

THE MARINE DECAPOD CRUSTACEA  
OF CALIFORNIA

WITH SPECIAL REFERENCE TO THE DECAPOD  
CRUSTACEA COLLECTED BY THE UNITED STATES  
BUREAU OF FISHERIES STEAMER "ALBATROSS" IN  
CONNECTION WITH THE BIOLOGICAL SURVEY OF  
SAN FRANCISCO BAY DURING THE YEARS 1912-1913

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## I. INTRODUCTION

The United States fisheries steamer "Albatross" was commissioned in October, 1911, by the Bureau of Fisheries, to make a biological survey of San Francisco Bay. The operations were directed by a board consisting of Dr. F. B. Sumner, naturalist, Professor C. A. Kofoid, of the University of California, and Commander G. H. Burrage, U.S.N., succeeded by Lieutenant-Commander H. B. Soule, U.S.N. The field work began on January 30, 1912, and continued until April 7, 1913, when the last dredge haul was made.

That portion of the results of this survey dealing with the physical conditions within San Francisco Bay has been published in a joint paper by Dr. F. B. Sumner, Dr. G. D. Louderback, Mr. W. L. Schmitt, and Mr. E. C. Johnston (1914). Discussions and detailed data are given regarding the temperature, salinity, depth of the water, and the character of the bottom for the various stations occupied by the "Albatross." These data serve as the basis for ecological studies now being made of the different groups of marine organisms obtained during the survey.

The fact that much of the literature dealing with the California decapods is to be found only in older publications, now out of print and in a large measure inaccessible to the average student, and that the more recent and very excellent works covering the region under discussion are either limited in circulation and consequently difficult to obtain or are very restricted in scope, prompted the expansion of this report upon the decapod Crustacea collected by the "Albatross" in the course of this survey of San Francisco Bay into a handbook of the marine decapod Crustacea of California.

In all 220 (+ 1, *Sergestes* sp. ?) valid species are known or reported from California waters. The vast majority belong to the so-called littoral, or continental shelf fauna; only thirty-six (+ 1 ?) are strictly deep sea, or abyssal forms, known only from depths exceeding 100 fathoms. The minimum depth from which the latter are known is indicated in all specific keys, thus distinguishing them from the forms with littoral records for which the California range limits are given. Eleven species appear to be new, not heretofore described: *Gennadas pectinatus*, *Palaemonetes hiltoni*, *Spirontocaris lagunae*,

*Spirontocaris franciscana*, *Crago lomae*, *Pachycheles holosericus*, *Petrolisthes rathbunae*, *Paguristes ulreyi*, *Dardanus jordani*, *Pylopagurus holmesi*, and *Homola faxoni*.

The forty-seven species taken in the course of the biological survey of San Francisco Bay are, following the systematic treatment of each, more or less fully discussed from the point of view of their distribution and habitat within the region covered by the survey. With the exception of five obtained only at shore stations, *Upogebia pugettensis*, *Emerita analoga*, *Oedignathus inermis*, *Petrolisthes cincipes*, and *Pachygrapsus crassipes*, and three from miscellaneous collections, *Acantholithodes hispidus*, *Randallia ornata*, and *Oregonia gracilis*, these forty-seven species were taken at 133 (89%) of the 150 dredging stations, and 152 (50%) of the 305 hydrographic stations at which collecting apparatus was employed. These stations are distributed as follows:

| Regions of the bay<br>(for limitations see p. 323) | Number of stations at which collecting apparatus was employed |              | Number of stations at which decapods were taken |              |
|--|---|--------------|---|--------------|
|  | Dredging  | Hydrographic | Dredging  | Hydrographic |
| Upper .....  | 22  | 80           | 22  | 37           |
| Middle .....                                       | 73  | 109          | 66  | 43           |
| Lower .....  | 38  | 107          | 28  | 72           |
| Outside .....                                      | 17  | 9            | 17  | ---          |
| Total .....  | 150   | 305          | 133   | 152          |

A summarized discussion of the distribution of the bay fauna together with a few remarks on the geographical distribution of the California decapods in general concludes this paper. These remarks are confined to littoral records only, for aside from the fact that the deep sea fauna, as a rule, is more or less cosmopolitan in its distribution our knowledge of that occurring off California is too incomplete at the present time to permit of more than a mere listing, which is included in appendix I. Beside this distributional list of all the California decapods, found in appendix I, there are two other appendices, which, however, deal only with the survey data. All extensions of range recorded are based on material contained in the collections of the U. S. National Museum. After figures indicative of salinity the expression per mille ( $^{\circ}/_{00}$ ) is to be understood.

With the exception of those designated U.S.N.M., obtained through the courtesy of the U. S. National Museum, the line drawings, both copies of figures already published as well as the several original



drawings, are the work of my wife, Alvina S. Schmitt. The photographs, from which all plates not otherwise credited were made, are the work of Mr. John Howard Paine.

Although no bibliography in the strict sense has been attempted, the literature listed includes not only works cited in the text, but also a number of useful papers collaterally consulted. In the condensed synonymy under each species, in addition to the citation of the original description, reference is made to all authors from whose works plates, figures, or extracts have been taken, and, wherever possible, to the three most recent and comprehensive works on California Crustacea, a very able paper by Weymouth (1910) on the crabs of Monterey Bay, and those landmarks, as it were, of California carcinology by Holmes (1900) and Rathbun (1904a).

From Weymouth I have taken many valuable color notes, several figures, and the greater part of his keys to the adult and juvenile specimens of the genus *Cancer* and the genera of the family Inachidae.

To the works of Holmes and Rathbun, however, my greatest debt of gratitude is due, for it is largely from them, as the reader will readily see, that the present paper has been compiled. The very comprehensive descriptions of Holmes have been freely drawn upon for many of the specific characterizations, as well as for the construction of several otherwise impossible keys for species I have not seen or was unable to examine. His excellent illustrations, for the greater part, have been reproduced.

In form and systematic arrangement I follow Miss Rathbun in the main, and from her monograph (1904a) the keys and characters for the species of *Pasiphaea*, *Pandalus*, *Spirontocaris*, *Crago*, and *Callianassa* have been taken practically intact. Her classificatory keys published in the *American Naturalist* (1900) were found very useful, especially in connection with the genera of the Inachidae and the Xanthidae. From her recent monograph on the *Grapsoid Crabs of America* (1918) considerable material relating to the family Pinnotheridae has been taken and a number of plates have been reproduced (plates 40 to 50 of the present paper).

Furthermore, to Miss Rathbun personally I owe much for numerous helpful and valuable suggestions, and for the use of certain of her manuscript notes, particularly those dealing with the genera *Randallia* and *Pinnixa*.

Acknowledgments are also due to Alcock, Bouvier, Borradaile, Calman, Ortmann, Smith and Weldon, from whose treatises the

classification of the higher groups of crustacea has been drawn; to Dr. Paul Bartsch, Dr. J. E. Benedict and Mr. Austin H. Clark of the U. S. National Museum; to Dr. F. B. Sumner of the Scripps Institution, naturalist of the "Albatross" during the period covered by the survey; to Dr. C. A. Kofoid of the University of California, under whose supervision this report took its inception, and Dr. S. J. Holmes of the same institution, under whose direction it has been completed, as well as to the Bureau of Fisheries and the U. S. National Museum for facilities so freely furnished in the way of study collections and literature.

The author realizes that this paper leaves much to be desired, but hopes that more thorough collecting and more intensive study will be encouraged thereby which will lead to a fuller knowledge of the Pacific Coast representatives of these interesting, and in many cases economically important forms.

*Transmitted April, 1916.*

## II. EXPLANATION OF TERMS AND MEASUREMENTS

The Decapoda are that order of Crustacea in which the carapace fuses dorsally with all the thoracic somites and in which the three anterior pairs of thoracic appendages are turned forward to act as maxillipeds, or foot-jaws. Their gills are contained within a special branchial chamber on each side of the thorax but underneath the carapace.

The order Decapoda includes the forms commonly known as crabs, shrimps, prawns, crayfish, lobsters, and hermit crabs.

The typical decapod crustacean is divided into three major body regions, head, thorax and abdomen, the first two of which are coalesced, and are dorsally covered by a common, unjointed, cephalo-thoracic shield, the carapace. Typically there are nineteen pairs of appendages, a pair to each of the nineteen true somites into which the body is divided, grouped as follows:

I. The *Head*, composed of five indistinguishably fused somites, covered by the anterior portion of the carapace, and carrying the first five pairs of appendages:

1. The first pair of appendages are the antennules, or first antennae as they are sometimes known.
2. The second pair of appendages are the antennae.
3. The third, the mandibles, or jaws proper.
- 4 and 5. The fourth and fifth pairs are the first and second pairs of maxillae, or accessory jaws.

In view of their development the eyes have not been considered true appendages here. Whether they are or not is a much mooted question (cf. Calman, 1909, p. 9).

