwards, 1830: 454; *Parathysanopoda* Illig, 1909 (*vide* Hansen, 1911).

Generic, characters.—The shape of the rostrum varies. The carapace may or may not have a cervical groove. The eyes are not constricted in the adults and are sometimes rather reduced in size. The first and second antennal flagella are greatly elongate. The exopod of the maxilla is very small. The first seven thoracic legs are uniform except in two regards: the terminal segments of the first two are somewhat shorter and more setose than those of the following appendages; the seventh thoracic leg is considerably shorter than the preceding ones. The endopodite of the eighth thoracic appendage is greatly reduced, but the exopodite is

normal. The posterior gills are arborescent and complex in structure. The male copulatory organs differ greatly according to species.

Of the fourteen species recognized in this genus, eleven are known from the region covered by this survey.

Four of the species which have been described in this genus can be grouped into two pairs. The two species in a given pair are very similar except that one of them possesses the spine-shaped process on the male copulatory organ (fig. 1, *b*), whereas the other species does not. *Thysanopoda microphthalma* Sars, 1885, which is widespread in the Indian Ocean and the Atlantic, differs from *T. spinula* MacDonald, 1929, in that the former species possesses spine-shaped processes. *T. spinula* was taken at two stations in the North Atlantic, in the same area from which *T. microphthalma* is known.

T. johnstoni Sheard, 1942, has been taken at three stations off southeastern Australia. It bears no spine-shaped processes and is closely allied to *T. acutifrons*, which has the process. *T. acutifrons* is well known in the North Atlantic; it is now known to occur in the North Pacific, and has been reported from *Dana* material taken near southeastern Australia (Einarsson, 1945). Sheard suggests that the *Dana* specimens may actually belong to *T. johnstoni*.

T. aequalis Hansen, 1956, and *T. subaequalis* Boden, 1954, also differ in that the former has been described as having no spine-shaped processes. Minor differences in the first antennal peduncle were noted, but none of these is outside the range of normal variation. *T. subaequalis* was thus established mainly on the presence of the spine-shaped process. Only a few specimens were taken from the Straits of Mozambique.

During the present survey, a number of specimens with the spine-shaped process have been noted. These have been indistinguishable from *T. aequalis* on grounds of other morphological characters or distribution. One specimen, taken near Japan, bore a spine-shaped process on the right copulatory organ but not on the left one.

The presence of a spine-shaped process is therefore a variable character of *T. aequalis* and cannot be used to separate this species from *T. subaequalis*. When this paper went to press it was our opinion that *T. subaequalis* should be canceled. A critical examination of further material, however, has revealed that the species can be separated on grounds of other morphological characters (e.g., a spinelike modification of the end segments of the third thoracic legs of the adult male) and distribution, and *T. subaequalis* is at present retained as a valid species. The description in Boden, 1954, will be modified in a subsequent paper.

It may be added in this connection that within the genus *Euphausia*, which is defined as lacking the spine-shaped process, Hansen (1912) incidentally remarks that a specimen of *E. lucens* Hansen was encountered which had the spine-shaped process "developed in the normal way."

KEY TO SPECIES OF THYSANOPODA

- 1a Carapace without a distinct cervical groove; sixth abdominal segment longer than fifth
- 2a Lateral denticle(s) present on inferior margin of carapace
- 3a One or more abdominal segments armed with dorsal spine
- 4a Dorsal spine on third abdominal segment only; fourth and fifth slightly produced;

- no spine at base of rostrum; single lateral denticle on carapace.....*monacantha*
- 4b Dorsal spine on fourth and fifth abdominal segments only; sixth abdominal segment only slightly longer than fifth.....*cristata*
- 4c Dorsal spines on third, fourth, fifth, and sixth abdominal segments; spine at base of rostrum; two lateral denticles on carapace.....*tricuspidata*
- 3b Abdominal segments without dorsal spines
- 5a Lappet at distal end of basal segment of first antennal peduncle produced beyond mid-point of second segment, and flares laterally and outward, covering upper, outer part of second segment.....*aequalis*
- 5b Lappet at distal end of basal segment of first antennal peduncle not produced as far as mid-point of second segment.....*obtusifrons*
- 2b No lateral denticle on inferior margin of carapace
- 6a Superior distal margin of lappet on basal segment of first antennal peduncle pectinate.....*pectinata*
- 6b Superior distal margin of lappet on basal segment of first antennal peduncle nonpectinate
- 7a Dorsal posterior margin of fourth and fifth abdominal segments very slightly acuminate; length of adult 23–38 mm.....*orientalis*
- 7b Dorsal posterior margin of fourth and fifth abdominal segments non-acuminate; length of adult 35–50 mm.....*acutifrons*
- 1b Carapace with well-developed cervical groove; sixth abdominal segment shorter than fifth
- 8a No heavy spines on each side of sixth abdominal segment
- 9a Small, vertical, conical process in center of frontal margin of carapace*cornuta*
- 9b No small conical process in center of frontal margin of carapace*egregia*
- 8b Heavy spine on each side of sixth abdominal segment.....*spinicaudata*

Thysanopoda monacantha Ortmann

(Fig. 6, a and b)

Thysanopoda monacantha Ortmann, 1893: 9, taf. 1, fig. 2; *T. agassizi* Ortmann, 1894: 99, 1 pl., figs. 1 and 2; Hansen, 1910: 87, pl. 13, fig. 3, a–g; *T. lateralis* Hansen, 1905a; 18–19, text figs. 14–16; *T. ctenophora* Illig, 1908: 112.

Diagnosis.—There is a triangular lobe on the upper distal margin of the basal segment of the first antennal peduncle. The base of this triangle is about half as wide as the segment and its apex extends as a spine-shaped process beyond the middle of the second segment. The lobe is setose. A spine-shaped process of the first antennal peduncle extends from the outer distal angle of the second segment to about the middle of the third segment (fig. 6). The third segment carries a high keel on its inner, upper surface.

There is a longitudinal furrow in the carapace just above the lateral margin, and a denticle at the posterior end of the lateral margin.

The third abdominal segment carries a dorsal spine, but the fourth and fifth are only slightly acuminate.

Length.—25–32 mm.

Remarks.—*Thysanopoda mansiu* Marukawa, 1928, may be the same as *T. monacantha*. The shape of the rostrum and the presence of abdominal spines agree with this species, but the figures of the copulatory organ, and the antennal peduncle of *T. mansiu*, together with the description, are not sufficiently detailed to assure its identity with *T. monacantha*.

Distribution.—North Pacific. This euphausiid occurs throughout the central Pacific. Its most northern record in the eastern Pacific is $37^{\circ} 28' N.$, $154^{\circ} 12' W.$ (“Northern Holiday” expedition). Its range extends to within 350–400 miles of the coast of California, between $35^{\circ} N.$ and $36^{\circ} N.$, and occasionally reaches to within 150

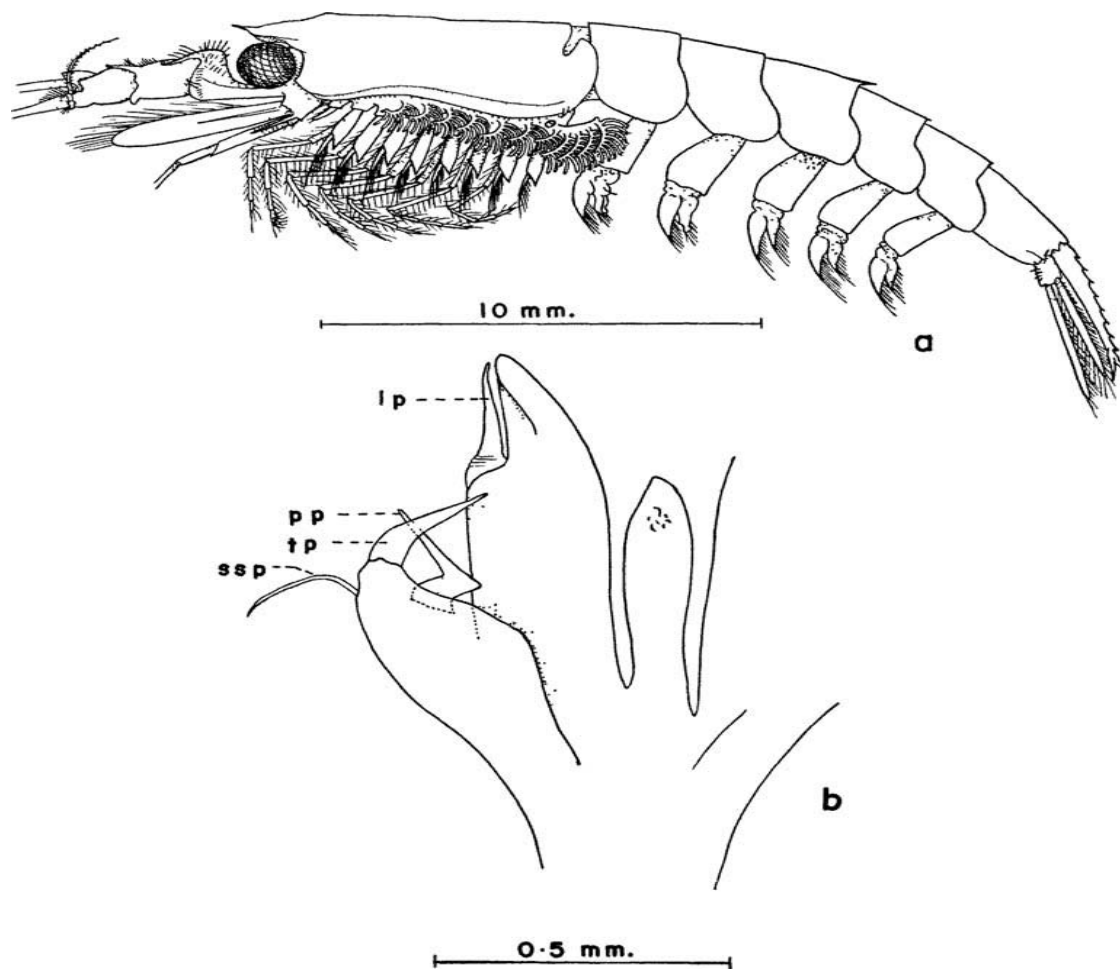


Fig. 6. *Thysanopoda monacantha* Ortmann. *a.* Adult male. *b.* Male left copulatory organ, unrolled and seen from behind, letters as in fig. 1, *b.*

miles of the southern California coast between $28^{\circ} N.$ and $32^{\circ} N.$ Its range reached north to $34^{\circ} 21.5' N.$, $138^{\circ} 40.5' E.$ near the coast of southeastern Japan, and to $35^{\circ} 36.8' N.$, $172^{\circ} 43.7' E.$ in the western central Pacific (“Transpacific” expedition).

Equatorial Pacific. *T. monacantha* is present in the equatorial mid-Pacific and occurs at most stations south of $10^{\circ} N.$ in the eastern region explored by the “Shellback” expedition. It was found eastward to the Gulf of Panama, where

Ortmann's type specimen was taken. It was missing from hauls taken in the Peru Current and in its extension into the South Equatorial Current, between 5° N. and the equator, westward to 125° W. It was caught south of Luzon in the Philippines (Hansen, 1916).

South Pacific. This species occurs throughout the southeastern central Pacific as far east as 14° 33' S., 84° 05.5' W. ("Shellback" expedition) and as far south as 21° 36.2' S., 94° 56' W.

Elsewhere. *T. monacantha* also occurs in the tropical and temperate waters of the Indian Ocean and the Atlantic.

Depth.—Adults, below 400 meters; larvae, frequently above 150 meters.

Thysanopoda cristata G. O. Sars

(Fig. 7, *a* and *b*)

Thysanopoda cristata G. O. Sars, 1883: 22; G. O. Sars, 1885: 104–106, pl. 18, figs. 15–20; *T. biproducta* Ortmann, 1893: 8, taf. 1, fig. 1.

Diagnosis.—The frontal plate is long with concave lateral margins. The rostrum is fairly short and slender and the base is narrower than the frontal plate. The frontal plate carries a median dorsal keel which ends in front in a sharp point below which the anterior margin is concave. This keel extends backward, is abruptly higher over the dorsal organ and rounds downward posteriorly. There are two oblique, short depressions on each side of the carapace and a longitudinal groove above its lateral margin. The carapace is armed with a denticle near the posterior end of the lateral margin.

The upper anterior margin of the basal segment of the first antennal peduncle is raised as a high, vaulted hood over the proximal end of the second segment. The second segment is also somewhat vaulted distally and its anterior margin is produced on the inner side as a triangular acute lobe. The third segment lacks a keel, but in addition to the flagella it carries a strong spine distally.

Both the fourth and fifth abdominal segments possess a mid-dorsal, posterior spine. The sixth abdominal segment is nearly as short as the fifth. There are seven pairs of dorsal spines on the telson.

The spine-shaped process of the male copulatory organ (fig. 7) is almost straight. The terminal process is curved at the middle with the convex margin outward. The flattened end of the process is a little widened and subacute. The proximal process is considerably longer than the terminal. It is slender and sinuate and tapers to a flattened, somewhat obtuse end. The median lobe carries a lamella which is bent inward and protects the lateral process. This process is long, tapered, and strongly curved. The additional process (not visible in the figure), situated at the base of the lamella, is short and thick and tapers suddenly to an acute, curved end.

Length.—38–48 mm.

Distribution.—Equatorial Pacific. *T. cristata* was caught at 14° 20' N., 149° 50' W. ("Midpacific" expedition), at 21° 42' N., 156° 19' W. ("Transpacific" expedition), and at 00° 04' N., 169° 00' E. and at 20° 29.5' S., 178° 21.8' E. ("Capricorn" expedition). It was taken in the Celebes Sea by the *Challenger*

(Sars, 1885), and at three stations in the eastern equatorial Pacific by the *Albatross*, the most southern and eastern record being $21^{\circ} 39.5' S.$, $104^{\circ} 29.8' W.$ (Hansen, 1912).

Elsewhere. This species occurs also in the tropical western Atlantic.

Depth.—Adults and juveniles, below 400 meters.

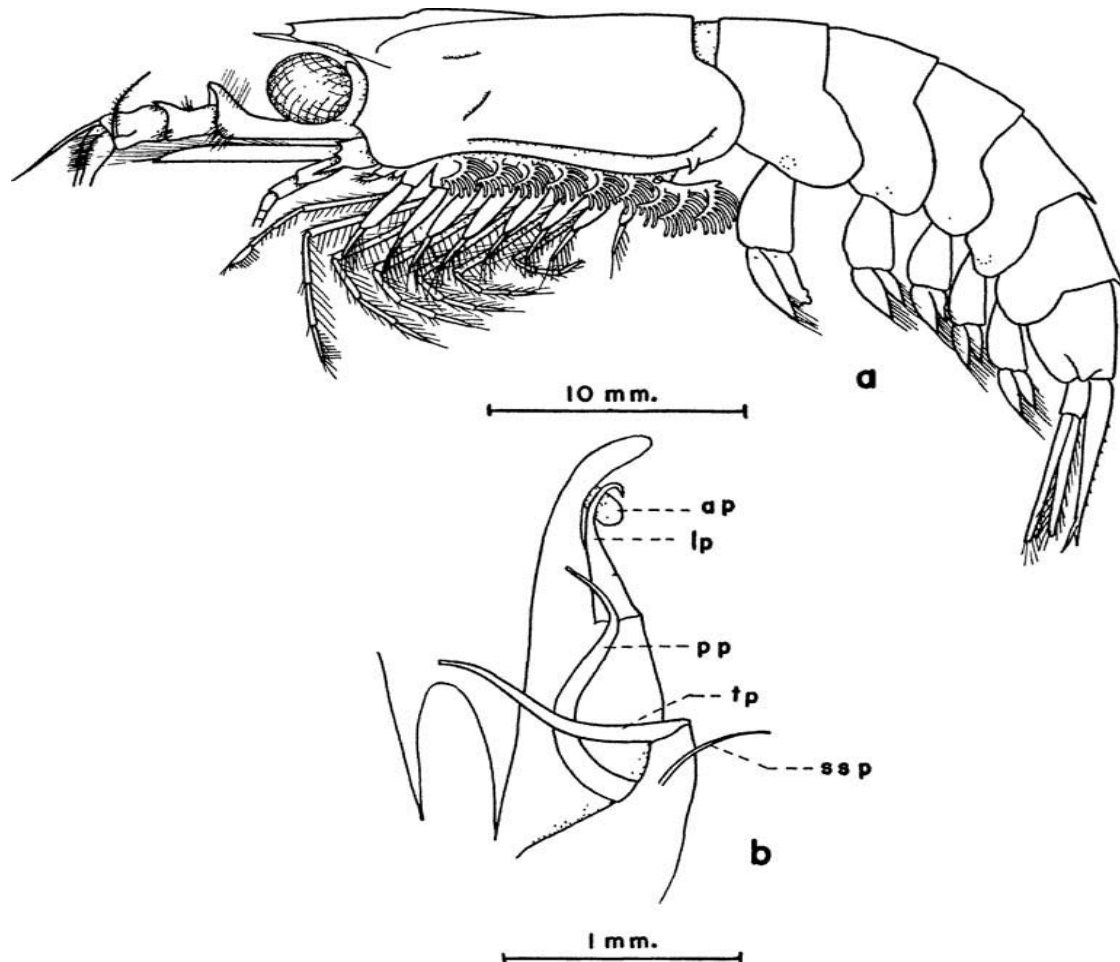


Fig. 7. *Thysanopoda cristata* G. O. Sars. a. Adult male. b. Male copulatory organ from behind.

Thysanopoda tricuspidata Milne-Edwards

(Fig. 8, a and b)

Thysanopoda tricuspide Milne-Edwards, 1830: 454, pl. 19; *Thysanopoda tricuspidata* Milne-Edwards, 1837: 466, pl. 26, figs. 1–6; G. O. Sars, 1885: 98–102, 165–169, pls. 17, 31, figs. 1–22; Hansen, 1910: 82–84, pl. 12, fig. 3, a and b; 1912: 208, pl. 4, fig. 2, a.

Diagnosis.—The distal margin of the basal segment of the first antennal peduncle is produced as a spine-shaped process above and as a small tooth from the

outer angle. The second segment is also armed with a sharp process on its upper distal margin. The third segment lacks a keel.

The frontal plate is produced as a long, sharp rostrum. A long, flattened, forward-pointing spine proceeds forward from the gastric area, on top of the carapace. There are two denticles on the lateral margins of the carapace.

The third, fourth, fifth, and sixth abdominal segments are armed with dorsal spines. There are denticles on the pleura, especially of the first segment.

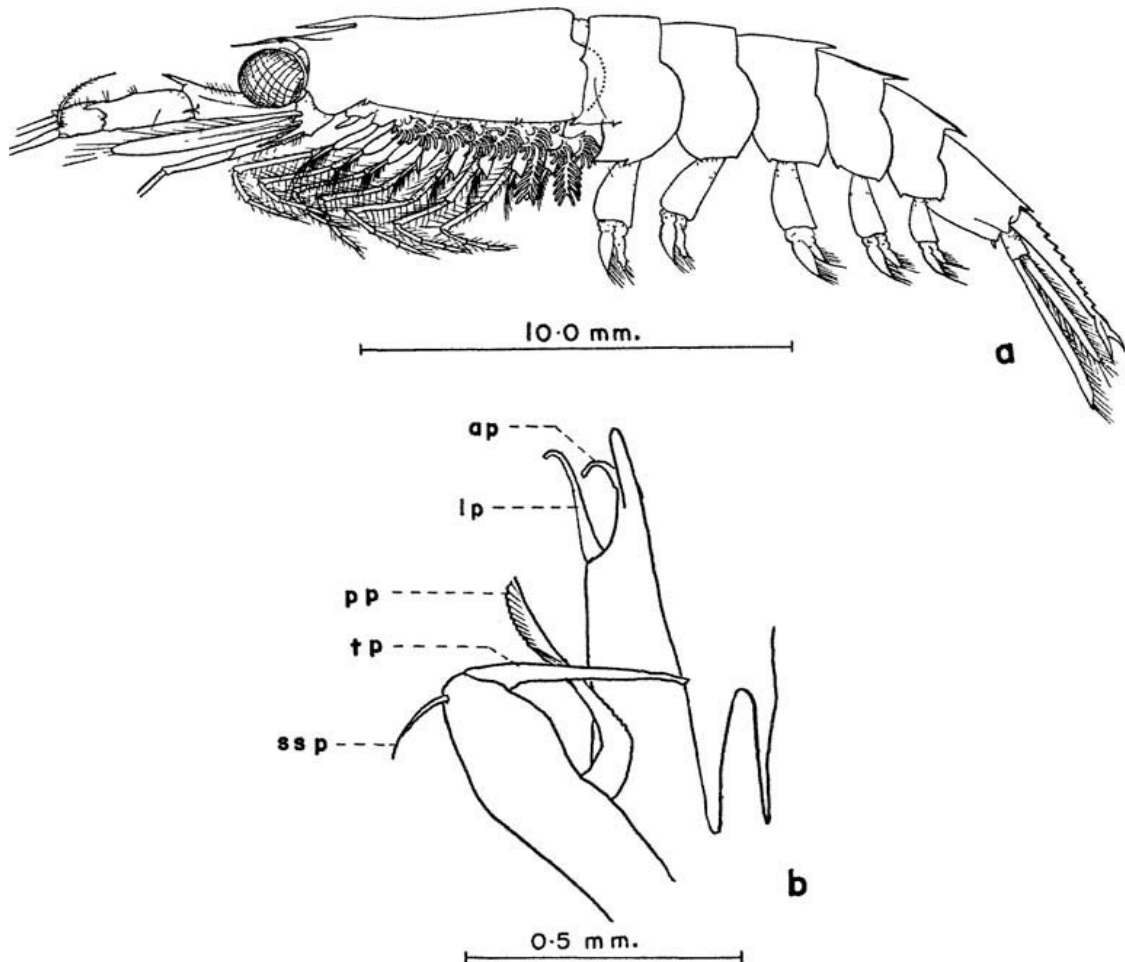


Fig. 8. *Thysanopoda tricuspadata* Milne-Edwards. *a.* Adult male. *b.* Male left Copulatory organ, unrolled and seen from behind.

The spine-shaped process of the male copulatory organ is slender and curved. The terminal process is directed upward. It is long, slightly curved, and has an expanded end. The distal end of the proximal process is expanded and has a straight outer margin and a convex, crenulated, inner margin. The lateral process is slender and long and curves to a blunt end. The additional process is strongly curved and also has a blunt end.

Length.—15–22 mm.

Distribution.—North Pacific. This essentially equatorial species was found north to $36^{\circ} 23.2' N.$, $145^{\circ} 30.4' E.$ off the east coast of Honshu Island and was

consistently present off southeastern Japan. It was found at most stations in the western central Pacific south of 36° N. ("Transpacific" expedition), but it has not been taken in the eastern central Pacific north of the latitude of Hawaii.

Equatorial Pacific. In the South China Sea this species reaches northward to at least 21° 31' N., 117° 53' E. (Hansen, 1916). It is present throughout the western equatorial Pacific, including the East Indian Archipelago (Hansen, 1910), and larvae have been taken from the lagoon of the Great Barrier Reef of Australia (Tattersall, 1939). The range of *T. tricuspidata* is not known to extend west of 140° W., north of the equator, except as two tongues penetrating westward to 05° 03.5' N., 102° 32.5' W. and to 00° 01.5' S., 99° 08.5' W., respectively ("Shellback" expedition). This species was caught as far south as 17° 36' S., 122° 35.6' W., and as far east as 15° 5.3' S., 99° 19' W. by the *Albatross* (Hansen, 1912).

Elsewhere. This species is also found in the tropical waters of the Indian Ocean and the Atlantic.

Depth.—Adults, 200–1,000 meters; larvae, above 200 meters.

Thysanopoda aequalis Hansen

(Fig. 9, *a-d*)

Thysanopoda aequalis Hansen, 1905*b*: 18–20; 1910: 84–85, pl. 12, fig. 4, *a-c*, pl. 13, fig. 1, *a*; 1912: 214, pl. 4, fig. 4, *a*.

Diagnosis.—The anterior part of the carapace projects forward as a trough, from the posterior end of which a low keel extends backward. The two sides of the trough extend backward beyond the anterior insertion of the keel. The thick anterior part of the carapace does not extend to the forward margin of the eyes. The small eyes are dark brown to black. On the carapace, somewhat behind the middle, lateral denticles are well developed.

The peduncles of the first antennae are very peculiarly shaped. There is a large lobe at the distal end of the basal segment (fig. 9). This lobe is directed first upward and backward and then flaps forward over the proximal end of the second peduncular segment. The posterior margin of the lobe, seen from above, is strongly convex. That part of the lobe which flaps over the second segment forms a rather flat plate, which is as wide at its forward margin as the entire breadth of the second segment. The outer distal part is very acutely triangular and is directed forward and downward reaching to or beyond the mid-point of the second peduncular segment. On the outer distal margin of the first peduncular segment proper, excluding the lobe, is an acute forward-projecting tooth. The lobe itself is setose on its upper surface, and rows of setae occur on parts of the free edge. The setae on the forward part are considerably shorter than those on the posterior, vaulted part. The dorsal surface of the rest of the first segment is hollowed out and the outer margin bulges somewhat. The outer distal margin of the second segment has a sharp edge but is nowhere produced as a tooth. The inner distal margin covers part of the proximal margin of the third segment.

The pleura of the abdominal segments have small emarginations. There are no keels or spines on the dorsal surface of any of these segments.

The inner lobe of the copulatory organ of the male sometimes lacks the spine-shaped process. The long and slender terminal process is feebly bent twice in opposite directions and tapers gradually to a fairly acute end. The proximal process is longer than the terminal. The basal part is thick and strong; the remainder tapers considerably to an acute point, and the whole is conspicuously bent. The median lobe is broad, proximally, nearly to the middle. It is then much narrower and terminates in a long triangle. At the junction of the broad and narrow parts the lateral process is inserted. This reaches not quite to the end of the median lobe, is thick at the base, narrows suddenly and tapers to an acute, strongly curved end. The additional process is long, strong, very curved, and acute. The auxiliary lobe is well developed. The setiferous lobe is a little longer than the median, has a pronounced pouchlike protuberance on its posterior surface, and is setose along almost the entire length of the outer margin.

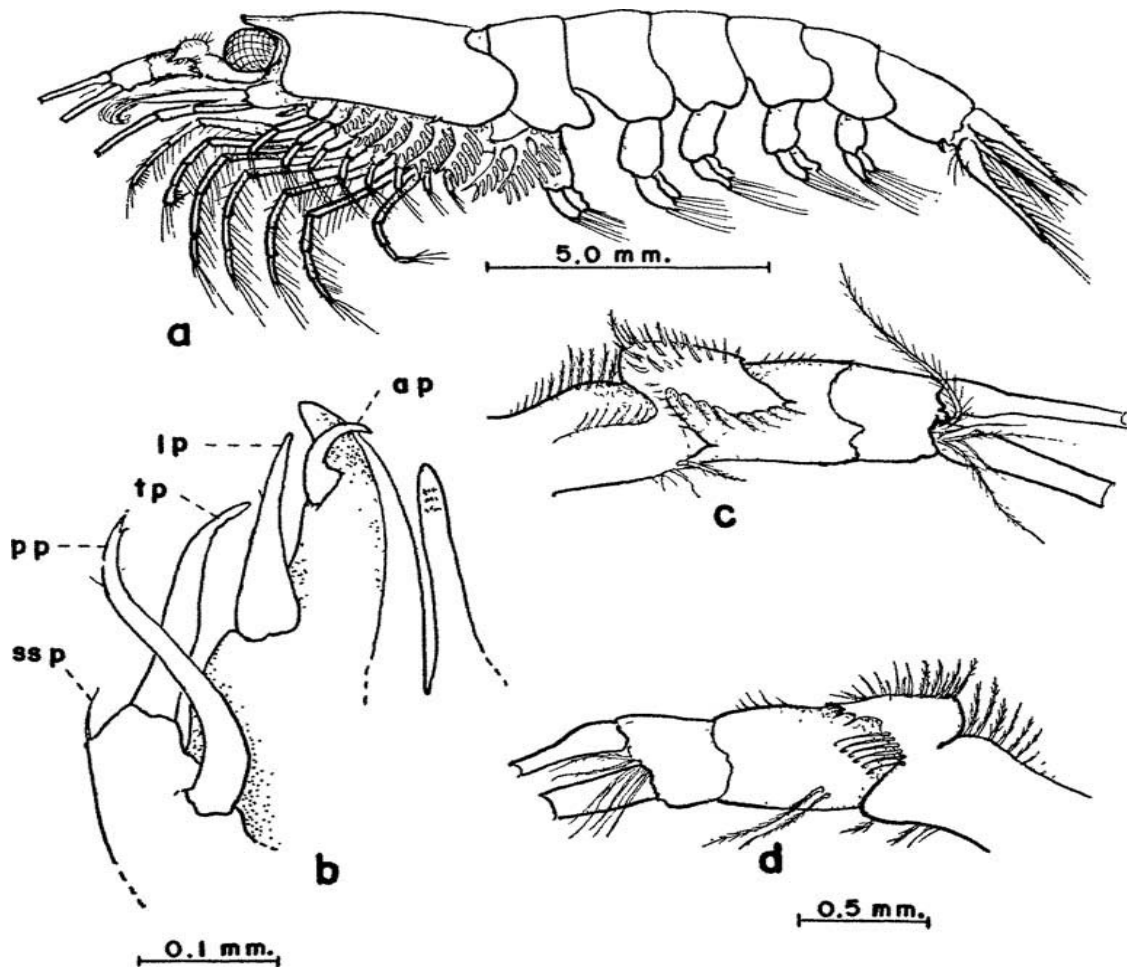


Fig. 9. *Thysanopoda aequalis* Hansen. *a.* Adult female. *b.* Male left copulatory organ from front. *c.* First antennal peduncle from outer side. *d.* First antennal peduncle from inner side.

Length.—13–20 mm.

Distribution.—North Pacific. The northernmost record for *T. aequalis* in the eastern central Pacific is 40° 21.5' N., 139° 24.5' W. ("Northern Holiday" expedition). Between this station and the California coast, its northward range is

reduced. It does not occur within 200–300 miles of the coast north of Pt. Conception, as its most northeastern record within the region of the California Current is $37^{\circ} 55' \text{ N.}$, $128^{\circ} 10' \text{ W.}$ This species sometimes reaches within 100 miles of the coast, south of 34° N. Its range again swings offshore south of 25° N. , off Baja California.

The most western record for *T. aequalis* in the North Pacific is $34^{\circ} 30.5' \text{ N.}$, $174^{\circ} 04.0' \text{ E.}$ (“Transpacific” expedition). This station is within a region where the ranges of *T. aequalis* and *T. subaequalis* overlap. *T. subaequalis* was present west of this station, and south of 40° N. , to the coast of Japan. The most eastern record for *T. subaequalis* is $28^{\circ} 06.5' \text{ N.}$, $151^{\circ} 25' \text{ W.}$ (“Northern Holiday” expedition).

Equatorial Pacific. *T. aequalis* was not found between 5° N. and 17° N. in the eastern equatorial region explored by the “Shellback” expedition. It has been taken near the equator at $04^{\circ} 41.1' \text{ N.}$, $140^{\circ} 06' \text{ W.}$ (“Mid-Pacific” expedition) and penetrates eastward, near the equator, as far as $02^{\circ} 16' \text{ N.}$, $109^{\circ} 12' \text{ W.}$ and $02^{\circ} 47' \text{ S.}$, $112^{\circ} 13' \text{ W.}$ Its most western record in the equatorial region is $00^{\circ} 04' \text{ N.}$, $169^{\circ} 00' \text{ E.}$ (“Capricorn” expedition). Hansen’s records (1910, 1916) from the Philippine Islands may be *T. subaequalis*. *T. aequalis* was absent from collections made in the western equatorial Pacific by the Scripps Institution in March, 1955, and *T. subaequalis* was widely distributed in this region.

South Pacific. This species occurs throughout the southeastern central Pacific surveyed by the *Albatross*. It has been taken as far east as $18^{\circ} 47.1' \text{ S.}$, $89^{\circ} 26' \text{ W.}$; its southernmost record is $25^{\circ} 27.3' \text{ S.}$, $103^{\circ} 29.3' \text{ W.}$ (Hansen, 1912). Both *T. aequalis* and *T. subaequalis* were taken near the Fiji Islands and at $13^{\circ} 05' \text{ S.}$, $124^{\circ} 17' \text{ W.}$, and $14^{\circ} 23' \text{ S.}$, $112^{\circ} 56' \text{ W.}$, by the “Capricorn” expedition. Only *T. aequalis* was caught at $16^{\circ} 15' \text{ S.}$, $166^{\circ} 46' \text{ W.}$, and at $17^{\circ} 36' \text{ S.}$, $152^{\circ} 52' \text{ W.}$

Elsewhere. *T. aequalis* is also found in the tropical and subtropical waters of the Indian Ocean and the Atlantic. *T. subaequalis* was described from the western Indian Ocean.

Depth.—Adults, 100–500 meters; larvae, above 150 meters.

Thysanopoda obtusifrons G. O. Sars

(Fig. 10, *a–c*)

Thysanopoda obtusifrons G. O. Sars, 1883: 21; 1885: 102–104, pl. 12, figs. 1–14; Haasen, 1910: 81; 1912: 215–217, pl. 4, fig. 5, *a–f*; *T. vulgaris* Hansen, 1905*a*: 15.

Diagnosis.—The frontal plate is thick, rounded, or weakly angular, and the rostrum is present as a small conical tooth. The lateral margin of the carapace carries a small denticle toward the posterior end, and may or may not have a weakly defined longitudinal furrow.

There is a small, flat tooth on the outer distal angle of the short, thick basal segment of the first antennal peduncle. This segment also carries a thick, setose lobe. This lobe covers less than half the proximal surface of the second segment and is entirely dorsal to the second segment, when seen in profile from the outer side (fig. 10, *b*). The third segment of the peduncle carries a low keel.

The abdominal segments lack dorsal spines, and the third, fourth, and fifth pleura are emarginate.

The male copulatory organ has a slender but well-developed spine-shaped process. The terminal process is only slightly curved, and its compressed, distal third has a convex inner margin and a serrated outer margin. There is a well-developed keel to the proximal process which curves strongly and tapers from a broad basal portion to a somewhat truncate end. The lateral process is slender and distally curved. The additional process is robust and only slightly shorter than the lateral process.

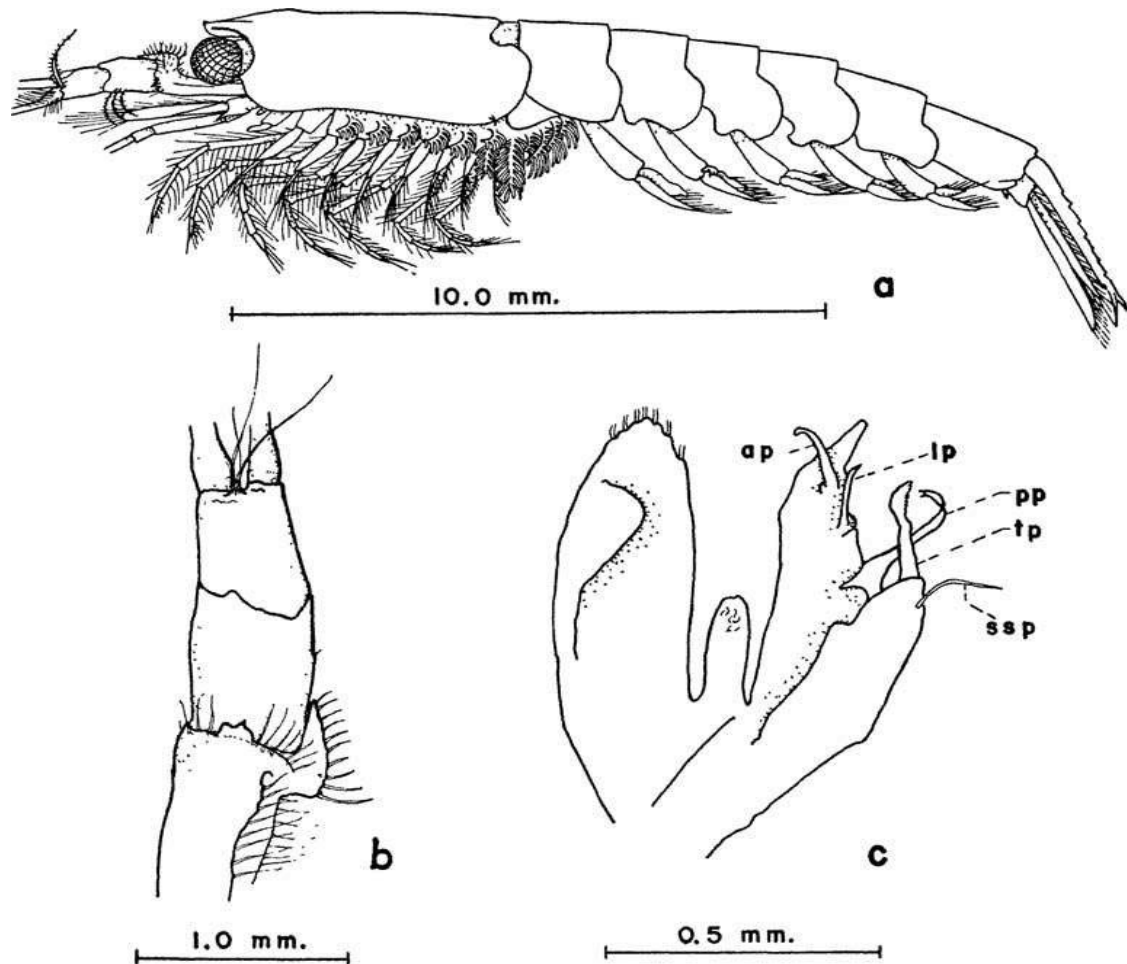


Fig. 10. *Thysanopoda obtusifrons* G. O. Sars. *a.* Adult male. *b.* Left first antennal peduncle from outer side. *c.* Male left copulatory organ from behind.

Length.—About 20 mm. in both sexes.

Remarks.—In the absence of adult males, this species is most easily distinguished from *T. aequalis* by the nearly straight, horizontal profile of the dorsal part of the lobe on the antennal peduncle, and by the more dorsal position of the part which covers the proximal surface of the second segment of the peduncle. Young specimens

(approximately 20 mm.) of *T. orientalis* are sometimes similar to this species but possess a more acute rostrum. The part of the peduncular lobe which overhangs the second segment of the peduncle is slightly more raised and more narrowly acute, distally, in *T. orientalis*.

Distribution.—North Pacific. This species has been taken only between 20° N. and 25° N. in the part of the ocean east of Hawaii. Its most eastern record is 20° 52' N., 124° 28' W. ("Shellback" expedition). In the western central Pacific it was present at two stations well off the coast of southern Japan (35° 04.5' N., 145° 07.5' E.; 31° 44.3' N., 142° 11.7' E.), and at several stations along the Midway Island-Hawaii chain between 30° 37' N. and 22° 50' N. The most southern record in the North Pacific is 17° 01' N., 176° 24' W. ("Mid-Pacific" expedition). It has not been taken in the equatorial region.

South Pacific. The most northern catch of *T. obtusifrons* by the *Albatross* was at 09° 2.1' S., 123° 20' W. It was present southward to 25° 27.3' S., 103° 29.3' W., and eastward to 20° 2.4' S., 91° 52.5' W. (Hansen, 1912). It was caught as far west as 20° 29.5' S., 178° 21.8' E. by the "Capricorn" expedition.

Elsewhere. This species has also been reported from the tropical and subtropical waters of the western Indian Ocean and the eastern Atlantic.

Depth.—Adults and juveniles, below 200 meters.

Thysanopoda pectinata Ortmann

(Fig. 11, *a-c*)

Thysanopoda pectinata Ortmann, 1893: 10; Hansen, 1905b: 25–26; 1912: 218–222, pl. 5, fig. 1, *a-m*;
Parathysanopoda foliifera Illig, 1909: 25.

Diagnosis.—The frontal plate is triangular, and the rounded apex carries a vestigial rostrum in the form of a minute, conical, vertical tooth. There are no lateral denticles on the carapace but there is a longitudinal furrow just above the lateral margin (fig. 11).

The distal margin of the basal segment of the first antennal peduncle projects forward and covers most of the proximal surface of the second segment. The upper surface of this lobe is setose, the posterior setae being longer than the anterior. The lobe at its base is less than half as wide as the second segment, but it widens anteriorly, becoming wider than the second segment, and carries eight to thirteen spines on its anterior margin. The second segment has its inner anterior margin produced as a lobe which covers about a third of the proximal surface of the third segment. The third segment has a low keel (fig. 11).

There are no dorsal teeth on the abdominal segments.

The copulatory organ of the male (fig. 11) has along, thin, spine-shaped process. The terminal process widens from a subcylindrical base to a flat, broadly rounded end. There is a concavity on the inner surface of the flattened part. There is a keel on the broad base of the proximal process. The process is strongly curved, and the distal third is compressed and has an oblique terminal margin which may carry a couple of irregular teeth. The lateral process is slender and ends distally in a hook. The additional process tapers from a very broad base to a slender, acute, strongly curved end.

Length.—The species is adult in the Pacific at about 29 mm. It reaches 44 mm. in the Atlantic.

Distribution.—North Pacific. The most northern record in the northeastern central Pacific is $31^{\circ} 54.3' N.$, $152^{\circ} 21.6' W.$ (“Northern Holiday” expedition).

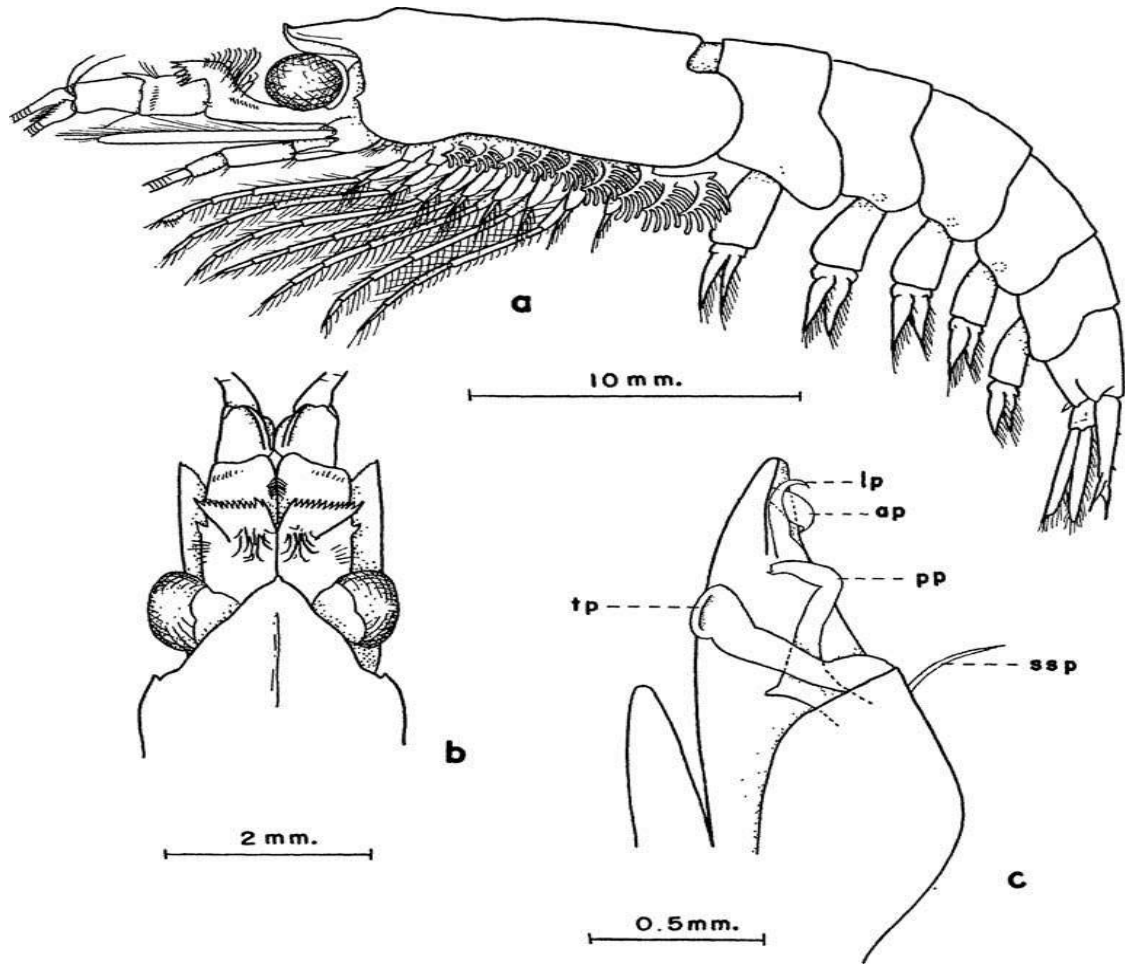


Fig. 11. *Thysanopoda pectinata* Ortmann. *a.* Adult female. *b.* Front part of carapace and first antennal peduncles seen from above. *c.* Male copulatory organ from behind.

This species occurs throughout the central ocean to within 300–400 miles of the coast of southern California. It has not been found within 600 miles of the coast of Baja California.

Larvae of this species were taken as far west as $32^{\circ} 02.3' N.$, $139^{\circ} 25.1' E.$ off

Japan, and as far north as $34^{\circ} 07' N.$, $156^{\circ} 11' E.$ in the western central Pacific (“Transpacific” expedition).