II. The *Thorax*, composed of eight somites which are dorsally fused with and also covered by the carapace, and which carry the next eight pairs of appendages:

- 6, 7 and 8. The first three pairs of thoracic appendages are the first, the second, and the third, or outer, external, pair of maxillipeds, foot-jaws.
9. The fourth pair of thoracic appendages is the first of the five pairs of legs from which this order of the Crustacea derives its name. The legs of this first pair are usually chelate, though they may be either subchelate or simple,

both or one only. When chelate or subchelate they are known as chelipeds. In the Brachyura, or true crabs, they are always chelate. When simple they are more properly called ambulatory legs.

10, 11, 12 and 13. The next four pairs of thoracic appendages are the second, third, fourth, and fifth pairs of legs. They may be either simple, chelate or subchelate, all or in part only. Although usually spoken of as the first, second, third and fourth pairs of ambulatory legs (except when the first legs, no. 9 above, are simple and included in the total number of ambulatory legs), strictly speaking only the simple pairs are ambulatory in the true sense of the word. In the Brachyura these four pairs of appendages are frequently designated simply as the first, second, third or fourth pairs of legs, in contradistinction to the chelipeds (no. 9, above). This nomenclature, however, has not been adopted in the characterizations of the species listed in this paper.

All mention of gills and branchial formulae has been purposely omitted as they are more or less difficult for the beginner or average student; only for the specialist have they peculiar interest.

III. The *Abdomen*, composed of six true somites, or segments, and a terminal joint, or segment, the telson, a flattened usually pointed tail-piece which never bears appendages and is not considered a true somite.

14, 15, 16, 17, and 18. The first five pairs of abdominal appendages are the pleopods, or "swimmerets," as they are sometimes called. The first one or two pairs in the males of some forms are variously modified to serve as accessory sexual organs; one or more, or all of the pleopods may be reduced, rudimentary, or wanting.

19. The last pair of abdominal appendages are the uropods and when present they constitute together with the telson the so-called "tail-fan."

The following seven diagrammatic figures give a graphic exposition of the parts, appendages, and body regions of typical decapod crustaceans:

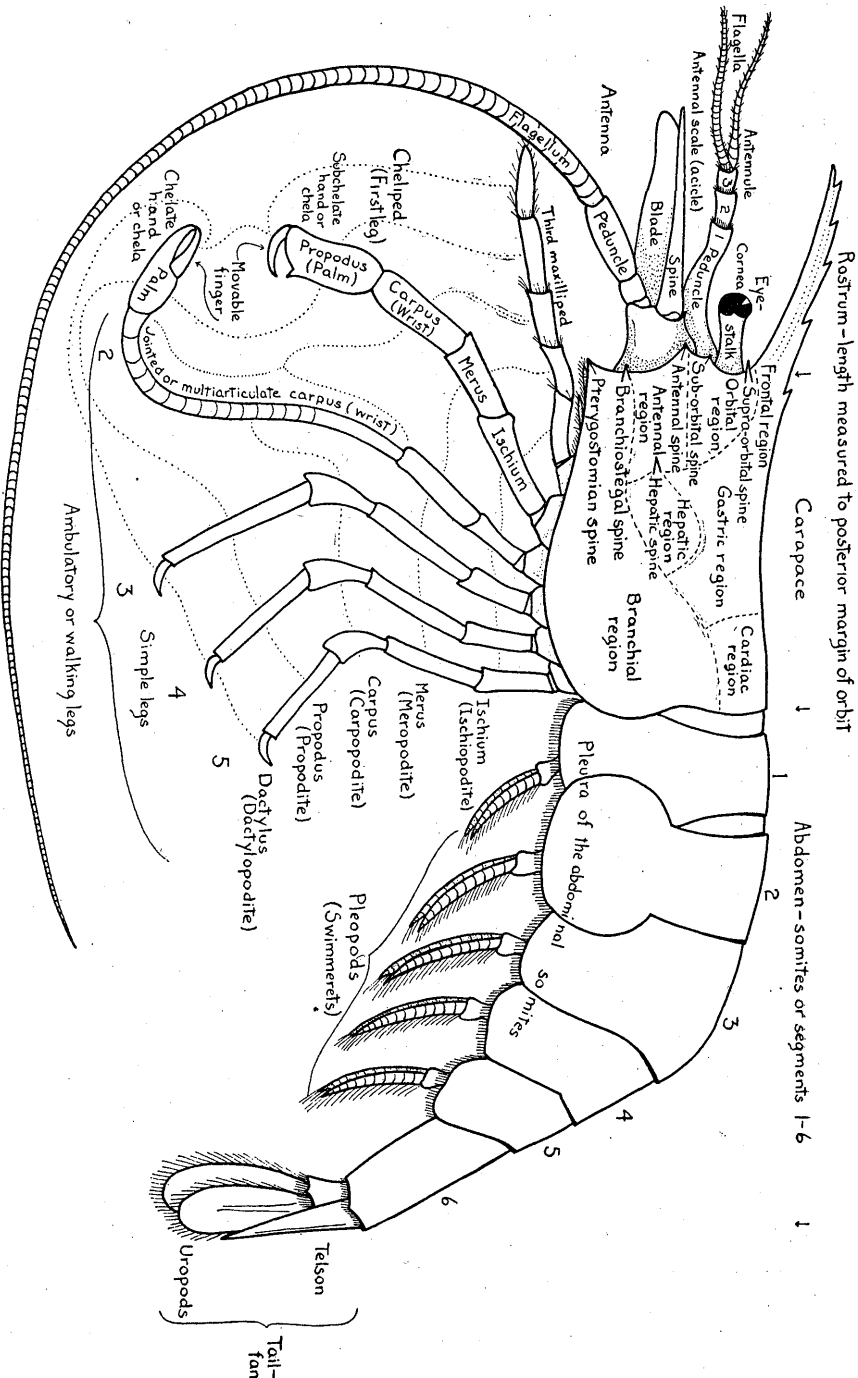


Fig. 1. Lateral view of a macruran (shrimp-like) decapod (in part after Stimpson).

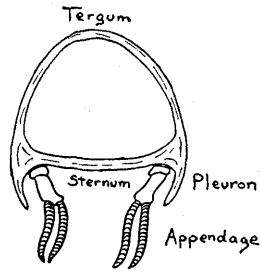


Fig. 2. Cross-section of a typical somite (adapted from Calman).

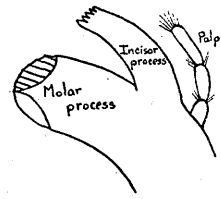


Fig. 3. Typical macruran mandible.

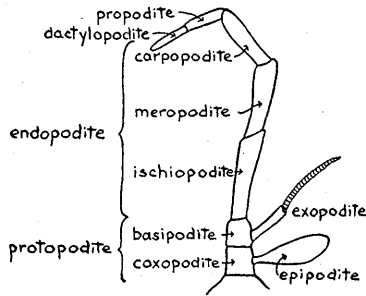


Fig. 4. Typical third maxilliped of a macruran decapod (adapted from Calman).

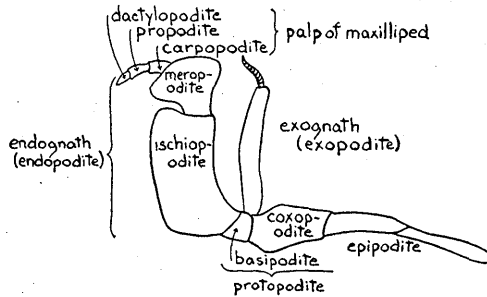


Fig. 5. Typical third maxilliped of a brachyuran (crab-like) decapod (adapted from Brooks).

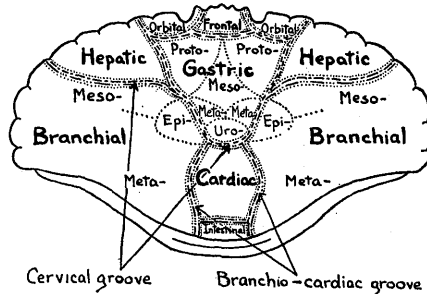


Fig. 6. Dorsal view showing regions on a brachyuran carapace (adapted from Pearson).

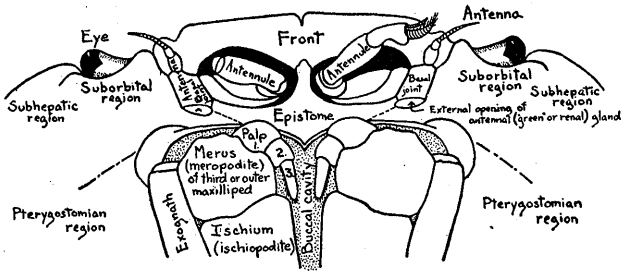


Fig. 7. Ventral view of anterior part of body of a brachyuran decapod. The roof of the buccal cavity is known as the endostome or palate.

*Measurements.*—Length is always measured on the median line from the anterior to the posterior margin. The length of the rostrum is measured from the line connecting, in shrimps, the posterior, and in crabs the upper margins of the orbits. “The length of segments is measured on the upper or anterior margin. The length of the whole cheliped or leg is measured on the lower margin from the articulation of the coxa with the sternum to the tip of the dactylus. The length of the immovable finger is measured from the tip to the extremity of the sinus between the fingers.” (Rathbun, 1918, p. 8.)