Equatorial Pacific. *T. pectinata* occurred south of $11^{\circ} 30' N.$ and eastward to $09^{\circ} 06' N.$, $88^{\circ} 32' W.$ in the eastern region explored by the “Shellback” expedition. It was not caught east of this longitude, either in the equatorial region or off the coasts of Ecuador and Peru. It is present in the Philippine Sea (Hansen, 1916) and in the central equatorial Pacific (“Mid-Pacific” and “Capricorn” expeditions).

South Pacific. The easternmost *Albatross* record as $18^{\circ} 47.1' S.$, $89^{\circ} 26' W.$ This species was taken as far south as $24^{\circ} 05' S.$, $100^{\circ} 20' W.$ (Hansen, 1912).

Elsewhere. The species is also found in the tropical and subtropical waters of the Indian Ocean and the Atlantic.

Depth.—Adults, below 400 meters; larvae, occasionally above 200 meters.

Thysanopoda orientalis Hansen

(Fig. 12, *a* and *b*)

Thysanopoda orientalis Hansen, 1910: 85–87, pl. 13, fig. 2, *a–i*; 1912: 222–223, pl. 5, fig. 2, *a–i*.

Diagnosis.—The frontal plate is triangular, and the apical angle is greater than a right angle. It carries a vestigial rostrum in the form of a short, forward and upward-pointing tooth. The lateral margin of the carapace is smooth.

The posterior margins of the fourth and fifth abdominal segments are slightly acuminate.

Seen from the side, the lobe on the basal segment of the first antennal peduncle is produced and pointed, but not spiniform. The distal margin of the second segment is produced and covers a part of the proximal surface of the third segment.

The copulatory organ of the male (fig. 12) has a slender, strongly curved, spine-shaped process and a straight, long, strong terminal process with a blunt, rounded end. The proximal process is nearly twice as long as the terminal, and its distal four-fifths curves almost to a semicircle. It carries a few teeth at its distal end. The lateral process is tapered and hooked. There are two, sometimes three, additional processes. The first of these is spatulate, whereas the second and third are slender. The median lobe ends very acutely.

Length.—23–38 mm.

Distribution.—North Pacific. The most northern record in the northeastern central Pacific is $41^{\circ} 42' N.$, $150^{\circ} 00' W.$ (“Northern Holiday” expedition). This species has not been caught at stations nearer than 150 miles to the California coast, north of $34^{\circ} N.$, but has been taken within 25 miles of the coast of southern California and Baja California. In the western North Pacific *T. orientalis* was taken northward to $39^{\circ} 56.4' N.$, $143^{\circ} 38.5' E.$, near Japan (“Transpacific” expedition), and was present at most stations southeast of Honshu Island. The most northern record in the western central Pacific is $38^{\circ} 31.5' N.$, $168^{\circ} 31.5' E.$

Equatorial Pacific. This species was not caught within 400 miles of the coast of Mexico between $24^{\circ} N.$ and $16^{\circ} N.$ It occurred at most stations south of $9^{\circ} N.$, exclusive of the region of the Peru Current and of its extension into the South Equatorial Current to $124^{\circ} W.$ (“Shellback” expedition). This species was caught at stations between $10^{\circ} N.$ and Hawaii in the equatorial mid-Pacific (“Mid-Pacific”

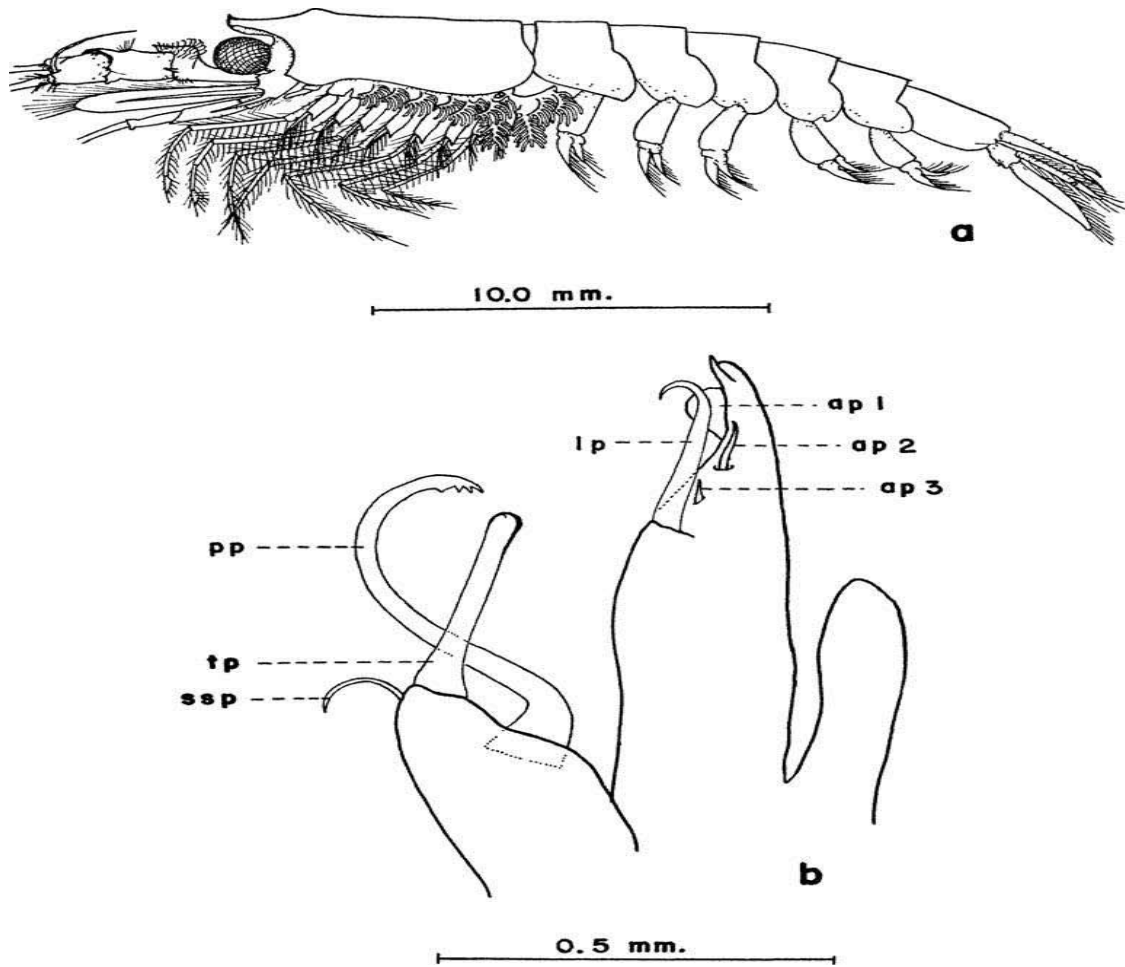


Fig. 12. *Thysanopoda orientalis* Hansen. a. Adult female. b. Male left copulatory organ from behind.

expedition) and at the equator at 169° E. ("Capricorn" expedition). It has been taken around the Philippines (Hansen, 1916), in the Celebes Sea (Hansen, 1910), and larvae were caught in the lagoon of the Great Barrier Reef of Australia (Tattersall, 1939).

South Pacific. The most eastern catch of this species was at 14° 59' S., 85° 04' W.

("Shellback" expedition), and the most southern record is 20° 29.5' S., 178° 21.8' E. ("Capricorn" expedition). It was taken at five stations in the southeastern central Pacific, north of 11° S., by the *Albatross* (Hansen, 1912).

Elsewhere. *T. orientalis* is reported also from the tropical and subtropical zones of the Indian Ocean and the Atlantic.

Depth.—Adults, below 400 meters; larvae, occasionally above 200 meters.

Thysanopoda acutifrons Holt and Tattersall

(Fig. 13, a-d)

Thysanopoda acutifrons Holt and Tattersall, 1905: 102–103; 1906: 8, pl. 1; Hansen, 1910: 85–86, text fig.; Einarsson, 1945: 16–21, 39–41, text figs. 4–7, 14; *T. pectinata* Hansen, 1905a: 16–17, fig. 12; (*nec* Ortmann, 1893: 10; *nec* Hansen, 1905b: 25).

Diagnosis.—The frontal plate is triangular and the apical angle is greater than a right angle. The rostrum is a short upward- and forward-pointing process, yet longer and directed more forward than the rostral "tooth" in *T. orientalis*. There are no denticles on the lateral margins of the carapace.

There are no teeth on the abdominal segments.

The outer distal angle of the basal segment of the first antennal peduncle bears a small, strong spine. The distal margin is produced as a roughly triangular lobe extending about one-third of the way along the second segment. This lobe is setose. The inner part of the anterior margin of the second segment carries a rounded, spineless lobe.

The spine-shaped process of the male copulatory organ (fig. 13) is almost straight. The terminal process is short and tapers to an acute, curved end. The moderately curved proximal process is more than twice as long as the terminal. The lateral process is slender and slightly hooked and is about as long as the terminal process. The first additional process is broad and subacute, whereas the second additional process is slender and acute.

Length.—35–50 mm.

Remarks.—*T. dubia* (Banner, 1949) was established with a female as the type specimen. The largest female Banner encountered was only 27 mm. long. Banner says, "The confirmation of *T. dubia* as a valid species must await the description of the first pleopods of the males." The males of *T. dubia* have never been taken, and, since young females of *T. acutifrons* frequently correspond with Banner's description, the probability that *T. dubia* was established on juvenile characters cannot be ignored.

Distribution.—North Pacific. This species was caught in the northeastern Pacific at stations between 39.5' N. and 49° N. by both the "Northern Holiday" and "Transpacific" expeditions. It was taken in the northwestern Pacific within approximately the same belt, between 37° 53.5' N., 166° 56.7' E., and 44° 06' N., 161° 39' E. Its range extends eastward within this belt nearly to the coast of Oregon, Washington, and British Columbia and swings northward to shelf waters of Alaska where Banner (1949) reports young specimens (*T. dubia*) from as far north as 57° 07' N., 131° 26' W.

South Pacific. This may be a bipolar species. The most northern *Dana* catch of

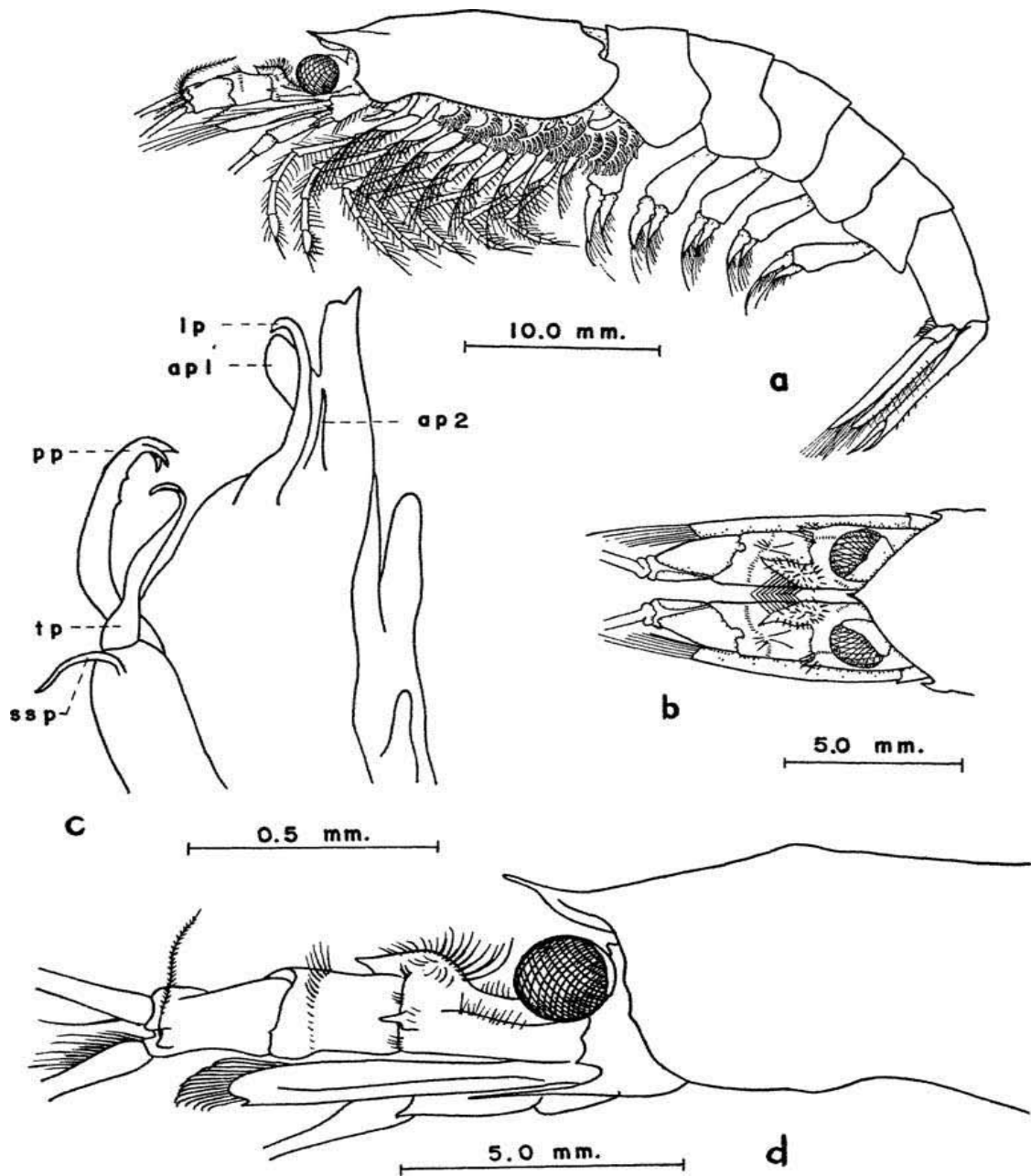


Fig. 13. *Thysanopoda acutifrons* Holt and Tattersall. *a.* Adult female. *b.* Front part of carapace and first antennal peduncles from above. *c.* Male left copulatory organ from behind. *d.* Antennal peduncle and front part of carapace of adult male.

T. acutifrons off southeastern Australia was $33^{\circ} 26' S.$, $157^{\circ} 02' E.$, whereas the easternmost record in the *Dana* material is $34^{\circ} 24' S.$, $178^{\circ} 42.5' E.$, northeast of New Zealand (Einarsson, 1945). Sheard (1953) suggests that these specimens may belong to *T. johnstoni*.

Elsewhere. This species has also been reported from the subarctic Atlantic (Einarsson, 1945) and from near the Cape of Good Hope (Tattersall, 1925).

Depth.—Adults, below 1,000 meters; larvae, sometimes above 200 meters.

Thysanopoda cornuta Illig

(Fig. 14, *a* and *b*)

Thysanopoda cornuta Illig, 1905: 663–665, figs. 1–3; Hansen, 1915: 65–66, pl. 1, fig. 1, *a*; Brinton, 1953: 408–411, figs. 4, 5, 8, 9; *T. insignis* Hansen, 1905a: 19–21, figs. 17–19.

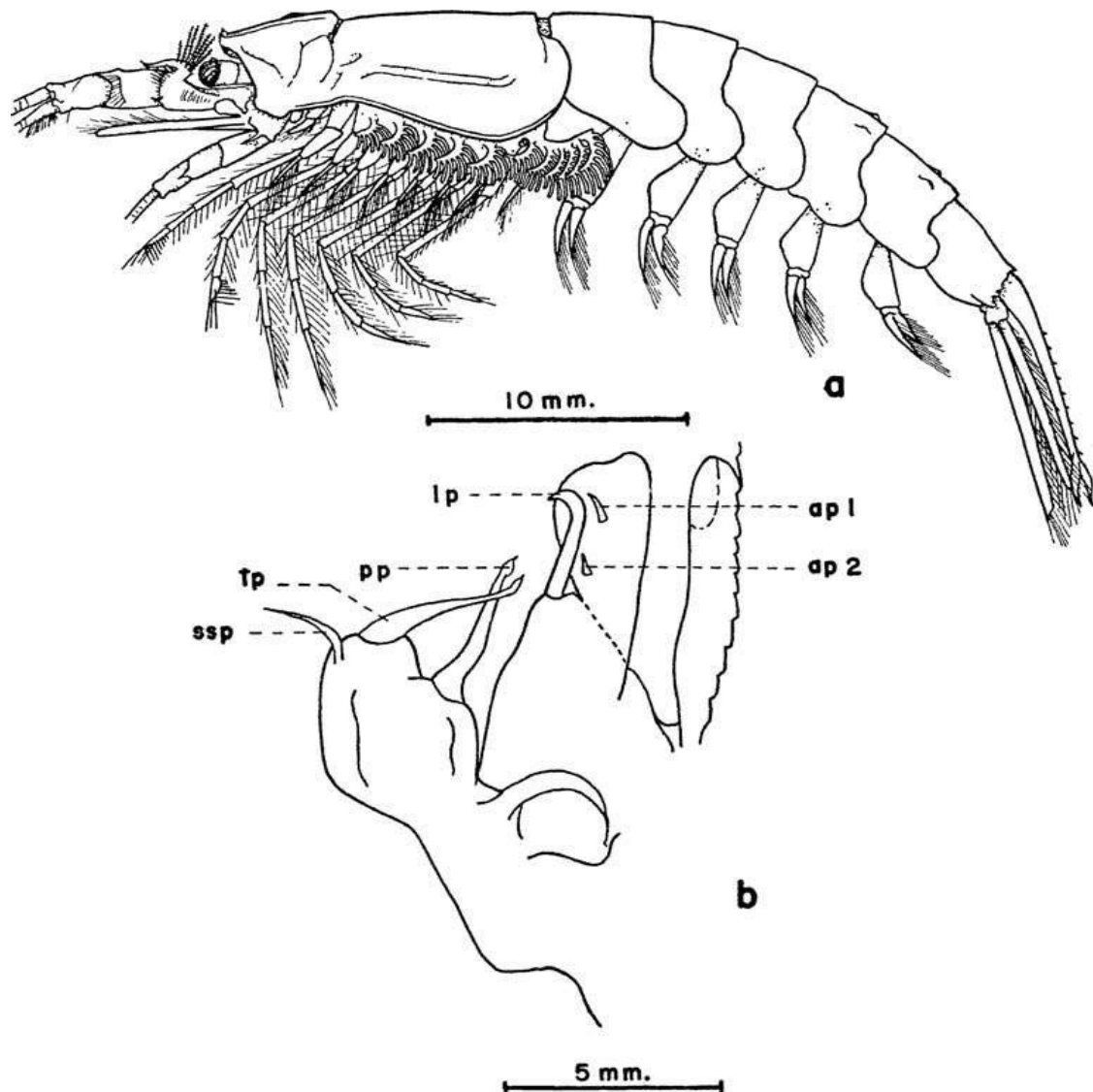


Fig. 14. *Thysanopoda cornuta* Illig. *a*. Adult female. *b*. Male copulatory organ from behind.

Diagnosis.—The frontal plate is triangular, and the rostrum persists as a small, conical process at the apex. There are no lateral denticles on the carapace. There is a deep cervical groove on the carapace which is connected with a more anterior lateral groove, on each side, by a short longitudinal groove. A long longitudinal

submarginal furrow parallels the lateral margin of the posterior two-thirds of the carapace.

A small tubercle projects from the upper, inner corner of the eyestalks. The eyes are relatively small.

The basal segment of the first antennal peduncle carries a forward-directed, setose lobe which partly covers the inner, upper surface of the second segment and ends in a short spine. The second segment has a concave, anterior, dorsal margin. A tuft of long, silky setae is present at the base of the lower flagellum of the first antenna. This tuft is more dense in males than in females.

There are no dorsal teeth on the abdominal segments, although the fourth and fifth segments bear small median keels near their posterior margins. These processes are flanked by a pair of small, submedian processes. The sixth abdominal segment is shorter than the fifth.

The male copulatory organ (fig. 14) carries a robust and curved spine-shaped process. The terminal and proximal processes are both almost straight, about the same length, dilated slightly before their ends, and then tapered to acute points. The lateral process is robust and strongly curved. Two small, acute additional processes are present on the median lobe.

Length.—Up to 95 mm.

Distribution.—North Pacific. This species, like *T. egregia*, occurs in oceanic waters seaward of the 3,000-meter bathymetric contour. The most northern record for an adult is 48° 58.3' N., 157° 49.8' W. ("Northern Holiday" expedition). Banner (1949) reports larvae, tentatively assigned to this species, as far north as 57° 07' N., 131° 26' W. in the Gulf of Alaska. Larvae and adults have been taken off the coast of California and Baja California. In the western central Pacific it has been taken at 41° 12' N., 168° 16' E. ("Transpacific" expedition), and at 31° 39' N., 132° 54.6' E. off southern Japan (Hansen, 1915).

Equatorial Pacific. *T. cornuta* has been caught as far east as 00° 37.5' N., 94° 09' W. ("Shellback" expedition), and at 12° 8.7' S., 79° 2.4' W. in the Peru Trench (Hansen, 1912). Its westernmost capture has been at 00° 04' N., 169° 00' E. ("Capricorn" expedition). The most southern record in the Pacific is 17° 26.4' S., 86° 46.5' W. (Hansen, 1912).

Elsewhere. Specimens have also been taken from the tropical and subtropical Atlantic in hauls from 4,000 meters (Illig, 1905; Hansen, 1905a).

Depth.—Adults, below 2,000 meters; larvae and juveniles, below 100 meters.

Thysanopoda egregia Hansen

(Fig. 15, a-c)

Thysanopoda egregia Hansen, 1905a: 22–23, figs. 20–21; Brinton, 1953: 408–411, figs. 2, 7, 12, 13.

Diagnosis.—The frontal plate is thick and bent downward. The anterior margin has an extremely obtuse angle and usually carries a small downward-pointing tooth, the vestigial rostrum. There is a low, poorly defined mid-dorsal keel which is abruptly higher in the region of the dorsal organ. The keel ends at the transverse, cervical groove. There is a nearly vertical lateral groove, but this is unconnected with the cervical groove. A longitudinal groove extends almost the length

of the carapace just above the lateral margin. The carapace also has a submarginal longitudinal furrow.

The eyestalk carries a small tubercle on its inner part.

The lobe on the distal margin of the basal segment of the first antennal peduncle is extremely setose. Its anterior margin is concave and its inner part is acutely produced to cover the inner part of the second segment. The outer, lower, distal angle of the basal segment carries a small protuberance. The anterior dorsal margin of the second segment is concave. The basal part of the lower flagellum of

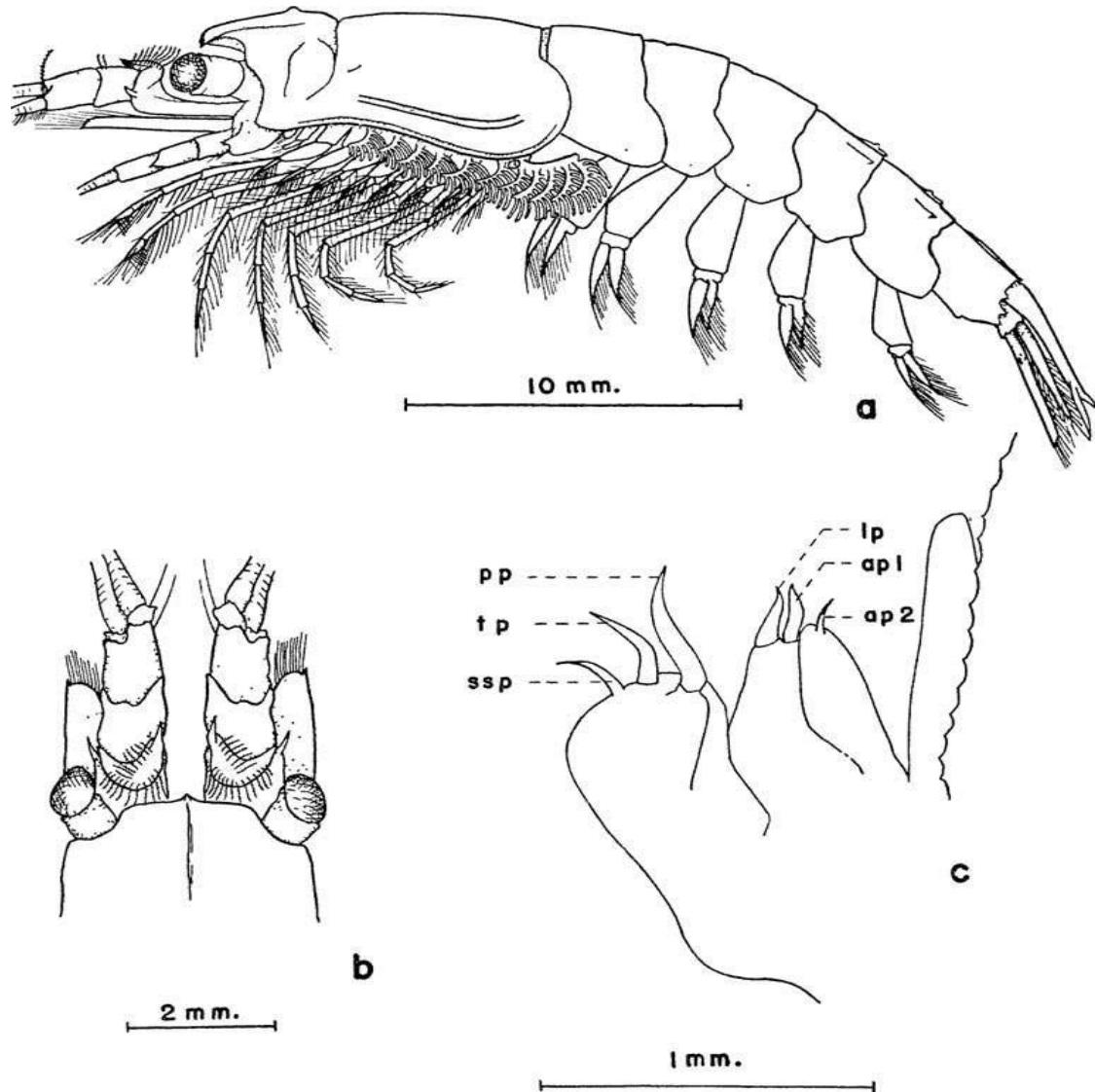


Fig. 15. *Thysanopoda egregia* Hansen. *a.* Adult female. *b.* Front part of carapace and first antennal peduncles from above. *c.* Male copulatory organ from behind.

the first antenna carries a tuft of long, silky setae, which is more dense in males than in females.

The abdominal segments do not carry dorsal spines, but the fourth and fifth segments are slightly keeled, posteriorly, in the median line. The fourth and fifth abdominal segments also carry a pair of small spines which flank the median process, as in *T. cornuta*. The sixth abdominal segment is shorter than the fifth.

The copulatory organ in figure 15, *c*, may be that of an immature male, although the specimen was 43 mm. long. The spine-shaped process is quite robust and only slightly curved. The terminal process bends slightly inward at the first one-third of its length and tapers to an acute point. The proximal process is about half as long again as the terminal; it is very stout and feebly sinuate, tapering to an acute point. The lateral process is short, pointed, and almost straight. The first additional process is about the same size as the lateral and is almost straight. The second additional process is very slightly curved, slender and pointed, and about half the length of the first.

Length.—About 40–62 mm.

Distribution.—North Pacific. Larvae, which may belong to *T. egregia* or *T. cornuta*, have been reported from as far north as 56° 55' N., 146° 07' W. in the Gulf of Alaska (Banner, 1949). The most northern record for an adult is 40° 35' N., 147° 55' W. ("Northern Holiday" expedition). Like *T. cornuta*, this species has been caught only to seaward of the 3,000-meter bathymetric contour. It has not been taken in the western North Pacific.

Equatorial Pacific. The most eastern records in the equatorial region are 04° 04' N., 97° 10.7' W. and 14° 01' S., 18° 48' W. off the coast of Peru ("Shellback" expedition). The most western record in the Pacific is also the most southern: 20° 29.5' S., 178° 21.8' E. ("Capricorn" expedition).

Elsewhere. *T. egregia* also occurs in the tropical and north subtropical Atlantic.

Depth.—Adults, below 2,000 meters; larvae and juveniles, below 200 meters.

Thysanopoda spinicaudata Brinton

(Fig. 16, *a-c*)

Thysanopoda spinicaudata Brinton, 1953: 408–411, figs. 1, 3, 6, 10, 11.

Diagnosis.—The frontal plate is slightly convex, and the rostrum persists as a strong vertical spine which is longer than the thickness of the frontal plate. A low median keel on the frontal plate extends backward to a cervical groove. Sub-vertical lateral furrows connect with the cervical groove as in *T. cornuta*. A longitudinal ridge is present just above the thickened lateral margins of the carapace. The lateral margins are without denticles.

The upper distal margin of the first antennal peduncle is extremely setose and is armed with an acute upward- and outward-pointing tooth with a slightly bulbous base.

The fourth and fifth abdominal segments are keeled posteriorly at the median line. Each keel is flanked by a pair of submedian keels. The pleura of the third and fourth segments are distinctly lobed at the anterolateral angles. The sixth segment carries a heavy backward- and outward-pointing spine on each side

shortly before its posterior margin. The sixth segment is somewhat hollowed, dorsally, and is shorter than the fifth segment, as in *T. cornuta* and *T. egregia*.

Length.—84 mm.

Distribution.—North Pacific. The one known locality for this species is 25° 52' N., 114° 40' W. off Baja California.

Depth.—The adult specimen was caught in the Isaacs-Kidd mid-water trawl, fishing at 2,220 meters in 4,070 meters of water.

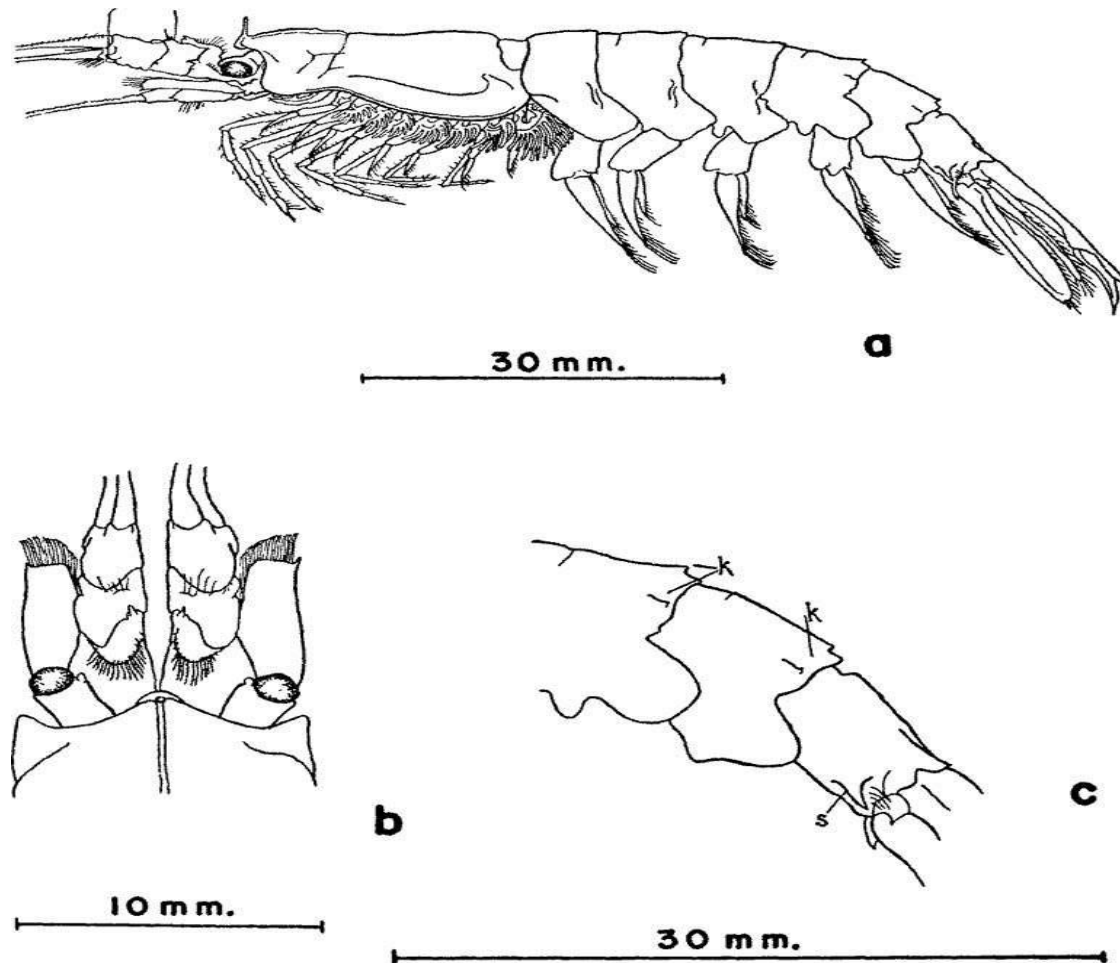


Fig. 16. *Thysanopoda spinicaudata* Brinton. *a*. Adult female. *b*. Front part of carapace and first antennal peduncles from above. *c*. Fourth, fifth, and sixth abdominal somites, showing dorsal keels and spine.

NYCTIPHANES G. O. Sars

Nyctiphanes G. O. Sars, 1883: 23.

Generic characters.—In general appearance, this genus resembles *Euphausia*. The first antennal peduncle is elongate and is stronger in the male than in the female. Its basal segment carries, distally and dorsally, a reflexed membranous lappet which differs in the two sexes. The third segment of the peduncle is of somewhat peculiar shape in the male (fig. 17, *e*).

In the adult and adolescent there is no lateral denticle on the inferior margin of the carapace.

The first six thoracic appendages are as in *Euphausia*. The terminal segments

are lacking from the seventh thoracic leg. The eighth thoracic appendage is quite rudimentary, consisting of a minute, digitiform, nonsetose process. The exopodites of the sixth and seventh thoracic appendages of the female are also lacking.

The egg sac of the female is double.

The inner lobe of the copulatory organ of the male is serrated along the outer margin. The proximal and terminal processes are lacking, but the lateral process is well developed. The median lobe is much reduced.

This genus contains only four species, each with a very limited near-shore range. The species occurring in these waters is *Nyctiphanes simplex* Hansen. *N. australis* is limited to Australia, *N. couchii* to the eastern North Atlantic, and *N. capensis* to South African waters.

Nyctiphanes simplex Hansen

(Fig. 17, a–e)

Nyctiphanes simplex Hansen, 1911: 20; 1912: 227–229, pl. 6, fig. 2, a–i, pl. 7, fig. 1, a and b; Esterly, 1914a: 9, pl. 1, figs. 6, 8, 10, 13, pl. 2, figs. 20, 25, 28, 32.

Diagnosis.—The frontal plate of the carapace is fairly long and acute, with the lateral margins raised. There is no distinct rostral process. There is a distinct median keel and cervical groove. The gastric area of the carapace is vaulted. The eyes are moderately large, spherical, and black.

The outer corner of the distal end of the basal segment of the first antennal peduncle is produced in a very conspicuous, subconical spine, which is directed forward and outward, has a thick base, and tapers to an acute point. The dorsal surface of the forward margin of this segment carries a very large leaflet or lappet, which is directed upward and backward, is about twice as long as broad at the base, and has a hollow anterior surface. In the female the upper end of this leaflet is rounded, with a small point on the inner side. In the male it is broadly truncate and much reflexed, and bears a sharp tooth on the outer margin. In the female the second segment of the peduncle is long and slender and carries a small, subacute tooth on its dorsal, distal, inner angle. In the male it is somewhat shorter and thicker, and the tooth is broader and more vertical, sometimes even bifid. In both sexes the third segment of the peduncle is very much shorter than the second and has an inconspicuous keel. This keel ends as a small tooth in the female. There is no such tooth in the male, and the segment is very strongly curved inward. The outer margin is very convex. The inner margin is concave and carries a group of strong setae near the middle.

In adolescent stages, the lappet on the first peduncular segment is neither rounded nor truncate, but tapers to an acute tip. Its inner margin is convex and its outer concave. The outer protuberance on the distal end of this segment is very much more pronounced than in the adult.

The scales of the second antennae do not reach to the end of the second segment of the peduncles of the first antennae.

There is a dorsal tooth at the end of the sixth abdominal segment.

The inner lobe of the copulatory organ of the male (fig. 17) is serrate along two-thirds of its outer margin. The inner lobe carries the long, bent, spine-shaped process. The proximal and terminal processes are lacking. The median lobe is

extremely short and poorly developed and carries the long lateral process. This process bends sharply outward at its acute end.

Length.—11–16 mm.

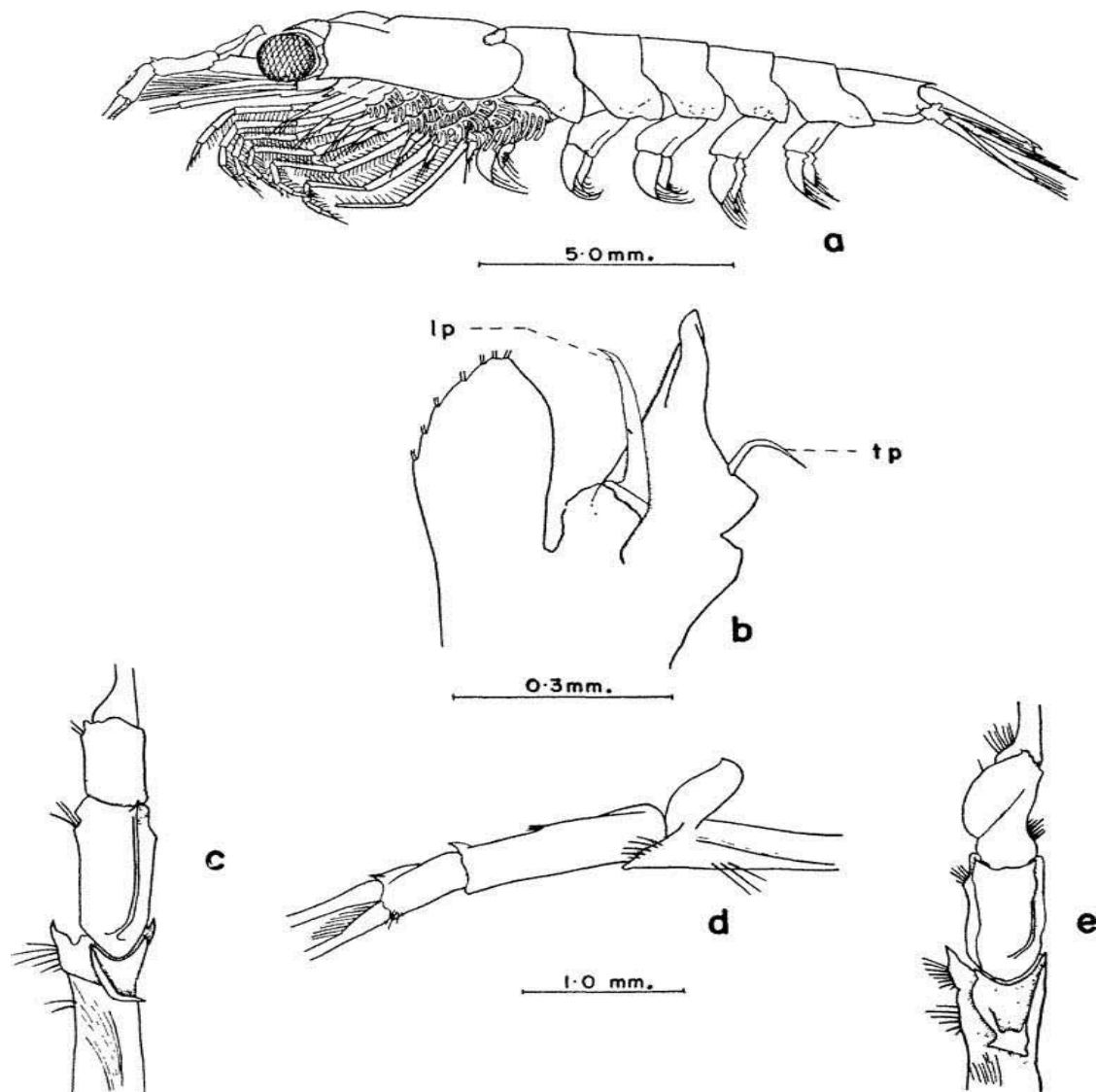


Fig. 17. *Nyctiphanes simplex* Hansen. *a.* Adult male. *b.* Male right copulatory organ, unrolled and seen from behind. *c.* Left first antennal peduncle of female from above. *d.* Left first antennal peduncle of female from left side. *e.* Left first antennal peduncle of adult male from above.

Remarks.—Esterly (1914*a*) stated that in the males of the San Diego specimens the copulatory appendage has no median lobe. This was not confirmed by an examination of the males of this collection, for in all of them there was a distinct though very much reduced median lobe. Hansen (1911) states that this lobe is abbreviated, “with no part along the outer margin of the lateral process.”

Distribution.—North Pacific. This predominantly inshore form is most abundant within 200 miles of the coasts of southern California and Baja California. The most southern record, off Cape San Lucas, is 22° 18.5' N., 111° 09' W. ("Shellback" expedition). It is numerous in the Gulf of California (Hansen, 1915; Steinbeck and Ricketts, 1941). The most northern record in the Scripps Collections is 36° 35' N., 122° 15' W., off Monterey (Marine Life Research Cruise 4911).

Equatorial Pacific. *N. simplex* is not known between the latitude of Cape San Lucas and 07° 31' N., 78° 42.5' W., and the most northern of three stations in the Gulf of Panama where Ortmann's (1894) specimens, identified by Hansen (1915), were taken. This species was not caught off central Mexico and Costa Rica by the "Shellback" expedition, but was abundant in the Peru Current, east of 86° W., and penetrated westward to 100° W. at the equator, between 01° N. and 05° S. *N. simplex* is numerous off the coast of Peru to at least 15° S., the southern limit of the "Shellback" survey.

Depth.—Adults and larvae, above 200 meters.

PSEUDEUPHAUSIA Hansen

Pseudeuphausia Hansen, 1910: 103.

Generic characters.—There is no rostrum, but the frontal plate is long and produced and ends in a broad transverse or slightly concave margin (fig. 18). There is a small lateral denticle toward the posterior end of the inferior margin of the carapace.

The three distal segments of the sixth thoracic leg of the male are together about half as long as those of the fifth thoracic leg. In the female the third and fourth segments of the sixth thoracic leg are strongly curved in a forward direction, and the three terminal segments are together only about half as long as the terminal segment of the fifth leg.

The male copulatory organs differ greatly from those of the closely allied genera *Euphausia* and *Nyctiphanes*. On the inner lobe there are three small, spine-shaped processes. The lateral process of the median lobe is replaced by a large, leaf-shaped plate. The auxiliary lobe is lacking, and the setiferous lobe is naked. On the basal part of the median lobe there are a few minute hooks. In the female the two ovisacs are fused.

The genus is monospecific.

Pseudeuphausia latifrons (G. O. Sars) Hansen

(Fig. 18, *a-c*)

Euphausia latifrons G. O. Sars, 1883: 19; 1885: 95–97, pl. 16, figs. 17–23; *Pseudeuphausia latifrons* Hansen, 1910: 103–106, pl. 15, fig. 1, *a-d*.

Diagnosis.—The frontal plate is long and produced; its lateral margins are concave, and it is truncated distally. Its surface is concave longitudinally (fig. 18).

The basal segment of the first antennal peduncle carries, dorsally, a pectinate keel extending obliquely from before the end of the inner margin to the outer distal corner. This keel carries nine or ten spines. Before the terminal margin of the second segment a closely curved row of stiff setae originates. These bend

downward and forward and converge near the mid-point of the upper surface of the third segment.

The male copulatory organ is described in the generic description (fig. 18, *c*).

Length.—8.5–9 mm.

Distribution.—Equatorial Pacific. This is the dominant euphausiid of lagoons and neritic waters of atolls of the equatorial Pacific, from the Marshall Islands (11.5° N.) (“Mid-Pacific” expedition; “Capricorn” expedition) to the Tonga Islands (21° S.) (“Capricorn” expedition). It is common around the East Indian Archipelago (Hansen, 1910), and around the Philippine Islands (Hansen, 1916). It is the only euphausiid which regularly inhabits the lagoon of the Great Barrier Reef of Australia (Tattersall, 1936). Sars (1885) reported this species from the southeast coast of Australia and Sheard (1953) also found it abundant in near-shore waters there.