Width of carapace, and of segments of the chelipeds and legs is measured at the widest part. “The fronto-orbital width is measured from the outer angle of one orbit to the outer angle of the other.” In crabs “the width of the rostrum is measured at its posterior end.” (*Op. cit.*, p. 8.)

### III. SYSTEMATIC DISCUSSION OF THE CALIFORNIA REPRESENTATIVES OF THE ORDER DECAPODA

#### KEY TO THE SUBORDERS OF THE DECAPODA

I. Body almost always laterally compressed (*macrurous*, shrimp-like). First abdominal segment not much smaller than the rest. First antennae usually having a scale at base; second antennae with scale generally large and lamellar. Legs usually slender except sometimes a stout chelate limb or pair, which may be any one of the first three pairs, with basipodite and ischiopodite never coalesced, and only one fixed point in the carpo-propodal articulation. Male genital apertures in the articular membrane between the coxopodites of the last (fifth) pair of legs, and the body; female genital apertures on the coxopodites of the third pair of legs, (except in one genus, *Leucifer*, not represented in California fauna; the sex of ovigerous females is self-evident). Pleopods always present in full number, well developed, and used for swimming.

*Natantia*, p. 18.

II. Body not well compressed, usually depressed (*anomurous*, hermit-crab-like, or *brachyurous*, crab-like, rarely *macrurous*, shrimp-like). First abdominal segment distinctly smaller than the rest. First antennae without a scale; second antennae, scale generally small or absent. Legs strong, first pair usually stouter than their fellows, others never so, basipodite and ischiopodite almost always coalesced in the first pair and generally in the others; two fixed points in the carpo-propodal articulation. Male genital apertures on the coxopodites of the last (fifth) pair of legs or on the sternum of the corresponding somite; female genital apertures on the coxopodites of the third pair of legs or on the sternum of the corresponding somite (the sex of ovigerous females is self-evident). Pleopods often reduced or absent, rarely used for swimming.

*Reptantia*, p. 104.

#### SUBORDER NATANTIA

##### KEY TO THE TRIBES OF THE NATANTIA

I. Pleura of second abdominal segment overlap those of first; abdomen generally with sharp bend. Third legs not chelate.

*Carides*, p. 26.

II. Pleura of first abdominal segment not overlapped by those of second; abdomen without sharp bend. Third legs chelate.

A. Legs of third pair not stouter than those of first two pairs.

*Peneides*, p. 19.

B. One or both legs of third pair longer and much stouter than those of first two pairs. (No representatives of this group found in the region covered by this paper.)

*Stenopides*.



Tribe PENEIDES

KEY TO THE CALIFORNIA FAMILIES OF THE PENEIDES

- I. Last two pairs of legs well developed. *Peneidae*, p. 20.
- II. Last one or two pairs of legs reduced in size, rudimentary or wanting. *Sergestidae*, p. 19.

Family SERGESTIDAE

Rostrum very small or wanting. Antennules with two flagella, one long and one short, rudimentary one which in the male is frequently furnished with a small tertiary branch. Mandibles with cutting edge smooth, and palp of two segments. First pair of legs simple, second and third pairs minutely chelate, legs increasing in length from first to third pairs; fourth and fifth pairs simple, reduced in size and number of segments.

Genus *Sergestes* Milne Edwards

Body long and slender, integument membranaceous. Rostrum very short. Antennules without a scale on inner edge; of the two antennular flagella, one is very long and the other very short, the short one in the male bifurcating to form a prehensile apparatus. Mandibular palp long, thin, and narrowly foliaceous. No exopodites on any of the thoracic appendages except the first maxillipeds.

KEY TO THE CALIFORNIA SPECIES OF SERGESTES

- I. Rostrum spiniform. Cornea larger than eye-stalk. (Known only from 145+ fathoms.) *similis*, p. 19.
- II. Rostrum lobiform. Cornea no larger than eye-stalk. (Known only from 417 fathoms.) *sp. indet.*, p. 20.

*Sergestes similis* Hansen

Plate 12, figure 7

*Sergestes atlanticus* Bate, "Challenger" Rept. Zool., 24, Macrura, p. 389, 1888 (part: specimen from station 232).

*Sergestes similis* Hansen, Proc. Zool. Soc. London, p. 60, pl. 11, figs. 6a-6d, 1903.

*Sergestes atlanticus* Rathbun, H. A. E., 10, 145, 1904 (part: only specimens taken by the "Albatross"), not *S. atlanticus* Milne Edwards.

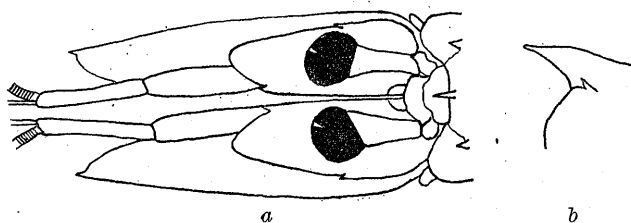


Fig. 8. *Sergestes similis*, a, dorsal view of anterior end, X 5; b, lateral view of rostrum, X 12 (after Hansen).

*Characters.*—Rostrum nearly oblong-triangular, with a distinct upward trend, tip acute. Anterior margin of carapace below the rostrum strongly convex and protruding; supraocular and hepatic spines well developed; gastro-hepatic groove distinct. Corneae large, broader than deep, scarcely as long as broad. First joint of antennular peduncle considerably longer than the third, outer margin as long as the same margin of the two distal joints together; second joint rather slender and scarcely longer than the slender third joint. Antennal scale moderately broad at the end, with spine projecting beyond the terminal margin. Third maxillipeds scarcely longer than the third legs. Sixth segment of abdomen twice as long as deep; about as long as, or slightly longer than fourth and fifth together.

*Dimensions.*—Type: length 54 mm.; of largest specimen measured by Miss Rathbun 52 mm.; average about 40 mm.

*Type Locality.*—Off Japan, 345 fathoms ("Challenger" station 232, lat. 35° 11' N, long. 139° 28' E).

*Distribution.*—Also taken by the "Albatross" from off Destruction Island, Washington, to the Gulf of California, northwest of Tiburon Island, 145 to 2228 fathoms. The depth for one station (4468) in Monterey Bay is recorded as 51-309-32 fathoms.

### *Sergestes* sp. indet.

*Sergestes* sp. indet., Rathbun, H. A. E., 10, 146, 1904.

"A single mutilated female *Sergestes*, without maxillipeds or trunk-legs, was dredged by the 'Albatross' in 417 fathoms off San Diego, California, station 2928. It resembles *S. mollis* Smith [Rept. U. S. Commissioner Fisheries for 1882, pp. 419-421]. Body stout; length about 38 mm. The rostrum and anterior outline are as in that species. There is a minute hepatic spine. A strong ridge runs from the anterior margin at the outer edge of the eye-stalk backward to the posterior margin; the front part of the ridge is higher up than in *S. mollis*; at its middle the ridge gives off a weaker branch directed obliquely downward and backward, and then backward to the posterior margin. Gastro-cardiac groove deep; cervical groove present. Eyes a little shorter than in *S. mollis*, reaching  $\frac{2}{3}$  the length of the first antennular segment; cornea brown. Antennular peduncle rather stout, first joint the longest,  $1\frac{2}{3}$  times the second joint; second and third subequal; notch in outer side of first segment very slight. Antennal scales broken off. Abdomen as in *S. mollis*. Telson broken off. No hairs visible on outer margin of outer uropod." (Rathbun.)

### Family PENEIDAE

Rostrum usually well developed, sometimes short and elevated, laterally compressed, often toothed. Antennules with two flagella; basal joint of peduncle dorsally concave for the eye, and strengthened at the base, on outer side, by a spine-like scale. Mandibles with incisor process, and palp of one or two segments. First three pairs of legs similar, chelate, and slender, increasing in length from before backward; remaining two pairs well developed, simple.

#### KEY TO THE CALIFORNIA GENERA OF THE PENEIDAE

- I. Rostrum toothed above and below. Inner border of first segment of antennular peduncle with a twisted setose scale. (Not known north of San Francisco Bay.)

*Peneus*, p. 21.

II. Rostrum if armed, toothed above only. Setose scale on inner border of first segment of antennular peduncle wanting or quite rudimentary.

A. Endopodites of second maxillipeds of the usual subpediform shape. (Known only from 331+ fathoms.)

*Benthesicymus*, p. 22.

B. Endopodites of second maxillipeds with merus thin, broad, and compressed, expanded into a thin, oval leaf-like process, or lamina, completely concealing the next three joints when flexed. (Known only from 266+ fathoms.)

*Gemadas*, p. 23.

### Genus *Peneus* Weber

Rostrum well developed, toothed above and below. Outer edge of basal joint of antennular peduncle produced anteriorly into a spine; inner edge, proximally, with a conspicuous, twisted, setose scale; antennular flagella shorter than the carapace. Mandibular palp large and broadly foliaceous, two jointed, second joint vastly larger than the first. Exopodites on all or all but the last pair of legs.