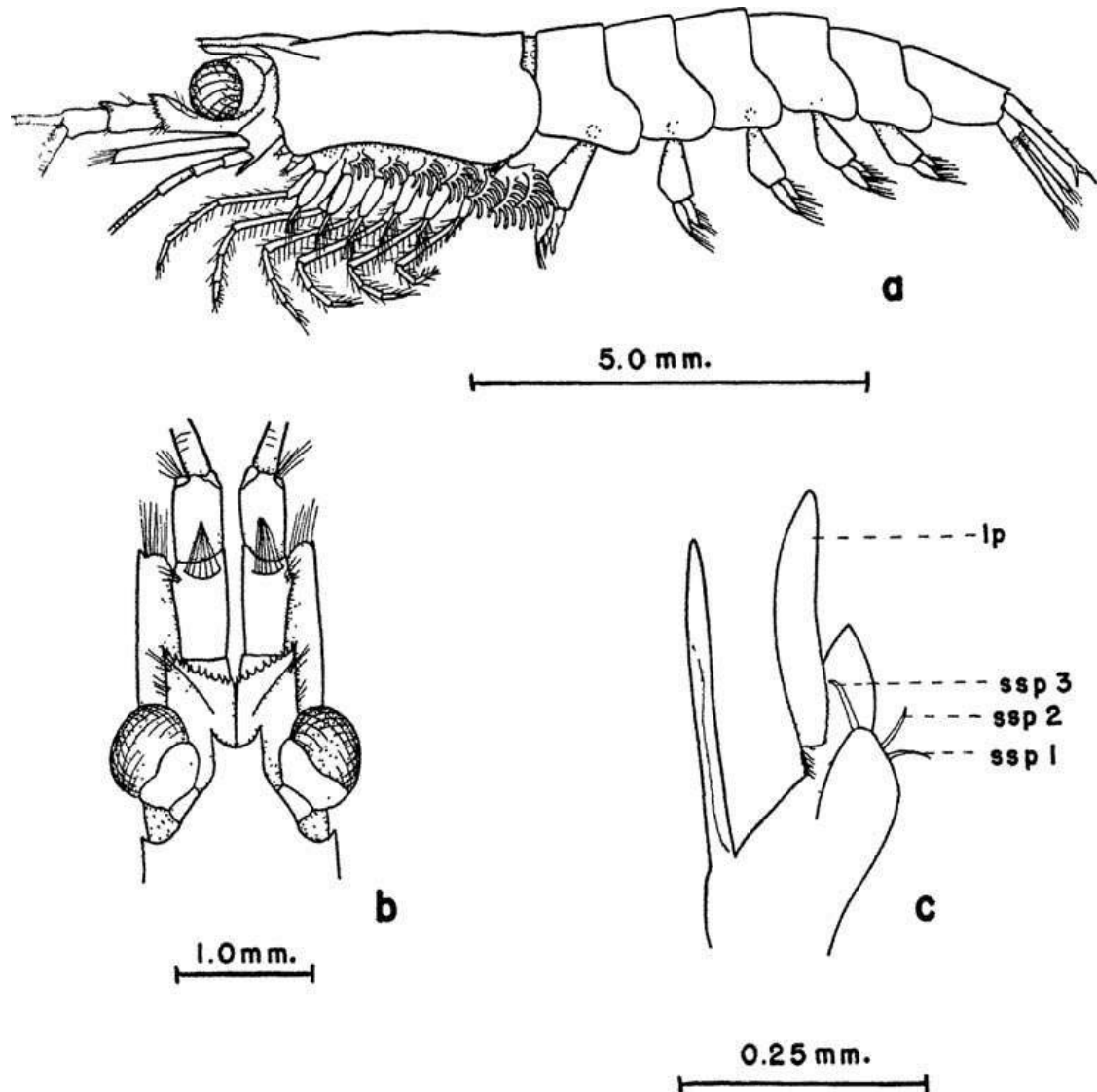


Fig. 18. *Pseudeuphausia latifrons* Hansen. *a*. Adult male. *b*. Front part of carapace and first antennal peduncles from above. *c*. Male copulatory organ from behind.

The “Transpacific” expedition found *P. latifrons* to be present, although rare,

as far north as 39° 44' N., 148° 24' E. in warm waters off northern Japan, as well as at near-shore stations east of the southern part of Honshu Island.

Elsewhere. This species occurs also in the tropical Indian Ocean.

Depth.—Adults and larvae, 150 meters to surface.

EUPHAUSIA Dana

Euphausia Dana, 1852: 639.

Generic characters.—The rostrum and anterolateral angles of the carapace are variable. The eyes are spherical and not constricted. The first antennal peduncle is usually alike in both sexes, occasionally showing sexual dimorphism. The basal segment of the peduncle is frequently provided dorsally with a small lappet at the distal end: both flagella are elongate and consist of numerous segments. The terminal segment of the maxilla is broad and the exopodite small. The seventh and eighth thoracic legs are rudimentary in both sexes, consisting of small, un-jointed, setose processes.

The terminal process of the male copulatory organ has a specially developed foot of varying breadth, from which a heel of varying length projects. The lateral process is armed with one to three teeth. The spine-shaped process on the inner lobe is lacking (except in one specimen of *E. lucens* noted by Hansen, 1912). The additional process on the median lobe is also frequently lacking.

The sexual dimorphism exhibited by the lappet on the distal end of the basal segment of the first antennal peduncle of *Euphausia recurva* and *E. tenera* has made it necessary to modify the generic diagnosis on this point. Sars (1885) states that the first antennal peduncle is alike in both sexes.

Hansen (1911) has referred the species to four groups:

- Group *a*. “Species with two pairs of lateral denticles on the carapace. No dorsal process on the third to fifth abdominal segment.” (*E. recurva*, *E. mutica*, *E. brevis*, *E. diomediae*, and *E. eximia* occur in the North Pacific; *E. krohnii* and *E. americana* are confined to the Atlantic).
- Group *b*. “Species with a single pair (rarely none) of lateral denticles on the carapace. No dorsal process on third to fifth abdominal segment.” (*E. pacifica*, *E. tenera*, and *E. similis* occur in the North Pacific; *E. superba*, *E. frigida*, *E. lucens*, and *E. crystallorophias* are antarctic and subantarctic species).
- Group *c*. “Species with a single pair of lateral denticles on the carapace. A protruding, acute, dorsal process on third abdominal segment, but without any dorsal process—at most with a minute denticle (*E. mucronata*)—on fourth and fifth abdominal segments.” (*E. paragibba*, *E. pseudogibba*, *E. hemigibba*, *E. distinguenda*, *E. lamelligera*, and *E. gibboides* occur in the North Pacific; *E. sibogae* and *E. fallax* are from around the East Indian Archipelago and the Philippines; *E. sanzoi* is from the Red Sea and Indian Ocean; *E. mucronata* and *E. gibba* are from the South Pacific; *E. vallentini* is from the antarctic; *E. alvae* and *E. consuelae* (?= *E. fallax* according to Sheard, 1953), both from around the East Indian Archipelago (Boone, 1935), are difficult to evaluate).

Group *d*. “Species with a single pair of lateral denticles on the carapace. A well-developed dorsal process on third abdominal segment and conspicuous dorsal denticles or processes on fourth and fifth segments.” (*E. hanseni* is from the South Atlantic; *E. triacantha*, *E. longirostris*, and *E. spinifera* are subantarctic species.

Hansen claimed that groups *a* and *d* “are well-separated from the others,” whereas groups *b* and *c* “separated exclusively by the existence or nonexistence of a dorsal process on the third abdominal segment, are somewhat badly defined, because two species show individual or local variation as to the existence of this process.”

The species reported here belong to groups *a*, *b*, and *c*. Group *d*, comprising four species, is confined to antarctic, subantarctic, and South Atlantic waters. John (1936) agrees with Hansen that groups *a* and *d* are natural groups but that groups *b* and *c* are not. Although groups *b* and *c* appear as rather artificial, they have been retained here for practical purposes, as the majority of individuals not belonging to group *a* can be referred to one or another of these groups immediately, the remainder being exceptions which are rather easily pointed out.

This genus, the largest of the order, probably contains twenty-nine or thirty species at present. It has undergone its maximum speciation in the lower latitudes, although it is remarkable that eight species of this genus are endemic to antarctic and subantarctic waters, as compared with none in the Arctic Ocean and only one, *E. pacifica*, in subarctic waters. Fourteen species occur in the region covered by this survey.

Esterly (1914a) has reported the presence of *E. gibba* from the San Diego region. He had no males in the collection and was, therefore, unable to examine the copulatory organ. The possibility does exist, therefore, that this was a misidentification, particularly as he describes certain peculiarities in the structure of the first antennal peduncle which agree with *E. gibboides*. *E. gibba* does not occur in our collections north of 18° S., and is regarded as outside the area covered in this report.

KEY TO SPECIES OF EUPHAUSIA

1a Two pairs of denticles on lateral margin of carapace

2a Long vertical or backward-leaning lappet on basal segment of peduncle of first antenna *recurva*

2b Small, forward-pointing, bifid lappet on basal segment of peduncle of first antenna

3a No processes on second segment of peduncle of first antenna.....*mutica*

3b One acute process, on outer distal margin only, on second segment.....*brevis*

3c Two processes, one on outer dorsal, distal margin and one on inner distal margin, on second segment.....*diomedea*

2c Lobe on basal segment of peduncle of first antenna comblike, with 6–10 spiniform denticles along margin.....*eximia*

1b One denticle on each lateral margin of carapace

4a No mid-dorsal spiniform processes on third to fifth abdominal segments

5a Frontal plate lacks acute, produced rostrum.....*pacifica*

5b Pointed rostrum produced from frontal plate

6a Basal segment of peduncle of first antenna without distal lobe or process (male), or with only a small, flat, upward-directed process (female)... *tenera*

6b Basal segment of peduncle of first antenna with high, forward-directed, bifid, dorsal, leaflet.....*similis*

4b Mid-dorsal spiniform process on third abdominal segment only

7a Mid-dorsal longitudinal keel, on third segment of peduncle of first antenna, low and flat or slightly rounded as seen from the side

8a Mid-dorsal keel on frontal plate conspicuously raised, rising sharply at a point immediately behind the acute rostrum.....*paragibba*

8b Mid-dorsal keel on frontal plate rises gently toward gastric area, tracing a nearly straight line in lateral profile.....*pseudogibba*

8c Mid-dorsal keel on frontal plate very low, concave in lateral profile, in region forward of posterior margin of eyes.....*hemigibba*

7b Third segment of peduncle of first antenna, as seen from the side, bears on its mid-dorsal, anterior portion a high toothlike keel which is acute near its most anterior point

9a Distal margin of basal segment of peduncle of first antenna somewhat convex but lacks true lobe.....*distinguenda*

9b Distinct lobe or leaflet present on basal segment of peduncle of first antenna

10a Second segment of peduncle of first antenna provided distally with large, moveable, curved lamella covering proximal half of upper surface of third segment.....*lamelligera*

10b Second segment produced as short lobe with concave anterior margin*gibboides*

Euphausia recurva Hansen

(Fig. 19, *a-e*)

Euphausia recurva Hansen, 1905b: 13–14; 1912: 233–235, pl. 7, fig. 3, *a-n*.

Diagnosis.—The frontal plate is short; rostrum acute, narrowly triangular. The gastric region of the carapace is keeled. The eyes are medium-sized, spherical.

The basal segment of the first antennal peduncle is twice as long as broad, and is armed distally with a conspicuous, reflexed lappet on the dorsal side. This lappet differs extremely in the two sexes (fig. 19). In the male it is a hollowed oblong-triangular plate with the base half as broad as the segment. Its upper end is acuminate and backward-leaning. In the female the plate is vertical or only slightly recurved, and double, forming two triangular, acute processes with a common base a little more than half as broad as the segment. The following two peduncular segments are thicker in the male than in the female. The second segment is armed dorsally on its outer distal margin with a short, conical protuberance, and somewhat toward the inner side with a longer, slender, spiniform, forward-projecting process. The last segment is slightly shorter than the second and carries, dorsally, a very high keel or lamella which ends distally in an acute tooth. The scale of the second antenna reaches about to the middle of the third segment of the first antennal peduncle.

The terminal process of the copulatory organ is moderately long and thick with a well-developed foot and long heel (fig. 19). Distally, it curves fairly evenly and tapers rather abruptly to a point. On the side of the curvature it carries a short, rather obtuse, secondary process. The proximal process is thick, and the basal part is inflated. It terminates in a flattened expanded plate of somewhat variable shape. The median lobe has a rather narrow neck above the insertion of the lateral process, and the distal portion expands suddenly as an inverted triangle. The lateral process has a thick base and a slender, broadly curved, distal part. The

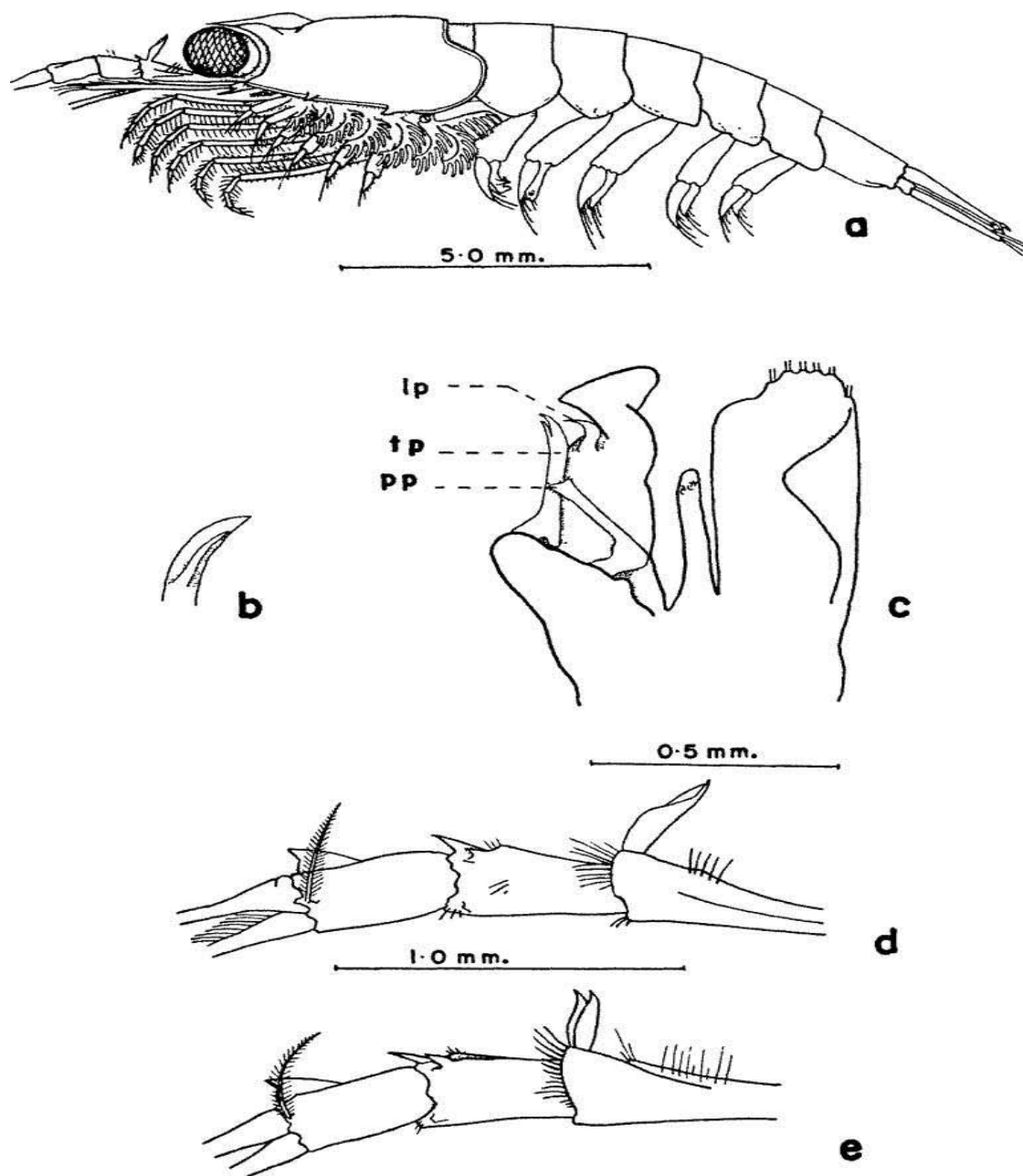


Fig. 19. *Euphausia recurva* Hansen. *a*. Adult male. *b*. Terminal end of terminal process showing secondary process. *c*. Male left copulatory organ, unrolled and seen from behind. *d*. Left first antennal peduncle of adult male from left side. *e*. Left first antennal peduncle of adult female from left side.

auxiliary lobe is long. The setiferous lobe has a partly truncate end with six or seven setae, and naked, parallel, lateral margins.

Length.—10–15 mm. Very large specimens reach 17 mm. in the Pacific.

Remarks.—One specimen is reported from the San Diego region by Esterly (1914*a*). He states that the leaflet on the first antennal peduncle curves forward and not backward, as described by Hansen. This modification was not observed in this collection, except in young females. Esterly's specimen was a female 12

mm. in length. The forward curve of the lappet has been noted in the present material only in young specimens smaller than about 8 mm.

Distribution.—North Pacific. *E. recurva* has been caught throughout the central North Pacific. The most northern record in the eastern part of the ocean is 40° 37' N., 143° 25' W. ("Northern Holiday" expedition); the most southern is 21° N., 156° 50' W., in Hawaiian waters (Hansen, 1915, based on Ortmann's specimens). The range of this species rarely reaches within 200–300 miles of the coast of California, north of 35° N., although the most near-shore record off northern California is 37° 12' N., 131° 25' W., near San Francisco Bay (Marine Life Research Cruise 4908). *E. recurva* frequently occurs within 50 miles of the coast of southern California and northern Baja California, to about 25° N., where the range again swings offshore. *E. recurva* was found as far north as 42° 07.9' N., 169° 28.1' W. in the northwestern central Pacific, and occurred south of 40° N. off Japan ("Transpacific" expedition). This species is recorded at 31° 20' N., 132° 29' W. off southern Japan (Hansen, 1912), and from the northern South China Sea (Hansen, 1916).

South Pacific. A single record is listed from the southeastern Pacific at 29° 33' S., 81° 34' W. (Hansen, 1915). Sheard (1953) found this species to be abundant in Australian waters.

Elsewhere. The species is also recorded from the subtropical zones of the Indian Ocean and the Atlantic.

Depth.—Adults, 500 meters to the surface; larvae, above 150 meters.

Euphausia mutica Hansen

(Fig. 20, *a–d*)

Euphausia mutica Hansen, 1905b: 14–15 (*partim*); 1910: 93–94, pl. 14, fig. 1, *a–d*.

Diagnosis.—The frontal plate is short, triangular, and carries a slender rostrum. A small bifid lappet, on the basal segment of the first antennal peduncle, is similar in both sexes: it is a little more than half as broad as the end of the segment, and is directed forward, upward, and outward, with the terminal spiniform processes straight and not curved downward (fig. 20). The second segment of the peduncle has no protuberances of any sort on the distal angles. The preanal spine is broad with three spines on the posterior margin in the male, and four in the female (fig. 20).

The copulatory organ of the male has all lobes well developed (fig. 20). The terminal process is long, fairly robust, curved distally, and tapers to an acute end. A small spine is present on the concave margin just before the end. The proximal process is curved, and ends in a large, distally rounded plate, which is proximally produced on its inner side as a protuberance directed toward the origin of the process. The lateral process is curved, acute. The median lobe resembles a bird's head, with an acute, curved, chitinized beak and thin neck.

Length.—10–15 mm.

Distribution.—North Pacific. This species is more widely distributed than the allied *E. recurva*, but occupies approximately the same area as the latter species in the northeastern central Pacific. Off North America, the most northern record is 40° 29' N., 134° 58' W. ("Northern Holiday" expedition). *E. mutica* reaches to

within 200–300 miles of the coast of California, north of Pt. Conception ($34^{\circ} 30' N.$), and frequently penetrates within 100 miles of the coast of southern California and northern Baja California, between $34^{\circ} N.$ and $25^{\circ} N.$ The most northern record in the northwestern central Pacific is $42^{\circ} 07.9' N.$, $169^{\circ} 28.1' E.$, and *E. mutica* was found at all stations east of Japan, south of $40^{\circ} N.$ (“Transpacific” expedition). It is present in Hawaiian waters (Hansen, 1915, based on Ortmann’s specimens; “Transpacific” expedition), off southern Japan at $31^{\circ} 20' N.$, $132^{\circ} 29' E.$, and in the northern part of the South China Sea (Hansen, 1912).

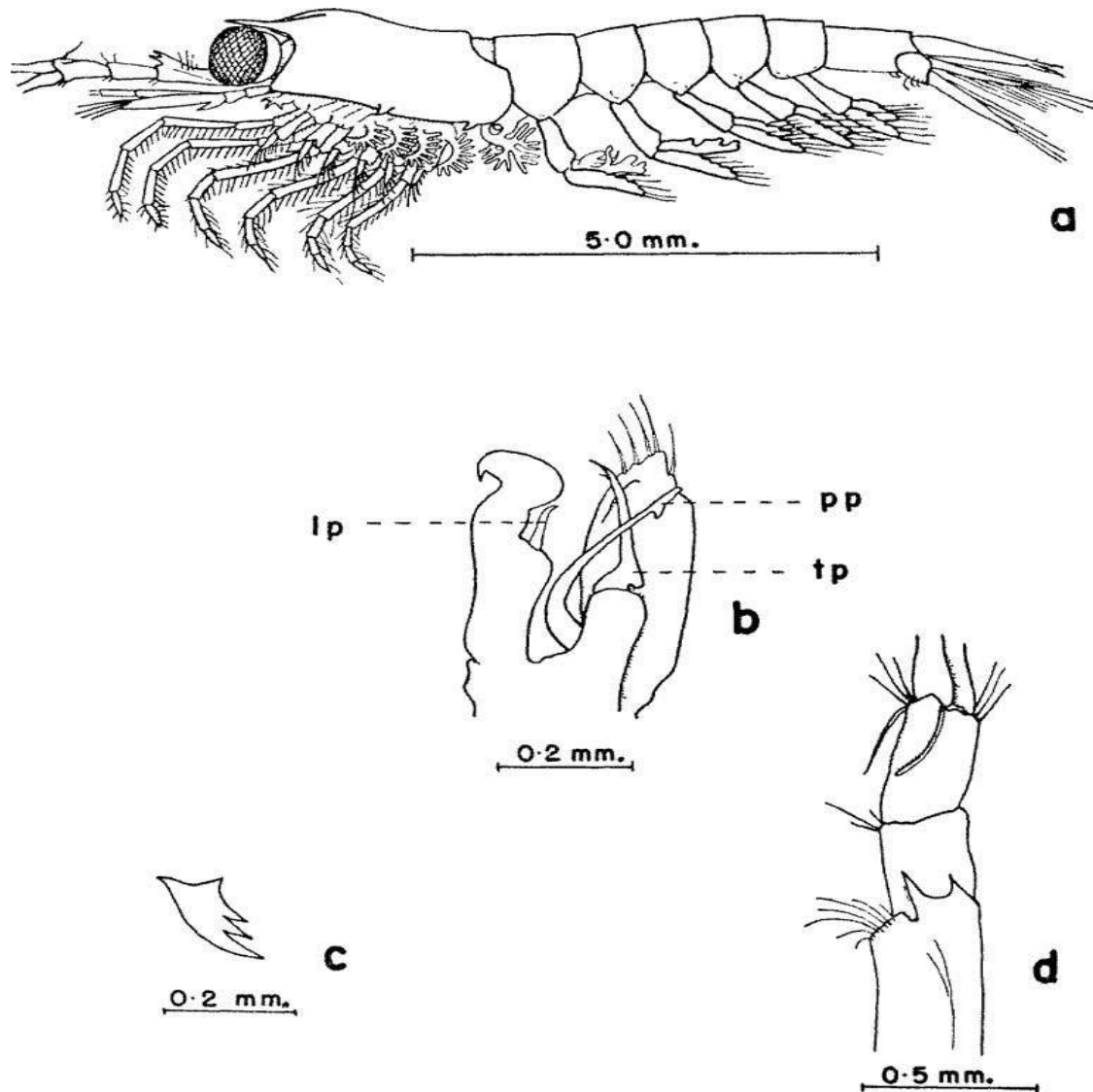


Fig. 20. *Euphausia mutica* Hansen. a. Adult male. b. Male left copulatory organ from behind. Processes from left to right: lateral, proximal, terminal. c. Preanal spine. d. Left first antennal peduncle from above.

Equatorial Pacific. *E. mutica* does not occur in our samples from the eastern equatorial Pacific. It has been caught in the East Indian Archipelago (Hansen, 1910) and inside the Great Barrier Reef of Australia (Tattersall, 1936). It is recorded from $06^{\circ} 34' N.$, $170^{\circ} 59' E.$ in the equatorial western central Pacific (Hansen, 1912).

South Pacific. This species is known from $20^{\circ} 29.5' S.$, $178^{\circ} 21.8' E.$ (“Capricorn” expedition), and from south of $10^{\circ} S.$, along the northern and eastern

margin of the South Pacific Central Water Mass. The most southern record, 29° 33' S., 81° 34' W. (Hansen, 1915), is also the most eastern record.

Elsewhere. Specimens have also been taken from the tropical and subtropical waters of the Indian Ocean and the Atlantic.

Depth.—Adults, 300 meters to the surface; larvae, above 150 meters.

Euphausia brevis Hansen.

(Fig. 21, *a-d*)

Euphausia brevis Hansen, 1905*b*: 15–16; 1912: 239–241, pl. 8, fig. 1, *a-g*.

Diagnosis.—The frontal plate is expanded over the eyestalks and carries a short, narrow rostrum. The carapace is keeled and vaulted over the gastric region.

There are two lateral denticles on the carapace. The abdominal segments are smooth above.

The anterior margin of the basal segment of the first antennal peduncle carries an upward- and inward-projecting lobe which curves in a forward direction (fig. 21). The lobe is bifid, the inner part being triangular with an acute apex, and the outer part spiniform. The base of the lobe is about half as wide as the segment. A little to the inside of the outer, upper anterior margin of the second segment is a conspicuous, acute, forward-directed tooth. The third segment is keeled above.

The male copulatory organ (fig. 21) carries a stout terminal process with a weakly curved, acutely tapered distal part which carries a secondary spine at its base. The proximal process is inflated from the base to the proximal half. It is strongly curved and ends as a flattened, rounded, oblong plate which bends backward and carries a forward-pointing protuberance at its base. The lateral process is fairly small, naked, and curved.

Length.—8.5–10 mm. This species is smaller than both *E. mutica* and *E. diomedae*. Its most useful character is the acute tooth on the upper, outer margin of the second peduncular segment.

Remarks.—Streets, in 1877, named and described incompletely *E. gibbosa* from the eastern Pacific area in which *E. brevis* Hansen is the dominant species of the genus. The two species appear to be the same. It has not been possible as yet to trace any type specimen of *E. gibbosa*, and the literature has had no reference to the species subsequent to its description 77 years ago. *E. brevis* is a well-known name in general use, hence, pending further detailed information, the name *E. gibbosa* is not revived here. Furthermore, this is thought to be in the spirit of the Copenhagen Decisions on Zoölogical Nomenclature (p. 26, paragraph 28), dealing with the Law of Priority considered at the Fourteenth International Congress of Zoölogy, Copenhagen, August, 1953.

Distribution.—North Pacific. This euphausiid has been caught only to the south of 33° 03' N., 136° 22.5' W. in the northeastern central Pacific ("Northern Holiday" expedition), and south of 32° 34.1' N., 176° 44.8' E. in the northwestern central Pacific. It was not found west of the above station by the "Transpacific" expedition but is reported from just south of the region of the Scripps survey, at 31° 20' N., 132° 29' E. (Hansen, 1912), off southern Japan. It reaches as far east as 29° 31' N., 120° 07' W. (Marine Life Research Cruise 4906) off southern Cali-

W. ("Shellback" expedition). *E. brevis* is known from Hawaiian waters ("Mid-Pacific" and "Transpacific" expeditions).

Equatorial Pacific. *E. brevis* has not been taken between 15° S. and 15° N. in the part of the ocean east of 170° W., nor was it present at the equator at 169° E. The southeastern limit of its range appears to be near $18^{\circ} 06' N.$, $124^{\circ} 07'$ ("Capricorn" expedition). It has been caught in the South China Sea and at one station, $00^{\circ} 36' N.$, $126^{\circ} 52.3' E.$, near the East Indian Archipelago (Hansen, 1910).

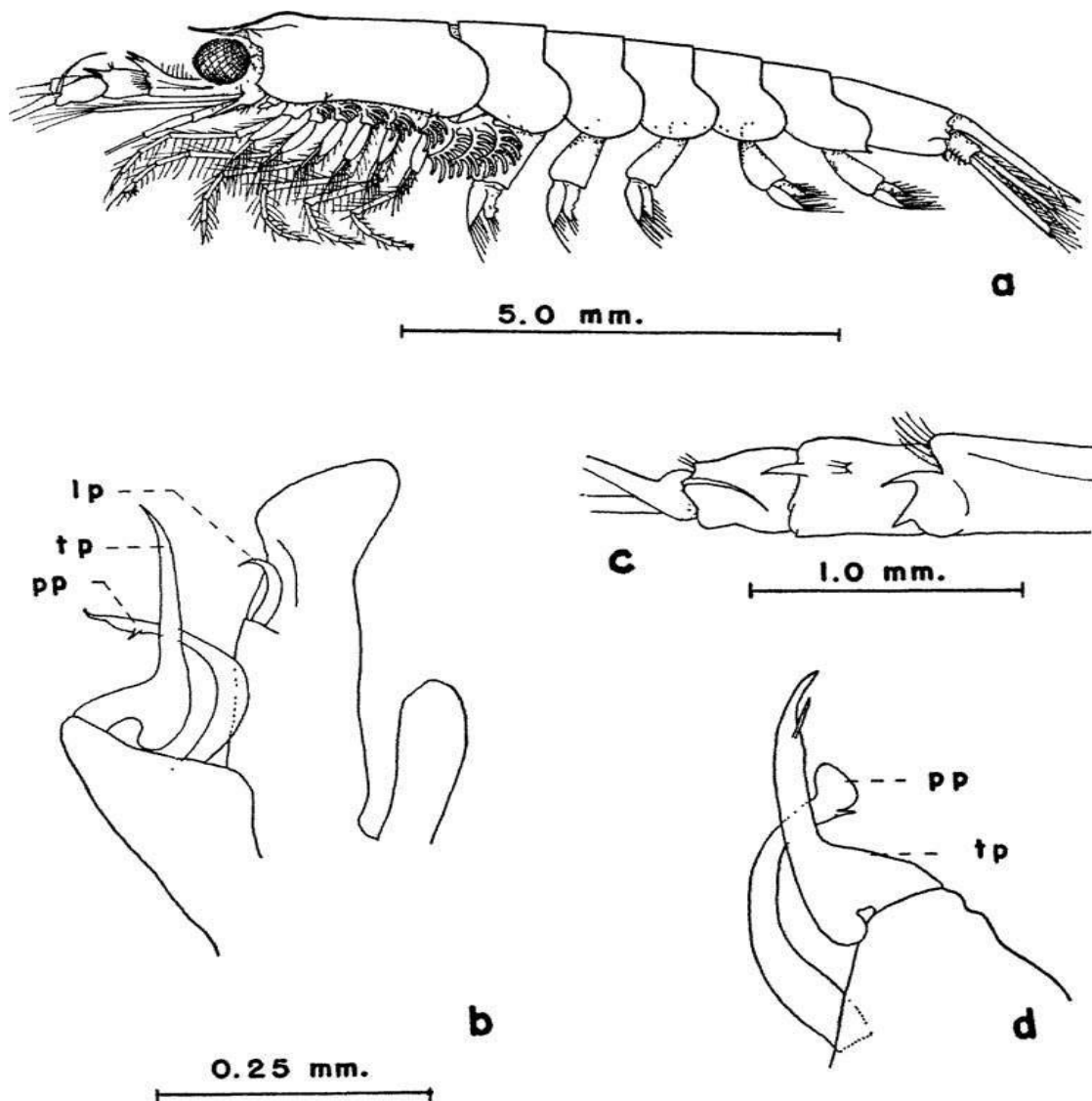


Fig. 21. *Euphausia brevis* Hansen. a. Adult male. b. Male left copulatory organ from behind. c. Right first antennal peduncle from above. d. Proximal and terminal processes from side.

South Pacific. *E. brevis* was taken in the southwestern central Pacific at $20^{\circ} 29.5' S.$, $178^{\circ} 21.8' E.$ ("Capricorn" expedition), and as far east as $21^{\circ} 36.2' S.$, $94^{\circ} 56' W.$ (Hansen, 1912). The most southern record is $33^{\circ} S.$, $120^{\circ} 57' W.$ (Hansen, 1915).

Elsewhere. The species is also widespread in the tropical and subtropical waters of the Indian Ocean and the Atlantic.

Depth.—Adults, 300 meters to surface; larvae, above 150 meters.

Euphausia diomedea Ortmann

(Fig. 22, *a-c*)

Euphausia diomedea Ortmann, 1894: 102, pl. 1, fig. 3; Hansen, 1910: 91–93, pl. 13, fig. 4, *a-e*; 1912: 235, pl. 7, fig. 4, *a*.

Diagnosis.—The frontal plate is short and bears a slender rostrum. Occasionally the frontal plate is broadly expanded over the eyestalks.

The upper anterior margin of the basal segment of the first antennal peduncle carries a forward- and outward-pointing bifid lobe, the base of which is a little wider than half the width of the segment (fig. 22). There are two processes on the upper distal end of the second segment. The outer of these is blunt and the inner spiniform. The third segment carries a short, low keel.

There are two lateral denticles on the carapace. The abdominal segments are unarmed dorsally. The terminal process of the male copulatory organ (fig. 22) has a well-developed heel. The terminal process is robust, long, and straight but ends in an abruptly tapered, strong hook. At the base of the hook is a small, secondary spine. The proximal process is longer than the terminal and curves from its inflated basal third to a flattened distal end. This flattened plate has at its base a forward-pointing, acute tooth. The lateral process is strong, curves abruptly to an acute end, and is naked.

Length.—12–17.5 mm.

Distribution.—North Pacific. The most northern record in the Scripps eastern Pacific material is 24° 37' N., 119° 21' W. off Baja California (Marine Life Research Cruise 4903). Hansen (1912) records specimens from as far north as 30° 35' N., 117° 15' W. *E. diomedea* occurs only to 14° 20' N., 149° 50' W. in the equatorial central Pacific near Hawaii ("Mid-Pacific" expedition). It penetrated as far as 40° N. near northern Japan, and eastward to 36° 35' N., 163° 46' E. in the Kuroshio Extension ("Transpacific" expedition).

Equatorial Pacific. Hansen (1916) lists it from 21° 31' N., 117° 53' E. in the China Sea. It is abundant around the Philippines (Hansen, 1916), around the East Indian Archipelago (Hansen, 1910), and was caught inside the Great Barrier Reef of Australia (Tattersall, 1936). The most southern record in the western Pacific is off Suva, Fiji Islands (approximately 18° S., 179° E.), and in the eastern Pacific it is 16° 32.5' S., 119° 59' W. (Hansen, 1912). This species did not occur within 150 miles of the coast of Ecuador and Peru, and was not present immediately south and east of the Galapagos Islands, although it was found throughout the rest of the region surveyed by the "Shellback" expedition.

Elsewhere. This species also occurs in the tropical waters of the Indian Ocean and the Atlantic.

Depth.—Adults, surface to 500 meters; larvae, above 200 meters.

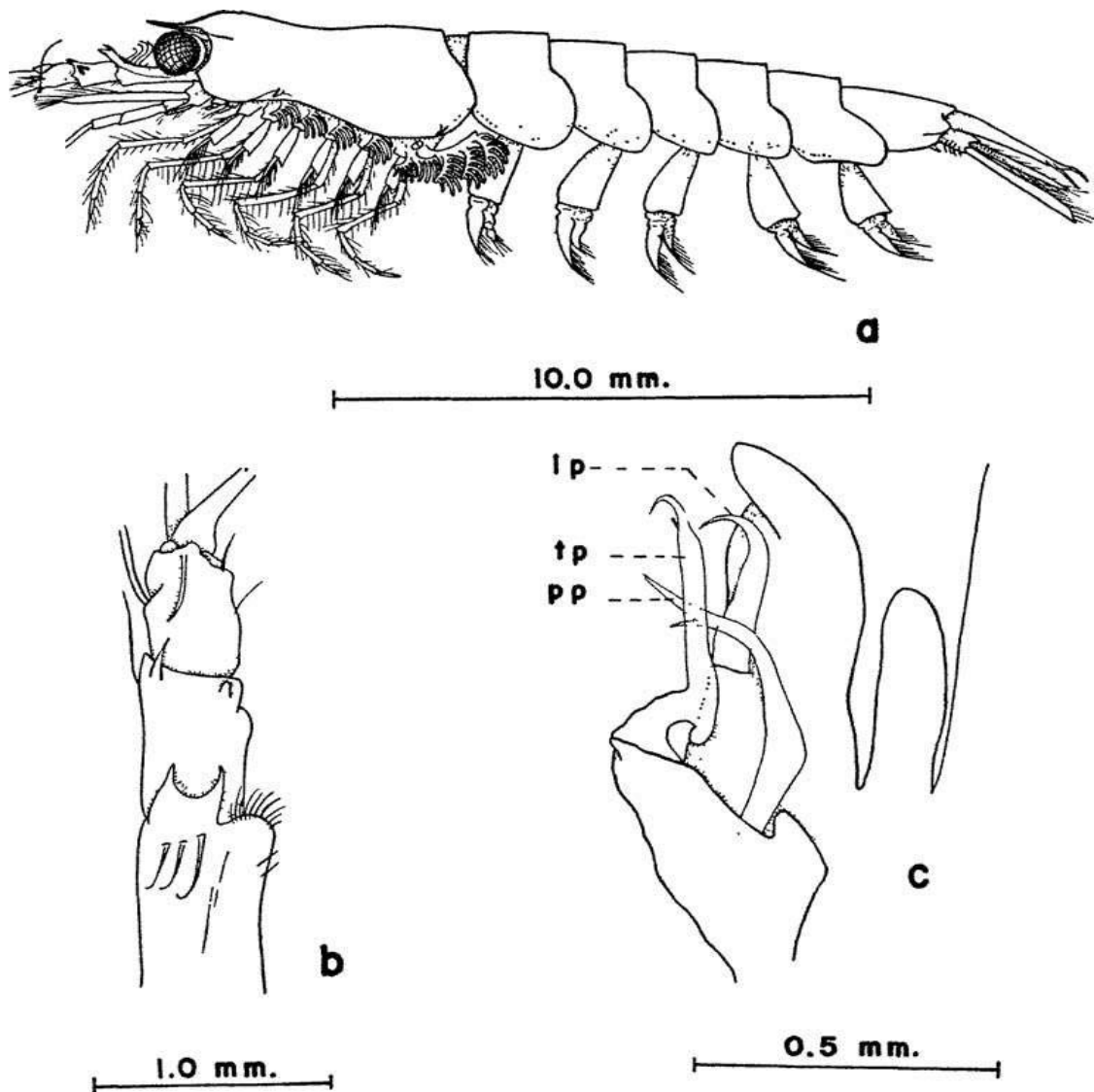


Fig. 22. *Euphausia diomedea* Ortmann. *a*. Adult male. *b*. Right first antennal peduncle from above. *c*. Male left copulatory organ from behind.

Euphausia eximia Hansen

(Fig. 23, *a-d*)

Euphausia eximia Hansen, 1911: 23, fig. 5; 1912: 230–233, pl. 7, fig. 2, *a-g*.

Diagnosis.—The short frontal plate is triangular and has a prominent, slender rostrum. The gastric region is vaulted, with a high keel reaching out onto the rostrum. The upper margin of the keel is sometimes angular. The eyes are medium-sized, spherical.

The first antennal peduncle is similar in both sexes (fig. 23). The first segment is nearly as long as the sum of the other two, and is armed on the dorsal side of the distal end with an almost vertical transverse lobe or plate. The anterior margin of this plate carries numerous (about twelve) spiniform processes, giving it a pectinate appearance. The second segment is a trifle longer than the third. The dorsal side of its margin bears two prominent, somewhat curved, forward-projecting protuberances. The inner protuberance may be bifurcate. The terminal segment

carries a keel or lamella dorsally. This keel is about two-thirds as long as the segment, and its anterior margin is concave; its uppermost part ends as a small tooth. The scale of the second antenna reaches about to the middle of the third segment of the first antennal peduncle. The outer spiniform process of the second antennal peduncle is about half as long as the scale.

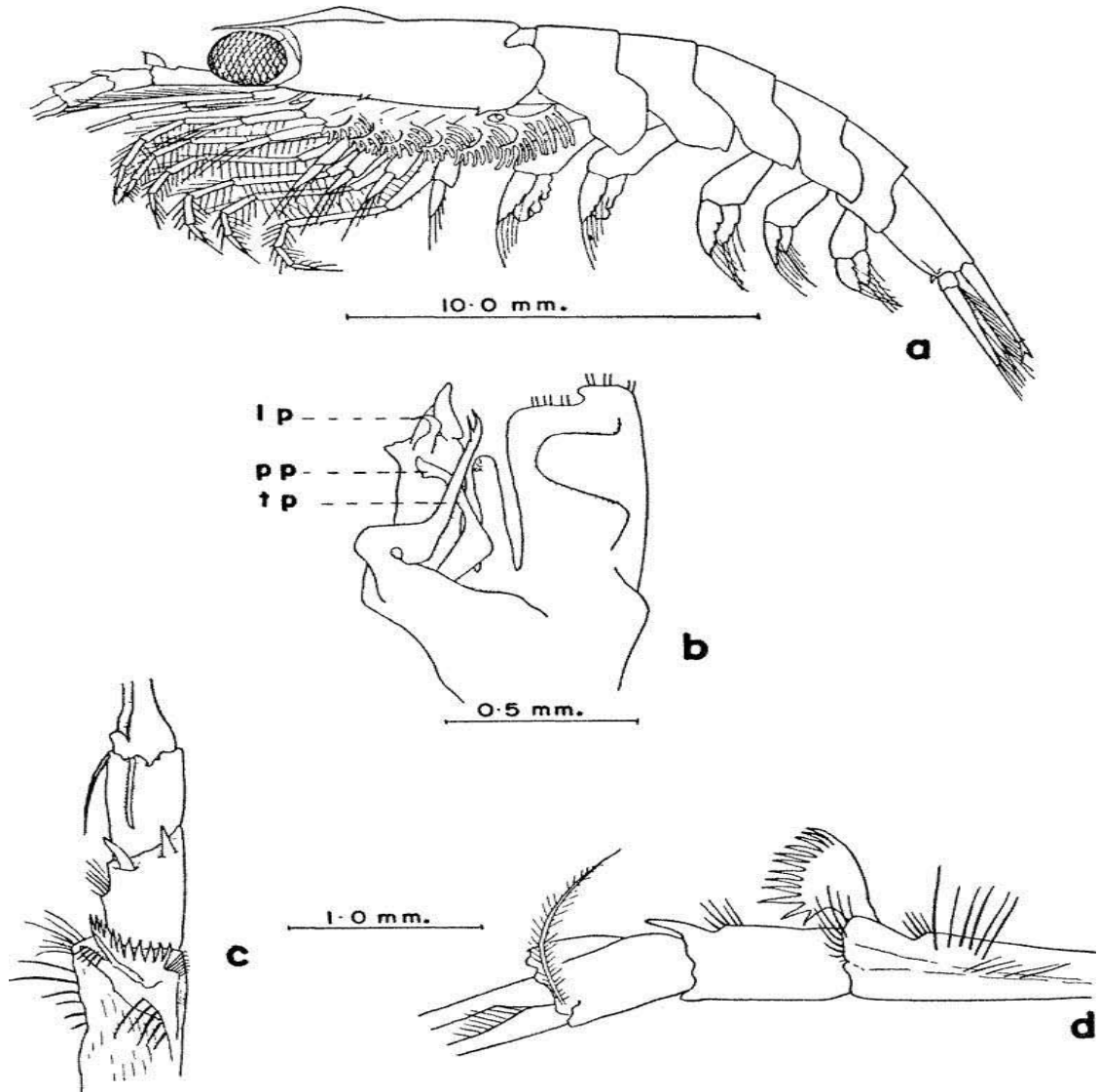


Fig. 23. *Euphausia eximia* Hansen. *a.* Adult male. *b.* Male left copulatory organ, partly unrolled and seen from behind. *c.* Left first antennal peduncle from above. *d.* Left first antennal peduncle from left side.

The terminal process of the male copulatory organ is long and fairly straight (fig. 23). The foot and heel are well developed. The distal part is slightly and evenly curved. At the beginning of the curvature is a slender, straight, fairly long spine, the tip of which does not quite reach the end of the process. The proximal

process is long and bent at the base, which is somewhat inflated. The remainder is slender and ends in a flattened plate with a posterior concave margin carrying a small protuberance. The distal part of the median lobe expands suddenly as a broad triangle. The lateral process is inserted just before this expansion. It is fairly large, with a thick basal part and a slender, broadly-curved, distal part. The auxiliary lobe is long and narrow. The setiferous lobe is of regular width and partly truncate at the end, which carries six or seven setae. The lateral margins are naked, and the pouch on the posterior surface of the lobe is conspicuous.

Length.—16–20 mm.

Distribution.—North Pacific. According to Hansen, this species is confined almost entirely to the tropical eastern Pacific. It was not reported from the San Diego area by Esterly, but it occurs occasionally in our present collections. It is found in waters east of the 125° W. meridian off the coast of southern California and Baja California where it may be abundant at some stations. The most northern record is inshore at 33° 24' N., 117° 54.8' W.

Equatorial Pacific. *E. eximia* occupies much of the eastern equatorial basin surveyed by the "Shellback" expedition. It was missing from an east-west belt between 07° N. and 03° N., although it has been taken in the Gulf of Panama (Hansen, 1915); it was not caught at the stations within 350 miles of the coast of Central Mexico. It is present in the Gulf of California (Hansen, 1912). The only latitudes at which *E. eximia* is known to reach west of 125° W. are between 11° N. and the equator. The most western record is 10° 01' N., 145° 10.9' W. ("Mid-Pacific" expedition) (cf. *E. distinguenda*). South of the equator this species occurred only to the west of 86° W., where it reached to 08° S., off Ecuador.

Depth.—Adults, surface to 500 meters; larvae, above 150 meters.

Euphausia pacifica Hansen

(Fig. 24, *a-e*)

Euphausia pacifica Hansen, 1911: 28–29, fig. 10; 1912: 241–242, pl. 7, fig. 5, *a* and *b*; Esterly 1914a: 6–7, pl. 1, figs. 9–11, pl. 2, figs. 18, 19, 23, 27, 29; 1915: 81–84, pl. 1, fig. 2, *a-g*; Banner, 1949: 33–36.