#### *Peneus brevirostris* Kingsley

*Peneus brevirostris* Kingsley, Proc. Acad. Nat. Sci. Phila., 30, 98, 1878.

*Penaeus californiensis* Holmes, Occas. Papers Calif. Acad. Sci., 7, 218, pl. 4, figs. 64-69, 1900.

*Penaeus brevirostris* Rathbun, Proc. Wash. Acad. Sci., 4, 287, 1902; H. A. E., 10, 146, 1904.

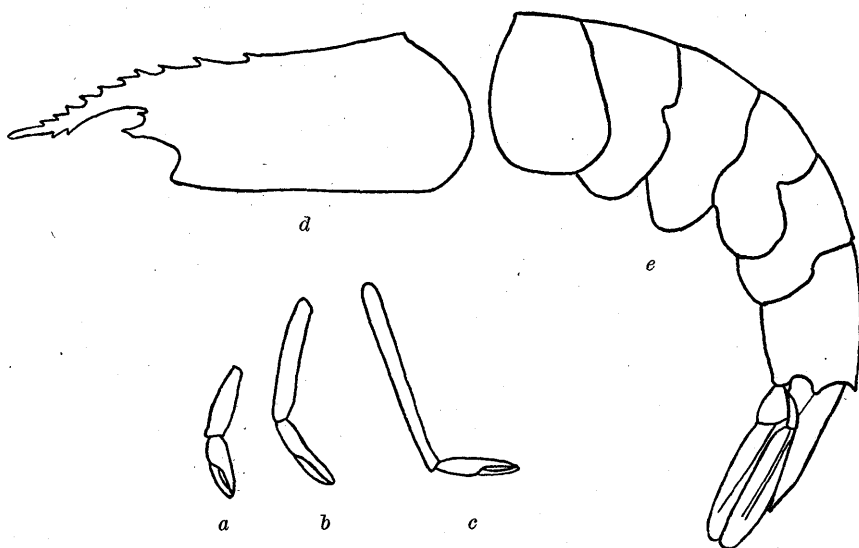


Fig. 9. *Peneus brevirostris*; a, hand and carpus of first pair of legs; b, hand and carpus of second pair; c, hand and carpus of third pair; d, lateral view of carapace; e, lateral view of abdomen (after Holmes).

*Characters*.—Rostrum exceeding eyes, but falling short of antennular peduncle; above ciliate and armed with nine to ten teeth, below with two small teeth near depressed tip; rostrum continued backward as a carina nearly to posterior margin of carapace and sulcate posterior to last tooth. Carapace with sulcus parallel to and on each side of dorsal carina, continued forward from posterior extremity of dorsal carina onto lateral ridges of rostrum; outer margins of sulci more prominent near last rostral tooth and distinctly flared outward. Telson acute, deeply sulcate above, and devoid of lateral spines or spinules; greatly exceeded by the uropods.

*Dimensions*.—Length 42 mm., carapace 10 mm., rostrum 5 mm. (Kingsley). Of specimen examined by Holmes, length from tip of rostrum to tip of telson 182 mm.; carapace, including rostrum, 41 mm.; rostrum 24 mm.

*Type Locality*.—Estero at Realijo, west coast Nicaragua (salt water).

*Distribution*.—San Francisco Bay, California to Panama; Galapagos Islands. To a depth of 51½ fathoms (Rathbun).

### Genus *Benthescymus* Bate

Rostrum short, elevated, compressed; if armed, toothed above only. Outer edge of basal joint of antennular peduncle armed with one or two spines; no scale on inner edge; antennular flagella longer than the carapace. Mandibular palp foliaceous, two-jointed, second joint narrower and shorter than the first. Exopodites of second maxillipeds much longer than endopodites; endopodites subpediform with last three joints more or less flexed on the merus. Exopodites on all the legs decreasing in size posteriorly until they become rudimentary on the last pair of legs.

#### KEY TO THE CALIFORNIA SPECIES OF BENTHESCYMUS

- I. Median carina of fifth and sixth abdominal segments terminating posteriorly in a small acute tooth. *tanneri*, p. 23.
- II. Fifth and sixth abdominal segments devoid of teeth; posterior margin of sixth segment raised to form a peculiar transverse ridge. *altus*, p. 22.

### *Benthescymus altus* Bate

Plate 11, figure 2

*Benthescymus altus* Bate, Ann. Mag. Nat. Hist., (5), 8, 191, 1881; "Challenger" Rept., Zool., 24, Macrura, p. 336, pl. 58, fig. 1, 1888; Faxon, Mem. Mus. Comp. Zool., 18, 203, 1895.

*Characters*.—Rostrum short, compressed, apex styliform, crest thin and armed with two teeth, continued back as a carina as far as the cervical groove, posterior to which the dorsal surface is smooth and rounded; last three abdominal segments much compressed, the fourth but slightly carinated, more so on the posterior half than anteriorly, the sixth segment with a small but decided carina, which fades out before it reaches the transversely elevated posterior margin.

*Dimensions*.—Type, female: length 120 mm.

*Type Locality*.—Between Australia and New Guinea, 1400 fathoms ("Challenger" station 184).

*Distribution*.—South Pacific; Philippines; Japan; South Atlantic, off Tristan da Cunha; 500 to 1900 fathoms (Bate). Gulf of Panama; west coast of Central

America; Galapagos Islands; 1360 to 2232 fathoms (Faxon). Off San Nicolas Island, California; 1350 to 2182 fathoms ("Albatross" station 4390).

*Remarks.*—In Bate's figure of this species there appears to be a small spine on the side of the carapace although none is mentioned in his description. In the "Albatross" specimens there is no spine at this place (Faxon).

### **Benthescymus tanneri** Faxon

*Benthescymus tanneri* Faxon, Bull. Mus. Comp. Zool., 24, 215, 1893; Mem. Mus. Comp. Zool., 18, 205, pl. H, 1895; Rathbun, H. A. E., 10, 147, 1904.



Fig. 10. *Benthescymus tanneri*, ♂, lateral view of carapace,  $\times \frac{4}{5}$  (after Faxon).

*Characters.*—Rostrum short, acute, laterally compressed, raised above the orbit into a crest, which is armed with two slender, acute teeth; rostral crest continued backward as a sharp keel on the median line of the carapace, as far as the cervical groove, behind which it is obsolescent. First three abdominal segments of the abdomen are thick, rounded, and devoid of dorsal carina, or tooth; the fourth faintly carinate but not toothed; the fifth and sixth distinctly carinate and armed with a small, acute posterior tooth; telson short, convex above, and armed with three pairs of lateral spinules.

*Dimensions.*—Type: length 112 mm.; length of carapace 44.5 mm.; of rostrum 8 mm.

*Color.*—When alive deep red, with a large patch of bright blue on the back of the second, third, and fourth abdominal segments; eyes black (Faxon).

*Type Locality.*—Gulf of California, 905 fathoms ("Albatross" station 3436).

*Distribution.*—From off San Diego, California, to Ecuador; Galapagos Islands; 331 to 1322 fathoms (Rathbun).

*Remarks.*—This species is very similar to *B. altus*, and regarding it Faxon says: "In this species the carina on the fifth and sixth abdominal segments terminates posteriorly in a small acute tooth, whereas in the preceding species, *B. altus*, these segments are destitute of teeth, the posterior margin of the sixth rising to form a peculiar transverse ridge."

### Genus **Gennadas** Bate

Very similar to *Benthescymus*. Exopodites of second maxillipeds only about as long as endopodites, which have a thin, broad, expanded oval merus, beneath which the three terminal joints are concealed when flexed.

#### KEY TO THE CALIFORNIA SPECIES OF GENNADAS

- I. Rostrum armed with a single tooth; dorsal carina distinct nearly to posterior margin of carapace. *borealis*, p. 24.
- II. Rostrum armed with two slender, acute teeth; dorsal carina fading out before reaching cervical groove. *pectinatus*, p. 25.

**Gennadus borealis** Rathbun

*Gennadus borealis* Rathbun, Proc. U. S. Nat. Mus., 24, 887, 1902; H. A. E., 10, 147, figs. 88 and 89, 1904.

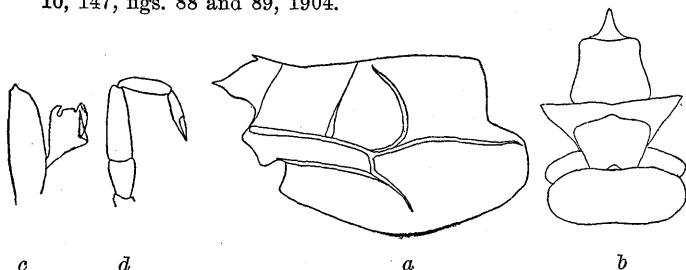


Fig. 11. *Gennadus borealis*; a, lateral view of carapace, ♀,  $\times 2$ ; b, thelycum,  $\times 5$ ; c, petasma,  $\times 5$ ; d, foot of first pair, ♂,  $\times 3$  (Rathbun, U. S. N. M.).