Diagnosis.—The anterior margin of the carapace is slightly produced as an obtuse angle or is rounded. No rostral process is developed. The dorsal surface of the carapace lacks a keel. A single, well-developed, lateral denticle is placed at about the middle of the inferior margin of the carapace. The eyes are large and spherical.

The first segment of the first antennal peduncle carries on its dorsal, distal margin a very acute, small, dentate process which projects over the second segment (fig. 24). There is also a row of very strong, recurved spines on the dorsal side of the first segment. The second segment is distinctly longer than the third and sometimes carries a toothlike process similar to, but considerably smaller than, that carried by the first. The third segment bears a low, dorsal lamella or keel. The peduncular scale of the second antenna reaches slightly beyond the distal end of the second segment of the first antennal peduncle.

The terminal process of the male copulatory organ has a rather long foot, whereas the heel is rather short, but well developed, and angular (fig. 24). Distally,

the terminal process first constricts and then ends as a flat, irregularly shaped blade lying at an angle to the rest of the process. The proximal process does not reach nearly to the end of the terminal. It is inflated at the base and ends distally in a large oblong plate strongly bent posteriorly and set at right angles to the rest of the process. Near the base of the plate is a small projection which overlaps and adheres to part of the plate. The median lobe appears crested and carries a long, distally hooked lateral process. There may or not be an accessory process. When present, it is carried on the median lobe near the hook of the lateral process and is small, simple, and styliform. The auxiliary lobe is slender, and the setiferous lobe carries a prominent pouch on its posterior surface.

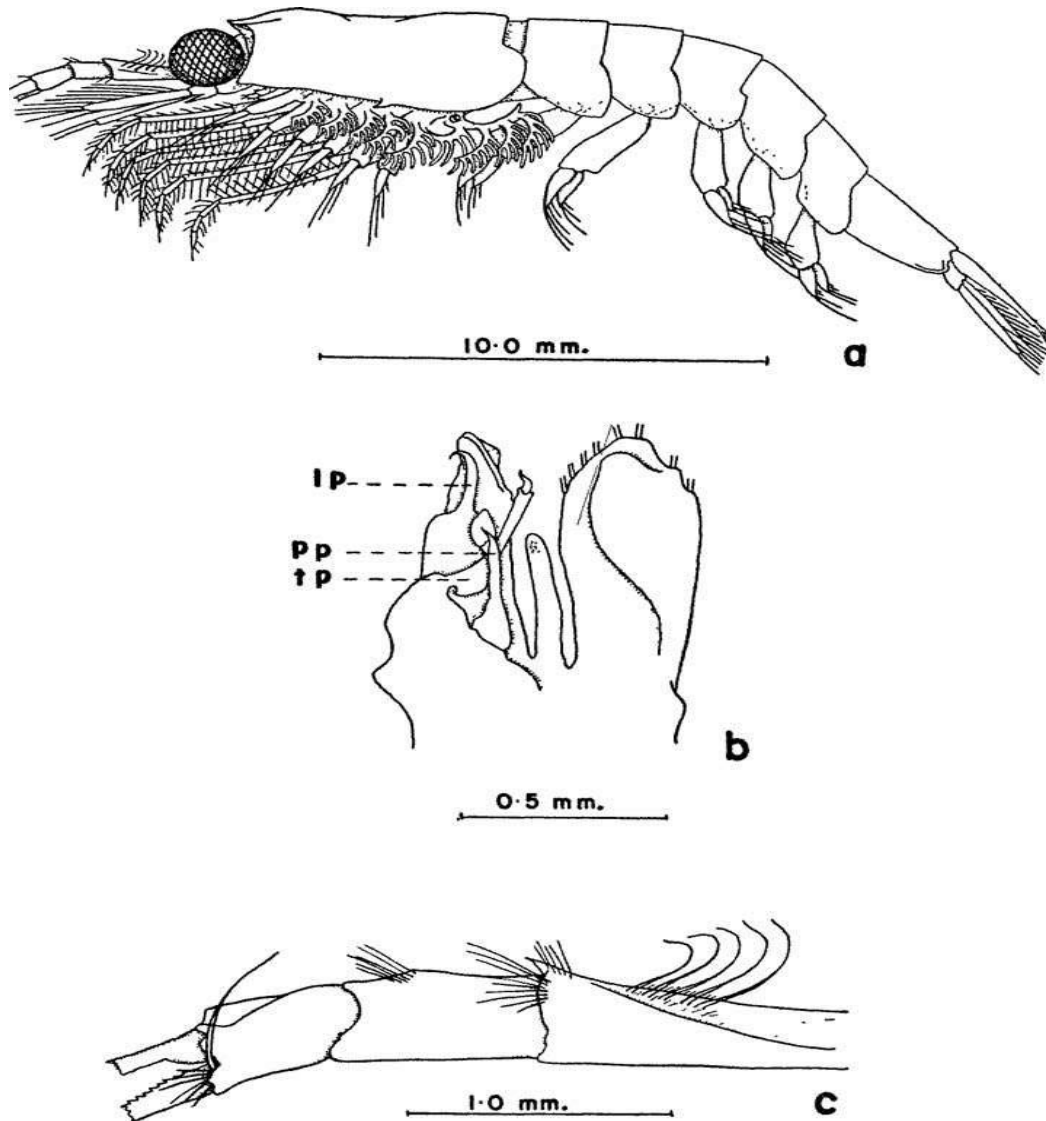


Fig. 24. *Euphausia pacifica*, Hansen. *a.* Adult female. *b.* Male left copulatory organ, partly unrolled and seen from behind. *c.* Left first antennal peduncle from left side.

Length.—Males up to 22 mm.; females up to 25 mm.

Remarks.—According to Hansen (1915), the proximal process bears no secondary processes. Esterly (1914a) mentioned a serrate lamella on the proximal process, and careful staining by Banner (1949) revealed that this is actually a secondary process. A careful examination of the specimens of this collection confirmed Banner's findings on this point.

Hansen (1910) stated that in all species of *Euphausia* known to him the median lobe lacks an additional process. Esterly, however, figures an additional process and states, "*E. pacifica* was described (by Hansen) in 1911 and the fact that the additional process is present should be added to his account." Ten out of fourteen specimens examined by Banner possessed an additional process; the remainder lacked it. Most specimens examined in this investigation lacked this process. Although these variations are probably unessential, the possibility that two forms are currently confused should not be overlooked.

Distribution.—North Pacific. This species is abundant throughout the subarctic Pacific, including the Gulf of Alaska, to as far south as 38° 30' N., 154° 25' W. in the northeastern central Pacific ("Northern Holiday" expedition). Its range swings southward along the California coast, and *E. pacifica* is the dominant euphausiid within 300–400 miles of the coast north of Pt. Conception (34.5° N.). It occurs within 200–250 miles of the coast between 34° N. and 27° N. The most southern record is 26° 09' N., 114° 08' W. (Marine Life Research Cruise 5003). Hansen (1915) reports specimens taken in the western Pacific from the China Sea, southward to Formosa. The "Transpacific" expedition found *E. pacifica* to reach as far south as 34° 07' N., 156° 11' E. in the northwestern central Pacific. Off southeastern Japan, it was present only near to shore, the most southern record being 32° 45' N., 137° 47.5' E. This species was present all the way across the southern Bering Sea, except at three stations near the mid-point of the traverse ("Transpacific" expedition). Hansen also lists this species from near Bering Island, and Banner (1949) reports neritic records in the southeastern Bering Sea. It is confined to the Pacific.

Depth.—Adults, 100–1,000 meters; larvae, 200 meters to surface.

Euphausia tenera Hansen

(Fig. 25, a–c)

Euphausia gracilis G. O. Sara, 1885: 89–91, pl. 15, figs. 12–23, (*nec E. gracilis* Dana, 1852: 644); *E. tenera* Hansen, 1905b: 9; 1910: 95–97, pl. 14, fig. 3, a–e.

Diagnosis.—The frontal plate is narrow and the rostrum fairly short but quite acute. The carapace is slightly keeled in the gastric region. The eyes are small and spherical.

The carapace has a single lateral denticle at its mid-point and the abdominal segments lack dorsal spines.

In the male the basal segment of the first antennal peduncle lacks lobes or processes but carries several strong, curved setae. In the female the anterior margin of the basal segment carries a small, flat, upward-directed process visible from the side. In the male the second segment is produced as a large, thin lobe which covers a considerable part of the upper surface of the third segment. In the female this lobe is reduced and terminates in an angle. There are no processes on the third segment of the peduncle in either sex.

The terminal process of the male copulatory organ (fig. 25) has a well-developed foot and heel, after which it is rather short and straight until it curves to an acute, naked end. The proximal process curves from an inflated base and ends as a four-toothed comb. At an angle to these teeth, there is a curved bifid hook with a small process on its concave margin. The lateral process has a heavy, strong base and ends, distally, in an acute hook with a sharp tooth on its convex margin.

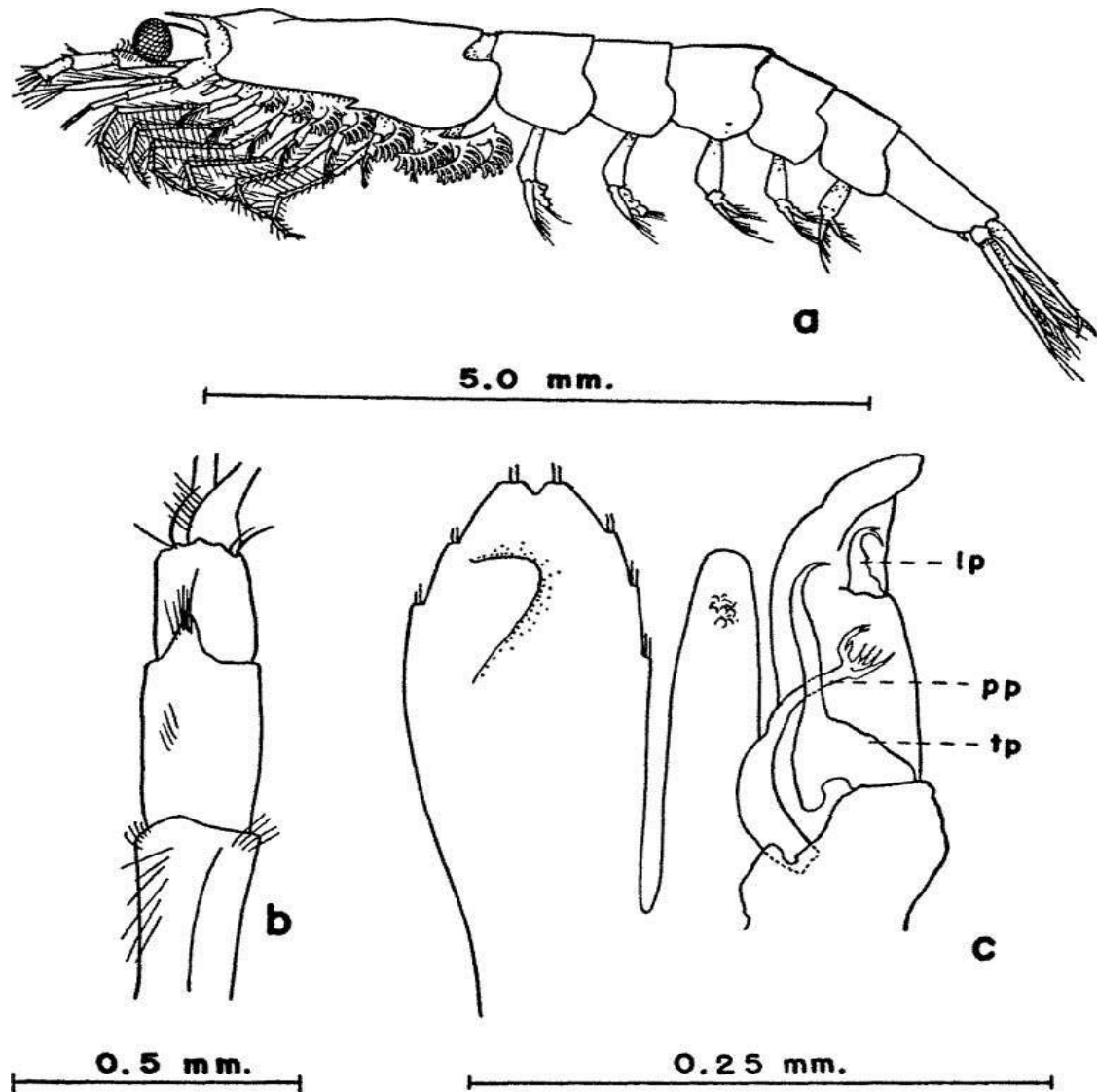


Fig. 25. *Euphausia tenera* Hansen. *a.* Adult male. *b.* Right first antennal peduncle from above. *c.* Male right copulatory organ from behind.

Length.—8–9 mm.

Distribution.—North Pacific. This species, it appears, occupies the broadest belt of latitude of any of the euphausiids whose principal affinity is with equatorial waters. It has been found to $26^{\circ} 16' N.$, $117^{\circ} 03' W.$, off Baja California. The most northern record in the eastern central Pacific is $30^{\circ} 25' N.$, $145^{\circ} 08' W.$ (“Northern Holiday” expedition). It reaches to $40^{\circ} N.$ near to northern Japan, and was found at all stations south of $39^{\circ} N.$ in the western central Pacific (“Transpacific” expedition).

It is reported from 21° 31' N., 117° 53' E. in the South China Sea (Hansen, 1916).

Equatorial Pacific. It was taken near the East Indian Archipelago (Hansen, 1910), and off northeastern Australia (Tattersall, 1936). It is common in the equatorial mid-Pacific ("Mid-Pacific" expedition; "Capricorn" expedition), and was present in the eastern equatorial basin explored by the "Shellback" expedition, except within 50–100 miles of the coasts of Ecuador and Peru. It was also missing from collections from waters directly south of Costa Rica to a distance of 250 miles, and from an east-west belt (from about 100° W. to 125° W.) between 07° N. and 10° N.

South Pacific. This species is recorded from off southeastern Australia (Sars, 1885). It was caught as far south as 20° 29.5' S., 91° 52.5' W. in the eastern South Pacific explored by the *Albatross* (Hansen, 1912).

Elsewhere. It is also found in the tropical and subtropical waters of the Indian Ocean and the Atlantic.

Depth.—Adults, above 300 meters; larvae, about 150 meters.

Euphausia similis G. O. Sars

(Fig. 26, *a–d*)

Euphausia similis G. O. Sars, 1885: 79–80, pl. 13, figs. 1–6; Hansen, 1913*a*: 29, pl. 4, fig. 3, *a–e*; John, 1936: 233–236, figs. 24–26.

Diagnosis.—The carapace bears a single denticle on each lateral margin. The frontal plate is produced into a slender, almost perfectly horizontal, rostrum which reaches to the anterior margin of the eyes. The eyes are large. The first segment of the peduncle of the first antenna is produced dorsally into a conspicuous, anteriorly directed, bifid process (fig. 26). The dorsolateral anterior margins of the second segment of the peduncle each bears a low keel which terminates in a toothlike process. Viewed laterally, the tooth and keel on the inner margin of the segment is higher than the slightly shorter keel on the outer margin.

The first three abdominal segments are each slightly produced as a rounded heel at the mid-dorsal posterior margin (fig. 26). In the present specimens, none of these projections is in the form of a tooth. The heel is less produced on the first and second segments than on the third. The sixth abdominal segment is as deep, or slightly deeper, near its mid-point than the preceding segment.

The male copulatory organ bears three processes. The proximal process bends sharply inward near its mid-point, and the distal half is broadened medially, terminating acutely. The terminal process is slender and terminates in a subacute hook. At the base of this hook, the distal part of the terminal process is slightly expanded, forming a small plate which projects from the process in the direction toward which the hooked tip curves. The lateral process is sharply hooked and adheres closely to the median lobe.

Length.—The largest males from Japan are 22 mm.; females up to 26 mm.

Remarks.—Two varieties of this species have been described. Var. *crassirostris* Hansen (1910), which is equatorial, possesses a vaulted and broadened frontal plate. This condition seems to be similar to an anomalous broadening of the frontal plate which has been noted in some Pacific specimens of *E. diomedea*.

Var. *armata* Hansen (1911) (= *E. similis* var. *lobata* Zimmer, 1914), which occurs in subantarctic waters together with *E. similis*, possesses a short tooth on the mid-dorsal posterior margin of the third abdominal segment. Both varieties are in essential agreement with Sars's *E. similis* and with the Seripps specimens in the structure of the copulatory organ, although John (1936) has demonstrated that there are slight differences in this organ between *E. similis* and *E. similis* var. *armata*.

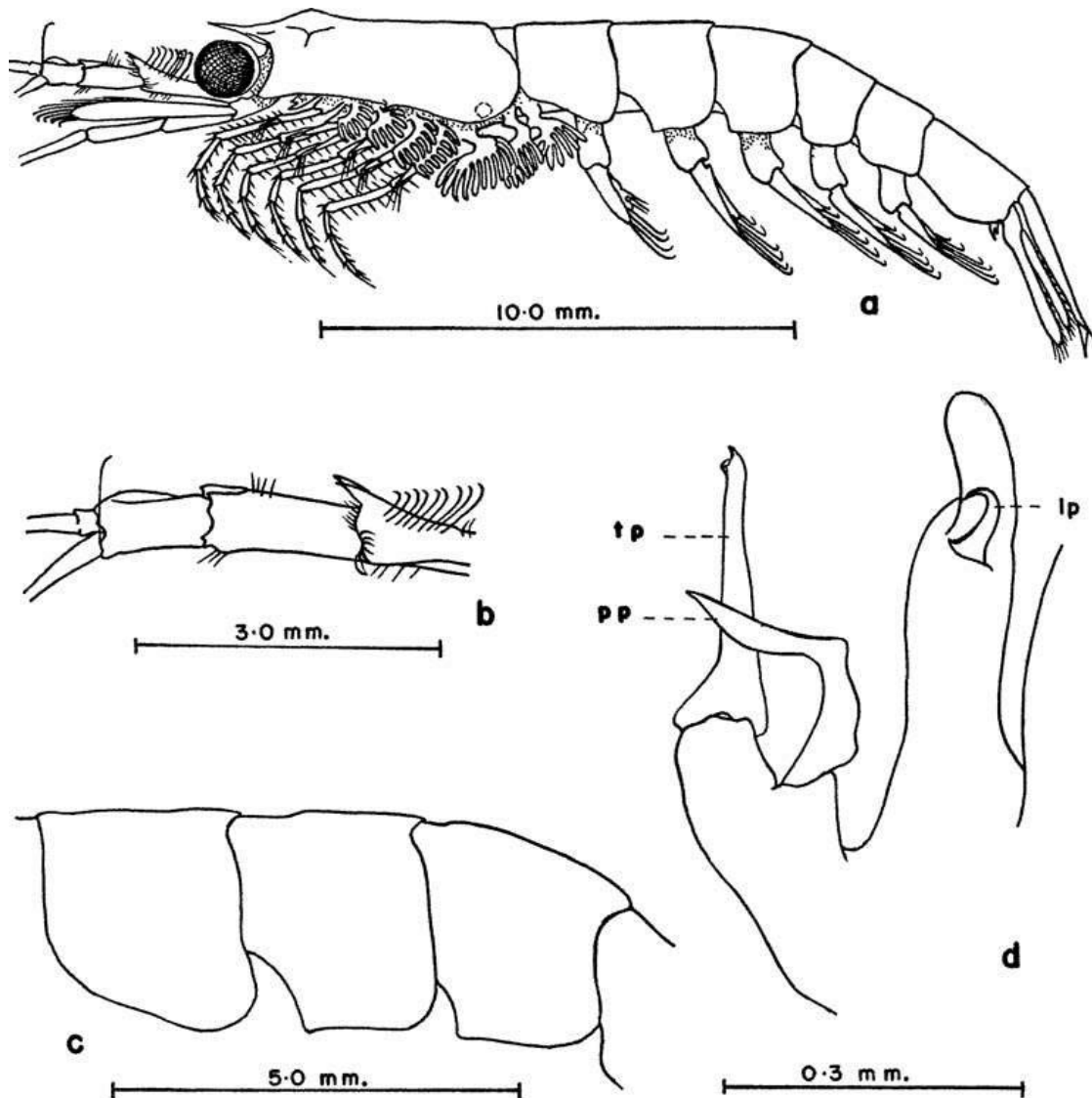


Fig. 26. *Euphausia similis* G. O. Sars. a. Adult male. b. Left first antennal peduncle from left side. c. First, second, and third abdominal somites seen from left side. d. Male left copulatory organ from behind.

E. similis may be sometimes confused with *E. gibboides*, owing to its large size and to the large size of the eyes in both of these species. *E. similis* differs, however, in having (1) a longer and deeper sixth abdominal segment, (2) no long tooth on the second segment of the peduncle of the first antenna, (3) no tooth on the third

abdominal segment (except in var. *armata*), and (4) in the structure of the copulatory organ.

Distribution.—Equatorial and North Pacific. *E. similis* inhabits waters of the Kuroshio system as far north as 39° 44' N., 148° 24' E. off northern Japan, and as far east as 36° 04' N., 162° 13.5' E. in the Kuroshio Extension ("Transpacific" expedition). It was present near shore off southern Japan and has been taken in Philippine waters (Hansen, 1916). Var. *crassirostris* occurs around the East Indian Archipelago.

South Pacific. *E. similis* and *E. similis* var. *armata* are present in subantarctic waters of the southern mid-Pacific and in New Zealand and South Australian waters (John, 1936); only *E. similis* has been taken south and west of Cape Horn.

Elsewhere. Var. *crassirostris* occurs in the Indian Ocean (Tattersall, 1939). Sars (1885) reported *E. similis* from off Buenos Aires. John (1936) shows that *E. similis* is circumpolar in subantarctic waters, var. *armata* being absent only from the Falkland sector.

Euphausia paragibba Hansen

(Fig. 27, a-d)

Euphausia paragibba Hansen, 1910: 100-101, pl. 14, fig. 6, a-d.

Diagnosis.—The frontal plate is short with a very acute rostrum.

There is a single pair of lateral denticles on the carapace and an acute, short, dorsal process on the third abdominal segment.

The basal segment of the first antennal peduncle carries a triangular process with its acute apex directed forward, upward, and outward (fig. 27). The base of this lobe is about half the width of the segment. The second segment carries a small, sharp tooth on its distal inner angle. The keel on the third segment reaches almost to the end of the second segment and gradually decreases in height in a posterior direction. The frontal plate bears a small mid-dorsal keel which is conspicuously raised above the lateral margins of the frontal plate, rising sharply at a point immediately behind the acute rostrum.

The terminal process of the male copulatory organ has an extremely long, well-developed heel (fig. 27). It curves weakly and is fairly slender. Its distal end is feebly hooked and is long and slender beyond the insertion of its lateral spiniform tooth. The proximal process is longer than the terminal, curved at the middle, and tapers gradually to an acute, hooked end. Terminally the median lobe dilates suddenly and is oval. The lateral process has a thick base, dilates in the middle, and its distal one-third is abruptly tapered and curved with three acute teeth on the convex outer margin.

Length.—12-16 mm.

Distribution.—Equatorial Pacific. This species is recorded from one station, 00° 17.6' S., 129° 14.5' E., in the Timor Sea (Hansen, 1910). It has been caught at 00° 04' N., 169° 00' E. ("Capricorn" expedition) and at 04° 41.1' N., 140° 06' W. ("Mid-Pacific" expedition). Its range seems to penetrate the equatorial eastern Pacific as three projections, reaching from a narrow equatorial belt to (a) the northeast, as far as 19° 05' N., 124° 38' W., off Baja California, (b) the east, as

far as $00^{\circ} 18' N.$, $89^{\circ} 40' W.$, north of the Galapagos Islands ("Shellback" expedition), and (c) the southeast, off Peru, at least as far as $18^{\circ} 47.1' S.$, $89^{\circ} 26' W.$ (Hansen, 1912).

Elsewhere. *E. paragibba* is also a tropical form in the Indian Ocean.

Depth.—Adults, above 500 meters; larvae, above 250 meters.

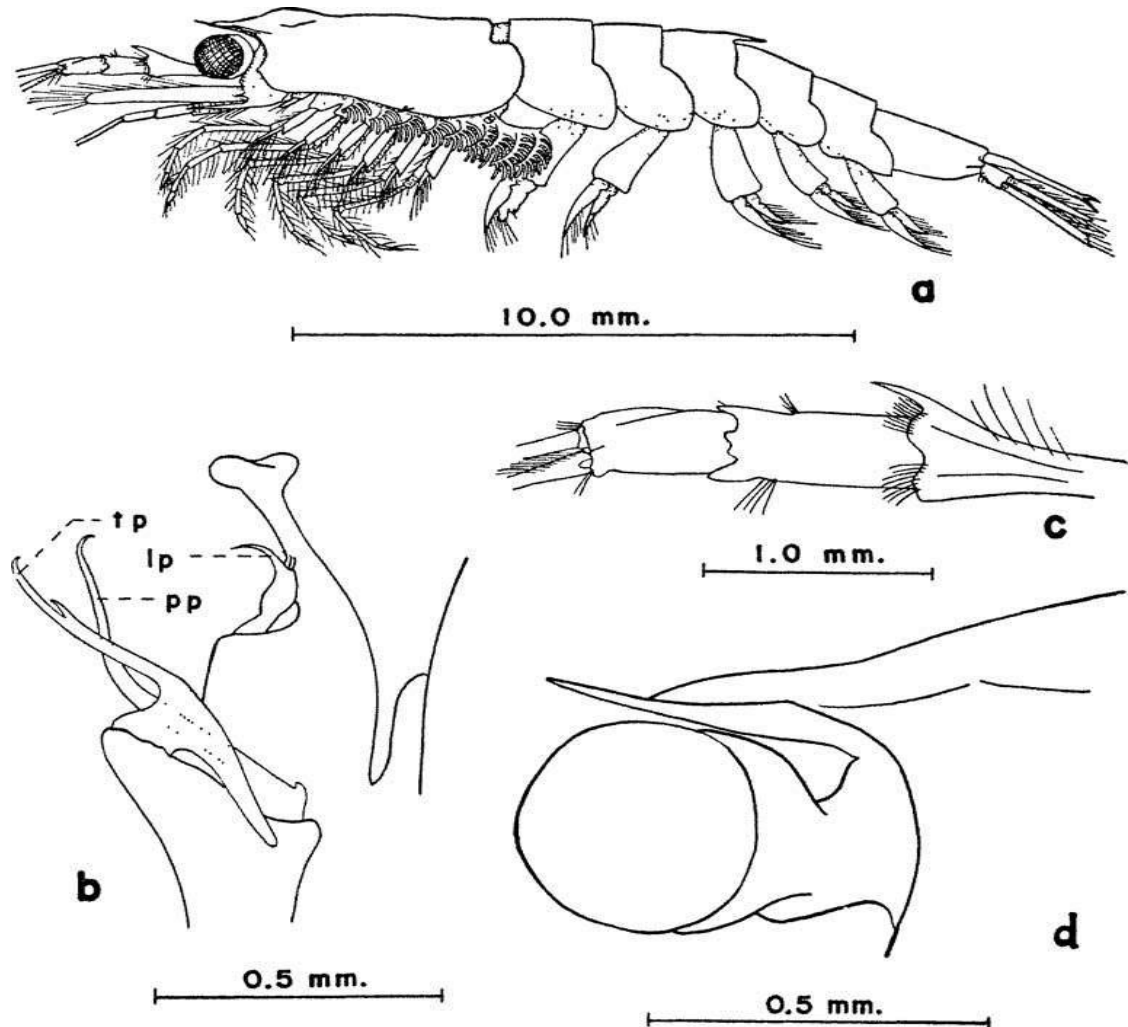


Fig. 27. *Euphausia paragibba* Hansen. a. Adult male. b. Male left copulatory organ from behind. c. Left first antennal peduncle from left side. d. Frontal plate, rostrum, and eye.

Euphausia pseudogibba Ortmann

(Fig. 28, a-d)

Euphausia pseudogibba Ortmann, 1893: 12, taf. 1, fig. 6; Hansen, 1910: 97-99, pl. 16, fig. 4, a-e

Diagnosis.—The frontal plate is short and bears a small, acute flange at each corner, above the eye. Viewed from the side (fig. 28), the dorsal margin of the rostrum slopes downward posteriorly, then traces a nearly straight, slightly raised, inclined line, as the keeled mid-dorsal part of the frontal plate rises toward the gastric area.

The first segment of the antennal peduncle bears a high, forward-curving, tooth-like

leaflet. The third segment bears a low keel which drops sharply away at a point two-thirds distant from the distal end of the segment (fig. 28). The eyes are small.

The third abdominal segment bears an acute process at its mid-dorsal posterior margin.

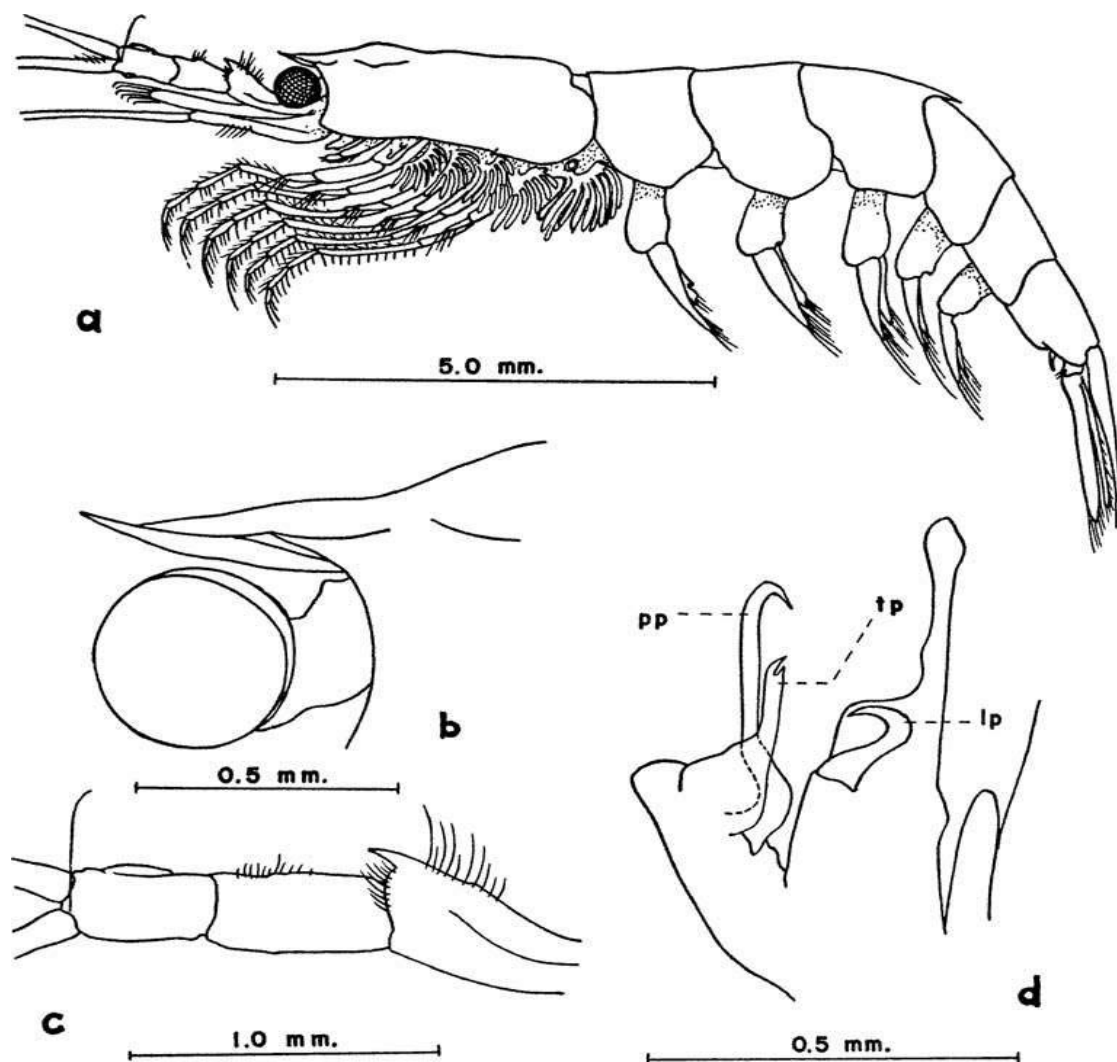


Fig. 28. *Euphausia pseudogibba* Ortmann. *a.* Adult male. *b.* Frontal plate, rostrum, and eye. *c.* Left first antennal peduncle from left side. *d.* Male left copulatory organ from behind.

The copulatory organ is unique in that the distal part of the median lobe is long, straight, and slender, compared with the basal part. The proximal process is strongly curved distally, and the terminal process is bifid at its tip.

Length.—12–14 mm.

Remarks.—Males of the four species of the *gibba* group, proper, are best separated by means of the characters of the copulatory organ. The form of the keel on the frontal plate has proved useful in separating females of the three North

Pacific species. This character should be equally useful in separating the females of the South Pacific species inasmuch as the keel on the frontal plate of *E. gibba* is as poorly developed as that of *E. hemigibba*. *E. gibba* is in the South Pacific and *E. hemigibba* in the central North Pacific. The flanges at the basal angles of the rostral plate are more acute in *E. pseudogibba* than in the other *gibba* species, and only in *E. pseudogibba* does the low keel on the third segment of the antennal peduncle drop sharply away at a point about two-thirds distant from the distal end of the segment.

Distribution.—Equatorial and North Pacific. *E. pseudogibba* was taken off the eastern coast of southern Japan only as far north as 33° 25.2' N., 135° 06.0' E. ("Transpacific" expedition). It occurs around the Philippines (Hansen, 1916) and in waters of the East Indian Archipelago (Hansen, 1910). Hansen (1912) records two specimens from about 15° S. in the central part of the eastern Pacific explored by the *Albatross*.

Elsewhere. This species is present in the tropical and subtropical waters of the Atlantic, north of the equator (Hansen, 1912), and from the equatorial part of the Indian Ocean.

Euphausia hemigibba Hansen

(Fig. 29, a–e)

Euphausia hemigibba Hansen, 1910: 100, pl. 14, fig. 5, a–f.

Diagnosis.—The body is slender. The frontal plate is short with a triangular, slender, and very acute rostrum. The median keel on the gastric region of the carapace is well developed, but, viewed from the side, this keel cannot be seen above the lateral margins of the frontal plate in the region immediately behind the rostrum. The eyes are very small and spherical.

The first segment of the first antennal peduncle is armed distally with an acute, toothlike projection directed forward, upward, and outward (fig. 29).

The distal margin of the second segment is armed on its inner angle with a small, sharp tooth. A little inside the outer lateral margin, the second segment projects forward as a low, sharp angle. The outer lateral margin is rounded. The dorsal keel on the third peduncular segment reaches nearly to the upper angle of the second segment. It is long and low.

The dorsal process on the third abdominal segment is at least half as long as the fourth abdominal segment.

The sixth abdominal segment tapers from about the middle. On its posterior margin the preanal spine in the female has one main spine and three smaller spines decreasing in size backward.

The terminal process of the male copulatory organ has an extremely long heel (fig. 29). The process is compressed for its distal third and ends in a triangular curved hook with a small curved spine at its base. The proximal process is somewhat curved, longer than the terminal, and ends with its distal one-fifth as a broad, oblong, oblique plate with its inner margin finely serrated. The lateral process is naked, slender, and hooked.

Length.—11–16.5 mm.

Distribution.—Hansen at first (1910) indicated that this form was not found

in the Pacific. Later (1915), however, he corrected this statement and changed Ortmann's (1905) identification of the Hawaiian Island forms from *E. pseudogibba* to *E. hemigibba*. According to Tattersall (1925), *hemigibba* is widely and generally distributed in the tropical and oceanic area of the Indian Ocean and the Atlantic and attains its maximum abundance at 100 meters, although it is frequently found at the surface.

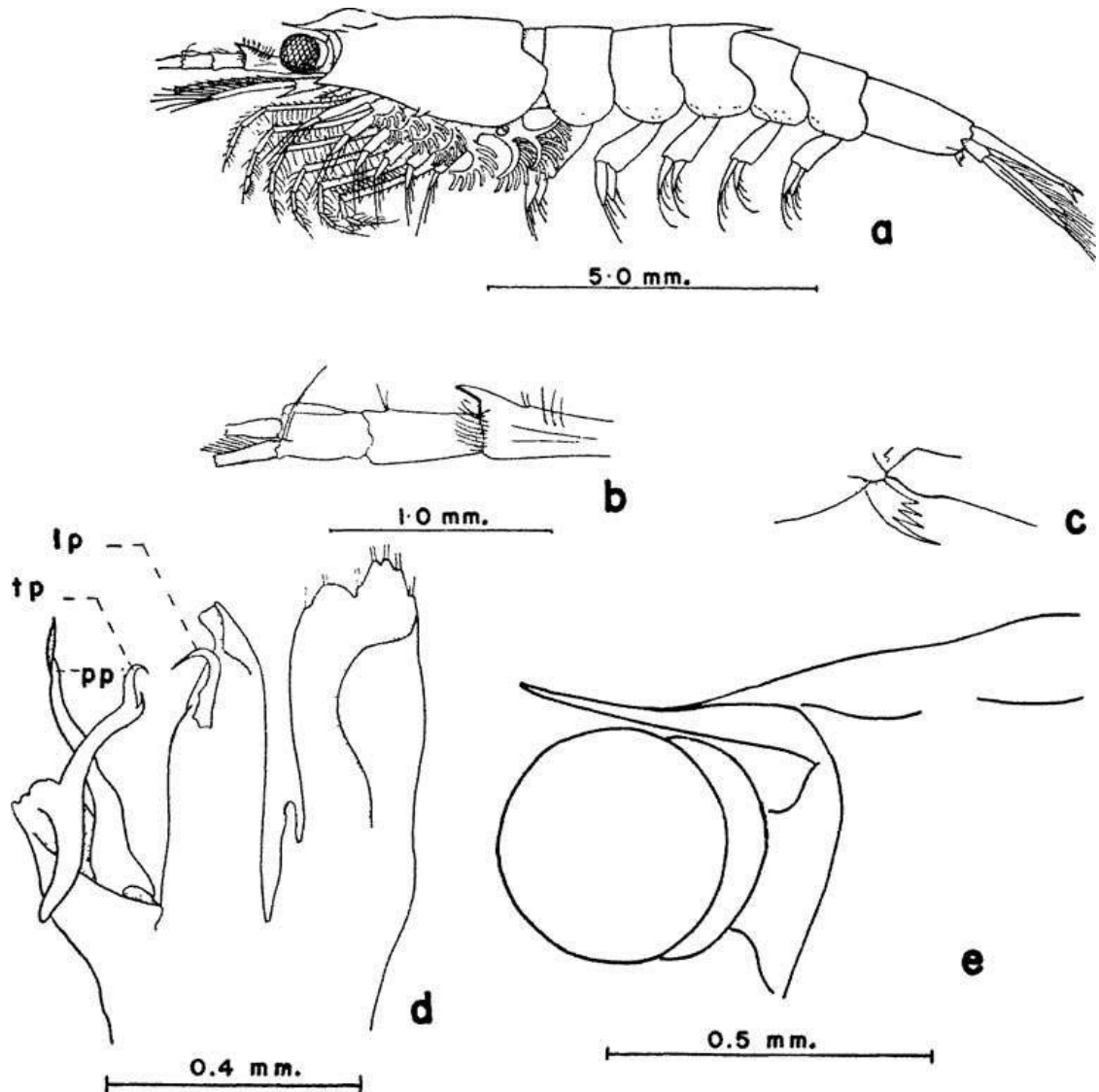


Fig. 29. *Euphausia hemigibba* Hansen. *a.* Adult female. *b.* Left first antennal peduncle from left side. *c.* Preanal spine. *d.* Male copulatory organ from behind. *e.* Frontal plate, rostrum, and eye.

North Pacific. This species has been caught throughout the northeastern central Pacific south of $40^{\circ} 34'$ N., $149^{\circ} 43'$ W. ("Northern Holiday" expedition). It was present at most stations south of $42^{\circ} 07.9'$ N., $169^{\circ} 28.1'$ E. in the northwestern central Pacific, and was taken south of 40° N., near to the eastern coast of Japan ("Transpacific" expedition). Sometimes it penetrates to within 200–300 miles of the coast of California north of 35° N., and frequently extends the eastern limit of its range to within 50–150 miles of the coast off southern California and northern Baja California. The range swings offshore south of 27° N.

Equatorial Pacific. This euphausiid occurs as far south as $14^{\circ} 21' N.$, $133^{\circ} 05' W.$ in the equatorial mid-Pacific ("Mid-Pacific" expedition). There are two records in the western Pacific: Hansen (1916) lists *E. hemigibba* from the China Sea at $20^{\circ} 58' N.$, $120^{\circ} 03' E.$, and (1910) from the China Sea at $00^{\circ} 17.6' S.$, $129^{\circ} 14.5' E.$

Depth.—Adults, above 500 meters; larvae, above 250 meters.

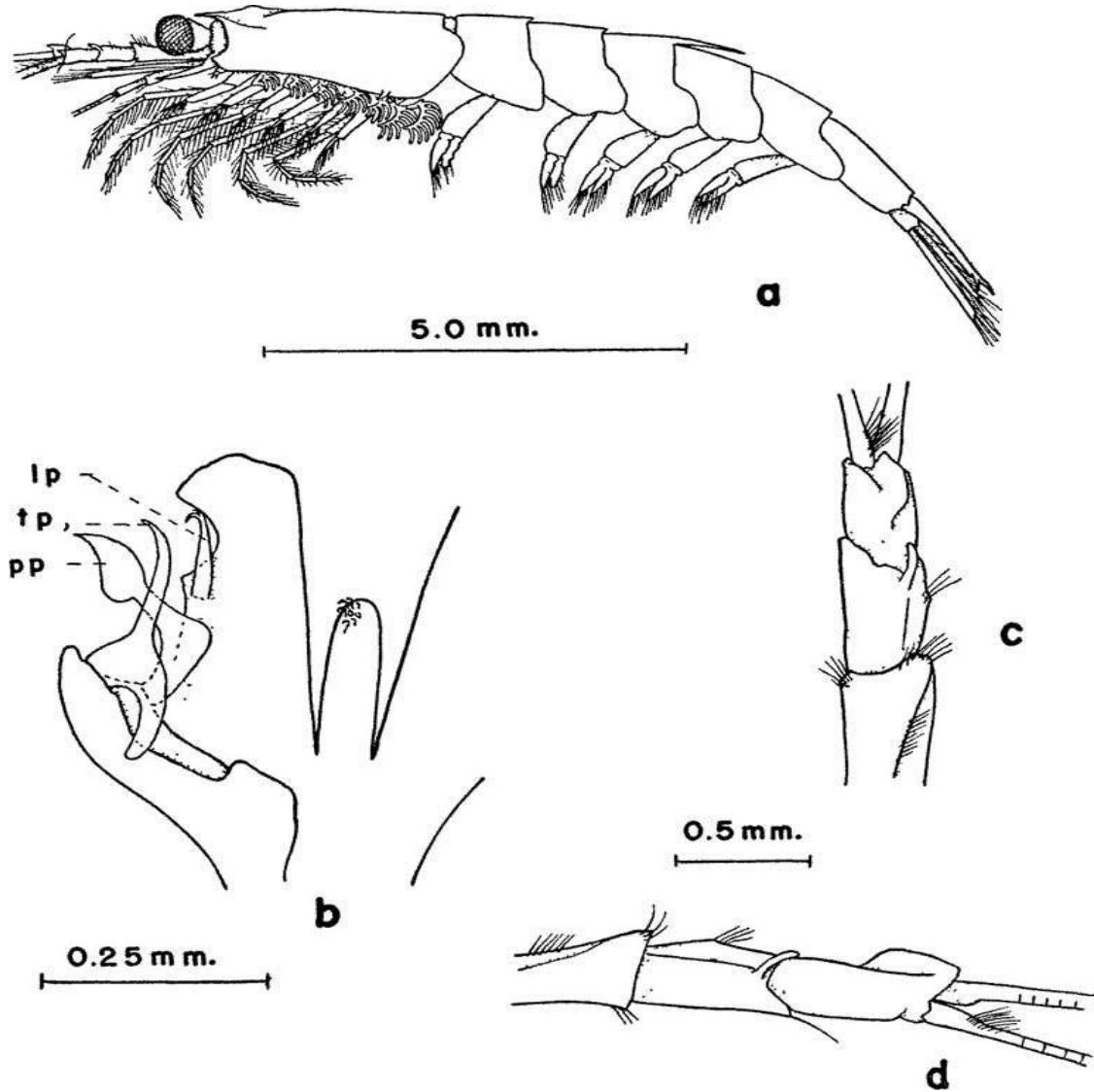


Fig. 30. *Euphausia distinguenda* Hansen. *a.* Adult male. *b.* Male copulatory organ from behind. *c.* Right first antennal peduncle from above. *d.* Same from side.

Euphausia distinguenda Hansen

(Fig. 30, *a-d*)

Euphausia distinguenda Hansen, 1911: 32; 1912: 248–250, pl. 8, fig. 3, *a-f*.

Diagnosis.—The frontal plate is narrow, and the rostrum is short and poorly defined but acute. The eyes are small.

The lateral process on the inferior margin of the carapace is situated toward the

posterior end. The third abdominal segment bears a long, compressed, and spiniform dorsal process.

The basal segment of the first antennal peduncle is somewhat raised distally (fig. 30). It lacks true lobes or processes, and its anterior margin is concave. The second segment carries a short oblique keel which ends distally in an upward- and forward-projecting, rounded process. The third segment bears a high, rounded keel on its distal half.