*Characters*.—Rostrum reaching at least half way along the eye-stalk, sometimes to the cornea, armed with a single tooth; carina very distinct nearly to the posterior margin of the carapace, but sharpest in front of the cervical groove; a sharp marginal spine at the angle of the antero-lateral sinus. Eyes light brown, globular, having a speck of black pigment near their base on the outer margin of the stalk; tubercle large and acute. Antennal scale extends beyond the antennular peduncle by about the length of the last segment of the peduncle. Chelae of first pair of feet narrow and elongate, as in the succeeding pairs.

Thelycum<sup>1</sup> consisting of a horizontal, convex, subtriangular plate, or tubercle, placed between the third pair of legs, followed by two transverse plates between the fourth and fifth pairs. The anterior of these two plates is subquadrilateral, narrowest in front; the posterior plate is somewhat fan-shaped, narrow behind, its anterior margin rounding and with a blunt median point. The andricum or petasma<sup>2</sup> consists of a pair of small leaves not in contact, each of which is attached at its proximal end; at extremities of distal margin are two lobes or teeth, the outer of which is curved; the inner portion is partially folded to form an irregular longitudinal plate.

Exopodites of first abdominal appendages not so long as the carapace; between the bases of these appendages is a sharp spine, equally developed in both sexes.

Sixth abdominal somite carinate, more than twice as long as fifth; telson with a small lateral spine at its posterior fourth, two spines at tip.

*Dimensions*.—Type, male: length of carapace and rostrum 13.6 mm., of abdomen on middle line 29 mm.; female: length of carapace and rostrum 18 mm., of abdomen on middle line 37 mm.

*Type Locality*.—Off Copper Island, Kamchatka, 1567 fathoms ("Albatross" station 3783).

*Distribution*.—Also taken by the "Albatross" from north of Rat Islands, Aleutians, to off South Coronado Island, Lower California, 266 to 2182 fathoms.

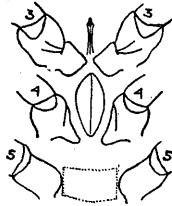
*Remarks*.—Very near *G. parvus* Bate, but differs in the longer rostrum, the presence of a lateral spine on the telson, the greater length of the antennal scale, the elongated chelae of the first pair of feet, and the different form of the thelycum and andricum or petasma (Rathbun).

<sup>1</sup> An accessory reproductive structure on the ventral surface of the cephalothorax peculiar to the female.

<sup>2</sup> A membranous accessory reproductive structure attached to the first pair of pleopods of the male.

**Gennadas pectinatus**, sp. nov.

Plate 11, figure 1

Fig. 12. *Gennadas pectinatus*; thelycum.

*Description*.—Rostrum slightly ascending, with a styliform apex, and armed above with two slender teeth, of which the posterior is situated just above the posterior margin of the orbit and the anterior just behind the middle of the rostrum; the rostrum exceeds the eyes by one-half the length of that portion lying anterior to the anterior dorsal spine; dorsal carina continued backward as far as the cervical groove, behind which the dorsal surface of the carapace is smooth and rounded; at the antero-lateral sinus is a sharp marginal spine. Eyes apparently devoid of pigment; tubercle on inner angle of somewhat flattened eyestalk, small and blunt. Spine of antennal scale falls short of the extremity of the blade by nearly the width of the blade at the end of the spine; antennular peduncle reaching a little beyond middle of antennal scale. Endopodites of external or third maxillipeds broken off. Palm and fingers of first pair of chelipeds subequal in length; of the second pair the palm is about four-fifths the length of the fingers.

Thelycum as figured (fig. 12), a hastate, medially carinated plate between the bases of the fourth pair of legs, a curved spine between the third pair, and a more or less rectangular pubescent area between the last pair of legs.

Exopodites of first abdominal appendages as long as distance from tip of rostrum to posterior margin of first abdominal segment, including carapace; between the bases of these appendages there is a thickened triangular plate with a blunt, forwardly-directed apex. Fifth and sixth abdominal segments carinated, carina of fifth ending in a small, sharp spine, which projects beyond the posterior margin of the segment. Sixth segment more than twice as long as the fifth, with posterior end partly broken away; it may have ended in a spine like the fifth. There is a small spine at the postero-ventral angle of the sixth segment, and a large one at the postero-dorsal angle of the epimeron of the fifth. Fourth abdominal segment armed on the posterior margin with a peculiar comb-like structure, a series of pectinations beginning with a few denticles just above the epimeron, which increase in size and become spine-like toward the median line, forming there quite conspicuous teeth which in the type specimen are as much as one and one-half millimeters long. Outer blade of uropods exceeding the inner by about one-third of their length; telson with four pairs of lateral spines, tip broken.

*Dimensions*.—Type, female: length of carapace and rostrum 41 mm., of abdomen to extremity of broken telson 74 mm.

*Type Locality*.—Known only from a single female specimen (Cat. No. 53329, U.S.N.M.), dredged by the "Albatross" in 1350 to 2182 fathoms, off Santa Catalina Island, California (station 4390).

*Remarks*.—This species differs, so far as I am aware, from all known species of *Gennadas* in the peculiar armature of the posterior margin of the fourth abdominal segment.

## Tribe CARIDES

## KEY TO THE CALIFORNIA FAMILIES OF THE CARIDES

- I. Exopodites on all legs; first two pairs chelate; second wrists undivided.
- A. Exopodites of second maxillipeds rudimentary or wanting. Rostrum short or wanting, often represented by a postfrontal tooth or spine.  
*Pasiphaeidae*, p. 27.
- B. Exopodites of second maxillipeds large. Rostrum moderately or well developed.  
*Oplophoridae*, p. 32.
- II. No exopodites on legs.
- A. One or both legs of first pair simple; legs of second pair unequal, second wrists subdivided (multiarticulate).
1. Only one leg of first pair simple, the other chelate. Rostrum not toothed except at apex, which is obscurely bifid. (Not known north of San Diego.)  
*Lysmatidae*, p. 80.
2. Both legs of first pair simple; first two pairs slender. Rostrum large and toothed.  
*Pandalidae*, p. 40.
- B. Both legs of first pair chelate or subchelate.
1. First pair of legs subchelate; second wrists undivided. Rostrum small, or wanting; occasionally a somewhat elongate suberect spine.  
*Crangonidae*, p. 81.
2. First pair of legs chelate; second wrists either subdivided or undivided.
- a. Second wrists undivided.
- i. First antennae with two flagella, one usually cleft a little distance from the tip. (Not known north of Santa Cruz Island.)  
*Pontoniidae*, p. 37.
- ii. First antennae with three flagella, owing to cleavage of one almost, or quite to the base. (Not known north of San Pedro.)  
*Palaemonidae*, p. 34.
- b. Second wrists subdivided (multiarticulate).
- i. Eyes covered by carapace. First legs much stronger than the rest; second wrists divided into five segments. Rostrum small or wanting.  
*Crangonidae*, p. 73.
- ii. Eyes not covered by carapace, free. First legs not much stronger than the rest; second wrists divided into three, seven, or many segments. Rostrum generally prominent.
- a. Second pair of legs equal or subequal; wrists divided into three, seven, or about thirty-two segments. Rostrum toothed; rarely reduced in size.  
*Hippolytidae*, p. 47.



- b. Second pair of legs unequal, wrist of longer leg about twice length of shorter one, wrists multiarticulate. Rostrum not toothed, except at apex, which is obscurely bifid. (Not known north of San Diego.)

*Lysmatidae*, p. 80.

### Family PASIPHAEIDAE

Rostrum short or wanting, often represented by a postfrontal (gastric) tooth or spine. Mandibles lacking molar process, consisting of incisor process alone, with or without palp of one or two segments. Exopodites present on all thoracic legs and on third or external maxillipeds, rudimentary or wanting on second maxillipeds but often constituting the chief part of the first maxillipeds. First two pairs of legs similar, ending in elongate chelae with long, slender fingers, and stouter than the remaining three pairs, which are undersized and imperfectly formed.

#### KEY TO THE CALIFORNIA GENERA OF THE PASIPHAEIDAE

- I. Rostrum wanting, represented by a postfrontal (gastric) tooth or spine.  
*Pasiphaea*, p. 27.
- II. A short, normally formed rostrum present.  
*Parapasiphaea*, p. 31.

### Genus *Pasiphaea* Savigny

Body strongly compressed. Rostrum wanting, represented by a postfrontal gastric spine or tooth. Frontal margin of carapace with orbits but slightly excavate and imperfectly defined. Mandibles without a palp.

#### KEY TO THE CALIFORNIA SPECIES OF PASIPHAEA

- I. Carapace carinated throughout its length.
- A. Telson truncate, not forked or notched. (Known only from 250 + fathoms.)  
*magna*, p. 28.
- B. Telson forked or notched.
1. Branchiostegal spine over the angle of the anterolateral sinus.  
*pacifica*, p. 29.
2. Branchiostegal spine farther forward, near or on anterior margin.
- a. Telson longer than sixth segment. (Known only from 250 + fathoms.)  
*emarginata*, p. 30.
- b. Telson shorter than sixth segment. (Known only from 750 + fathoms.)  
*corteziana*, p. 30.
- II. Carapace not carinated in its posterior half. (Known only from 950 + fathoms.)  
*affinis*, p. 31.