The terminal process of the male copulatory organ has a short foot and a long, curved heel (fig. 30). The process is rather short and tapers to an acute, curved end. The proximal process is somewhat shorter than the terminal. The proximal half is dilated and very curved with the outer margin very convex. The mid-part of the process narrows considerably, and then the process dilates suddenly until it is as thick as it is at the base. The distal third then tapers, first gradually and then rather suddenly, to an acute, inward-bent end. The lateral process is of medium size and distally hooked with an acute end. The hook carries a small, acute tooth on its outer curvature.

Length.—8–8.5 mm.

Distribution.—Equatorial Pacific. This euphausiid occurs throughout the eastern equatorial basin surveyed by the “Shellback” expedition, except in waters 50–100 miles from the coasts of Ecuador and northern Peru. The most northern oceanic record is 25° 30.7' N., 119° 44' W., off Baja California (Marine Life Research Cruise 5003). The species is recorded at about 28° N. in the Gulf of California (Hansen, 1915, based on Ortmann's specimens). The westernmost record of *E. distinguenda* is 10° 01' N., 145° 10.9' W. (“Mid-Pacific” expedition), to which longitude the range penetrates westward as a tongue. The most southern record for this species is 14° 59' S., 85° 03' W. off Peru (“Shellback” expedition).

Elsewhere. The species has also been taken from the tropical western waters of the Indian Ocean.

Depth.—Adults and larvae, above 400 meters.

Euphausia lamelligera Hansen

(Fig. 31, *a–d*)

Euphausia lamelligera Hansen, 1911: 32–33; 1912: 248–250, pl. 8, fig. 3, *a–f*.

Diagnosis.—The body is slender. There is no rostrum, and the frontal plate is very feebly produced as an obtuse angle along the frontal margin. There is no gastric keel, but the gastric region is highly vaulted. The eyes are relatively large, spherical, and black (fig. 31).

The first antennal peduncle is similar in both sexes. Its first segment carries a small but conspicuous upward- and forward-pointing bifid lobe on its upper distal margin. The second segment carries a large moveable lamella on its upper distal margin. This lamella covers about half of the upper, outer surface of the proximal part of the third segment. The third segment is armed with a high dorsal keel on its distal half.

The third segment of the abdomen is armed with a dorsal spine not quite a third as long as the fourth abdominal segment. There are no spines or protuberances on the following segments.

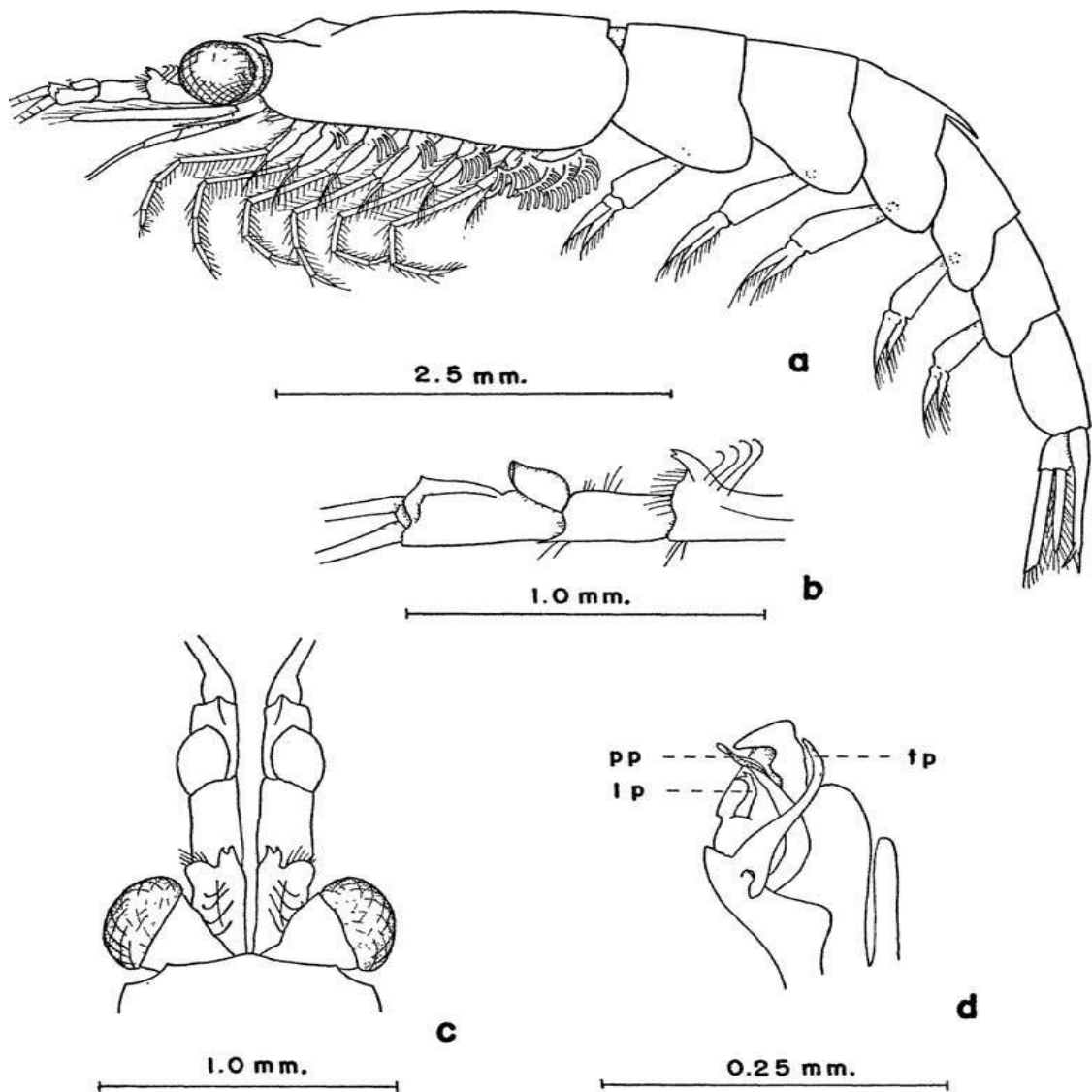


Fig. 31. *Euphausia lamelligera* Hansen. *a.* Adult female. *b.* Left first antennal peduncle from side. *c.* Front part of carapace and first antennal peduncles from above. *d.* Male copulatory organ from behind.

The terminal process of the male copulatory organ has a short, curved heel (fig. 31). The process tapers uniformly to an acute end and curves strongly. The proximal process has a heavy, curved base. The mid-part of the process is thicker than the base. Beyond the mid-part the process becomes flattened and expanded and then tapers to a thin, round end. The median lobe carries, terminally, a narrow short lobe with a rounded end. This lobe is directed obliquely forward. The lateral

process is fairly strongly curved and carries a sharp dorsal tooth on the outer part of the curvature. The auxiliary lobe is long and thin.

Length.—7–11 mm.

Distribution.—Equatorial Pacific. This euphausiid inhabits waters off southern Mexico, Central America, and South America as far south as 10° S. It occurs within a distance of 300–500 miles from the coast (“Shellback” expedition). North of 15° N., *E. lamelligera* has not been taken farther than 120 miles from shore. The most northern record, off Baja California, is 26° 19′ N., 113° 48.5′ W. (Marine Life Research Cruise 5009). This species occurs in the Gulf of Panama (Hansen, 1915). Its range extends westward to 101° W. between the equator and 03′ N., as determined by the “Shellback” expedition, but penetrates only to 90° W. south of the equator. The most southern record is 11° 16′ S., 79° 20′ W., off Peru. This species is confined to the eastern equatorial Pacific.

Depth.—Adults and larvae, above 300 meters.

Euphausia gibboides Ortmann

(Fig. 32, *a* and *b*)

Euphausia gibboides Ortmann, 1893: 12, taf. 1, fig. 5; Hansen, 1911: 33; 1912: 252–255, pl. 9, fig. 2, *a–h*.

Diagnosis.—The body is fairly thickset. The short frontal plate is produced into a rostrum that is broad at the base but spiniform distally. The vertical angle at which the rostrum is projected is variable. It may be a uniformly rising continuation of the frontal plate as Banner (1954) has noted or may rise more abruptly, as Hansen’s description states. The gastric region is conspicuously keeled. There is a single lateral denticle on the inferior margin of the carapace.

The eyes are large and spherical. The inner distal margin of the first antennal peduncle is produced into a long lobe projecting forward and upward for the first half of its length, beyond which it tapers abruptly and bends sharply outward. The upper distal margin of the second segment is concave but projects as a lobe over the proximal end of the third segment. The third segment has a high dorsal keel with the distal edge produced dorsally as a tooth. The scale of the second antennal peduncle reaches to about the middle of the third segment of the first antennal peduncle. The spiniform process on the outer side is not quite half as long as the scale.

The third abdominal segment is armed dorsally with a short tooth. The fourth and fifth segments lack any dorsal processes. The preanal spine is simple in both sexes.

The terminal process of the male copulatory organ has a foot of moderate length with a short, thick, straight heel (fig. 32). The remainder of the process is moderately long, slender, and curved, and tapers to an acute end. The proximal process is long, slender, and curved. Beyond its rather robust basal part, the process expands somewhat and then tapers gradually to a little before the end. The terminal part is a broad, oblong, distally rounded plate, with a long, slender tooth at its base. On the inner side of the base of the median lobe is a small, conical tubercle. At the insertion of the lateral process, the median lobe is somewhat broadened and then tapers to a moderately acute tip. The lateral process itself is

thick at the base and considerably curved. The setiferous lobe is broad and moderately setose on the distal part of the inner margin and on the terminal margin.

Length.—Males up to 22 mm.; females up to 27 mm.

Distribution.—Hansen (1912) gives the distribution of this species as temperate and tropical North Atlantic, and tropical East Pacific. He states it is very rarely taken at the surface.

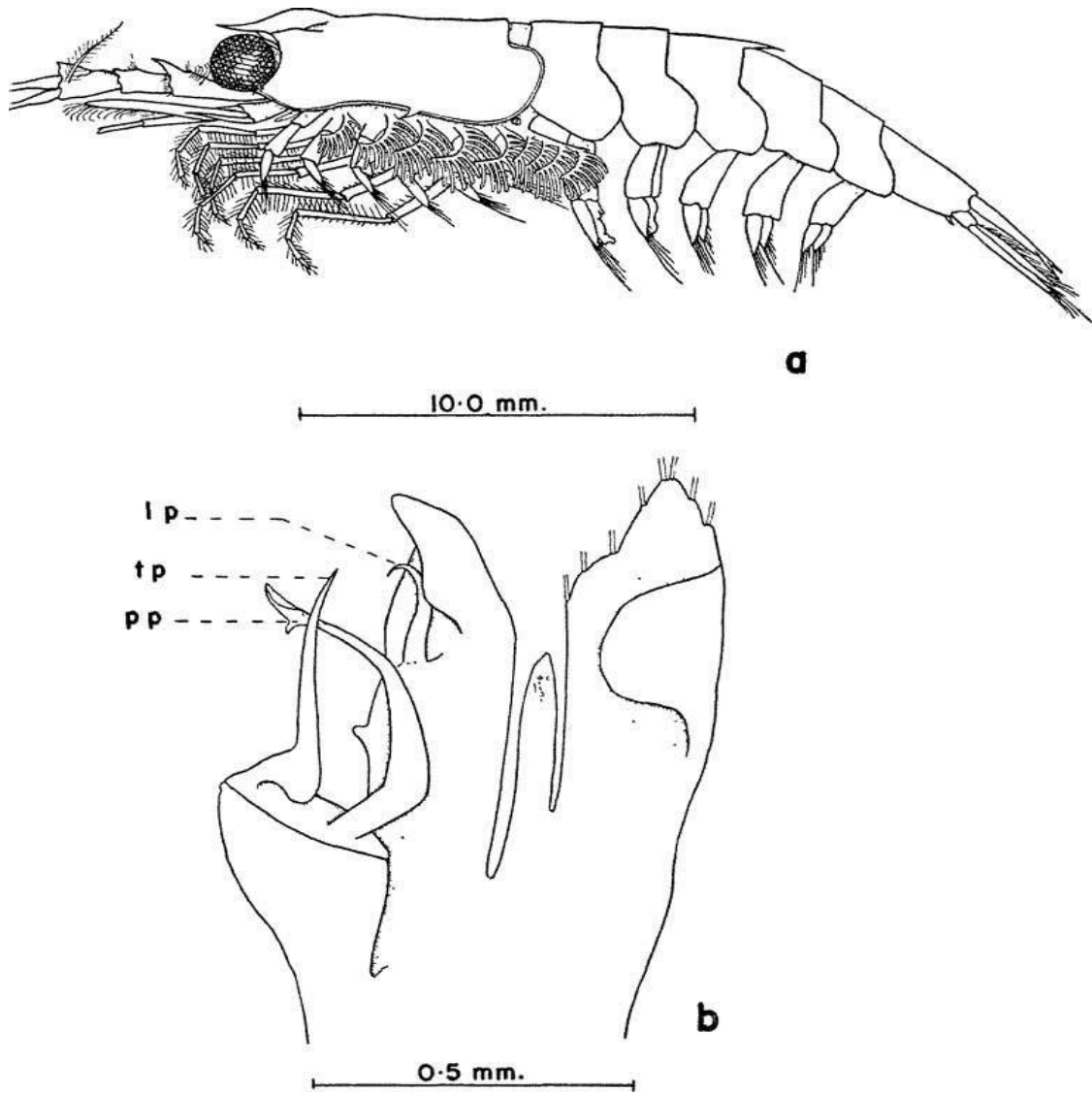


Fig. 32. *Euphausia gibboides* Ortmann. *a.* Adult male. *b.* Male left copulatory organ from behind.

North Pacific. *E. gibboides* was found by "Transpacific" expedition to be present as far south as 30° N. off southeastern Japan. It was present as far north as 40° 54.5' N., 149° 25.7' E., east of Hokkaido Island, and occupied an east-west area between 43.5° N. and 28.5° N., in the northwestern central Pacific. This species was taken by the "Northern Holiday" expedition between 38° N. and 41° N. within an east-west belt across the northeastern central Pacific. This belt swings

southward along the coast of California and broadens to a width of about 500 miles between 30° N. and 35° N. The eastern limit of the range of *E. gibboides* is 100–300 miles from the coast in waters north of 35° N. but sometimes reaches to neritic waters south of Pt. Conception. The most western record off southern California is 32° 53' N., 134° 13' W. (“Northern Holiday” expedition), and off Baja California it is 29° 07.2' N., 126° 30.2' W. (Marine Life Research Cruise 5009).

Equatorial Pacific. This euphausiid was not caught in Philippine waters (Hansen, 1916) or around the East Indian Archipelago (Hansen, 1910). A record from the western Pacific at 09° 40' N., 109° 20' E., in the South China Sea, is based upon a specimen in the Copenhagen Museum (Hansen, 1912). The species was taken at the Fiji Islands by Dr. Agassiz (Hansen, 1912), but it is not known from the equatorial mid-Pacific or from the South Pacific. It was not taken between 20° N. and 05° N. in the eastern area explored by the “Shellback” expedition, except off Costa Rica, where it occurred to 10° N. It was present as far west as 120° W. at stations between 05° N. and 04° S., and at the outer fringe of the Peru Current system as far south as 14° 59' S., 85° 03' W.

Elsewhere. *E. gibboides* also occurs in the cooler tropical and temperate waters of the Indian Ocean and the Atlantic.

Depth.—Adults, 100–500 meters; larvae, above 200 meters.

5.8. THYSANOËSSA Brandt

Thysanoëssa Brandt, 1851: 128; *Rhoda* Sim, 1872: 186.

Thysanoëssa G. O. Sars, 1885: 119–120; *Boreophausia* G. O. Sars, 1886: 13.

Generic characters.—The rostrum is always well developed, being long to very long. The eyes are usually higher than broad and constricted transversely; sometimes almost circular. The first antennal peduncles usually show sexual differences. The flagella are short in both sexes, but the two distal joints of the peduncle are more slender in the female.

The first six pairs of thoracic legs are normally developed, as in *Euphausia*. When the second pair is elongate and thick, as it frequently is, the two terminal segments have spinelike bristles along both edges. The endopodite of the seventh thoracic appendage is lacking in the males, but it is present in the females, in which it has either one or two segments, and is shorter to very little longer than the exopodite. The endopodite of the eighth thoracic appendage is absent in both sexes; the exopodite is represented by a small styliform process.

The male copulatory organs have the spine-shaped process of the inner lobe thin and curved; proximal, terminal, and lateral processes are well developed. The additional process is usually absent, or very poorly developed if present.

Holt and Tattersall (1905) have referred this genus to their subfamily Nematoscelinae and the genus *Boreophausia* G. O. Sars to the subfamily Euphausiinae. Hansen (1911), however, has shown them to be in error. He has proved *Roda inermis* Krøyer and *Thysanoëssa neglecta* Krøyer (*T. borealis* G. O. Sars) to be variations of the same species, and that no generic differences can be pointed out between *Rhoda inermis* and the single other species *Rhoda raschii* M. Sars. He has therefore included the genus *Rhoda* Sim (*Boreophausia* G. O. Sars) in the genus *Thysanoëssa*.

The genus is closely related to *Nematoscelis*, but differs from it in structure of the second pair of thoracic legs and of the copulatory organs and in the mode of egg-bearing: the eggs of *Thysanoëssa* are shed before hatching, whereas those of *Nematoscelis* are retained in a type of brood pouch consisting of a glutinous membrane which adheres to the ventral surface of the thorax.

KEY TO SPECIES OF THYSANOËSSA

1a Median keel on dorsal surface of some abdominal segments

2a Large process on dorsal keel of fourth abdominal segment; somewhat smaller process on dorsal keel of fifth abdominal segment. Second thoracic leg slightly elongate. Eye sub-ovoid*spinifera*

2b No process on dorsal keel of abdominal segments, or long process on third and very short processes on fourth and fifth segments. Second thoracic leg greatly elongate. Eye divided into upper and lower parts.....*longipes*

1b No median keel on dorsal surface of abdominal segments

3a Acute dorsal process on posterior margin of sixth abdominal segment. No lateral denticles on carapace*inermis*

3b No processes on abdominal segments

4a Lateral denticle posterior to mid-point of inferior margin of carapace. Second thoracic leg greatly elongate

5a Setae on fifth and sixth (carpal and propodal) joints of first to third thoracic legs short, compared with terminal setae on seventh joint.....*parva*

5b Setae on fifth and sixth joints of first to third thoracic legs as long as, or longer than, terminal setae on seventh joint*gregaria*

4b Lateral denticle anterior to mid-point of inferior margin of carapace. Second thoracic leg slightly elongate*raschii*

Thysanoëssa spinifera Holmes

(Fig. 33, a–d)

Thysanoëssa spinifera Holmes, 1900: 229, pl. 4, fig. 81; Hansen, 1911: 38, 41; 1915: 90–93, pl. 3, fig. 1, a–k; Banner, 1949: 18–21, pl. 2, fig. 21, a–d.

Diagnosis.—The rostrum is narrowly triangular, long, and very acute. Its tip reaches nearly to the end of the first segment of the first antennal peduncle. A prominent supraorbital spine is carried on either side of the base of the rostrum. The anterolateral angle of the carapace is very acute and has a short spine just above it. The lateral margins of the carapace are without denticles. The eyes are large, slightly more narrow dorsally than ventrally, but without a transverse constriction.

The first segment of the peduncle of the first antenna is flattened, and the outer, forward margin is armed on the lower side with a small spine (fig. 33). The second segment is prismatic and a little longer than the third. These two segments are more slender in the female than in the male. In the male the dorsal, distal margin of the second segment is produced into a lobe which carries a bunch of thick, curved setae. The second antenna is short. Its peduncle is about as long as the scale. The scale reaches almost to the end of the second segment of the first antennal peduncle and bears a small spine on the outer distal margin.

The second thoracic leg is not greatly elongate, but is a trifle longer and thicker than the others. The meral segment is setose on the posterior margin only; the carpal segment is furnished distally with long spines; the propodus is setose

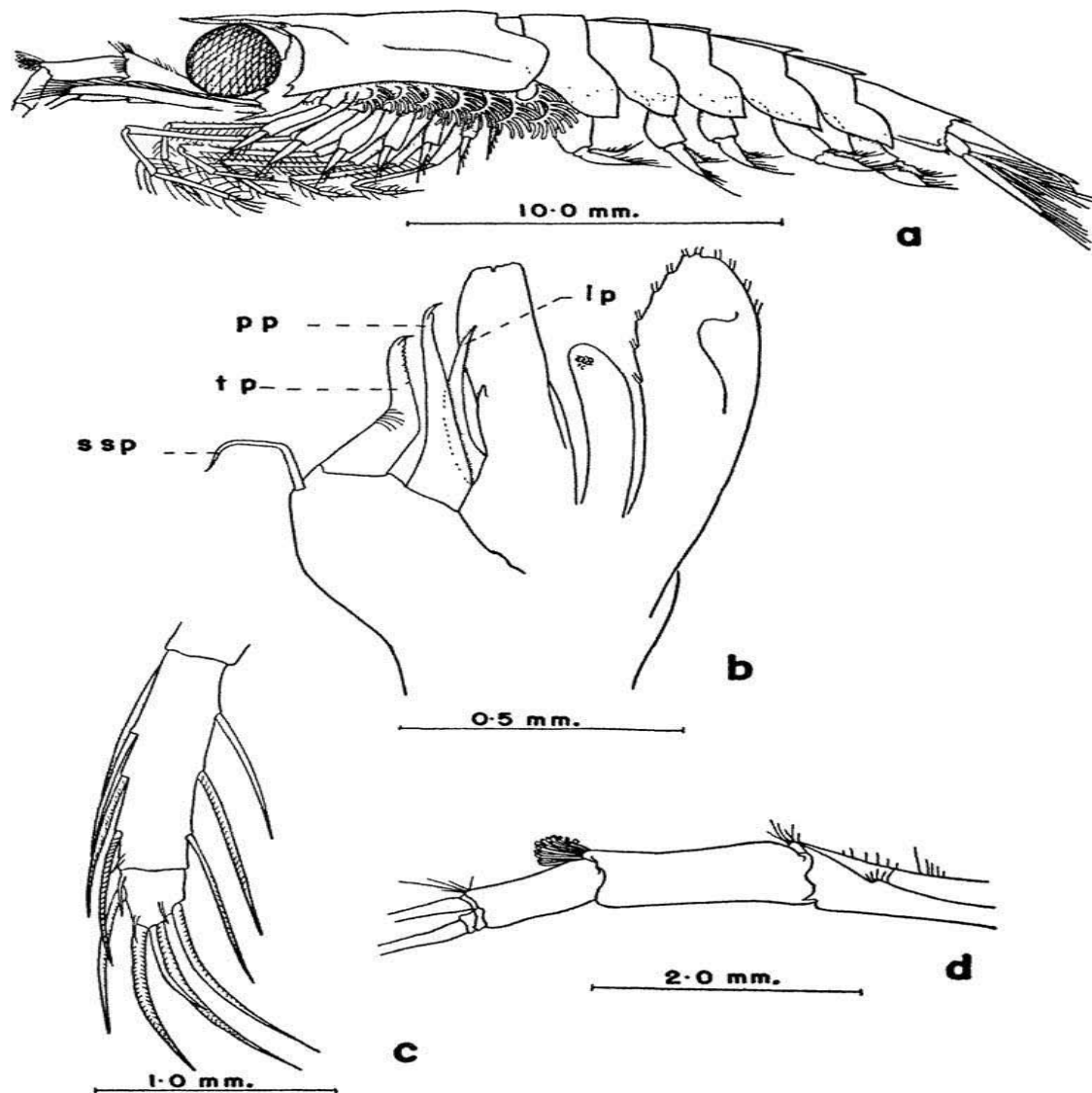


Fig. 33. *Thysanoëssa spinifera* Holmes. *a*. Adult male. *b*. Male left copulatory organ, unrolled and seen from behind. *c*. Terminal segments (propodus and dactylus) of elongated second thoracic leg, traced from photomicrograph. *d*. Left first antennal peduncle from left side.

along the length of both margins; and the dactylus is armed with four or five very strong, long spines and several shorter ones. The dactylus and propodus are together about as long as the carpus, and the extremely short dactylus is about as long as broad.

The lateral angles of the abdominal segments are acute. The first five segments are keeled above. The keels of the fourth and fifth segments project backward as spines. The sixth segment is rounded above but ends posteriorly in a small dorsal spine. The preanal spine is simple in both sexes.

The male copulatory organ has a long, thin, much-curved spine-shaped process (fig. 33). The terminal process is rather short, with the proximal half very thick. The distal half is at an angle to the rest and tapers to an acute, outwardly turned point. The proximal process is longer and thinner than the terminal. It is not as much curved, is thick at the base, and tapers to an end similar to that of the terminal process. The lateral process is inserted in the median lobe a trifle distally to the base of the proximal process and is slightly curved or straight. It tapers to an acute point some distance from the end of the lobe. There is no additional process, but the median lobe frequently shows a slight cleft where this process is present in other genera. The median lobe is truncate distally and has a small V-shaped indentation on the distal margin.

Length.—Males about 20 mm.; females up to 38 mm.

Remarks.—This species is most abundant at near-shore stations in this collection. On the 9th of June, 1948, huge swarms were washed up on the beach adjacent to Scripps Institution. These were all spent females. The water temperature on that day was 15.53° C. On the 8th of June the temperature was 17.22° C., which corresponds with average daily temperature for June.

Distribution.—It occurs along the western coast of North America from northern Baja California to the southeastern Bering Sea, usually within 200 miles of shore.

Thysanoëssa longipes Brandt

(Fig. 34, a-c)

Thysanoëssa longipes Brandt, 1851: 128, pl. 6, figs. 1-14; Hansen, 1911: 38, 40; Banner, 1949: 21-24; *T. armata* Marukawa, 1928: 4, pl. 2, figs. 19-22.

Diagnosis.—The carapace is produced as a long, narrow, keeled rostrum. Each side of the base of the rostrum protrudes as a curved, supraorbital flange in the same position as the supraorbital spine in *T. spinifera*. The rostral keel extends backward over the vaulted, gastric region of the carapace. There is a lateral denticle on the inferior margin of the carapace, somewhat behind the middle. The eyes are large, and their dorsal section is considerably narrower than the ventral and is separated from it by a transverse constriction.

In the female the two distal segments of the first antennal peduncle are long and slender. The third segment is conspicuously slenderer and a little longer than the second. In the male these segments are considerably heavier than in the female, and the third segment is only slightly thinner than the second. The flagella are very short. The peduncular scale of the second antenna reaches to about the middle of the third peduncular segment of the first antenna.

The second thoracic legs are extremely elongate. The distal end of the meral segment (second segment) reaches beyond the end of the first antennal peduncle. The ischial and meral segments are very strong and heavy. The carpal segment is curved and carries about six setae distally. The propodal segment is less than half as long as the carpal and is setose on both margins. The terminal segment, or dactylus, is broader than long and bears four strong setae. The following thoracic legs are very finely setose.

The posterolateral angles of the abdominal segments are acute. The third to

fifth abdominal segments are strongly keeled dorsally. In young specimens (approximately 8–12 mm.) the keel on the third segment begins at a point about half-way back on the segment. The keel of the third segment may or may not be produced backward as a strong, compressed spine. If it is, the fourth and fifth segments then carry similar, but smaller, spines. The sixth segment is a little shorter than the two preceding segments combined. It is rounded on top, with a small, median spine arising from its dorsal, distal margin. The preanal spine is simple in both sexes.

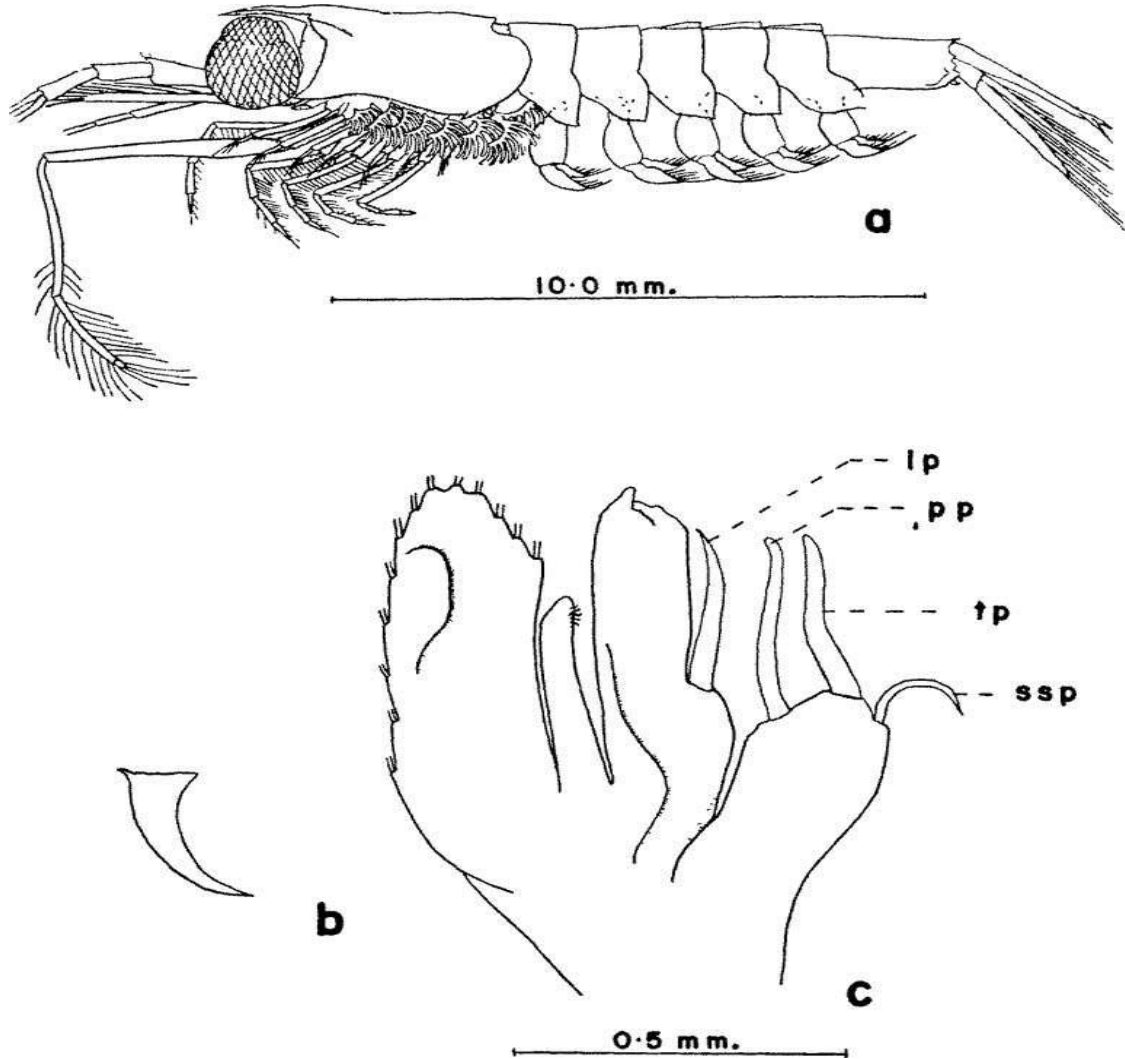


Fig. 34. *Thysanoëssa longipes* Brandt. *a.* Adult male of spineless form from the left side. *b.* Preanal spine. *c.* Male right copulatory organ from behind.

The spine-shaped process of the copulatory organ of the male is rather long and much curved (fig. 34). The terminal process is long, slender, and curved, proximal to the middle. Distally, it tapers somewhat to a blunt end. The proximal process is straighter and longer and has a thinner base, but a similar blunt end. The long median lobe is truncate distally and has an oblique emargination on the distal margin. The lateral process is rather straight and tapers. Its insertion in the median lobe is distal to the insertion of the proximal process. The auxiliary lobe is well developed.

Length.—Small, spineless form up to 18 mm. Females, large form, up to 30 mm.; males up to 24 mm.

Remarks.—According to Banner (1949), there are two forms of this species in the northwest Pacific: a small form about 15 mm. in length and a large one about 30 mm. long. The larger form was fully redescribed by Hansen in 1915, and is readily recognizable by the dorsal abdominal spines. The smaller form, which an examination of the copulatory organs reveals to be fully mature, lacks these spines, but, according to Banner, “agrees perfectly with the spined form on all characters of primary taxonomic importance, as the form of the rostrum, the lateral denticles of the carapace, the divided eyes, the first and second antennal peduncles, the mouth parts, the elongate thoracic legs, and the presence of dorsal ridges on the abdominal segments. Finally, there is perfect agreement between the two forms in the copulatory organs.” No published description, previous to Banner, of the spineless form can be traced. The Scripps material indicates that only specimens longer than 17 mm. bear the heavy spine on the third abdominal segment. Occasionally, males, without the spine, will reach 18 mm. These, or smaller, male specimens frequently possess a greatly enlarged eye. The large specimens of *T. longipes*, which bear abdominal spines, are rarely taken south of 50° N., whereas the southern limit of the range of the smaller form is about 40° N.

Distribution.—North Pacific. *T. longipes* inhabits the entire subarctic water mass. It was described from specimens from the Sea of Okhotsk (Brandt, 1851), and is recorded from the Bering Sea (Hansen, 1915; Banner, 1949), and from the Arctic Ocean near Pt. Barrow, Alaska (Schmitt, 1919), and northward to 73° 22' N. (Johnson, unpublished manuscript). The most southern record in the eastern Pacific is 40° 29' N., 134° 58' W. (“Northern Holiday” expedition), except within waters of the California Current where it has penetrated as far as 38° 24' N., 123° 35' W. (Marine Life Research Cruise 5009). Its most southern record in the western Pacific was 34° 07' N., 156° 11' E.

Elsewhere. This species has not been reported from the Indian Ocean or the Atlantic.

Depth.—Adults and larvae, surface to 500 meters.

Thysanoëssa inermis (Krøyer) Hansen

(Fig. 35, a-d)

Thysanopoda inermis Krøyer, 1846: pl. 7, fig. 2; 1859: 294, pl. 5; *Thysanopoda neglecta* Krøyer, 1846: pl. 7, fig. 3; *Thysanoëssa aberdonensis* Sim, 1872, pl. 5, figs. 1–8; *Euphausia inermis* G. O. Sars, 1883: 51, pl. 1, fig. 15; *Thysanoëssa borealis* G. O. Sars, 1883: 53, pl. 1, figs. 16–18; *Boreophausia inermis* G. O. Sars, 1886: 13; Hansen, 1887b; 253, pl. 23, fig. 3; *Thysanoëssa neglecta* Hansen, 1887a: 54; *Rhoda inermis* Sim, 1872: 186; Stabbing, 1893: 263; Zimmer, 1904: 420, figs. 6–9; *Thysanoëssa inermis* Hansen, 1911: 8–13; 1915, 93–96, pl. 2, fig. 2, a–d; Einarsson, 1945: 30–34, 46–50, figs. 12, 18–19; Banner, 1949: 24–27, pl. 3, fig. 23, a and b.

Diagnosis.—The rostrum is narrow and acute, reaching beyond the eyes. It sweeps somewhat downward, forward of the mid-point of the eyes, so that the tip is lower than the frontal plate.

The carapace lacks lateral denticles. There is no dorsal keel on the abdominal segments, but the sixth segment carries a dorsal spine. The sixth segment is shorter than the sum of the fourth and fifth, and bears a slender, acute spine at its mid-dorsal posterior margin.

The eyes are almost circular, sometimes slightly higher than broad.

The second thoracic leg may be elongate and thickened with partly naked fourth and fifth segments, or nonelongate, slender, and uniformly setose.

The basal segment of the first antennal peduncle of the male has, on its inner side, a rounded lobe directed forward and upward and bearing two rows of slightly curved spines (fig. 35). This is lacking in the female. In the male the second segment has its outer, anterior margin produced dorsally as a fingerlike process. Its inner margin is produced as an upward-pointing lobe with its upper margin armed with hook-shaped spines. This is also lacking in the female.

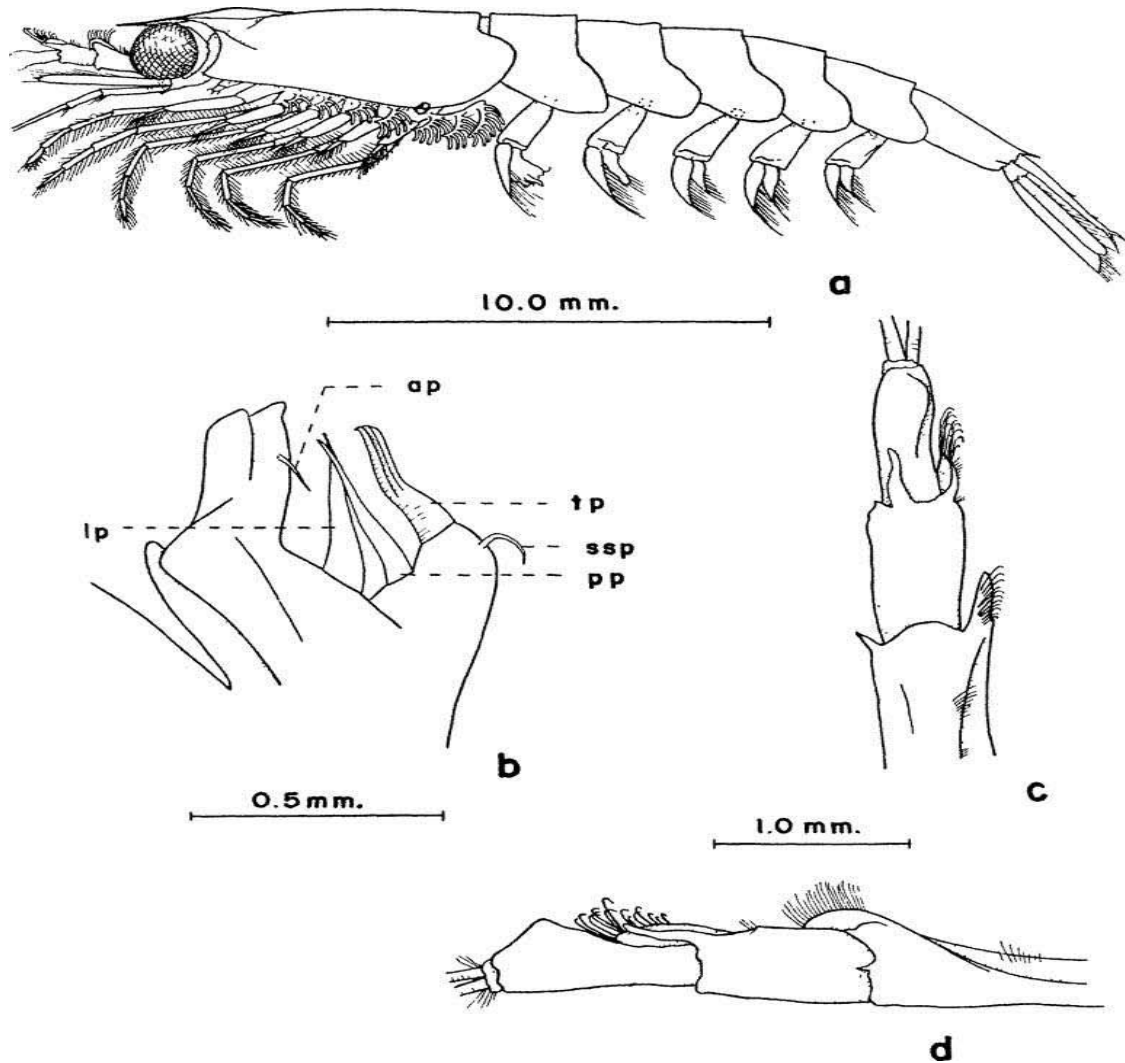


Fig. 35. *Thysanoëssa inermis* (Krøyer) Hansen. *a.* Adult male. *b.* Male copulatory organ from behind. *c.* Left first antennal peduncle from above. *d.* Same from left side.

The male copulatory organ carries a slender, curved, spine-shaped process (fig. 35). The terminal process has, on its inner side, two long, thin, membranous expansions between which runs a canal from the distal end almost to the base. The distal end is fairly blunt. The proximal and lateral processes are cylindrical, straight, and tapered to acute ends. There is a slender, straight, acute additional process which is directed upward.

Length.—Up to 32 mm. in the Atlantic; the largest Pacific specimens are 25 mm.

Distribution.—North Pacific. This species occurs in the central part of the Gulf of Alaska as far south as 53° 35' N., 146° 05' W. ("Northern Holiday" expedition) and extends south to 51° 56' N., 128° 52' W. in shelf waters off British Columbia (Banner, 1949). It occurs in the Bering Sea (Hansen, 1915; Banner, 1949) and is reported from the Alaskan and Canadian Arctic Coast (Schmitt, 1919; Johnson, unpublished manuscript). It has been caught at 46° 39.5' N., 145° 46' E. in the Sea of Okhotsk (Hansen, 1915) and reached south to 43° 09' N., 151° 52' E., east of the Kurile Islands ("Transpacific" expedition).

Elsewhere. *T. inermis* has also been reported from the arctic and subarctic waters of the Atlantic Ocean.

Depth.—Surface to about 300 meters.

Thysanoëssa raschii (M. Sars) Hansen

(Fig. 36, a–c)

Thysanopoda raschii M. Sars, 1864: 83; (*nec Thysanopoda raschii* Vanhöffen, 1897: pl. 1, fig. 1); *Rhoda jardineana* Sim, 1872: 6; *Euphausia raschii* G. O. Sars, 1883: 51; *Boreophausia raschii* Norman, 1886: 156; *Rhoda raschii* Stebbing, 1893: 263; Zimmer, 1904: 442, figs. 10–11; *Thysanoëssa raschii* Hansen, 1911: 42–43; Einarsson, 1945: 34–38, 51–52, figs. 13, 20; Banner, 1949: 27–29, pl. 3, fig. 22, a and b.

Diagnosis.—The rostrum is well developed and forms a long, oblong plate which is broader in the male than in the female (fig. 36).

The carapace carries a small lateral denticle before the middle of the inferior margin. There are no processes or keels on the abdominal segments. The sixth segment is much shorter than the combined length of the fourth and fifth.

The eyes are subovoid to nearly spherical, without any constriction.

The second thoracic leg is only slightly elongate.

The male copulatory organ carries a robust, curved, spine-shaped process (fig. 36). The terminal process carries on its inner side two membranous wings, one of which protrudes freely; the other, together with a thin keel from the outer side, forms a groove running from the base to the end. The process is distally hooked and is quite acute. The proximal process is very robust proximally, tapers to an acute point, and is nearly straight. The lateral process is heavy, bent sharply at its proximal one-third and again at its distal one-third to form a sharp hook. There is no additional process.

Length.—20–25 mm.

Distribution.—North Pacific. This species was taken in neritic waters off Kodiak Island, Alaska, by the "Northern Holiday" expedition. It inhabits neritic and

inland waters of Alaska, Canada, and the United States as far south as $45^{\circ} 39' N.$, $124^{\circ} 49' W.$, off Oregon (Banner, 1949). *T. raschii* is recorded from $46^{\circ} 29.5' N.$, $145^{\circ} 46' E.$ in the Sea of Okhotsk (Hansen, 1915), and from two stations east of northern Japan ($40^{\circ} 25.3' N.$, $145^{\circ} 29.3' E.$; $40^{\circ} 54.6' N.$, $142^{\circ} 18.1' E.$; "Transpacific" expedition). It was taken at three stations south of the Komandorski Islands and north of $49^{\circ} N.$, in the northeastern Pacific. It is present near shore in the American Arctic Ocean (Schmitt, 1919) and also penetrates at least to $74^{\circ} N.$ within the pack ice (Johnson, unpublished manuscript). It was found in the eastern Bering Sea (Banner, 1949), but was not encountered in the southern traverse of the Bering Sea, except near the Komandorski Islands, by the "Transpacific" expedition.