**Pasiphaea magna** Faxon?

*Pasiphaea magna* Faxon, Bull. Mus. Comp. Zool., 24, 209, 1893; Mem. Mus.

Comp. Zool., 18, 176, pl. 45, figs. 2-2c, 1895.

*Pasiphaea magna?* Rathbun, H. A. E., 10, 19, fig. 1, 1904.

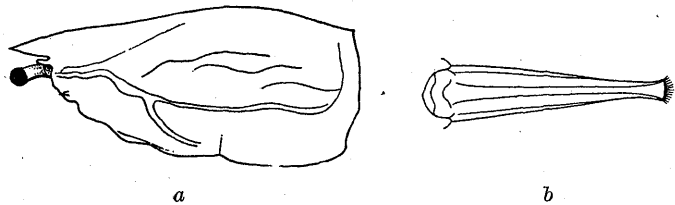


Fig. 13. *Pasiphaea magna*, a, lateral view of carapace,  $\times \frac{4}{5}$  (after Faxon); b, telson,  $\times 1\frac{1}{3}$  (from Rathbun, U. S. N. M.).

Miss Rathbun had a number of specimens from California which she doubtfully referred to this species. Regarding them, she said (1904, p. 19):

"The identification of these specimens with *P. magna* is doubtful, but as I have not had the opportunity of comparing them with the type, they are placed here provisionally. Though from the same depth of water, the integument is much firmer in our examples than in the type, the carapace is deeper and its dorsal outline less arched, the branchial ridge is straighter throughout the posterior half of its course, the palm of the first pair of chelae is longer than the fingers.

The largest specimen, an ovigerous female... is 155 mm. long. The telson is a little longer than the sixth segment of the abdomen, and reaches about to the end of the inner uropod; it is broadly channeled, extremity truncate or slightly convex, and armed with about 13 slender bristles... In the first pair of legs the palm is about one-third longer than the fingers; in the second pair the right merus has 14 spines, the left 13.

*Characters.*—Of *Pasiphaea magna*, taken from Faxon: Carapace a little less than two-fifths of the length of the whole body; laterally compressed, dorsally carinate; carina rounded, except on anterior part of gastric area, where it assumes the form of a sharp keel, and is continuous with the acute-tipped, blade-like tooth which simulates a true rostrum; this tooth reaches forward nearly to the anterior extremity of the eyes; its lower margin is convex, with its hinder part resting closely upon and apparently ankylosed with the frontal region of the carapace. Palm of first pair of legs somewhat shorter than the dactylus; merus armed with four or five spines on its inferior edge. Second pair of legs a little longer than the first pair, with a longer and more slender chela. The second segment (basipodite) is armed with a small spine at the distal end of the inferior edge; inferior edge of merus armed with thirteen spines; carpus armed with one long spine at distal end of lower margin. All abdominal segments dorsally carinated; carina obsolete on first segment.

*Dimensions.*—Type of *P. magna*: length 145 mm.; carapace, including anterior dorsal tooth, 55 mm.

*Type Locality.*—Gulf of Panama, 458 fathoms ("Albatross" station 3384).

*Distribution.*—Also taken by the "Albatross" from off Point Arena to off Point Loma, California, 276 to 552 fathoms.

***Pasiphaea pacifica* Rathbun**

*Pasiphaea pacifica* Rathbun, Proc. U. S. Nat. Mus., 24, 905, 1902; H. A. E., 10, 20, fig. 2, 1904.

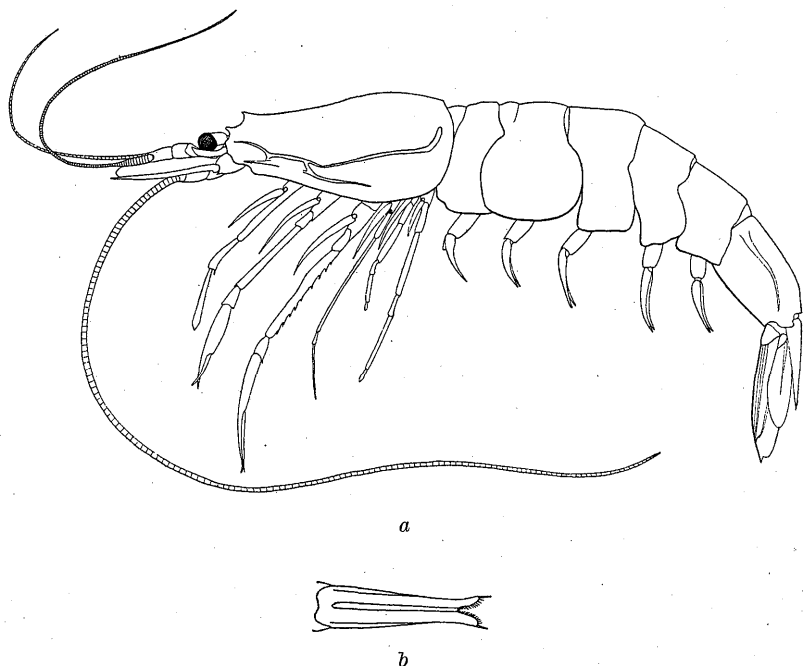


Fig. 14. *Pasiphaea pacifica*; ♀, a, lateral view,  $\times 1\frac{1}{8}$ ; b, telson,  $\times 3\frac{1}{8}$  (from Rathbun, U. S. N. M.).

*Characters*.—Carapace a little less than half the length of the abdomen. Gastric tooth variable, more or less inclined upward, terminally usually slender, anterior margin concave; continued back as a thin, sharp keel, which becomes a rounded ridge behind the gastric region. Branchiostegal spine situated over the angle of the anterolateral sinus. Second to sixth abdominal segments, inclusive, carinate. Telson four-fifths as long as sixth somite of abdomen; dorsal surface channeled; extremity with a deep notch.

*Dimensions*.—Type, female: length 64.8 mm.; length of carapace 20.3 mm.

*Type Locality*.—Off Point Sur, California, 328 fathoms (“Albatross” station 3186).

*Distribution*.—From Unalaska and the Gulf of Alaska, to the Gulf of California, in 53 to 799 fathoms. Most frequent between 200 and 300 fathoms off the California coast. “One specimen from 13 fathoms, if label be correct” (Rathbun).

*Remarks*.—Differs from other species with carinated carapace in having the branchiostegal spine situated above the anterolateral sinus (Rathbun).

***Pasiphaea emarginata* Rathbun**

*Pasiphaea emarginata* Rathbun, Proc. U. S. Nat. Mus., 24, 905, 1902;  
H. A. E., 10, 22, fig. 4, 1904.

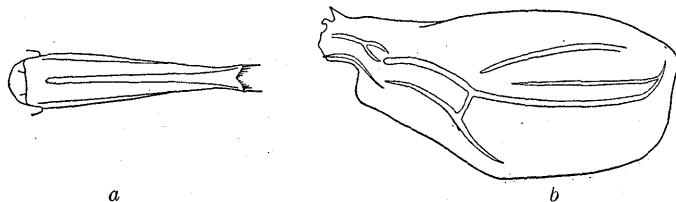


Fig. 15. *Pasiphaea emarginata*; ♀, a, telson,  $\times 3\frac{1}{2}$ ; b, lateral view of carapace,  $\times 1\frac{1}{2}$  (from Rathbun, U. S. N. M.).

*Characters*.—Carapace equal to the first five segments and half of the sixth segment of the abdomen. Gastric tooth spiniform, continued back in a blunt carina nearly to the posterior margin. First to fifth segments of abdomen slightly carinated, sixth compressed above but scarcely carinate; telson longer than the sixth segment of the abdomen, extremity with a very shallow V-shaped notch.

*Dimensions*.—Type, female: length 81 mm.; length of carapace 33.3 mm.

*Type Locality*.—Gulf of California, off Concepcion Bay, 857 fathoms ("Albatross" station 3009).

*Distribution*.—Also from off the Santa Barbara Islands and Santa Barbara Channel to off San Diego, California, 216 to 680 fathoms.

***Pasiphaea corteziana* Rathbun**

*Pasiphaea corteziana* Rathbun, Proc. U. S. Nat. Mus., 24, 905, 1902;  
H. A. E., 10, 24, fig. 5, 1904.

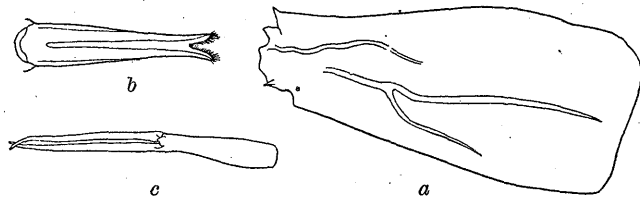


Fig. 16. *Pasiphaea corteziana*, ♂; a, lateral view of carapace,  $\times 2$ ; b, telson,  $\times 2\frac{2}{3}$ ; c, hand of second pair,  $\times 2\frac{2}{3}$  (from Rathbun, U. S. N. M.).