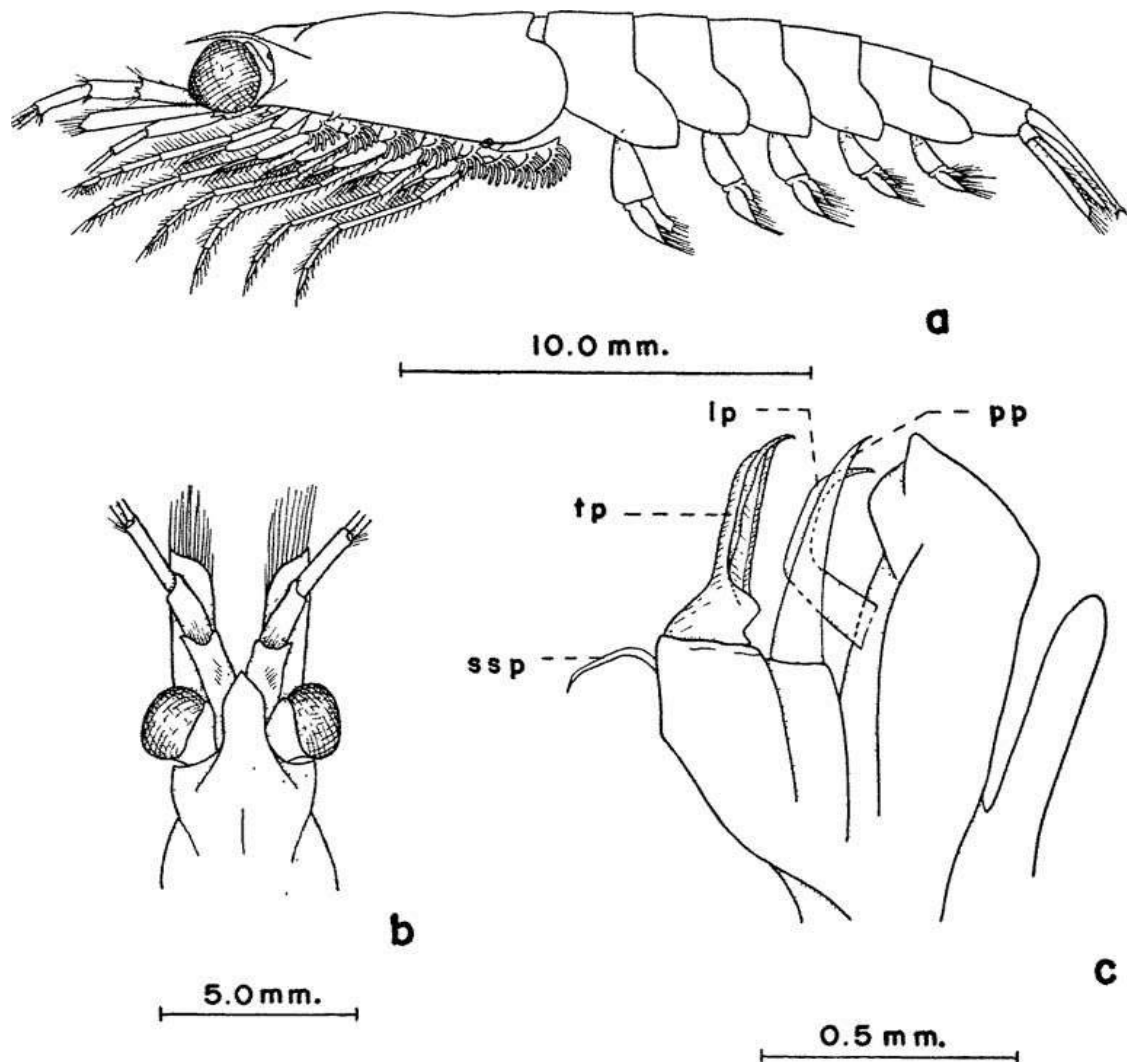


Fig. 36. *Thysanoëssa raschii* (M. Sars) Hansen. *a.* Adult male. *b.* Front part of carapace and first antennal peduncle of female from above. *c.* Male copulatory organ from behind.

Elsewhere. It also occurs in the arctic and subarctic near-shore waters of the Atlantic Ocean.

Depth.—Adults and larvae, usually above 300 meters.

Thysanoëssa parva Hansen

(Fig. 37, a-c)

Thysanoëssa parva Hansen, 1905a: 25-26, figs. 22-24; 1905b: 27; 1911: 43, fig. 14.

Diagnosis.—The body and thorax are somewhat slender, as compared with the closely allied *T. gregaria*. The carapace bears a very small denticle near the posterior angle of the lateral margin. The slender rostrum is produced, horizontally, to the anterior margin of the eyes. The second and third segments of the peduncle of the first antenna are cylindrical and of equal length. The eye is smaller than in *T. gregaria*, and retains its very black pigmentation somewhat better than in that species. The upper part of the eye is a little smaller and more sharply de-marked than in *T. gregaria*.

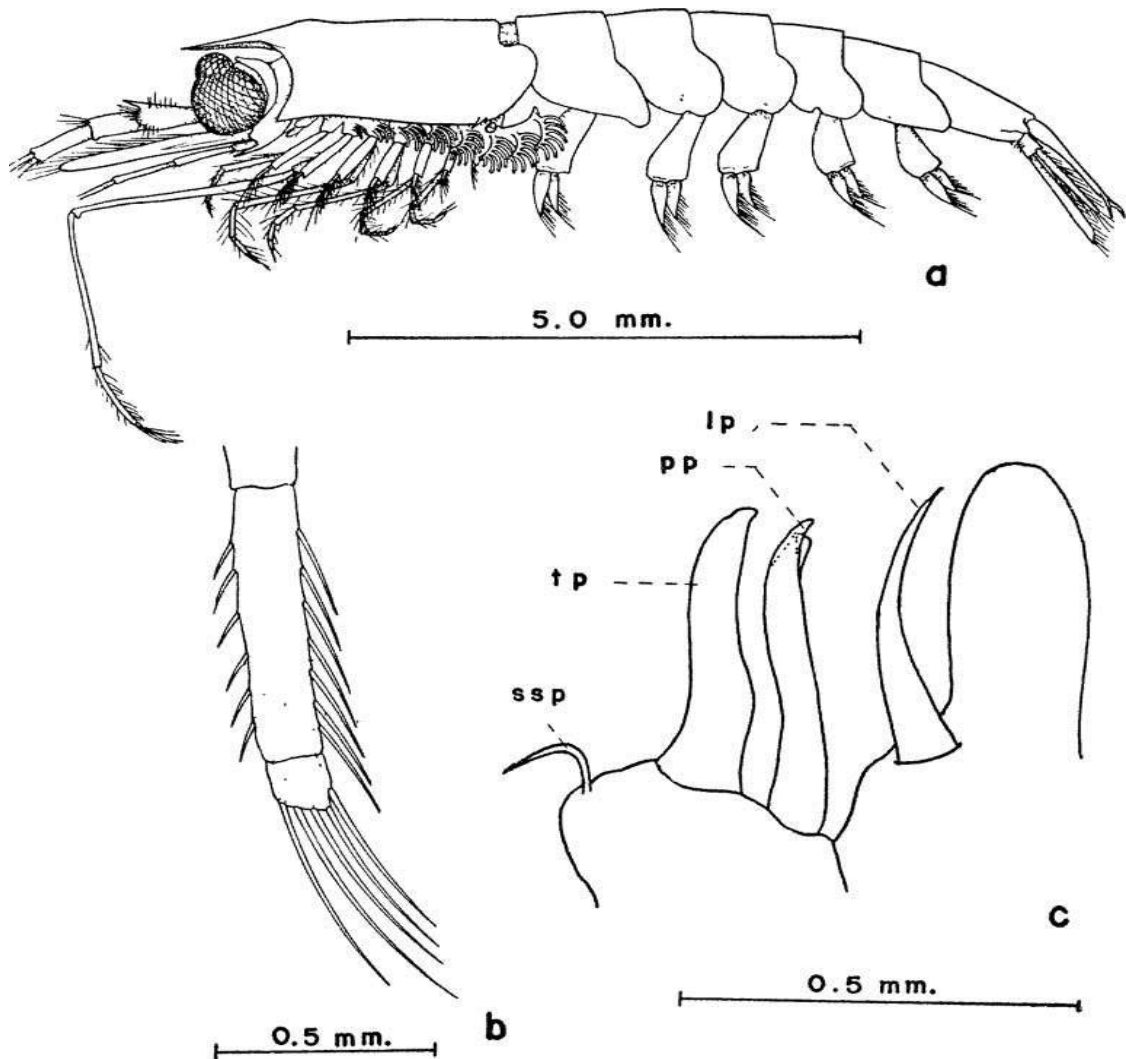


Fig. 37. *Thysanoëssa parva* Hansen. a. Adult male. b. Terminal segments of elongated second thoracic leg. c. Male left copulatory organ from behind.

The setae along both the upper and lower margins of the fifth and sixth (carpal

and propodal) segments of the second to fourth thoracic legs are short and slender compared with the terminal setae on the seventh segment. Some of these setae on both the upper and lower margin are finely plumose.

The sixth abdominal segment is slightly less long than the two preceding segments, and is twice as long as deep.

The male copulatory organ bears a heavy terminal process which ends in a smooth, rounded tip. It was not observed to be “scarcely serrate” as described by Hansen (1911) for Atlantic specimens. The proximal process agrees with Hansen’s figure but is somewhat less broad at its distal truncated end. The truncated end, when viewed from behind, is nearly obscured by a broad tooth on the inner distal angle.

Length.—9–10.5 mm.

Remarks. *T. parva*, *T. gregaria*, and young specimens of *T. longipes* are sometimes difficult to separate. In the Pacific, however, there is little overlap in their distributions. By the time it has attained a length of about 6–7 mm., *T. longipes* begins to show a keeled area on the posterior dorsal part of the third abdominal segment. *T. parva* is best distinguished from *T. gregaria* by the shortness of the subterminal setae on the second to fourth thoracic legs, and by the fact that minute cross hairs on these setae are not visible with a magnification of less than about 100 times. Hansen did not observe any of these setae to be plumose on Atlantic specimens of *T. parva*.

Distribution.—North Pacific. *T. parva* has been taken in deep hauls at a distance of 400–600 miles off the coast of southern California, between 28° N. and 33° N. It was taken by the “Transpacific” expedition at three stations off southern Japan, between 32° 02.3′ N., 139° 25.1′ E. and 32° 22.8′ N., 137° 06.7′ E. It was also present at a greater distance from Japan at 34° 07′ N., 156° 11′ E.

Elsewhere. This species occurs on both sides of the North Atlantic, between 27° N. and 40° N., and in the South Atlantic west of South Africa. It is not known whether the east–west distribution is continuous in either ocean.

Depth.—Below 500 meters.

Thysanoëssa gregaria G. O. Sars

(Fig. 38, *a–d*)

Thysanoëssa gregaria G. O. Sars, 1883: 26; 1885: 120–124, pl. 21, figs. 8–17; Hansen, 1905*a.*: 25–26; 1905*b.* 27–28; 1911: 53–54, fig. 15; 1913*a.*: 37, pl. *b*, fig. 1, *a–b*.

Diagnosis.—The body is short and rather clumsy. The rostrum is large, triangular, and acute. The carapace bears a well-developed, lateral denticle behind the middle of the inferior margin. The basal segment of the first antennal peduncle is about as long as the other two combined. The anterior margin is somewhat produced dorsally and rather setose. The following two segments are slender and cylindrical. The third is a trifle longer than the second. The flagella are exceedingly short. The second antennal scale reaches to about the middle of the third segment of the first antennal peduncle. The very large eyes have a transverse constriction separating the narrow upper part of the cornea from the broader lower part.

The second thoracic leg is remarkably elongate. The distal end of the meral

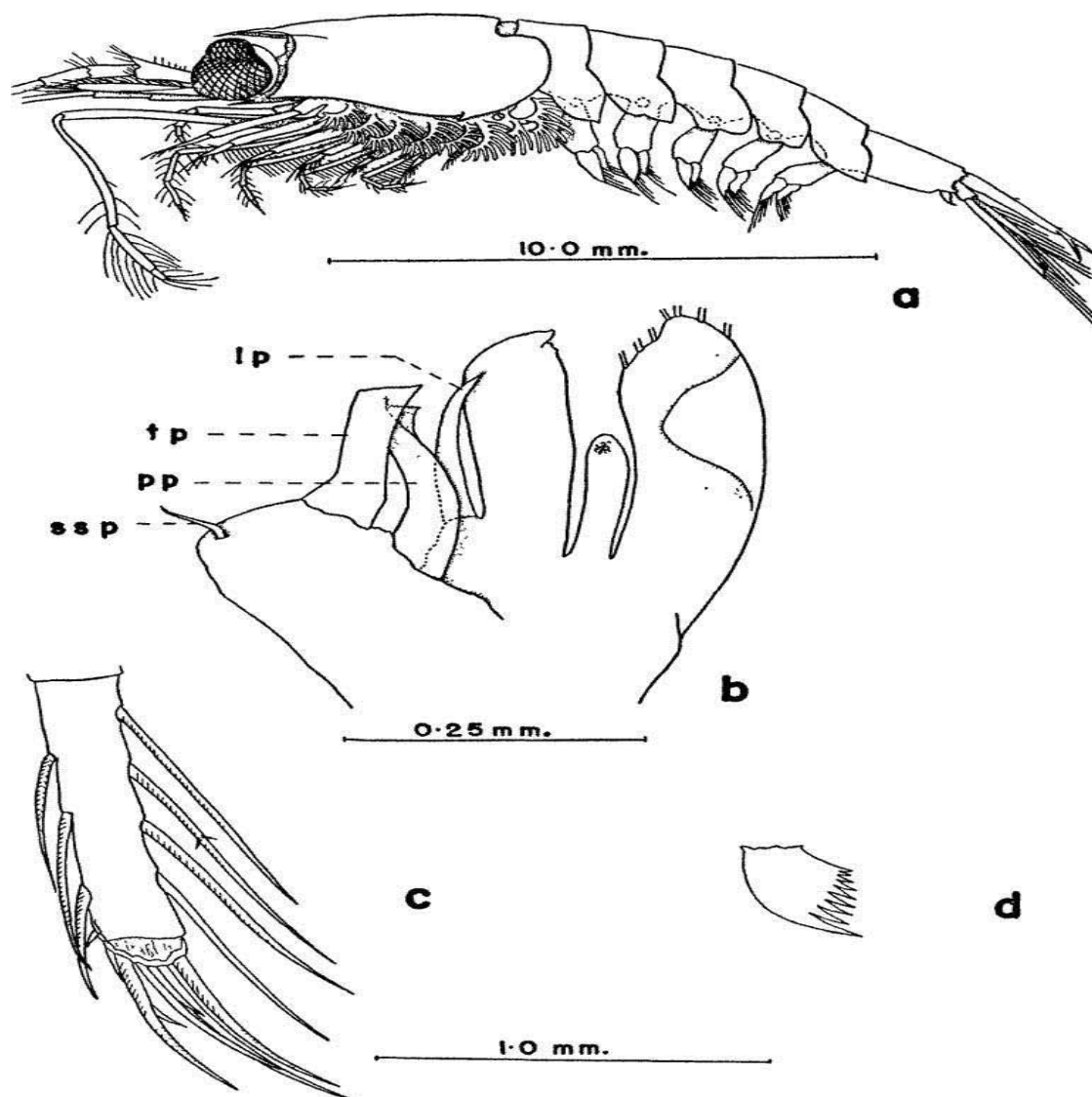


Fig. 38. *Thysanoëssa gregaria* G. O. Sars. *a.* Adult female. *b.* Male left copulatory organ from behind. *c.* Terminal segments (propodus and dactylus) of elongated second thoracic leg, traced from photomicrograph. *d.* Preanal spine.

segment reaches to the end of the first antennal peduncle. The setae on the lower margins of the sixth (propodal) segment of the second to fourth thoracic legs are strong, plumose, and as long or longer than the terminal setae on the seventh (dactyl) segment.

The pleura of the abdominal segments are rather angular, but not as acute as in the preceding two species. The abdominal segments are rounded above and lack keels or spines. The sixth segment is a trifle longer than the fifth. The preanal

spine is broad and compressed (fig. 38). A number of denticles on its posterior margin gives it a pectinate appearance.

The spine-shaped process of the male copulatory organ is small, slender, and not very strongly curved (fig. 38). The terminal process has a broad base, curves slightly at the first one-third of its length, and then maintains the same breadth until it expands somewhat at its broad, truncate, delicately serrate edge. The proximal process is longer and more slender than the terminal, and somewhat curved. Distally, it ends as a triangular, winglike expansion, which is serrate along the distal margin. Beyond this extension is a short, slender, somewhat curved, subacute process with teeth along the outer margin. The lateral process is long and slightly curved. Its level of insertion is considerably distal to that of the proximal process. The median lobe is narrow and truncate. The auxiliary lobe is shorter than that of *T. longipes*.

Length.—11–16 mm.

Distribution.—North Pacific. *T. gregaria* extends across the eastern and western central North Pacific between 35° N. and 45° N. (“Northern Holiday” and “Transpacific” expeditions). Its range swings southward along the California coast where it is found at 29° 31.5' N., 125° 40' W. (Marine Life Research Cruise 5009), a distance of 500 miles off the coast of southern California. South of 28° N., this species has been found only within 200–300 miles of the coast of Baja California. Its southernmost record is 24° 35' N., 115° 40' W. (Marine Life Research Cruise 5011). *T. gregaria* is recorded from the western North Pacific from near Bering Island, 54° 48' N., 164° 54' B. (Hansen, 1915). It is probable that this last record was based upon a young specimen of *T. longipes*. *T. gregaria* was found only as far north as 42° N. in the western central Pacific, and to 40° N. within 200 miles of Japan (“Transpacific” expedition). It penetrated southward, off Honshu Island, to about 34° N.

South Pacific. This bipolar species extends northward to 14° 43.5' S., 85° 04' W. in the eastern South Pacific (“Shellback” expedition). It was caught in the central South Pacific and off the Australian coast by the *Challenger* (Sars, 1885).

Elsewhere. *T. gregaria* has a bipolar distribution in the Atlantic, and is present in the southern part of the Indian Ocean.

Depth.—Adults and larvae, commonly above 200 meters but occurring to depths of about 500 meters at the southern limits of its range in the Northern Hemisphere.

TESSARABRACHION Hansen

Tessarabrachion Hansen, 1911: 46.

Generic characters.—The frontal plate is small, short, broad, and triangular. There are no rostral processes.

The second and third thoracic legs are extremely elongate, identical and similar in appearance to the elongate thoracic leg of *Thysanoëssa*. The remaining legs are as in *Thysanoëssa*.

The eyes are large, higher than broad, and transversely constricted.

The basal segment of the first antennal peduncle lacks distal lobes and is very much broader than the next two. The following two segments are broader in the

male than in the female. In the male the upper flagellum is shorter than the compressed lower one.

The copulatory organ of the male carries only two or three fine marginal spines on the inner lobe, which is not separated from the median lobe. The setiferous lobe and the auxiliary lobe with its hooks are both well developed.

The genus is monospecific.

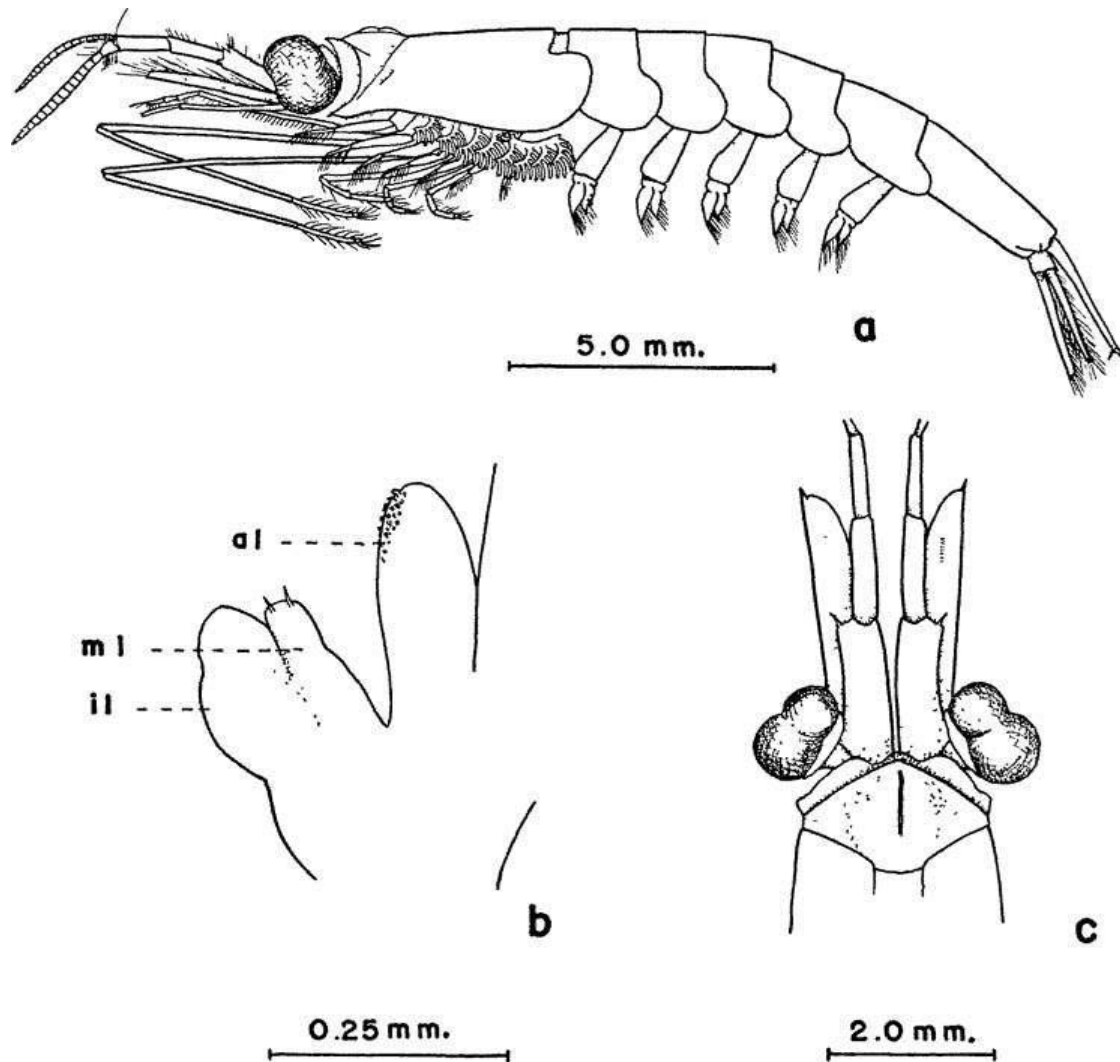


Fig. 39. *Tessarabrachion oculatus* Hansen. *a*. Adult male. *b*. Male copulatory organ from behind. The processes are reduced to marginal spines. *c*. Front part of carapace and first antennal peduncles from above.

Tessarabrachion oculatus Hansen

(Fig. 39, *a-c*)

Tessarabrachion oculata Hansen, 1911: 47; *Tessarabrachion oculatum* Hansen, 1915: 103–104, pl. 4, fig. 1, *a-m*; Banner, 1949: 32–33.

Diagnosis.—The frontal plate is a short triangle with its obtuse apex slightly upturned. The sides of the triangle are also conspicuously upturned. There is a low keel on the frontal plate (fig. 39).

The lateral margins of the carapace lack denticles and the abdominal segments are unarmed.

The eyes are very large and divided by a feeble transverse constriction into an upper and lower part, the upper being nearly as broad as the lower.

The two distal peduncular segments of the first antenna are more slender in the female than in the male. The third segment, particularly, is very slender in the female.

The thoracic legs and copulatory organs of the male have been treated in the generic description (fig. 39).

Length.—Males up to 20 mm.; females up to 26 mm.

Remarks.—The specific ending has been altered here to agree with the gender of the genus.

Distribution.—North Pacific. *T. oculatus* was caught at most stations along the 40° N. parallel, between the coast of California and 150° W., by the “Northern Holiday” expedition. Its southern limit was 47° 05.5' N., 157° W. This species occurs throughout the Gulf of Alaska and rarely extends south of 40° N. in the California Current. Its occurrence in the Bering Sea is apparently limited to waters immediately adjacent to the Aleutian Islands (“Transpacific” expedition), but it is present off Japan as far south as 37° 58.9' N., 146° 01.1' E. It is limited to the North Pacific.

Depth.—Adults, below 100 meters; juveniles and larvae, frequently above 100 meters.

NEMATOSCELIS G. O. Sars

Nematoscelis Gr. O. Sars, 1883: 27.

Generic characters.—The rostrum is variable in shape. The large eyes have a transverse constriction. The peduncles of the first antennae are elongate and slender in the female, shorter and thicker in the male. The mandibular palp is very small. The first pair of thoracic legs have the terminal segment flattened and pectinate in appearance. The second pair of thoracic legs is remarkably elongate. Bristles are borne only on the terminal segment or on the terminal one and distal end of the preceding one (fig. 40). The seventh thoracic leg is biarticulate in the female, lacking in the male. The exopodite of the seventh thoracic appendage is present in both sexes. The eighth thoracic appendage consists of a simple setose plate. The inner lobe of the copulatory organ of the male possesses all three processes, but the spine-shaped process is almost straight and parallel with the other two. The additional process is lacking and the lateral is never hooked.

Hansen (1911) has divided the six species of this genus into two groups. He regarded the presence or absence of bristles on the distal end of the propodal segment of the second thoracic leg as one of the dividing characters. Our Pacific collections of this genus contain all of the known species except *N. lobata* Hansen (1916) from the Philippines, and *N. megalops* G. O. Sars (1883) from the Atlantic Ocean.

KEY TO SPECIES OF NEMATOSCELIS

1a Second pair of thoracic legs with long spines from terminal segment and from distal end of preceding segment. Third to sixth thoracic legs with three segments beyond knee. Rostrum downward-curved, obtuse, or lacking. Eye large, with lower part larger than upper. Adults longer than 20 mm.....*difficilis*

1b Second pair of thoracic legs with long spines from terminal segment only. Third and fourth thoracic legs with only two segments beyond knee, and fifth and sixth with only one

- 2a Lower part of eye much smaller than upper*tenella*
 2b Lower part of eye about the same size as upper, or, at most, very little larger
 3a Eye symmetrical, with upper part same size and shape as lower. Rostrum straight, reaching to anterior margin of eyes in female, variable in male.....*microps*
 3b Eye slightly asymmetrical, with lower part larger than upper
 4a Rostrum does not reach to anterior margin of eyes. Eye with upper part appearing to be bent somewhat forward*gracilis*
 4b Rostrum reaches to, or beyond, anterior margin of eyes.....*atlantica*

Nematoscelis difficilis Hansen

(Fig. 40, *a-d*)

Nematoscelis difficilis Hansen, 1911: 48–50, fig. 18; Esterly, 1914a: 12, pl. 1, figs. 1, 3, 4, 12, 15, pl. 2, figs. 22, 34, 35; Banner, 1949: 29–31.

Diagnosis.—The rostral process of the female is very long and thin and tapers to an acute point. In the males there is much variation in the shape of the rostrum. It may be long and slender, as in the female, or merely a short semitriangular projection, or, most commonly, of an intermediate shape. The rostrum bears a keel that extends backward over the vaulted gastric area of the carapace. There are no lateral denticles on the inferior margin of the carapace. The eyes are about three-fourths as broad as high, with a transverse constriction above the middle, but the upper part is not noticeably narrower than the lower. The peduncles of the first antenna are shorter and thicker in the male than in the female. The dorsal, distal margin of the first segment is produced and setose but there are no lappets or protuberances. The scale of the second antenna reaches about to the middle of the ultimate segment of the first antennal peduncle.

The flattened final segment of the first thoracic leg bears about ten strong, feathered spines on its posterior margin (fig. 40). The second thoracic leg is extremely elongate and fragile. The distal end of its meral segment reaches beyond the end of the first antennal peduncle. The geniculate bend is followed by the three terminal segments, the last of which is extremely short. The penultimate segment carries a group of bristles at its extreme distal end, and the short dactylus carries numerous similar bristles (fig. 40). The following thoracic legs are short and thick. The endopodite of the seventh thoracic appendage consists of two segments in the female and is lacking in the male. The eighth thoracic appendage is rudimentary in both sexes.

The terminal process of the male copulatory organ has a proximal part that is bent outward, and a longer, more slender, distal part that is set off at an angle (fig. 40). The distal part has a strongly curved tip and about twenty-seven serrations along the concave outer margin. The proximal process is shorter than the terminal, and its distal part is straight, slender, and delicately serrated along the outer margin. The distal end of this process reaches considerably beyond the middle of the serrate margin of the terminal process. The long, straight, and strong spiniform process is about half the length of the terminal process. The lateral process, which is of about the same length as the spine-shaped process, is sinuate. It is inserted beyond the base of the median lobe, so that its tip is nearer the tip of the proximal process than is the tip of the spine-shaped process.

Length.—22–25 mm.

Remarks.—As pointed out by Hansen (1911) and Esterly (1914a), this species is closely allied to *N. megalops* G. O. Sars, from which it is separated solely by structure of the male copulatory organ. Banner (1949) has included *N. megalops* (Sars) Ortmann (1884) (*partim*) and *N. microps* (Sars) Ortmann (1894) (*partim*) in the synonymy of this species. As Ortmann gives no descriptions or figures in the reference cited, it is not possible

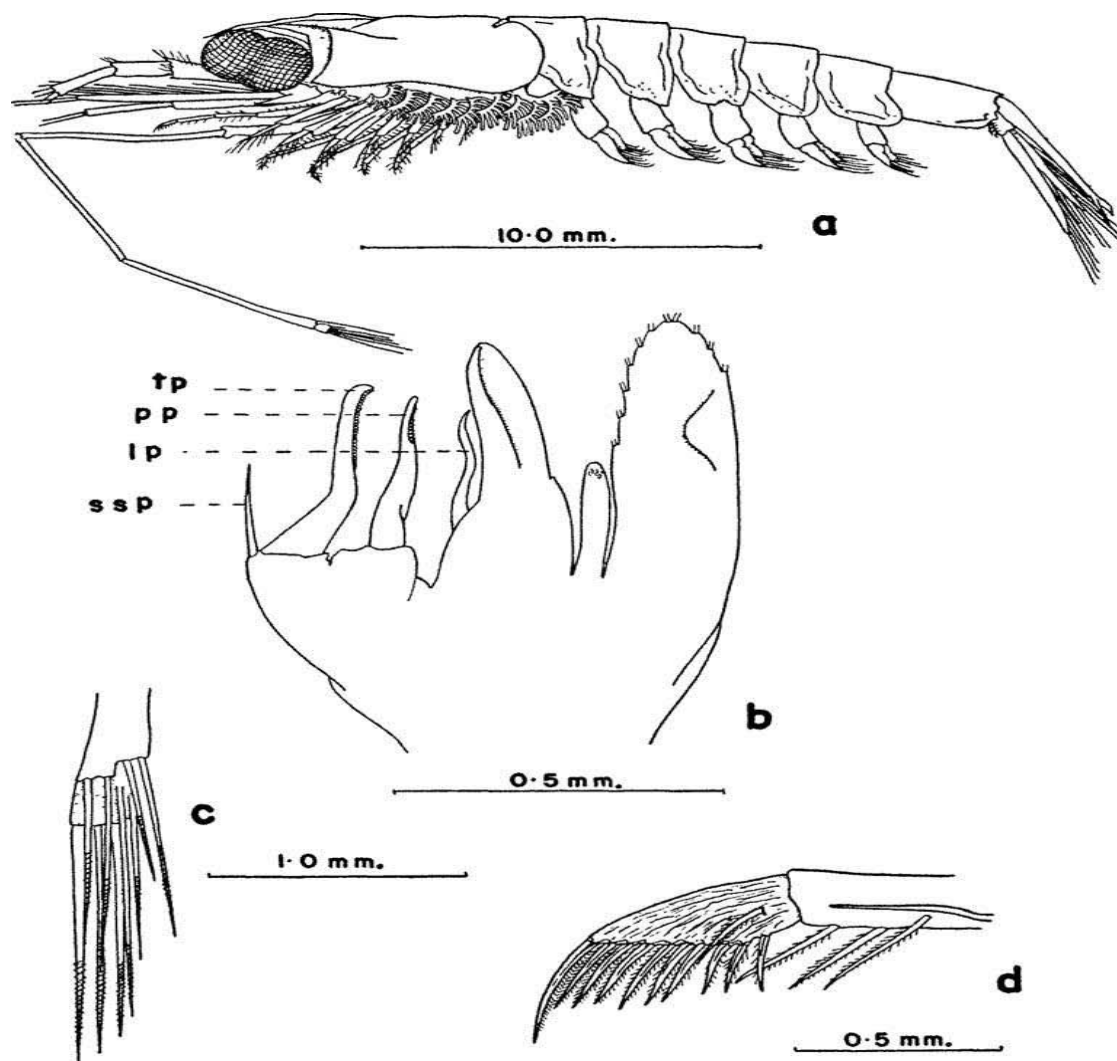


Fig. 40. *Nematoscelis difficilis* Hansen. *a.* Adult male. *b.* Male left copulatory organ from behind. *c.* End of propodus and dactylus of elongated second thoracic leg. *d.* Terminal segment of elongated first thoracic leg, traced from photomicrograph.

to assess the accuracy of this inclusion. These names have been omitted from the synonymy given above.

N. difficilis was held by Einarsson (1942) to be probably synonymous with the Atlantic species *N. megalops*, inasmuch as he found no difference in the structures

of the spermathecae. Boden (1954), however, pointed out that the differences Hansen (1911) found in the copulatory organs of males are real and consistent.

Distribution.—North Pacific. This species was captured at the stations within the Kuroshio Extension between about 34° N. and 42° N., with one record off northern Japan at 44° 46.1' N., 159° 54.9' E., and one off southern Japan at 32° 02.3' N., 139° 25.1' E. ("Transpacific" expedition). It is present between 43° 14' N., 155° 55.5' W. and 37° 28' N., 154° 12' W., in the eastern North Pacific ("Northern Holiday" expedition). Its range extends northward to 51° 50' N., 130° 24' W. in shelf waters of British Columbia (Banner, 1949). It reaches southward within the region of the California Current and is abundant as far as the latitude of Pt. Conception, 34.5° N. *N. difficilis* occurs only within 200 miles of the coast off southern California and Baja California. It is reported from the Gulf of California (Hansen, 1915), but is not known from Mexican waters south of 26° N.

Elsewhere. Sheard (1953) found this species to be abundant off southeastern Australia.

Depth.—Adults, occasionally above 100 meters; larvae, 200 meters to surface.

Nematoscelis tenella G. O. Sars

(Fig. 41, *a-c*)

Nematoscelis tenella G. O. Sars, 1883: 28; 1885: 133–134, pl. 15, figs. 5, 7; Hansen, 1910: 110–112, pl. 15, fig. 4, *a-m*; 1912: 263–264, pl. 10, fig. 3, *a-c*; *N. mantis* Chun, 1896: 165.

Diagnosis.—The rostrum is moderately short and oblong-triangular. In the Pacific specimens the lateral denticle on the inferior margin of the male carapace is lacking. It is present on adult males from the Atlantic. It is never apparent in females.

The dark-brown upper section of the eye is very much larger than the lower, and they are separated by a lighter, transverse band.

The elongated third thoracic leg carries seven spines on its terminal segment, but none on the subterminal segment (fig. 41).

The male copulatory organ has the spine-shaped and terminal processes extremely reduced, and the terminal process is shorter than the spine-shaped one (fig. 41). The proximal process is long, straight, and tapered to a rounded distal end which carries a number of strong saw-teeth on its outer margin. The lateral process is about the same size and shape as the proximal, and on its oblique, rounded end there are a number of delicate incisions separated from each other by a rounded margin.

Length.—15–21 mm.

Distribution.—North Pacific. This species occurs throughout the central North Pacific. Its most northern record is 37° 04' N., 140° 08' W. ("Transpacific" expedition). It is present 200–300 miles offshore north of Pt. Conception, California, but frequently reaches within 150 miles of the coasts of southern California and Mexico between 35° N. and 23° N. *N. tenella* is present south of 40° 34.5' N., 170° 02.3' E. in the western central Pacific and was taken at nearly all stations south of 40° N., off eastern Japan ("Transpacific" expedition).

Equatorial Pacific. *N. tenella* is found throughout the eastern equatorial Pacific

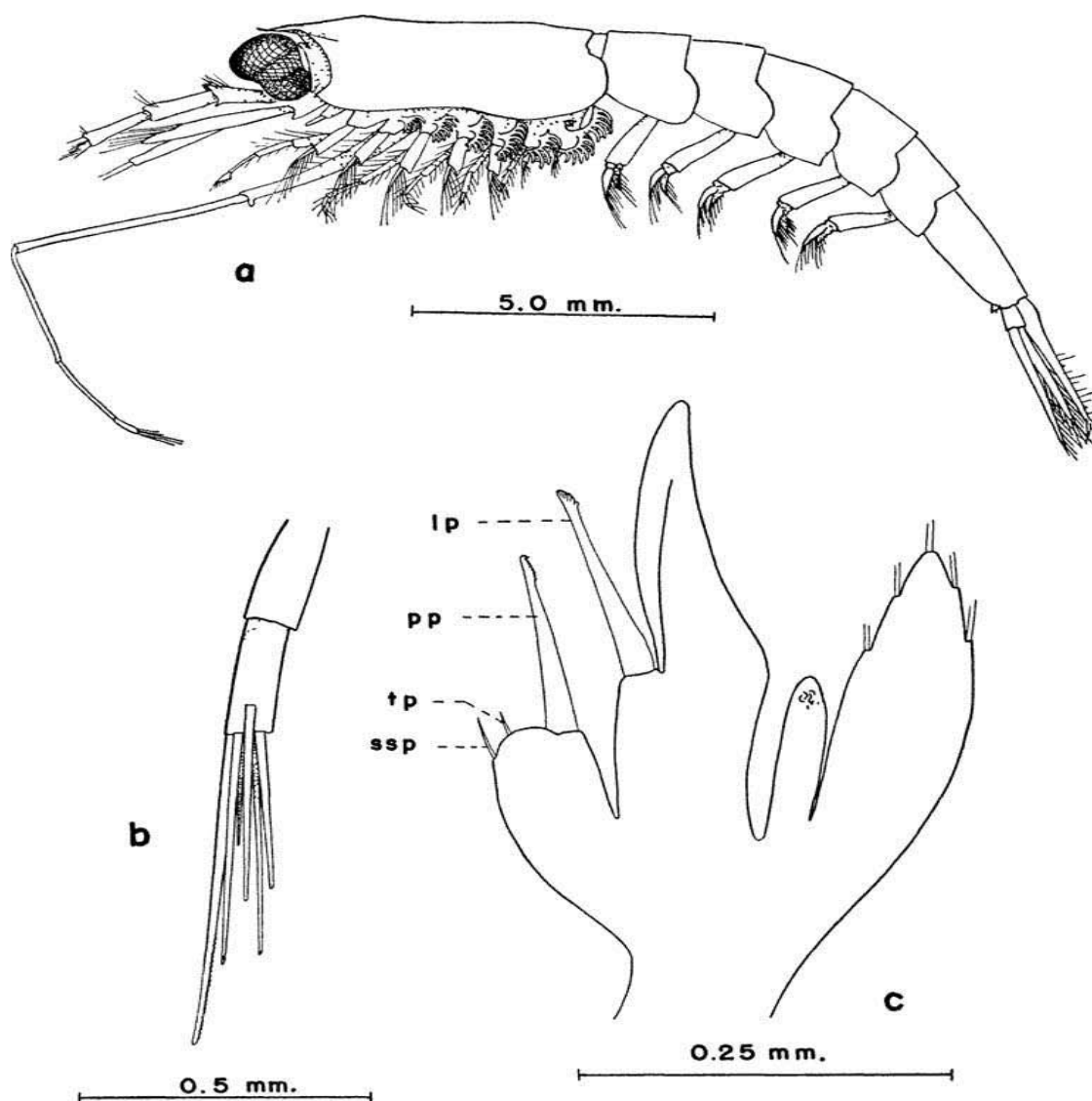


Fig. 41. *Nematoscelis tenella* G. O. Sars. *a.* Adult female. *b.* Terminal segment of first thoracic leg. *c.* Male copulatory organ from behind.

between 09° N. and 05° S. ("Shellback" expedition). It was not found between 09° N. and 23° N., east of 124° W., off Mexico and Central America. It is also missing from the Peru Current region and from a tongue extending northwestward from it to about 97° W., between 05° S., and 10° S. This species is present around the East Indian Archipelago (Hansen, 1910) and in waters of the Philippines (Hansen, 1916).

South Pacific. The westernmost record is 14° 59' S., 85° 03' W. ("Shellback"

expedition), and the southernmost record is $25^{\circ} 27.3' S.$, $103^{\circ} 29.3' W.$ (Hansen, 1912).

Elsewhere. The species is tropical and subtropical in the Indian Ocean and the Atlantic.

Depth.—Adults, below 200 meters; larvae, frequently above 100 meters.

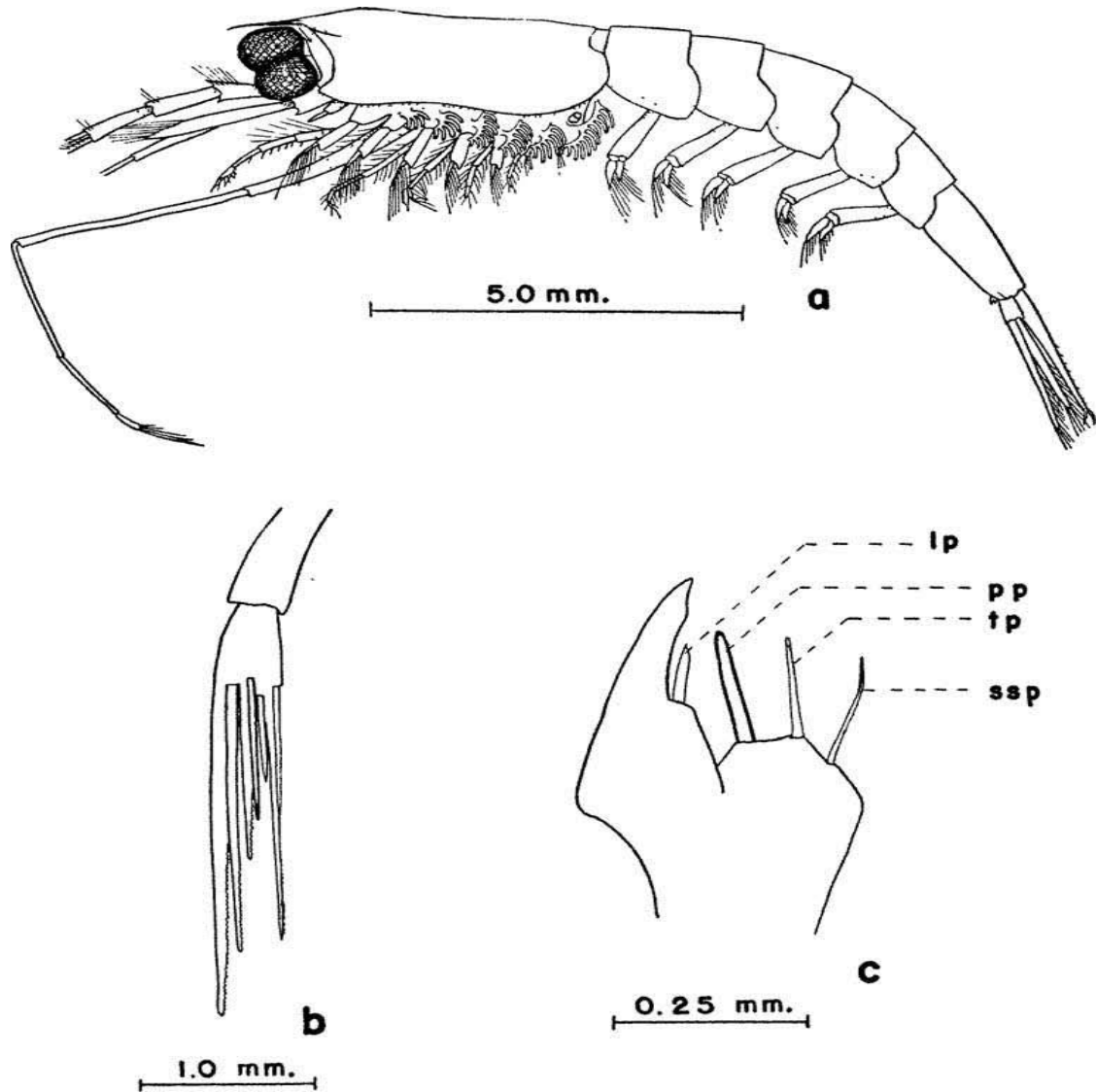


Fig. 42. *Nematoscelis microps* G. O. Sars. *a*. Adult male. *b*. Terminal segment of elongate first thoracic leg. *c*. Male right copulatory organ from behind.

Nematoscelis microps G. O. Sars

(Fig. 42, *a-c*)

Nematoscelis microps G. O. Sars, 1883: 28; 1885: 131–133, pl. 15, figs. 1–4; Hansen, 1910: 107–109, pl. 15, fig. 2, *a-k*; 1912: 259–261, pl. 9, fig. 4, *a-d*, pl. 10, fig. 1, *a-b*; *N. rostrata* G.O. Sars, 1885: 135–136, pl. 15, figs. 8–10.

Diagnosis.—In the male the rostrum is usually short; in the female it is long and acute. In the adult male there is usually a lateral denticle on the inferior margin of the carapace. This is lacking in the female. The keel on the dorsal anterior part of the carapace is well defined.

The upper section of the eye is about equal in size to the lower, and the sections are separated by a transverse constriction. The eye is symmetrical, in that a plane perpendicular to the plane of the constriction would divide the eye into equal parts.

Seven strong serrated spines are carried by the terminal segment of the elongated third thoracic leg (fig. 42).

The copulatory organ of the male carries an extremely long, slender, and slightly curved spine-shaped process (fig. 42). This is usually slightly longer than the terminal process which is slender, straight, and gradually tapered to a rounded end. The proximal process is the same shape as the terminal but longer and more robust. The lateral process is also robust but much shorter, distally, than the proximal and subacute.

Length.—15–20 mm.

Distribution.—North Pacific. The most northern record for *N. microps* in the eastern Pacific is 28° 06.5' N., 151° 25' W. (“Northern Holiday” expedition). Its easternmost capture was 17° 48' N., 124° 07' W., off Baja California. This species occurs within the waters surveyed by the Marine Life Research Program only in the most southern offshore part. It penetrates eastward to 117° E. between about 25° N. and 20° N. In the western Pacific, *N. microps* is found as far north as 40.5° N. (“Transpacific” expedition).

Equatorial Pacific. *N. microps* occurred only at the most southern station occupied by the “Mid-Pacific” expedition, 04° 41.1' N., 140° 06' W., in the equatorial Pacific. It penetrates along the equator into the eastern equatorial region as far as 00° 42' N., 110° 12.1' W. (“Shellback” expedition). This species sometimes occurs inside the Great Barrier Reef of Australia (Tattersall, 1936), around the East Indian Archipelago (Hansen, 1910), and in the Philippine and China Seas to 20° 58' N., 120° 03' E. (Hansen, 1916).