*Characters*.—Carapace equal to the first five and part of the sixth segment of the abdomen. Gastric tooth dentiform, continued back in a very blunt carina. Branchiostegal spine small, inserted near the anterolateral angle of the carapace just behind the anterior margin. Abdominal segments not carinate. Telson very nearly as long as the sixth abdominal segment; forked, with a deep notch.

*Dimensions*.—Type, male: length 64 mm.; length of carapace 23.8 mm.

*Type Locality*.—Near Cortez Bank, California, 776 fathoms ("Albatross" station 3627).

*Distribution*.—Also taken by the "Albatross" off Point San Pedro, Santa Cruz Island, California, in 764 to 891 fathoms (station 4428).

**Pasiphaea affinis** Rathbun

*Pasiphaea affinis* Rathbun, Proc. U. S. Nat. Mus., 24, 905, 1902; H. A. E., 10, 24, fig. 6, 1904.

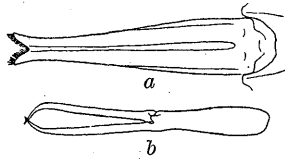


Fig. 17. *Pasiphaea affinis*, ♂, a, telson,  $\times 3\frac{1}{2}$ ; b, hand of second pair,  $\times 2$  (from Rathbun, U. S. N. M.).

*Characters*.—Carapace equal to the first four and half of the fifth segment of the abdomen; not carinated behind gastric tooth; otherwise much as in *P. corteziana*. Second to sixth abdominal segments, inclusive, carinate. Telson very nearly as long as the sixth abdominal segment; extremity less deeply notched than in *P. corteziana*.

*Dimensions*.—Type, male: length 67 mm.; length of carapace 22 mm.

*Type Locality*.—Near Cortez Bank, California, 984 fathoms ("Albatross" station 2919).

**Genus Parapasiphae** Smith

Body moderately compressed. Rostrum present, short, normally formed. Mandibles with slender, two-jointed palp.

**Parapasiphae serrata** Rathbun

*Parapasiphae serrata* Rathbun, Proc. U. S. Nat. Mus., 24, 904, 1902; H. A. E., 10, 25, fig. 7, 1904.

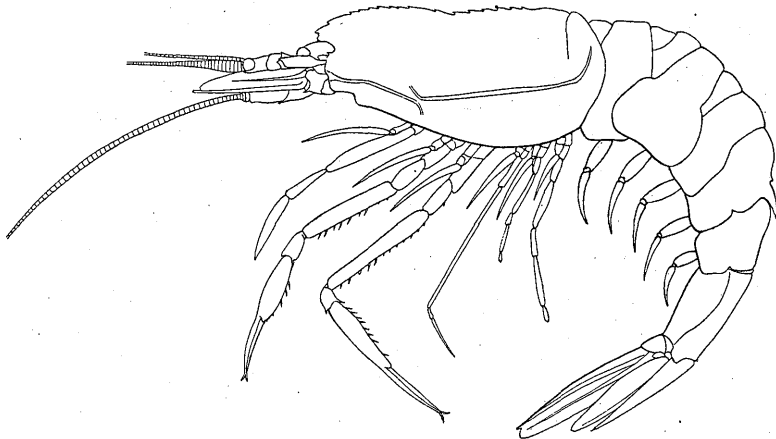


Fig. 18. *Parapasiphae serrata*, ♀,  $\times$  about  $1\frac{1}{2}$  (from Rathbun, U. S. N. M.).

*Characters.*—Carapace and rostrum as long as the first five abdominal segments. The median carina extends backward to the posterior fifth of the carapace, or the cervical groove, and forward along the high, thin rostrum, which reaches half way along the eye-stalks; carina is armed with sixteen small teeth or spines, two of which are on the rostrum and one terminal; below this spine the rostrum is a compressed, finely crenulate lobe. Antennular scale as long as basal joint of peduncle. Antennal scale nearly half as long as carapace proper. First three abdominal segments not carinate; fourth segment posteriorly produced in a thin, compressed spine, which is carinate and has a slight notch at its base, visible in profile; sixth with a longitudinal groove on either side. Telson a little longer than sixth abdominal segment; extremity truncate.

*Dimensions.*—Type, ovigerous female: length of carapace and rostrum 23.6 mm.; rostrum 1.8 mm.; abdomen 42 mm.

*Type Locality.*—Off Cortez Bank, California, 984 fathoms ("Albatross" station 2919).

*Remarks.*—This species is akin to *P. gilesii* Wood-Mason, from the Indian Ocean, which also has a serrated carina running the whole length of the carapace, but the character of the rostrum alone separates it distinctly from that species. In *P. gilesii* the rostrum is a fine, acute, incurved spine, extending about a third its length beyond the eyes (Rathbun).

#### Family OPLOPHORIDAE (HOPLOPHORIDAE)

Rostrum moderately or well developed. Mandible with a stout, three-jointed palp, and with incisor and molar process distinct but almost confluent; molar process small. All eight pairs of thoracic appendages with well developed exopodites. First two pairs of legs ending in small but well formed chelae; last three pairs of moderate length and subequal.

#### KEY TO THE CALIFORNIA GENERA OF THE OPLOPHORIDAE

- I. Rostrum armed with teeth above and below. Second to sixth abdominal somites, inclusive, sharply carinate. (Known only from 485 + fathoms.)  
*Acanthephyra*, p. 32.
- II. Rostrum toothed above only. Abdomen devoid of a median carina. (Known only from 322 + fathoms.)

*Hymenodora*, p. 33.

#### Genus *Acanthephyra* Milne Edwards

Body compressed. Rostrum rarely short, usually long; armed with teeth above and below. Endopodite of first maxillipeds composed of three segments; the two inner distal lobes of the second maxilla narrow and projecting beyond the basal lobe. Abdomen more or less carinate; carinae of some segments ending posteriorly in a tooth or spine. Eggs, so far as known, small and numerous.

***AcanthePHYra curtirostris* Wood-Mason**

*AcanthePHYra curtirostris* Wood-Mason, Ann. Mag. Nat. Hist. (6), 7, 195, 1891; 9, 364, fig. 5, 1892; Illus. Zool. "Investigator," Crustacea, pl. 3, fig. 4, 1892; Faxon, Mem. Mus. Comp. Zool., 18, 164, pl. 43, figs. 2-5, 1895; Rathbun, H. A. E., 10, 27, 1904.

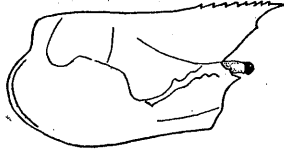


Fig. 19. *AcanthePHYra curtirostris*, ♂, lateral view of carapace (after Faxon).

*Characters.*—Carapace and rostrum less than half as long as the abdomen; carapace not distinctly carinated behind the gastric region. Rostrum a very thin, high, obliquely ascendant frontal crest, the acuminate peak of which does not exceed the antennular peduncle; armed above with seven to nine teeth, and below with one or, more rarely, two spines at or before the middle of the ventral border; occasionally the ventral tooth is obsolescent or but obscurely indicated. Second to sixth abdominal segments, inclusive, sharply carinate; each carina ends in a small tooth, that on the third segment being the larger, while that on the second and frequently also that on the sixth is scarcely defined; sixth segment more than half again as long as the fifth.

*Dimensions.*—Type, male: length from tip of rostrum to end of telson 85 mm.

*Color.*—In life crimson (Alcock).

*Type Locality.*—Bay of Bengal, 840 fathoms ("Investigator" station 100).

*Distribution.*—Arabian Sea, 937 to 1043 fathoms; Bay of Bengal, 364 to 913 fathoms; Andaman Sea, 922 fathoms (Alcock). From off San Clemente Island, California, to off Gulf of Panama, 485 to 2232 fathoms.

**Genus *Hymenodora* Sars**

Body almost round, not compressed; carapace only compressed in dorsal part, forming a sharp, high, median keel. Rostrum usually short, rarely long, armed with teeth above only. Endopodite of first maxillipeds composed of only two segments; the two inner distal lobes of the second maxilla rather broad and not projecting beyond the basal lobe. Abdomen not carinate. Eggs usually of considerable size.

**Hymenodora frontalis** Rathbun

*Hymenodora frontalis* Rathbun, Proc. U. S. Nat. Mus., 24, 904, 1902;  
H. A. E., 10, 28, 1904.

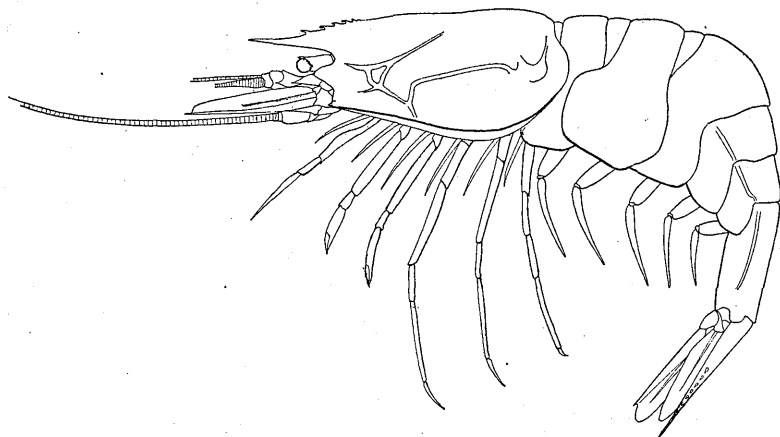


Fig. 20. *Hymenodora frontalis*, ♀, × about 2 (from Rathbun, U. S. N. M.).