South Pacific. It occurs throughout the central South Pacific. The most eastern record is 17° 26.4' S., 86° 46.5' W., and the most southern capture by the *Albatross* was 25° 27.3' S., 103° 29.3' W. (Hansen, 1912).

Elsewhere. *N. microps* is a tropical and subtropical species in the Indian Ocean and the Atlantic.

Depth.—Adults, below 150 meters; adolescents, occasionally above 100 meters.

Nematoscelis gracilis Hansen

(Fig. 43, a–d)

Nematoscelis gracilis Hansen, 1910: 109–110, pl. 15, fig. 3, a–g; 1912: 261–263, pl. 10, fig. 2, a.

Diagnosis.—The rostrum is slightly more pronounced in the male than in the female, and the frontal plate is narrower. The rostrum rarely extends forward of the mid-point of the eyes. The lateral margins of the carapace lack denticles in all specimens of this collection, although Hansen (1910) reports rudimentary denticles on the males. According to Hansen, the eye is the same as in *N. microps*.

In fully adult specimens the upper part of the eye is as broad as the lower, but the eye of *N. gracilis* is smaller. The upper part of the eye appears to be bent somewhat forward.

The first antennal peduncle is shorter and more robust in the male than in the female.

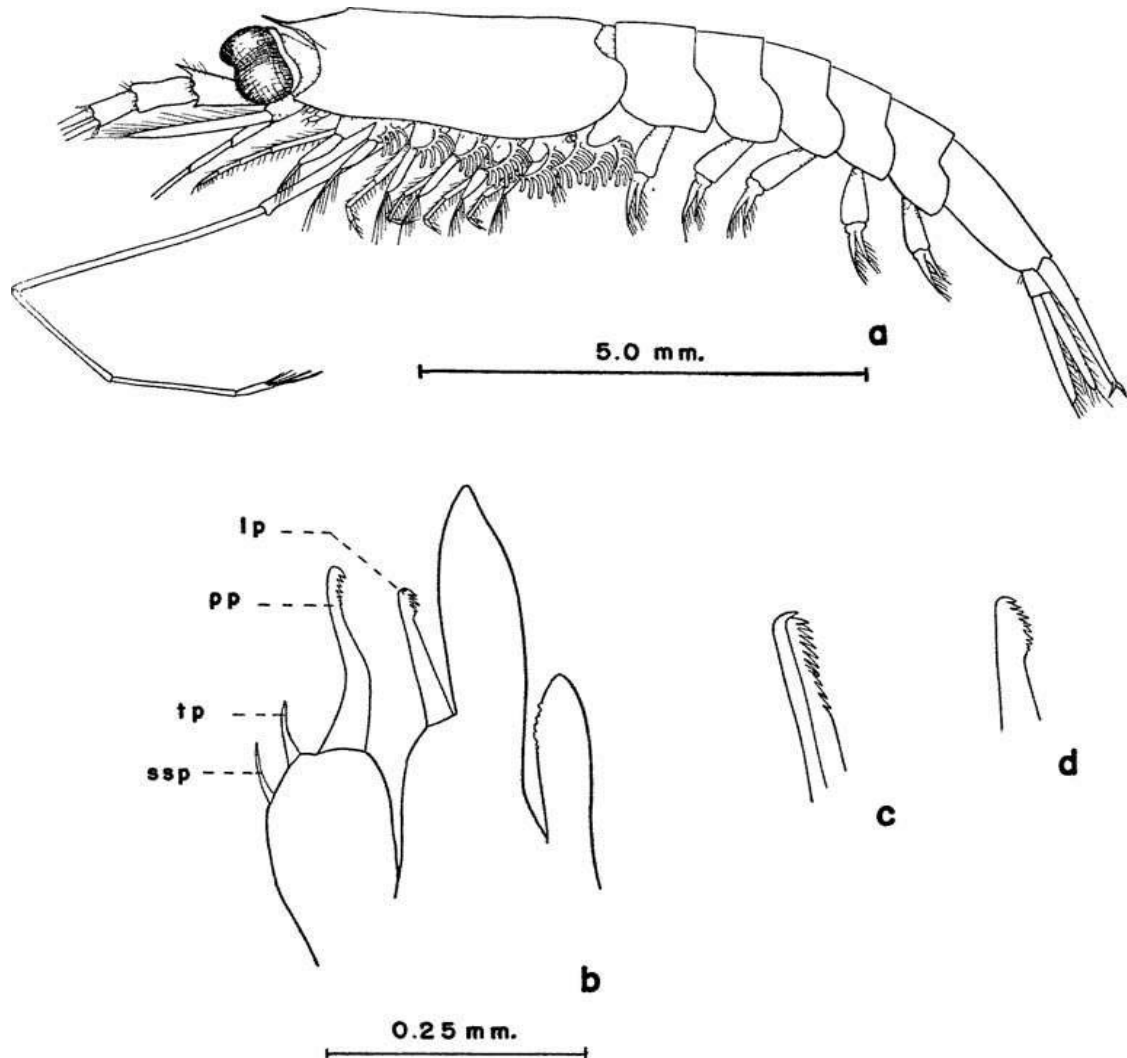


Fig. 43. *Nematoscelis gracilis* Hansen. *a*. Adult female, *b*. Male left copulatory organ from behind, *c*. Distal end of proximal process, *d*. Distal end of lateral process.

Hansen's description of the male copulatory organ must be somewhat modified. The spine-shaped process and the terminal process are more nearly equal in length than he describes, and the terminal process is slightly more robust than the spine-shaped process (fig. 43). The proximal process curves slightly, and the distal end is serrated as in *N. tenella*. The lateral process is straight, shorter than the proximal, and its somewhat bulbous end is armed with saw-teeth.

In the shape of the eye and structure of the male copulatory organ, this species

is intermediate between *N. microps* and *N. tenella*. It is more slender than either of these species.

Length.—Males up to 11.5 mm.; females up to 15.5 mm.

Distribution.—North Pacific. *N. gracilis* occurs as far north as 25° N. off Baja California, but is missing from the central North Pacific.

Equatorial Pacific. This species is found throughout the equatorial Pacific. It penetrates to neritic waters between 25° N. and 13° S. in the eastern Pacific (“Shellback” expedition). It is present around the East Indian Archipelago (Hansen, 1910) and in waters of the Philippine Archipelago (Hansen, 1916). It is present in waters near to the southeastern coast of Japan and at two stations, 36° 23.2' N., 145° 30.4' E., and 36° 04' N., 162° 13.5' E., in the Kuroshio Extension (“Transpacific” expedition).

South Pacific. *N. gracilis* occurred throughout the area explored by the “Shellback” expedition and in most of the region sampled by the *Albatross* (Hansen, 1912), its southernmost record being 20° 02.4' S., 91° 52.5' W.

Elsewhere. It is also found in the tropical Indian Ocean.

Depth.—Adults, usually below 100 meters; larvae, 150 meters to surface.

Nematoscelis atlantica Hansen

(Fig. 44, a–c)

Nematoscelis atlantica Hansen, 1910: 106–110; Ruud, 1936: 11–14, 42–46, figs. 3, 4, 16.

Diagnosis.—The rostrum of the male is variable in length. It may not reach quite to the anterior limit of the eyes, or may extend somewhat beyond. In the female the rostrum consistently reaches beyond the anterior limit of the eyes. A denticle is present on each lateral margin of the carapace in juvenile specimens, but these are lacking in the adult.

The proximal process of the male copulatory organ is as long as, or slightly longer than, the terminal and spine-shaped processes. The latter two are equal in length. The terminal process is inserted more distally than the spine-shaped process on the inner lobe of the copulatory organ; hence, it “over-reaches” the latter, as Hansen states. Hansen’s Atlantic specimens had the proximal process “not longer, or even a little shorter, than the terminal process.” Ruud (1936) notes that subadult males from the Atlantic may bear a proximal process which is clearly longer than the terminal. Our subadult Pacific specimens also show this deviation from the adult males. The proximal process has a filmy, transparent appearance, well described by Hansen as “diaphanous” and its rounded end bears a minute acute projection. In *N. microps* the proximal process is longer in both the subadult and adult male, and it is more opaque and robust than in *N. atlantica*.

Length.—Males, 10.5–12 mm.; females, 11–15 mm.

Remarks.—It is difficult to separate females or immature specimens of *N. gracilis*, *N. microps*, and *N. atlantica*. Ruud, who did not have *N. gracilis* to contend with in the Atlantic, devised a graphical method for separating *N. microps* from *N. atlantica*. Carapace length (which is taken as the distance from the most posterior part of the postorbital margin to the most posterior, lateral part of the carapace) is plotted as an ordinate, and the proportion of the carapace length to eye length is plotted as the abscissa. Eye length is measured normal to the plane

of eye constriction. Ruud found that a straight line will separate all individuals of *N. atlantica* from *N. microps*. For a given length of carapace (i.e., 3.3 mm.) the carapace/eye ratio will be greater for *N. atlantica* (3.4–3.9) than for *N. microps* (2.8–3.2). The eye of *N. microps* is consistently larger than the eye of either *N. atlantica* or *N. gracilis*.

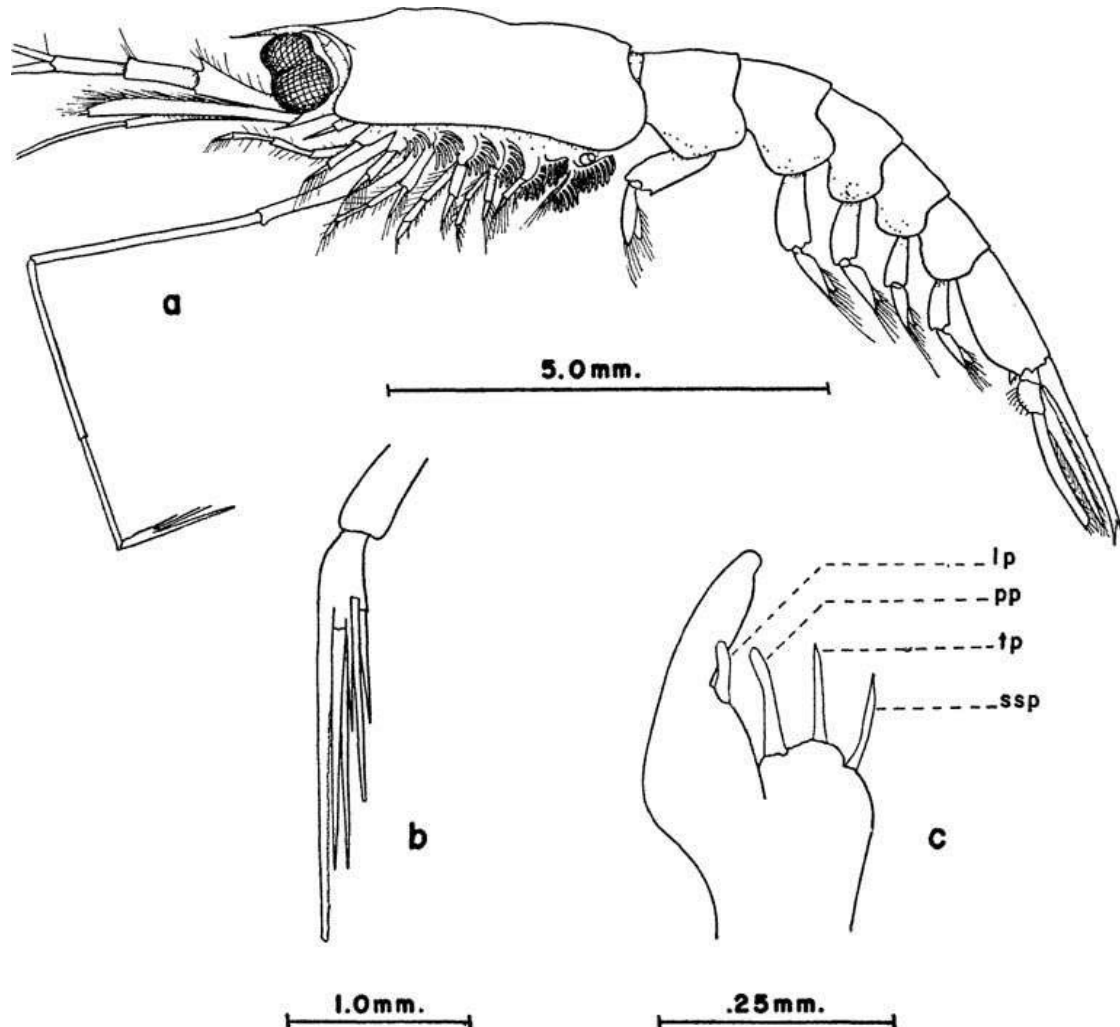


Fig. 44. *Nematoscelis atlantica* Hansen. *a.* Adult female, *b.* Terminal segment of elongate first thoracic leg. *c.* Male right copulatory organ from behind.

Distribution.—North Pacific. *N. atlantica* is widely distributed in the central North Pacific between 39° N. and 19° N. It has not been encountered nearer than 300 miles from the California coast north of Pt. Conception (34.5° N.). Between this latitude and 27° N. its range is extended to within 150 miles of the coast. This species is missing from the Kuroshio Current near Japan, its most western record being 30° 09' N., 143° 15.7' B. ("Transpacific" expedition).

South Pacific. The species is recorded from a single locality, 20° 30' S., 178° 30' E., in the western South Pacific ("Capricorn" expedition).

Depth.—Adults, 100–500 meters; juveniles, above 200 meters.

NEMATOBRACHION Calman

Nematodactylus Calman, 1896: 16; *Nematobrachion* Calman, 1905: 153.

Generic characters.—The carapace has a cervical groove and is with or without a lateral denticle. The eyes are large and are transversely constricted, with the upper section larger than the lower. The first antennal peduncle is robust and similar in both sexes: the flagella are long and slender. The outer spine on the second antennal peduncle is about as long as the scale is broad. The mandible has a three-segmented palp.

The second thoracic leg is a trifle longer than the first. Its terminal segment is short, widened, and furnished with short, stiff setae. The third thoracic leg is greatly elongated. Its merus is peculiarly bent at the proximal end, and its dactylus is elongated and armed at the tip with very long, serrated spines. The seventh thoracic leg is short, but has the full number of segments. The eighth leg is rudimentary.

The male copulatory organ of the first pleopod, somewhat similar to that of *Thysanopoda*, is armed with five well-developed processes. The preanal spine is simple in the male, simple or bifid in the female.

Four genera of the Euphausiidae possess one pair of elongated thoracic legs. In *Thysanoëssa* and *Nematoscelis* it is the second pair, whereas in *Nematobrachion* and *Stylocheiron* it is the third pair. *Nematobrachion* differs widely from the three other genera in that the first antennal peduncle is similar in both sexes, and the seventh thoracic leg has the full complement of five segments. In the other three genera this appendage has at most two segments in the female and is wanting in the male. In these characters, and also in the structure and number of the copulatory processes, *Nematobrachion* more closely resembles the genus *Thysanopoda*.

All of the three known species are represented in the present collection.

KEY TO SPECIES OF NEMATOBRACHION

1a Rostrum, lateral denticle on carapace, and dorsal processes on some abdominal segments present

2a Mid-dorsal acute process on posterior margins of third to fifth abdominal segments.....*flexipes*

2b No mid-dorsal acute process on third abdominal segment; mid-dorsal process on fourth to fifth segments flanked on each side by a smaller, acute process.....*sexspinosus*

1b Rostral process, lateral denticles on carapace, and dorsal processes on abdomen all lacking
boöpis

Nematobrachion flexipes (Ortmann) Calman

(Fig. 45, *a-c*)

Stylocheiron flexipes Ortmann, 1893: 18, pl. 1, fig. 7; *Nematodactylus flexipes* Calman, 1896: 16; *Nematobrachion flexipes* Calman, 1905: 153; Hansen, 1911: 51; 1912: 269–272, pl. 10, fig. 5, *a-m*; Banner, 1949: 15–18.

Diagnosis.—The frontal plate terminates in a long, slender, spiniform, somewhat compressed rostrum. The anterior part of the carapace has a well-developed keel. There is a conspicuous lateral denticle on the inferior margin of the carapace. This statement is contrary to what Hansen (1912) found. He stated, “...even in

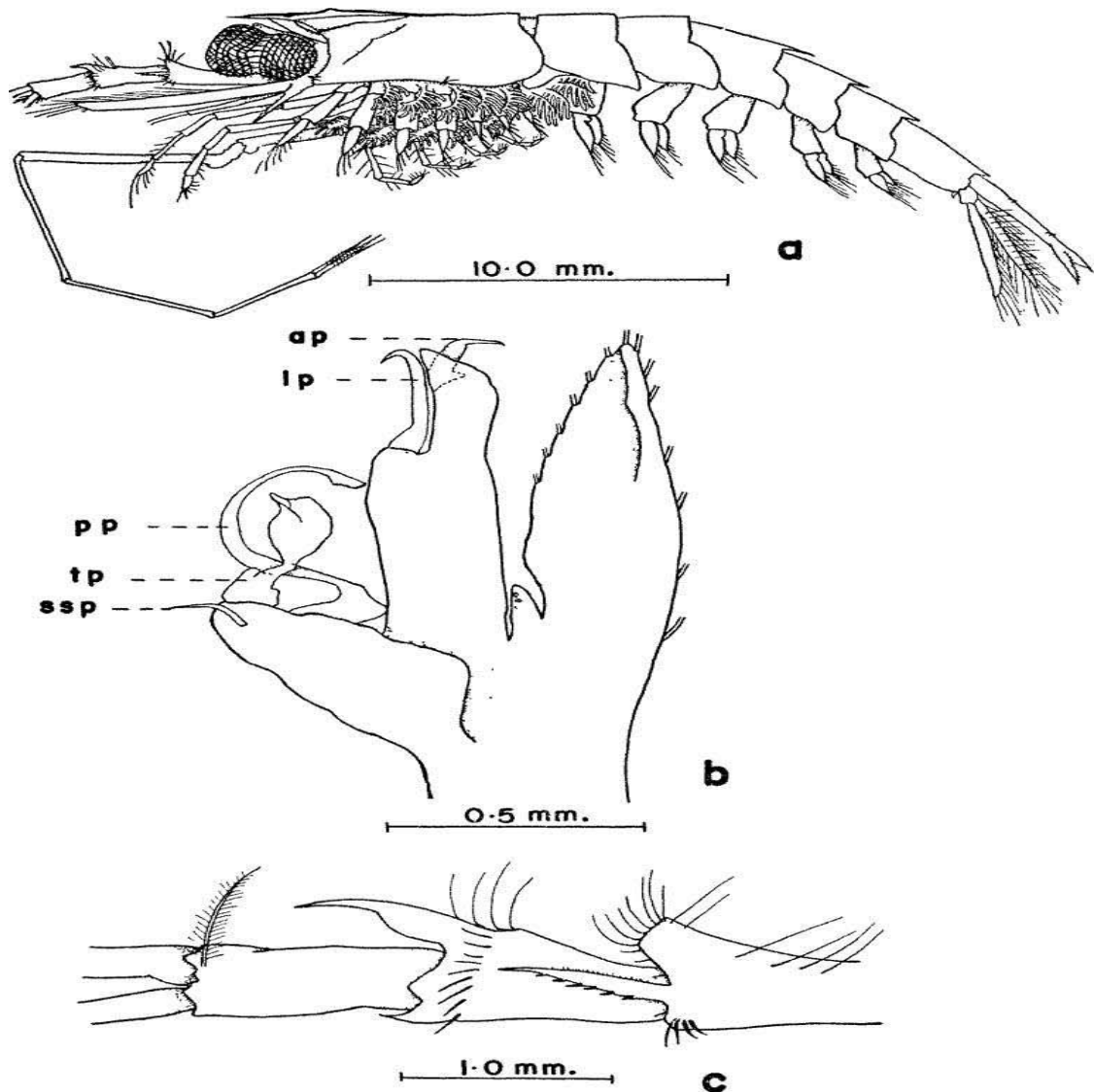


Fig. 45. *Nematobrachion flexipes* (Ortmann) Calman. *a.* Adult female. *b.* Male left copulatory organ from behind. *c.* Left first antennal peduncle.

less than half-grown specimens the carapace has no vestige of any tooth on the lateral margins." However, it agrees with Tattersall's (1926) observations on the species, and the generic definition herein has been altered accordingly.

The eyes are large and transversely constricted, with the upper section markedly larger than the lower. The first segment of the first antennal peduncle has a very concave outer margin from which a long, spiniform process projects forward to beyond the middle of the second segment (fig. 45). The dorsal tip of the first segment

is raised as a low, setiferous lobe. The second segment is produced at its outer distal corner in a process, lamellar at the base but tapering rapidly so that its distal half forms a spine directed forward, upward, and outward. The third segment has a very short, low dorsal keel.

The scale of the second antennal peduncle reaches nearly to the middle of the third segment of the first antennal peduncle.

The thoracic legs conform to the generic description. The gill structure is complex.

The third, fourth, fifth, and sixth segments of the abdomen are armed mid-dorsally on their hind margins with conspicuous spines. The spine on the third segment is generally longer than the others. The pleura of the abdominal segments have their posterolateral angles rather acute, and those of the fifth segment are somewhat produced. The preanal spine is simple in the male and bifid in the female. The exopod of the uropod is armed dorsally with long, stiff setae.

The terminal process of the male copulatory organ is thickened at the base, tapers to a narrow middle, and then expands strongly to a flattened plate, on the distal end of which is a small raised portion (fig. 45). The base of the proximal process is expanded, and the whole process is curved strongly and evenly and terminates in a flattened, considerably expanded plate, with a finely serrated margin. The lateral process is moderately thick and has a short, curved distal part. The basal part of the additional process is oblong and very feebly curved. Attached to its end is an extremely thin distal portion that is pointed outward and forms an acute angle with the thick base. The median lobe is thin and narrow. The auxiliary lobe is fairly short, and the setiferous lobe is long, narrow, and setose along the distal part of the outer margin.

Length.—Males up to 22 mm.; females up to 23 mm.

Remarks.—Banner (1949, 1954) noted that *N. flexipes* in the northeastern Pacific differed from Hansen's (1912) description in that it (1) bore lateral denticles on the carapace, (2) possessed a series of spinules on the dorsal surface of the subapical telson spines, and (3) showed the angle of the anterior margin of the carapace, when viewed dorsally, to be 90°. The first two discrepancies are confirmed by examination of the Scripps specimens. The carapace denticles of Hansen's specimens may have been broken off, as they were on one of Banner's specimens. The spinules of the subapical telson spines may well have been overlooked by Hansen, as Banner has suggested. Examination of both equatorial and more northern specimens shows that the angle formed by the frontal plate is somewhat variable, being anywhere from 92° to about 110° in the present material.

Distribution.—North Pacific. This species occurs throughout the central North Pacific and the region of the California Current. Its most northern capture in oceanic waters was at 43° 8.5' N., 50° W. ("Northern Holiday" expedition), but its range extends northward to 56° 09' N., 137° 05' W. in the slope waters of British Columbia (Banner, 1949). This species was found between 41.5° N. and 34.5° N. in the western central Pacific, but it was not taken near Japan ("Transpacific" expedition).

Equatorial Pacific. It is present in the equatorial mid-Pacific ("Mid-Pacific" expedition) and in the eastern equatorial Pacific, except in an area 300 miles wide

along the coast of central Mexico between 95° W. and 105° W. ("Shellback" expedition). *N. flexipes* was caught in Philippine waters (Hansen, 1916), but was not taken near the East Indian Archipelago (Hansen, 1910).

South Pacific. It occurs throughout the central South Pacific and the Peru Current. The southernmost record is 25° 27.3' S., 103° 29.3' W. (Hansen, 1912).

Elsewhere. *N. flexipes* occurs also in the tropical and subtropical waters of the Indian Ocean and the Atlantic.

Depth.—Adults, 100 meters (at night) to 600 meters; larvae, frequently above 200 meters.

Nematobranchion sexspinosus Hansen

(Fig. 46, a–d)

Nematobranchion sexspinosus Hansen, 1911: 51; 1912: 272–273, pl. 10, fig. 6, a, and pl. 11, fig. 1, a–i; Tattersall, 1926: 24.

Diagnosis.—The gastric area and frontal plate are raised into a high, somewhat broadened keel. The rostrum extends forward as a slender, laterally compressed continuation of this keel. The rostrum of the female is longer and the gastric area is somewhat more vaulted than in the male.

A single denticle is present at the posterior angle of the lateral margin of the carapace. A small, almost toothlike flange is present behind each eye at each posterior angle of the frontal plate.

The proximal segment of the peduncle of the first antenna is raised distally into a blunt lobe. A sharp process extends forward and slightly upward from the outer distal margin. The second segment of the peduncle bears a dorsal leaflet which overhangs the third segment. This leaflet is more raised and spiniform in the male than in the female.

The eyes are large, with the upper part considerably larger than the lower. As in *N. flexipes*, the eye of the female is more elongate than that of the male and is also more constricted medially.

The third abdominal segment bears no spine, but the fourth and fifth segments each possess a mid-dorsal spine which is flanked by a pair of somewhat smaller spines.

The copulatory organ is similar to that of *N. boöpis*, but in *N. sexspinosus* the terminal process is shorter, not reaching to the end of the long, inward-curved proximal process. The lateral process is long and sharply curved at its distal end.

Length.—The adult male is 21 mm.; the largest female is 25 mm.

Remarks.—This species is most similar to *N. flexipes*, but is best distinguished by the absence of a spine on the third abdominal segment, by the presence of the three spines on each of the two succeeding segments, and by the somewhat larger size of the eyes. *N. boöpis* is easily separated owing to the fact that it has no rostral process.

Distribution.—North Pacific. Three young specimens were taken in three tows at two stations (25° 12.4' N., 166° 56' W., and 23° 55.3' N., 163° 39.6' W.) along the northern side of the Midway-Hawaii chain. One adult was taken immediately south of Hawaii and another off southern Japan at 32° 26.8' N., 140° 36.6' E. Two larvae, probably belonging to this species, were taken near this last station ("Transpacific" expedition).

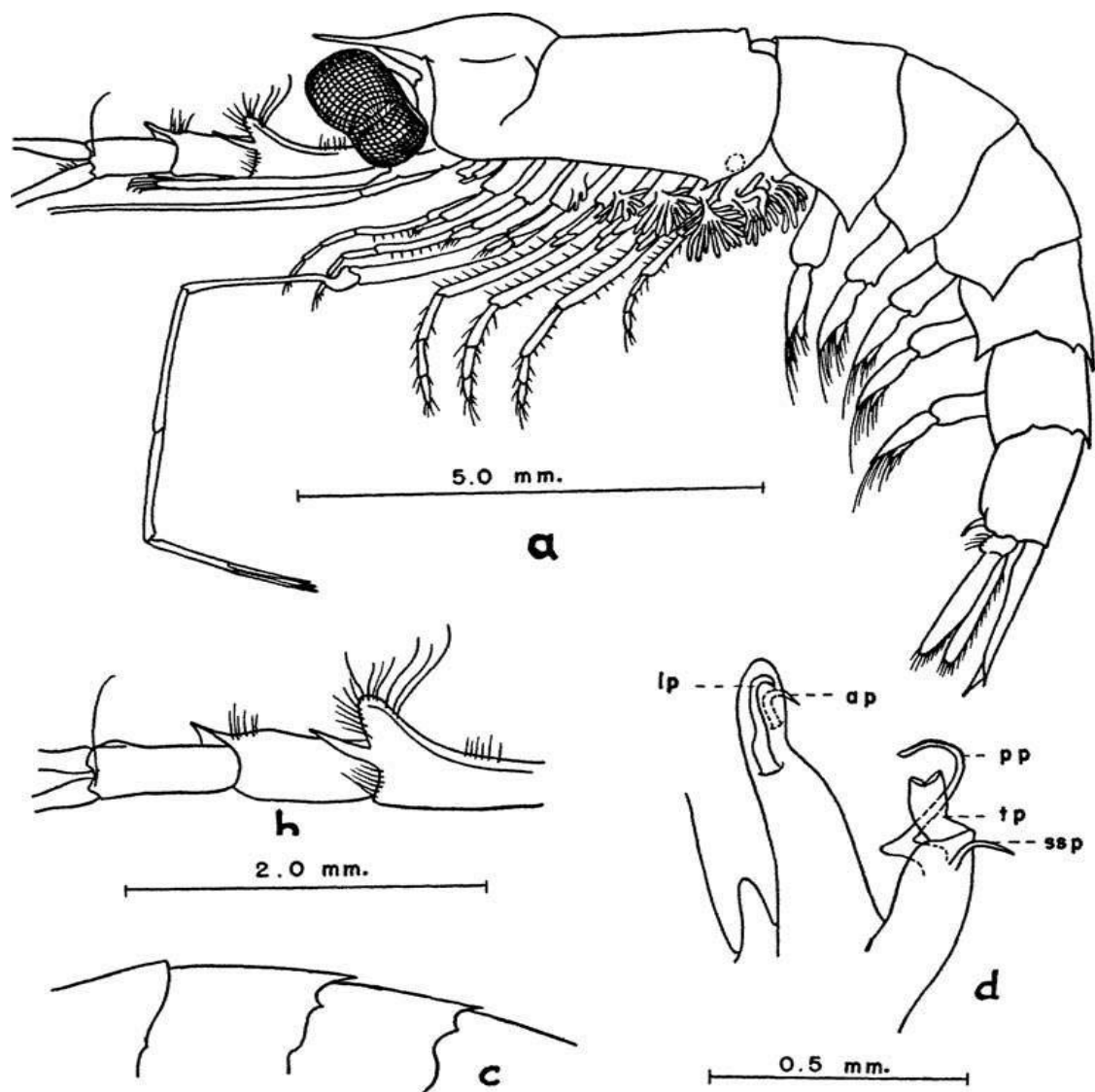


Fig. 46 *Nematobranchion sexspinosus* Hansen. *a.* Female 14 mm. long *b.* Left first antennal peduncle from the left side. *c.* Upper part of third, fourth, and fifth abdominal segments, from the left side. *d.* Right copulatory organ of an adult male 22 mm. long, from behind.

South Pacific. Two specimens were taken from the subtropical waters of the South Pacific by the *Albatross* at 21° 39.5' S., 104° 29.8' W.

Elsewhere. A total of five specimens are recorded from the northern temperate Atlantic (Hansen, 1911; Tattersall, 1926; Leavitt, 1938).

Nematobranchion boöpis Calman

(Fig. 47, *a* and *b*)

Nematodactylus boöpis Calman, 1896: 17; *Nematobranchion boöpis* Calman, 1905: 153–154 pl. 26; Hansen, 1912: 267–269, pl. 10, fig. 5, *a–m*.

Diagnosis.—The frontal plate lacks a rostrum and is obtusely rounded. It carries a low keel. A cervical groove is present on the dorsal part of the carapace, which lacks lateral denticles.

The eye is very large and is divided into a small lower and larger upper part by a light-colored band. There is no transverse constriction.

The anterior margin of the basal segment of the first antennal peduncle is produced as a rounded lobe which projects forward high above the second segment. The second segment is vaulted distally and projects over the proximal part of the third as a feebly angular lobe. There is a short, low keel on the third segment.

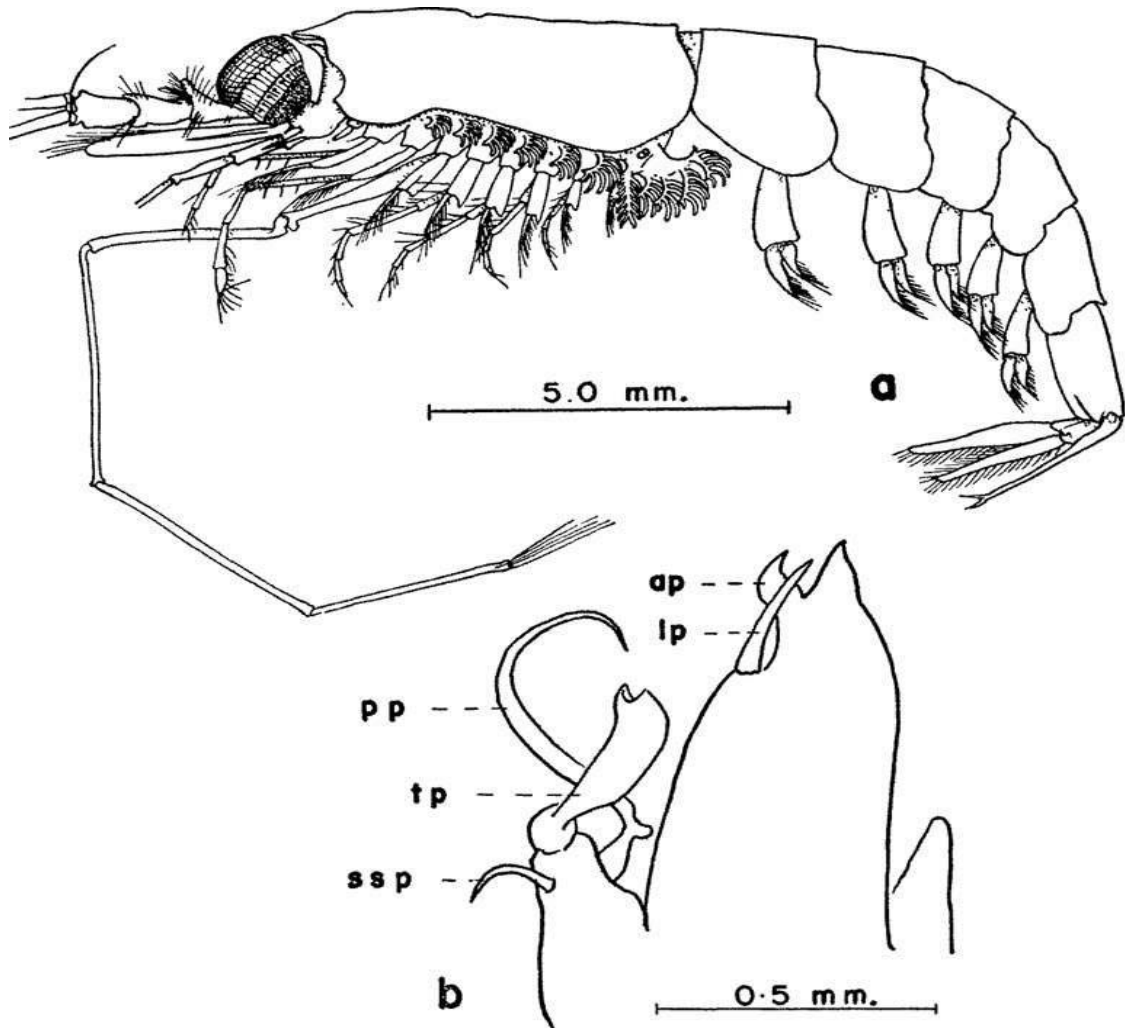


Fig. 47. *Nematobranchion boöpis* Calman. a. Adult female. b. Male left copulatory organ from behind.

The male copulatory organ carries a very small, curved, spine-shaped process (fig. 47). The terminal process is broad at the base, then narrow, and then it expands considerably into a very large, flat plate which is sometimes distally emarginate. The base of the proximal process carries a small conical protuberance. The process is very long, slender, and curved to an acute, hooked point. The lateral process is slender and curves distally to a short, sharp hook. The additional process is very robust and strongly curved.

Length.—19–21 mm.

Distribution.—North Pacific. This species is present throughout the central North Pacific. Its most northern record is 41° 42' N., 150° 00' W. (“Northern Holiday” expedition). It was taken south of 40° N., off Japan (“Transpacific” expedition). *N. boöpis* has not been found within 200 miles of the coast north of Pt. Conception, but penetrates into waters of the southern California continental borderland south of 34° N.

Equatorial Pacific. *N. boöpis* is found in the equatorial mid-Pacific (“Mid-Pacific” expedition). Its most eastern record of capture on the “Shellback” expedition was 00° 59' N., 91° 45' W. It was not found east of 140° W. between 05° N. and 20° N., or east of 100° W. off the coasts of Ecuador and Peru. It was caught by the *Siboga* near the East Indian Archipelago (Hansen, 1910) and in Philippine waters by the *Albatross* (Hansen, 1916).

South Pacific. It is missing from the region of the Peru Current off South America. Its southernmost record is 25° 22.4' S., 107° 45' W. (Hansen, 1912).

Elsewhere. The species is tropical and subtropical in the Indian Ocean and the Atlantic.

Depth.—Adults, below 400 meters; larvae, occasionally above 300 meters.

STYLOCHEIRON G. O. Sars

Stylocheiron G. O. Sars, 1883: 29

Generic characters.—The body is variable in form, and the size is generally small. The eyes are more or less irregularly shaped. The carapace always lacks denticles on the lateral margin.

The second and particularly the third peduncular segments of the first antennae of the female are long and slender. In the male these segments, particularly the third, are shorter and much thicker. The upper flagellum is shorter than the lower. In the female the segments are slender and cylindrical; in the male they are flattened and expanded. The peduncle of the second antennal endopod, particularly the penultimate segment, is extremely elongate. This segment reaches beyond the end of the scale.

The first and second thoracic legs are feebly developed. The third thoracic leg is greatly produced and geniculate and bears short ischial and long meral and carpal segments. The strong spiniform bristles of the swollen propodal segment and the curved spines of the terminal segment together form a prehensile hand (fig. 48). The other thoracic legs diminish in length. The last one is rudimentary.

The inner and median lobes of the copulatory organ are coalesced. The median lobe is oblong and distally rounded. The processes are small, relative to the organ, and are at most slightly curved. The lateral process is inserted near the base of the inner margin of the lobe, and there is never an additional process. The auxiliary lobe is placed on the inner side of the setiferous lobe and is much reduced.

Of the nine species recognized in the genus, all but *S. insulare*, which Hansen (1910) has described from the East Indian Archipelago, were encountered in the material examined.

KEY TO SPECIES OF STYLOCHEIRON

1a Penultimate segment of elongated third thoracic leg with lateral setae only (fig. 48). Upper eye with numerous (7–8), slightly enlarged crystalline cones in transverse row. Thorax slender.....*carinatum*

1b Third thoracic leg terminates in false chela (fig. 48). Upper eye with conspicuous, elongate, crystalline cones in transverse row

2a Upper eye with from two to six crystalline cones in transverse row

3a Upper eye with four or five, rarely six, crystalline cones in row.....*affine*

3b Upper eye with three crystalline cones in row.....*suhmii*

3c Upper eye with two crystalline cones in row.....*microphthalma*

2b Upper part of eye as broad or nearly as broad as lower part. Numerous (more than eight) crystalline cones in transverse row

4a Sixth abdominal segment nearly three times as long as fifth.....*elongatum*

4b Sixth abdominal segment very little longer than fifth.....*longicorne*

1c Third thoracic leg terminates in true chela (fig. 58). Upper eye with or without slightly enlarged crystalline cones

5a Upper section of eye much smaller than lower, with numerous slightly enlarged crystalline cones. Fourth and fifth abdominal segments bear low, mid-dorsal keels.....*abbreviatum*

5b Upper section of eye at most slightly smaller than lower, with no enlarged crystalline cones. Fourth and fifth abdominal segments unarmed.....*maximum*

Stylocheiron carinatum G. O. Sars

(Fig. 48, a-c)

Stylocheiron carinatum G. O. Sars, 1883: 31; 1885: 137-142, pl. 26; Hansen, 1910: 113-115, pl. 16, fig. 1, a-h; 1912: 274-276, pl. 11, fig. 2, a and b.

Diagnosis.—The frontal plate is short and bears a long, pointed rostrum. A short keel is present above the anterior part of the gastric region.

The basal segment of the first antennal peduncle is similar in both sexes and bears no lobes or processes. The flagella are shorter than the peduncle, the lower being a little longer than the upper. The lower flagella of the male are much thickened at the base.

The elongated third thoracic leg, which terminates in the false chela, bears a high tubercle armed with a spine at the distal end of the antepenultimate segment (fig. 48). The penultimate segment has three long setae on its lower margin.

The terminal process of the male copulatory organ is short, flat, and broad, with a transversely crenulated end (fig. 48). The proximal process, also broad, is longer than the terminal, and is broadest at its mid-point. It is much expanded distally on the inner side, with the inner margin forming a rounded angle. The lateral process is a little shorter and more slender than the proximal process. It terminates in an acute point and bears an outer tooth just before the end.

The lower part of the eye is nearly circular. The upper part is narrow, with its lateral margins essentially parallel, and there is a transverse row of 7-8 slightly enlarged crystalline cones.

Length.—Males up to 10 mm.; females, 10-12 mm.

Remarks.—The false chela on the elongated third thoracic leg allies this species with *S. affine*. In casual observation, it is occasionally confused with *S. abbreviatum*, owing to the small size of the crystalline cones and the dark pigmentation of the eye. The true chela of *abbreviatum*, when it is not broken off, will separate the two species; otherwise, the relatively slender thorax is a good character for *S. carinatum*.

Distribution.—North Pacific. The range of this species extends as far north as 36° 44' N., 137° 23.7' W. in the northeastern central Pacific and to 39° 44' N.,

148° 24' E. in the northwestern Pacific ("Transpacific" expedition). It reaches to within 200–300 miles of the coast of southern California, but it apparently swings offshore to as far as 500–600 miles off Baja California south of 28° N.

Equatorial Pacific. This euphausiid occurs from the Philippine waters (Hansen, 1916) and from the East Indian Archipelago waters (Hansen, 1910). It has been taken within the Great Barrier Reef (Tattersall, 1936), and is present in the equatorial mid-Pacific ("Capricorn" expedition; "Mid-Pacific" expedition). South of 20° N. it occurs throughout the eastern equatorial region surveyed by the "Shellback" expedition, exclusive of coastal waters of Ecuador and Peru, to a distance of 100–150 miles.

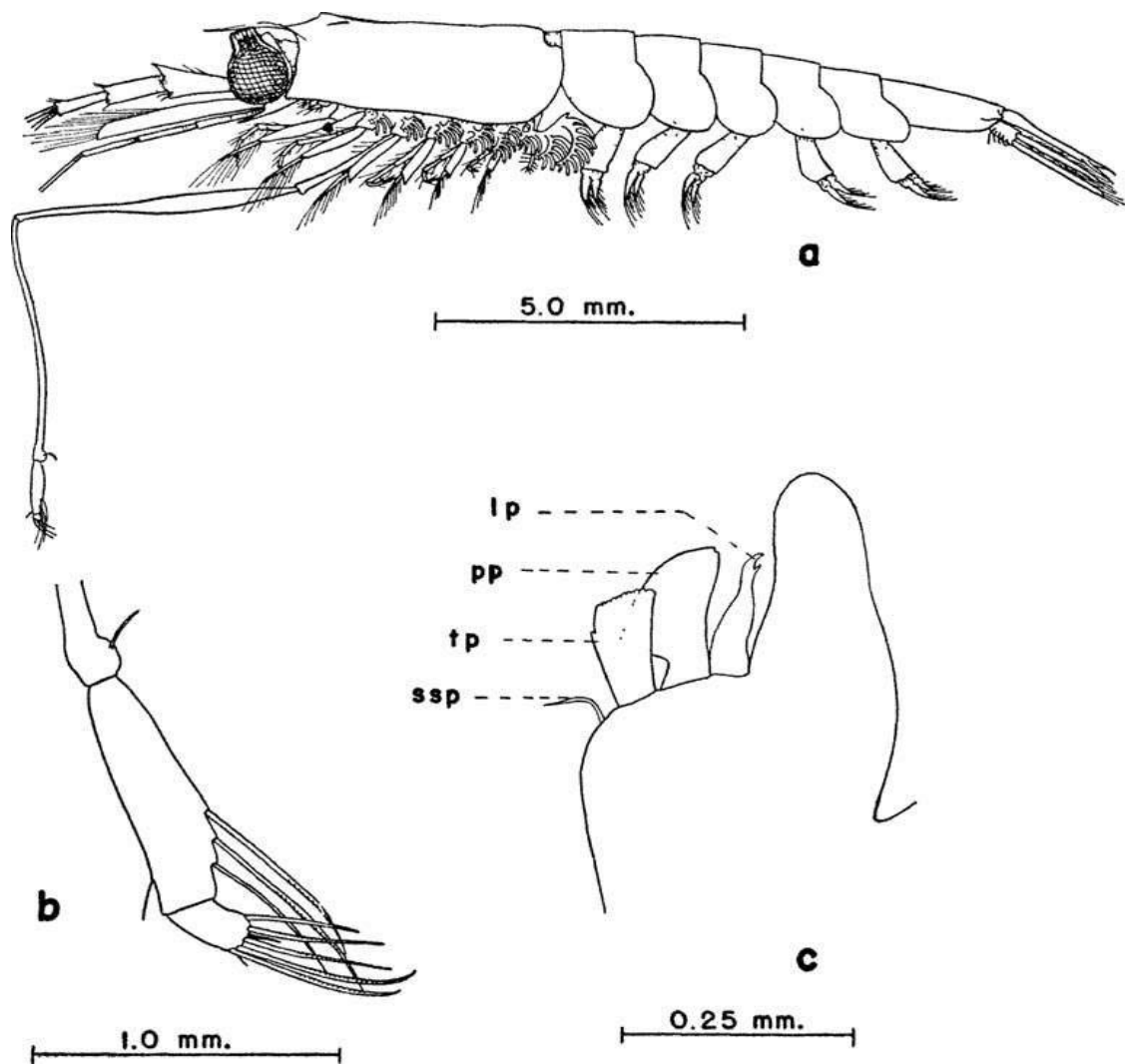


Fig. 48. *Stylocheiron carinatum* G. O. Sars. *a.* Adult female. *b.* Terminal segments of elongate third thoracic leg. *c.* Male left copulatory organ from behind.

South Pacific. *S. carinatum* was taken at 20° 29.5' S., 178° 21.8' E. by the "Capricorn" expedition. The most southern record in the southeastern central Pacific is 24° 05' S., 100° 20' W. (Hansen, 1912).

Elsewhere. It is widespread throughout the temperate and tropical Indian Ocean and Atlantic.
Depth.—Adults and larvae, above 300 meters.

Stylocheiron affine Hansen

(Fig. 49, a-c)

Stylocheiron affine Hansen, 1910: 118–120, pl. 16, fig. 4, a–d; 1912: 278–279, pl. 16, fig. 4, a–d.

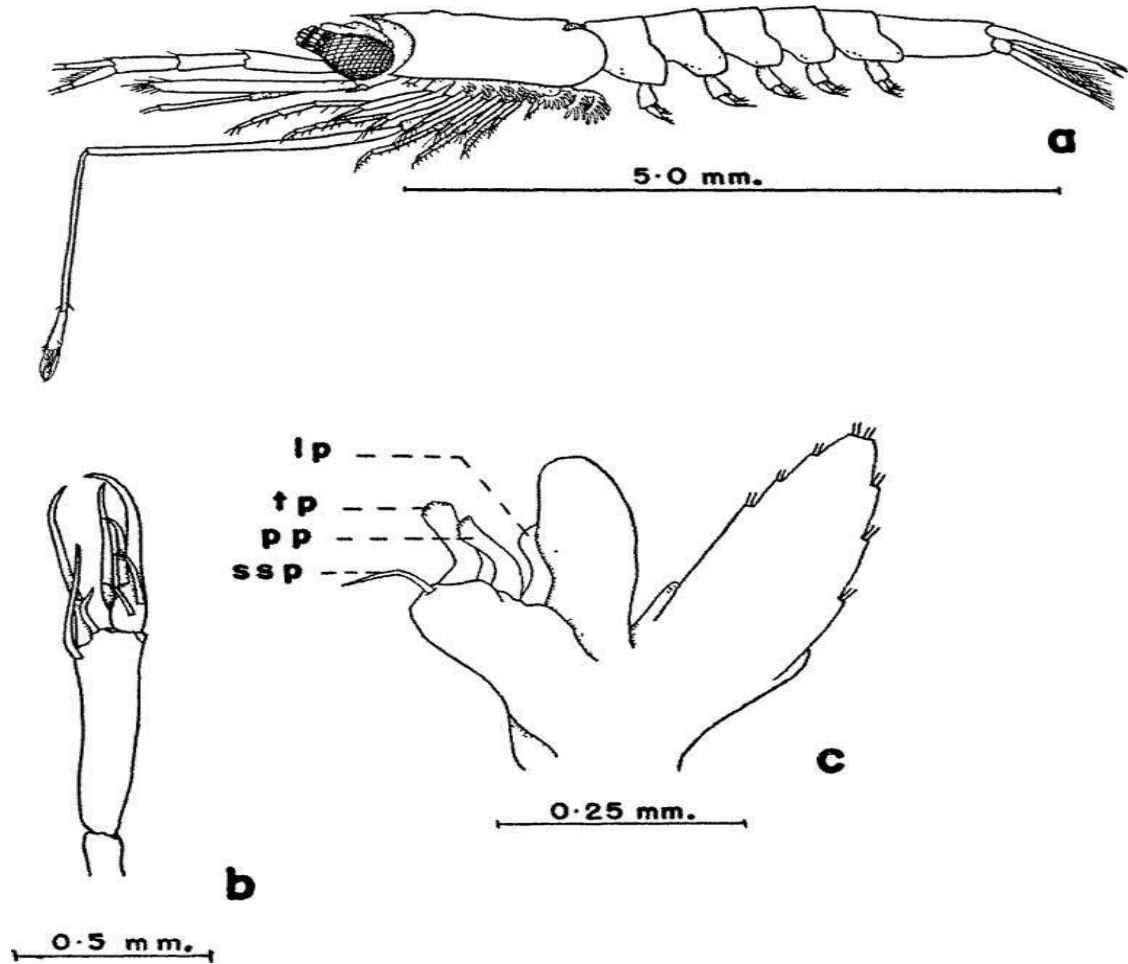


Fig. 49. *Stylocheiron affine* Hansen. a. Adult male. b. False chela of third thoracic leg. c. Male left copulatory organ from behind.

Diagnosis.—The frontal plate is produced into a rostrum which in the female is long and slender and reaches to, or beyond, the anterior limit of the eye, whereas in the male it is acute but does not reach to the anterior limit of the eye. The eyes are from one and one-half to one and three-quarters as high as the lower part is broad. The upper eye bears from four to seven enlarged crystalline cones in a transverse row.

In both sexes the first antennal peduncle is about as long as the carapace, but in the male it is relatively shorter and thicker. This is particularly true of the two terminal segments of the peduncle. In the female the upper flagellum is cylindrical and slender and is about as long as the peduncle. In the male the

distal parts of both flagella are flattened and expanded. The scale of the second antenna is long, reaching to the third segment of the peduncle of the first antenna.

The false chela of the elongated third thoracic leg bears a long, distally curved spine and two shorter spines on the penultimate segment. Several spiniform bristles are present on the terminal segment (fig. 49).

The terminal and lateral processes of the male copulatory organ are curved inward (fig. 49). They fan out slightly at their distal ends, on which there are numerous small teeth.

Length.—Males, 7 mm.; females, 8 mm.

Distribution.—North Pacific. *S. affine* was taken as far north as 41° 42' N., 150° 00' W. in the northeastern central Pacific. Its range rarely reaches within 100–200 miles of the California coast north of 35° N. South of this latitude, it penetrates to the neritic waters of southern California and Baja California. In the western Pacific, this species reached north to 39° 44' N., 148° 24' E., east of northern Japan, and was present at all stations in the western central Pacific (“Transpacific” expedition).

Equatorial Pacific. This species occurs in Philippine waters and in the South China Sea (Hansen, 1916), in the East Indian Archipelago (Hansen, 1910), and inside the Great Barrier Reef of Australia (Tattersall, 1936). It is present in the equatorial mid-Pacific (“Mid-Pacific” expedition; “Capricorn” expedition), and was found throughout the eastern equatorial area surveyed by the “Shellback” expedition.

South Pacific. *S. affine* was not found south of 13° 47.5' S., 114° 21.6' W. by the *Albatross* in the southeastern central Pacific, whereas the most southern catch in the western Pacific was at the Fiji Islands (Hansen, 1912).

Elsewhere. This species is taken also from the tropical and subtropical zones of the Indian Ocean and the Atlantic.

Depth.—Adults and larvae, above 300 meters.

Stylocheiron suhmii G. O. Sars

(Fig. 50, a–c)

Stylocheiron suhmii G. O. Sars, 1883: 31; 1885: 142, pl. 27, figs. 1–4; Hansen, 1912: 277–278, pl. 11, fig. 3, a and b; *S. mastigophorum* Chun, 1896: 144, pl. 9 (*partim*).

Diagnosis.—The frontal plate is produced into a slender spiniform rostrum in the adult females and into a shorter, acutely triangular plate in the males. The eyes are divided into a broad lower section and a narrow upper section, having merely three crystal cones in a transverse row. The eyes are twice as high as the lower section is broad.

The first antenna and their peduncles show the sexual dimorphism characteristic of the genus. The first antennal peduncles of the males are much less elongate and slender than those of the females.

The elongated third thoracic leg terminates as a false chela similar to that of the related species (fig. 50). The grasping margins of the long bristles of the penultimate and terminal joints bear smaller, finer, denticulate serrations than do the bristles of the false chelae of *S. affine* and *S. longicorne*.

The sixth abdominal segment is half again as long as deep.

The spine-shaped process of the male copulatory organ is bent inward as in the other members of the *longicorne* group (fig. 50). The terminal process is expanded distally and has a smooth margin. The proximal process is a little longer than the terminal process and is slightly concave along the outer distal margin. The lateral process is shorter and more slender than the other processes.

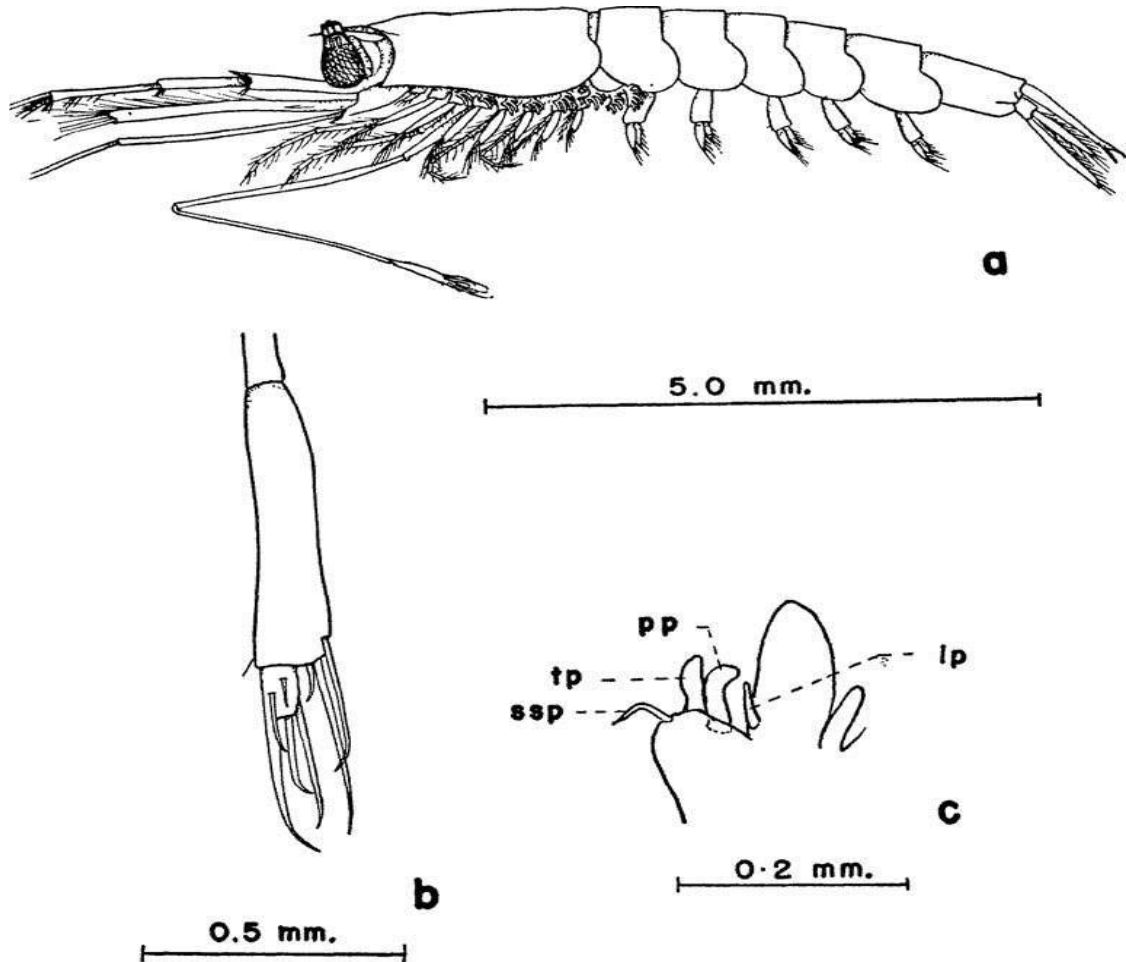


Fig. 50. *Stylocheiron suhmii* G. O. Sars. *a.* Adult female. *b.* False chela of elongated third thoracic leg. *c.* Male left copulatory organ from behind.

Length.—Males, 6.2 mm.; females, 6.8 mm.

Remarks.—*S. suhmii* is closely allied in distribution and morphology to *S. affine*. The adult is best distinguished by the fewer number of crystal cones in the upper eye.

Distribution.—North Pacific. The most northern record is 33° 30' N., 153° 05' W. in the northeastern central Pacific. The range of this species reaches within 100–200 miles of the coast of southern California, but again swings offshore south of 27° N. It is present in the western North Pacific, as far north as 39° 56.4' N., 143° 38.5' E., off Japan ("Transpacific" expedition).

Equatorial Pacific. *S. suhmii* is reported from the China Sea, off Luzon (Sars, 1885), although Hansen (1916) did not find it in material from the Philippines, or in the *Siboga* collections from the East Indian Archipelago (1910). Sars (1885)

recorded this euphausiid from north of New Guinea, and Tattersall (1936) occasionally found it within the Great Barrier Reef of Australia. It occurs in the equatorial mid-Pacific ("Capricorn" expedition; "Mid-Pacific" expedition) and penetrates the eastern region explored by the "Shellback" expedition as far as 86° W., between 10° N. and 5° S. Between 10° N. and 21° N., *S. suhmii* occurred consistently eastward only as far as 121° W., although it was present at four stations within 250 miles of the coast of central Mexico.

South Pacific. This species was caught at the Fiji Islands (Hansen, 1912). In the southeastern central Pacific it has previously been taken only between 17° S. and 26° S. (Hansen, 1912), but the range is now known to extend as far north as 11° S., within 170 miles of the coast of Peru ("Shellback" expedition).

Elsewhere. It is tropical, subtropical, and temperate in the Indian Ocean and the Atlantic.

Depth.—Adults and larvae, above 300 meters.

Stylocheiron microphthalmalma Hansen

(Fig. 51, *a-c*)

Stylocheiron microphthalmalma Hansen, 1911: 117–118, pl. 16, fig. 3, *a-d*.

Diagnosis.—The frontal plate is triangular in the adult male but is produced into a slender rostrum in the female. The eyes are small, the upper part having only two crystal cones in a transverse row. The antennae of the males are much thickened proximally, and the antennular peduncles are thicker and shorter than in the females.

The false chela of the elongated third thoracic leg has a long, distally curved spine and two shorter spines on the penultimate segment (fig. 51). The terminal segment possesses several strong spiniform bristles.

The sixth abdominal segment is one and a quarter times as long as deep. The terminal process of the male copulatory organ is slightly less than three times as long as broad (fig. 51). The proximal process is the same length as the terminal process and is produced, at its tip, into an acute point which is directed laterally toward the outer side of the organ.

Length.—Males, 6 mm.; females, 7 mm.

Remarks.—The eyes of this species are small compared with those of *S. suhmii* and *S. affine*, and the abdomen of *S. microphthalmalma* is somewhat more robust. Adults of *S. microphthalmalma* are readily distinguished by the very narrow upper eye which bears only two crystalline cones in a row, although young of *S. suhmii* may also bear only two cones in a transverse row.

Distribution.—North Pacific. This equatorial species reaches north to 39° 56.4' N., 143° 38.5' E. near the east coast of Japan, and to 38° 31.5' N., 168° 31.5' E. in the Kuroshio Extension. It was also taken by the "Transpacific" expedition at stations south of 26° 28.5' N., 170° 23' W., between Midway Island and the Hawaiian Islands. The most northern record in the eastern Pacific is 28° 32' N., 121° 50.5' W. (Marine Life Research Cruise 4903), off Baja California.

Equatorial Pacific. This species is present in the South China Sea and in Philippine waters (Hansen, 1916), and in the East Indian Archipelago (Hansen, 1910). Its range reaches eastward as far as 00° 02.5' N., 85° 02' W., off Ecuador. This

species was not found in waters off Mexico, Central America, and South America for a distance of 300–400 miles, and it was not present in collections from the region of the Peru Current, or in its extension into the South Equatorial Current, at least as far east as 120° W. It occurs in the equatorial region south of this current system, the most eastern and southern record being 14° 59' S., 85° 03' W. (“Shellback” expedition).

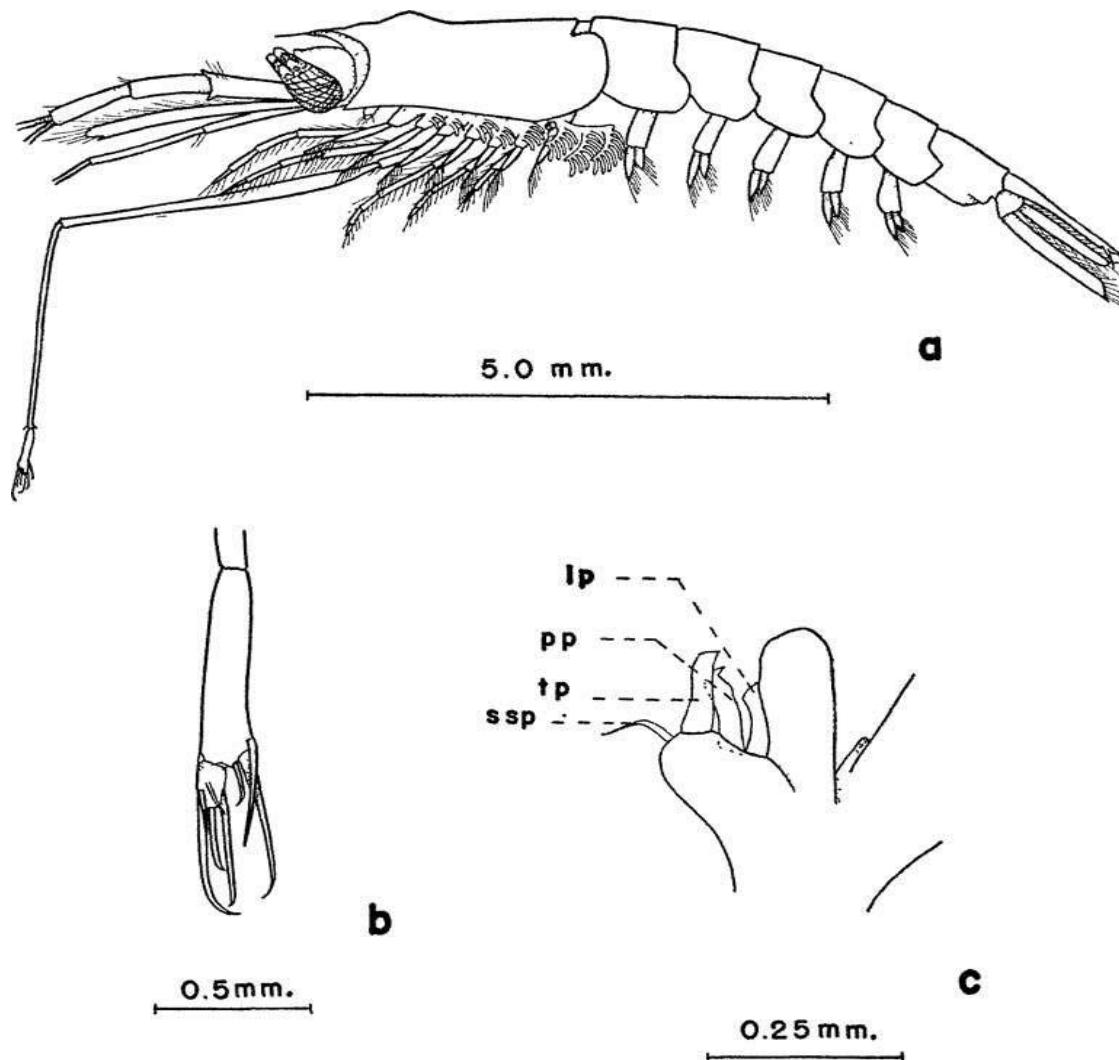


Fig. 51. *Stylocheiron microphthalmum* Hansen. *a.* Adult female. *b.* False chela of elongated third thoracic leg. *c.* Male copulatory organ from behind.

Elsewhere. This species occurs also in the tropical waters of the Indian Ocean.

Depth.—Adults and larvae, above 300 meters.

Stylocheiron elongatum. G. O. Sars

(Fig. 52, *a–c*)

Stylocheiron, elongatum G. O. Sars, 1883: 32; 1885: 146–147, pl. 27, figs. 6–10.

Diagnosis.—The frontal plate is produced into an acute triangle in both males and females. The eyes are elongate and of nearly uniform breadth. The upper

section, the facets of which bear numerous enlarged crystalline cones, may be very slightly narrower than the lower section, or of equal width.

The body is very long and slender. The sixth abdominal segment is three times as long as it is deep. The uropods are as long as the telson.

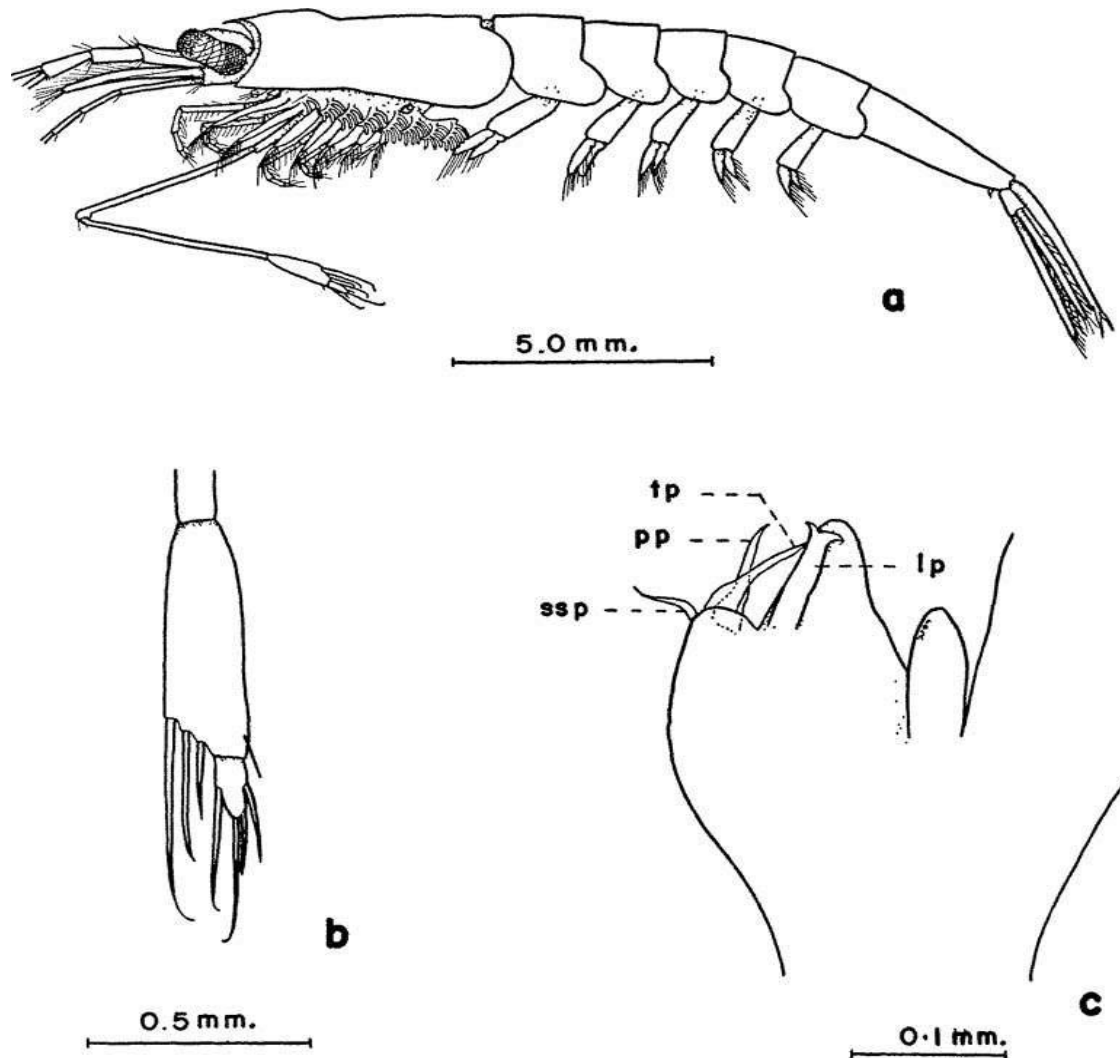


Fig. 52. *Stylocheiron elongatum* G. O. Sars. *a.* Adult male. *b.* False chela of elongated third thoracic leg. *c.* Male copulatory organ from behind.

The terminal and proximal processes of the male copulatory organ taper to acute points (fig. 52). The lateral process is as long as the terminal and proximal processes, and distinctly broader and split at the tip.

Length.—Males up to 13 mm.; females up to 16 mm.

Remarks.—This species is easily identified by means of its very elongated sixth abdominal segment. The terminal and proximal processes of the copulatory organs of the male specimens are more acute than in other species of the *longicorne* group. The third thoracic leg is slightly less elongated and more robust than in other species of this same group, and bears the bristles characteristic of a false chela (fig. 52).

Distribution.—North Pacific. There have been a few scattered catches of this species in waters off southern California and Baja California. The most northern record is near Catalina Island at 33° 10.9' N., 118° 23.2' W. (Marine Life Research Cruise 5009). In the western Pacific, it was generally present in a belt between about 34° N. and 40.5° N., but was missing at more southern stations, except near the coast of southern Japan ("Transpacific" expedition).

Equatorial Pacific. *S. elongatum* is reported from the lagoon of the Great Barrier Reef of Australia (Tattersall, 1936). In the eastern equatorial Pacific, it has been caught at only seven stations, between 02° N. and 10° N., west of 102° W. ("Shellback" expedition).

South Pacific. There is a single record at 24° 05' S., 100° 20' W. (Hansen, 1912).

Elsewhere. It occurs also in the tropical, subtropical, and temperate zones of the Indian Ocean and the Atlantic.

Depth.—Adults and larvae, below 300 meters.

Stylocheiron longicorne G. O. Sars

(Fig. 53, a-c)

Stylocheiron longicorne G. O. Sars, 1883: 32; 1885: 144–145, pl. 27, fig. 5; Hansen, 1910: 120–121, pl. 16, fig. 5, *a* and *b*; 1912: 279–280, pl. 11, fig. 4, *a* and *b*; Banner, 1949: 37–38, pl. 4, fig. 25, *a*; *S. mastigophorum* Chun, 1887: 30 (*partim*).

Diagnosis.—The frontal plate is produced into a short, acute rostrum. The gastric region of the carapace is raised medially and bears a short, low keel. The eyes are more than twice as high as broad and usually reach above the level of the rostrum. The upper eye, which bears numerous enlarged crystalline cones, is as broad, or nearly as broad, as the lower eye.

In the female the first antennal peduncle is slender and cylindrical and is longer than the carapace. In the male it is of about the same length as the carapace and is thicker than in the female.

The false chela of the elongate third thoracic leg bears a number of strong spiniform bristles on the terminal and penultimate segment (fig. 53).

The sixth abdominal segment is one and one-half to one and three-quarters times as long as deep, and is slightly longer than the fifth segment.

The terminal and lateral processes of the male copulatory organ are nearly equal in length and are bent toward the spine-shaped process (fig. 53). The base of the terminal process is slightly broader than the rest of the process, the distal end of which bears about six very small teeth. The lateral process is shorter and thinner than the terminal process.

Length.—Males, 6.5–9.5 mm.; females up to 13 mm.

Distribution.—North Pacific. The most northern record in the northeastern central Pacific is 44° 33' N., 150° 21' W. ("Northern Holiday" expedition). *S. longicorne* penetrates as far north as 52° 28' N., 131° 48' W. in the shelf waters off British Columbia (Banner, 1949). It occurs throughout the central North Pacific, including the region of the California Current, and, in the western Pacific, was present in Japanese waters as far north as 39° 44' N., 148° 24' E.

Equatorial Pacific. This species is present near the Philippines (Hansen, 1916) and near the East Indian Archipelago (Hansen, 1910). It has been caught in the

equatorial mid-Pacific ("Capricorn" expedition; "Mid-Pacific" expedition). *S. longicorne* was found throughout the eastern equatorial basin explored by the "Shellback" expedition, except in three areas: (1) east of 124° W., between 25° N. and 10° N.; (2) within 50 miles of the coasts of Ecuador and northern Peru; (3) within a tongue 350 miles in width, reaching in a northwestern direction to about 95° W. from the coast of southern Peru.

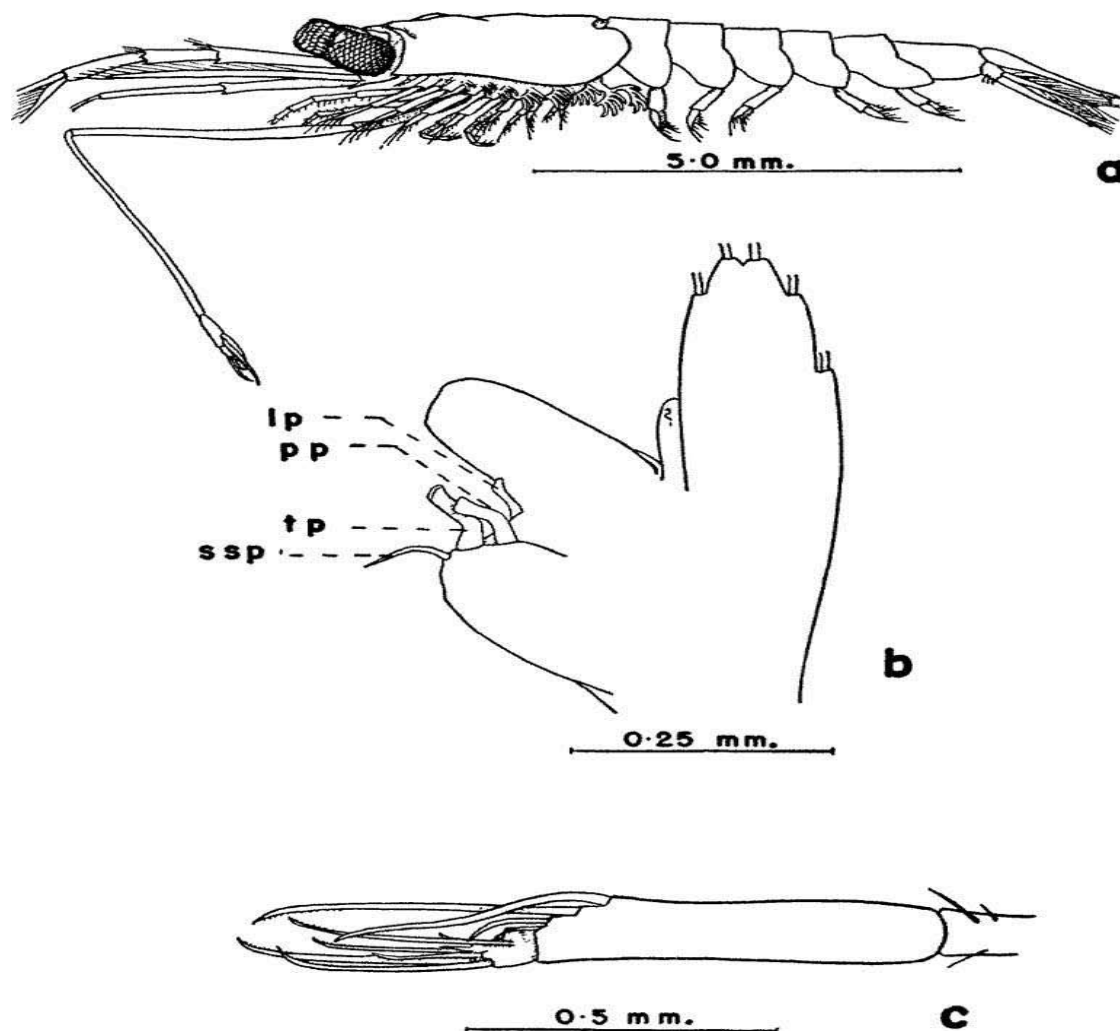


Fig. 53. *Stylocheiron longicorne* G. O. Sars. *a.* Adult male. *b.* Male left copulatory organ from behind. *c.* False chela of elongated third thoracic leg.

South Pacific. This species was caught at 20° 29.5' S., 178° 21.8' E. in the western South Pacific ("Capricorn" expedition). The most southern record, 25° 27.3' S., 103° 29.3' W., is in the southeastern central Pacific (Hansen, 1912).

Elsewhere. It also occurs in the tropical, subtropical, and temperate waters of the Indian Ocean and the Atlantic.

Depth.—Adults and larvae, 100–500 meters.

Stylocheiron abbreviatum G. O. Sars

(Fig. 54, a-c)

Stylocheiron abbreviatum G. O. Sars, 1883: 33; 1885: 147-148, pl. 17, figs. 11-13; Hansen, 1910: 121-123; 1912: 280-283, pl. 11, fig. 5, a-f; *S. chelifera* Chun, 1896: 162, taf. 1, figs. 1-8.

Diagnosis.—The frontal plate is produced into a long, acute rostrum which reaches slightly beyond the anterior limit of the eyes. The gastric region of the carapace is raised and bears a short keel. The eyes are pyriform, the upper part bearing numerous slightly enlarged crystalline cones. The second and third segments of the peduncle of the first antenna are slender, the third segment being slightly longer than the second. These two segments are much thickened in the male, and the third is shorter than the second. The flagella of the first antenna are much shortened and thickened in the male. The upper flagellum is shorter than the peduncle and is expanded proximally and flattened distally. The lower flagellum is half again as long as the upper and is much constricted between its

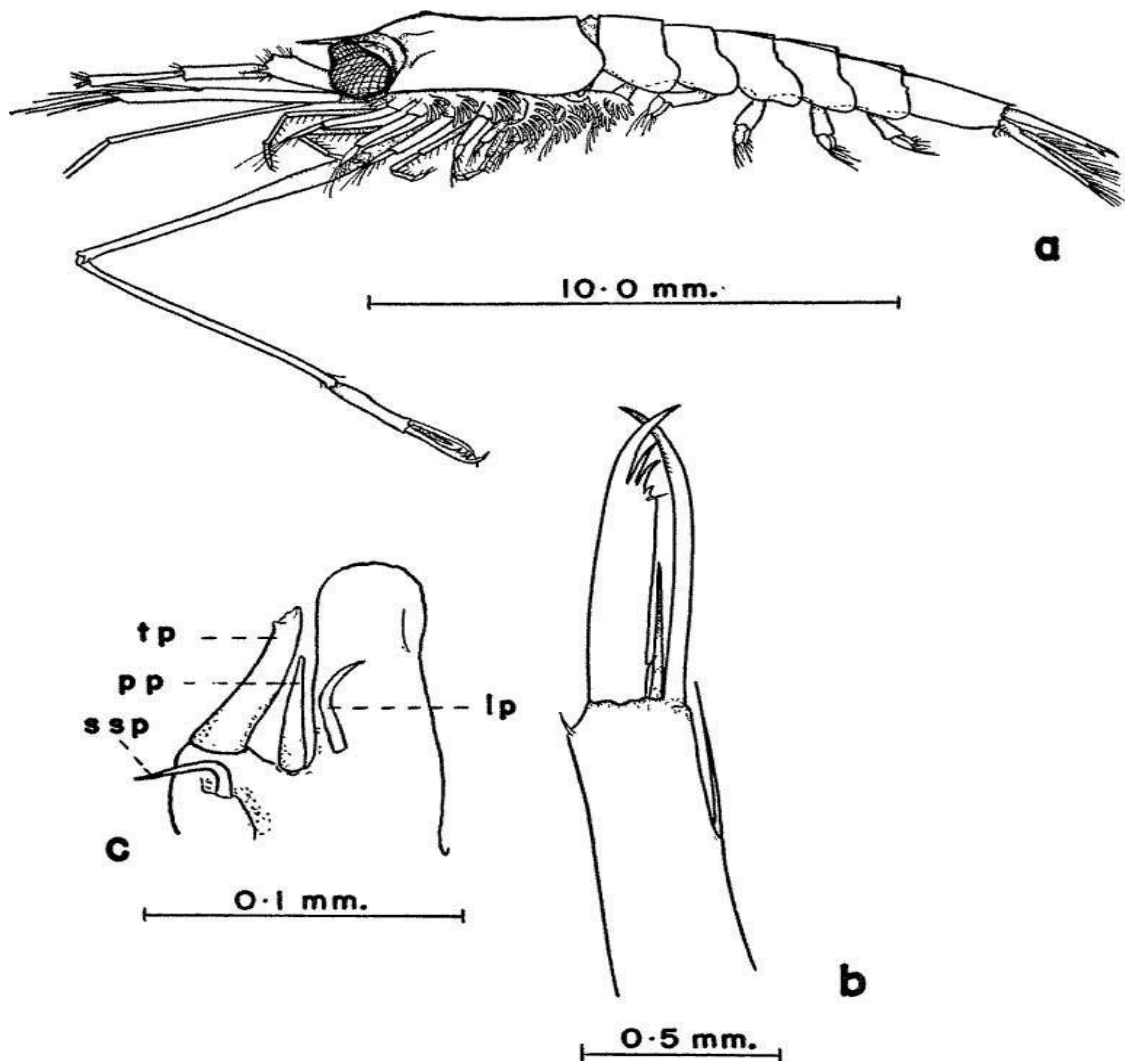


Fig. 54. *Stylocheiron abbreviatum* G. O. Sars. a. Adult female. b. True chela of elongated third thoracic leg. c. Male copulatory organ from behind.

second and fifth segments. The elongated third thoracic leg bears a true chela. (fig. 54)

The fourth and fifth abdominal segments of adults sometimes bear low mid-dorsal keels.

The terminal process of the male copulatory organ is much larger than the other processes, and tapers toward a bifid distal end (fig. 54). The proximal process is as long as the terminal process but is half its width. The lateral process is slightly longer than the proximal process and curves outward.

Length.—Males, 15 mm.; females, 16 mm.

Distribution.—North Pacific. This oceanic species reaches as far north as 37° 04' N., 140° 08' W. ("Transpacific" expedition) in the northeastern central Pacific and to 40° 05' N., 146° 45' E. off northern Japan. Its eastward range extends to within 200—300 miles of the coast of southern California, whereas the most westward record is 20° 58' N., 120° 03' E. in the South China Sea (Hansen, 1916).

Equatorial Pacific. *S. abbreviatum* is present in Philippine waters (Hansen, 1916), and in the East Indian Archipelago (Hansen, 1910). It has been taken within the Great Barrier Reef of Australia (Tattersall, 1936), and at the Fiji Islands (Hansen, 1912). It was caught in the equatorial mid-Pacific ("Capricorn" expedition; "Mid-Pacific" expedition) and is present south of 10° N. in the equatorial region east of 122° W. ("Shellback" expedition). This species was not caught in the region of the Peru Current, off Ecuador and Peru.

South Pacific. *S. abbreviatum* was caught at 20° 29.5' S., 178° 21.8' E. by the "Capricorn" expedition. The most southern record is 25° 27.3' S., 103° 29.3' W. in the southeastern central Pacific (Hansen, 1912).

Elsewhere. This species also occurs in the tropical and subtropical waters of the Indian Ocean and the Atlantic.

Depth.—Adults and larvae, 100—400 meters.

Stylocheiron maximum Hansen

(Fig. 55, *a-d*)

Stylocheiron maximum Hansen, 1908: 92; 1910: 121–122, pl. 16, fig. 6, *a-d*; Banner, 1949: 39–42, pl. 4, fig. 26, *a-j*.

Diagnosis.—The frontal plate is produced into a long, sharp rostrum which reaches to the anterior limit of the eyes. The gastric region of the carapace is somewhat vaulted or domed, and bears a keel anteriorly. The thoracic region is very robust, and the gills are extremely arborescent. The elongated third thoracic leg bears a true chela (fig. 55).

The very large, elongate eye is constricted medially. The upper, more anterior part is about four-fifths the width of the lower part. No conspicuously enlarged crystalline cones are present, although the facets of the upper part of the eye are slightly larger than those of the lower.

The male copulatory organ possesses a slender spine-shaped process which is bent strongly inward below the mid-point. The terminal and proximal processes are slightly curved, nearly equal in length and quite variable in shape, especially at the tip (fig. 55, *b* and *c*). The lateral process is about half as long as the proximal process. Banner (1949) made a detailed study of the variability of the male

copulatory organ in this species and records considerable variation in all but the spine-shaped process.

Length.—Males, 20–25 mm.; females, 25–30 mm.

Remarks.—The large size of this euphausiid readily separates it from adults of related species. In the adult, the upper eye is much broader than in *S. abbreviatum*. The young of these two species may be confused on this characteristic, though the more pyriform eye of young *S. abbreviatum* is diagnostic.

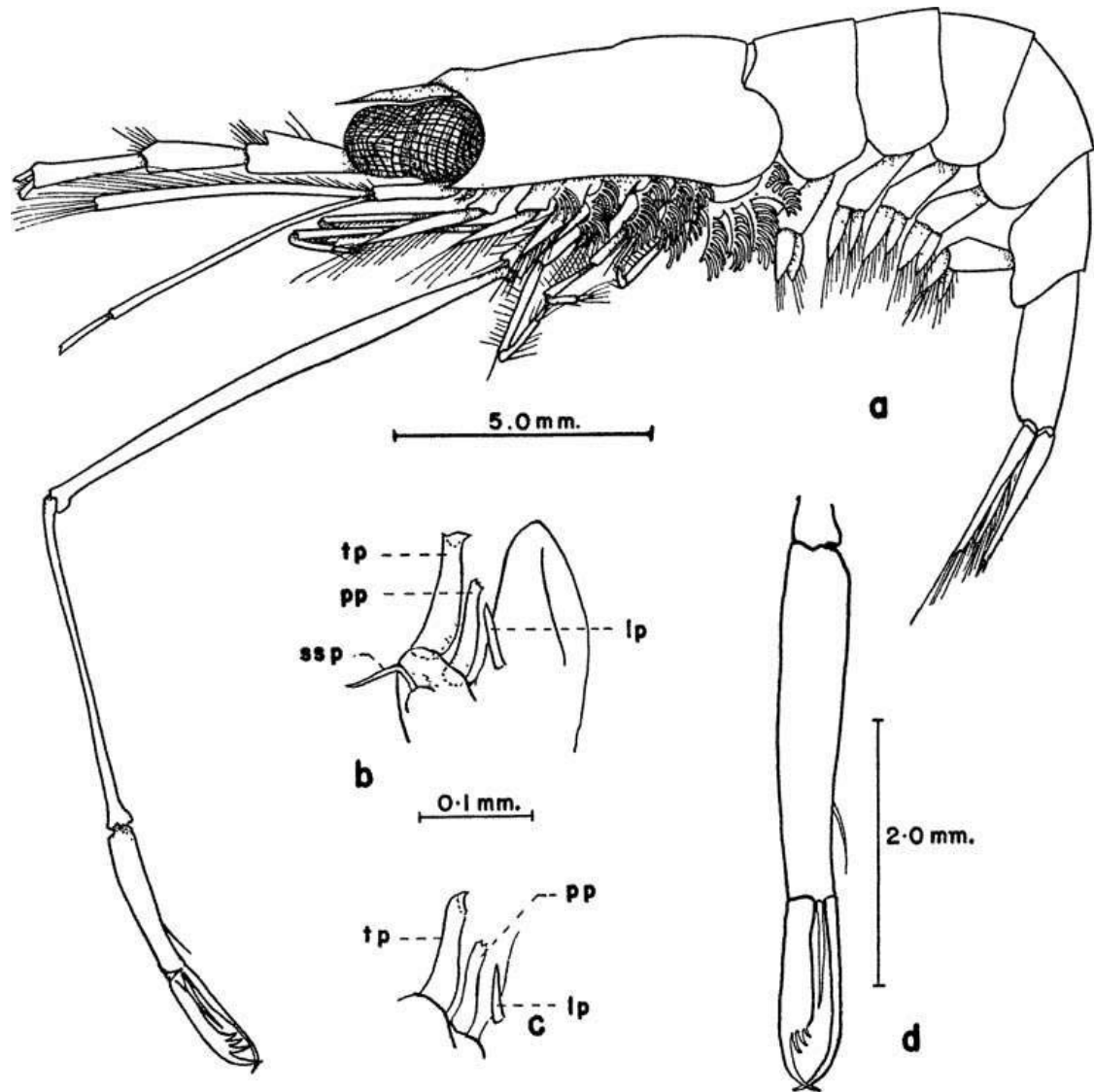


Fig. 55. *Stylocheiron maximum* Hansen. *a.* Adult female. *b.* Male left copulatory organ from behind. *c.* Male copulatory organ showing variation in tip of processes. *d.* True chela of elongated third thoracic leg.

Distribution.—North Pacific. There are no records of this species from the Bering Sea or from the western Arctic Ocean. *S. maximum* occurs throughout the eastern Gulf of Alaska (“Northern Holiday” expedition; Banner, 1949). It reached north to 44° 46.1' N., 159° 54.9' E. in the western central Pacific but was missing from stations off the Kuriles and northern Japan. It is present in the region of the California Current.

Equatorial Pacific. This species is present in Philippine waters (Hansen, 1916) and near the East Indian Archipelago (Hansen, 1910). It was taken at the equator at 169° E. ("Capricorn" expedition) and in the equatorial mid-Pacific ("Mid-Pacific" expedition). It occurred throughout the eastern equatorial region surveyed by the "Shellback" expedition. The most southern record in the Pacific is 17° 26.4' S., 86° 46.5' W. (Hansen, 1912).

Elsewhere. *S. maximum* is also found in the temperate, subtropical, and tropical waters of the Indian Ocean and the Atlantic. It was taken as far north as 61° 49' N., 14° 11' W. by the "Ingolf" expedition.

Depth.—Adults, below 400 meters; larvae, below 150 meters.

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ABBREVIATIONS USED ON FIGURES

al: auxiliary lobe
ap: additional process
en: endopod
ex: exopod
h: heel (of inner lobe)
il: inner lobe
k: keel
li: labium
lp: lateral process
lr: labrum

m: mouth
md: mandible
ml: median lobe
mp: mandibular palp
pp: proximal process
ps: pseudo exopod
s: spine
sl: setiferous lobe
ssp: spine-shaped process
tp: terminal process

INDEX TO GENERA AND SPECIES

(Those defined are in **boldface**, those mentioned incidentally, in roman. Synonyms are in *italics*.)

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