*Characters.*—Surface covered with very fine wrinkles or rugose lines. Carapace and rostrum more than half as long as abdomen; median carina advanced in a rostrum which is unusually long for the genus, being from two-fifths to one-half as long as the remainder of the carapace and reaching the end or a little beyond the end of antennular peduncle. Rostrum a slender, sharp-pointed spine, distal half slightly curved upward, basal half armed above with three to six spines, two or three of which are beyond the line of the orbit. Abdomen devoid of a median carina or median spines; sixth segment two and a half times as long as fifth, and between three-fourths and four-fifths as long as telson.

*Dimensions.*—Type, male: length of carapace and rostrum 19 mm.; of rostrum 6.5 mm.; of abdomen 32.5 mm.

*Type Locality.*—West of Unalaska, 322 fathoms ("Albatross" station 3327).

*Distribution.*—From Bering Sea to off San Clemente Island, California, and Kamchatka; 322 to 1771 fathoms.

*Remarks.*—The unusually long rostrum distinguishes this from other species of *Hymenodora* (Rathbun).

## Family PALAEMONIDAE

Rostrum well developed, laterally compressed, and armed with teeth. Antennules with three flagella, owing to cleavage of one almost or quite to the base. Mandibles with incisor process, and with or without palp of three segments. First pair of legs chelate and shorter than second. Second pair equal and chelate, with segmented carpus, chelae generally larger than in first pair.



KEY TO THE CALIFORNIA GENERA OF THE PALAEMONIDAE

I. Rostrum prominently toothed above only, about two-thirds as long as carapace, pronouncedly convex above, armed with five to seven teeth, with one or two small teeth below near tip; behind rostrum there is a median gastric spine. An hepatic spine present. Mandible without palp. (Not known north of San Diego Bay.)

*Urocaris*, p. 37.

II. Rostrum prominently toothed above and below. No hepatic spine.

A. Rostrum about as long as carapace, armed with six to ten teeth above, one or two of which are behind the orbit, and with two to four teeth below. Mandible without palp. (Known only from San Pedro.)

*Palaemonetes*, p. 36.

B. Rostrum longer than carapace; armed with seven to eight teeth above, one or two of which are behind the orbit, and with three teeth below. Mandible with palp. (Not known north of San Diego.)

*Palaemon*, p. 35.

Genus *Palaemon* Fabricius

Rostrum prominently toothed above and below. Carapace furnished with antennal and branchiostegal spines, but without hepatic spine. Mandible with three-jointed palp.

*Palaemon ritteri* Holmes

*Palaemon ritteri* Holmes, Proc. Calif. Acad. Sci. (2), 4, 579, pl. 21, figs. 29-35, 1895; Occas. Papers Calif. Acad. Sci., 7, 216, 1900; Rathbun, H. A. E., 10, 29, 1904.

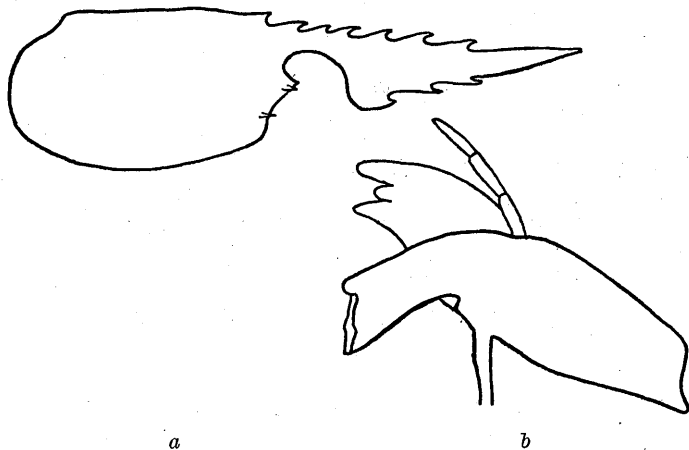


Fig. 21. *Palaemon ritteri*; a, lateral view of carapace; b, mandible (after Holmes).

*Characters.*—Rostrum longer than carapace, and tapering more or less evenly from the widest portion (which is about one-fourth as wide as the rostrum is long) to an acute tip; armed above with seven to eight teeth, one or two of which are behind the orbit; below with three teeth. Ocular peduncles short and stout; the ocellus lies between the cornea and the stalk. Antennal scale is shorter than the rostrum, with blade exceeding the spine.

*Dimensions.*—Type: length 45 mm.

*Type Locality.*—San Diego, California.

*Distribution.*—From San Diego, California, to Gulf of California (Rathbun). Bay of St. Elena, Ecuador (Nobili).

### Genus *Palaemonetes* Heller

Rostrum prominently toothed above and below. Carapace furnished with antennal and branchiostegal spine, but without hepatic spine. Mandible without palp.

#### *Palaemonetes hiltoni* sp. nov.

Plate 12, figure 5

*Description.*—Closely allied to *P. kadiakensis* Rathbun (1902, p. 903; 1904a, p. 30, fig. 9), from Alaska, and intermediate between it and *P. vulgaris* Say (1818, p. 248), of the Atlantic.

It differs from both *P. kadiakensis* and *P. vulgaris* in the proportional length of the propodal and carpal joints of the first two pairs of legs and in the relative length of the sixth abdominal segment as compared to the fifth. The following table will suffice to show these differences in the three species mentioned above:

|                                      | <i>Palaemonetes kadiakensis</i> | <i>P. hiltoni</i> | <i>P. vulgaris</i> |
|--------------------------------------|---------------------------------|-------------------|--------------------|
| First pair of legs,                  |                                 |                   |                    |
| propodus : carpus .....              | 1 : 2.20                        | 1 : 1.75          | 1 : 1.50           |
| Second pair of legs,                 |                                 |                   |                    |
| propodus : carpus .....              | 1 : 2.00                        | 1 : 1.00          | 1 : 0.60           |
| merus : carpus .....                 | 1 : 1.50                        | 1 : 1.00          | 1 : 0.88           |
| Abdomen, fifth segment : sixth ..... | 1 : 2.00                        | 1 : 1.66          | 1 : 1.50           |

Otherwise the description and figure of *P. kadiakensis* as given by Miss Rathbun does very well for *P. hiltoni*. On the whole *P. hiltoni* is the stouter of the two with less elongate and attenuate legs and a relatively shorter and stouter sixth abdominal segment.

Regarding the number of rostral teeth of *P. hiltoni*, as only four specimens have been seen, no positive statement can be made. Those examined all had nine teeth on the rostrum and an additional one on the carapace behind the orbit; beneath the number ranged from three in three of the specimens to four in the fourth one. In *P. kadiakensis* the count based on a large number of specimens ranges from six to ten teeth above, of which one or two are behind the orbit, and from two to three teeth below.

*Dimensions.*—Holotype (Cat. No. 48991, U. S. N. M.): length from tip of rostrum to end of telson 26 mm.; carapace and rostrum together 10.5 mm. The three paratypes are respectively 20, 21, and 24 mm. in length.

*Type Locality.*—San Pedro, California (Stout and Stafford coll.).

Genus *Urocaris* Stimpson

Rostrum prominently toothed above only. Carapace with an hepatic spine, with or without antennal spine, and without branchiostegal spine. Mandible without palp.

*Urocaris infraspinis* Rathbun

*Urocaris infraspinis* Rathbun, Proc. U. S. Nat. Mus., 24, 903, 1902;  
H. A. E., 10, 31, fig. 10, 1904.

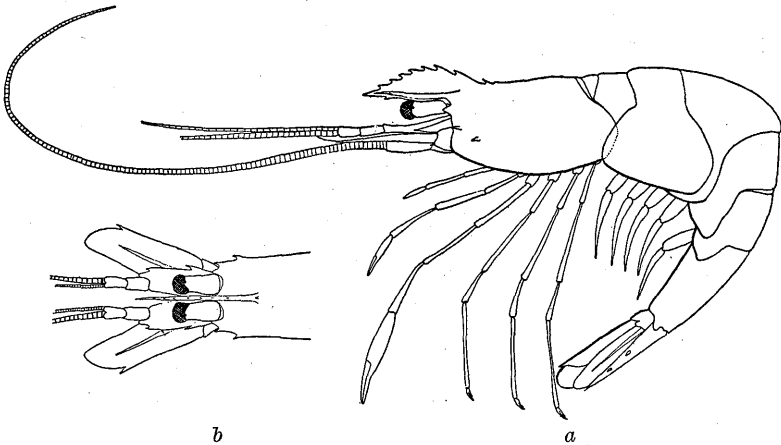


Fig. 22. *Urocaris infraspinis*, ♀,  $\times 3\frac{1}{2}$ ; a, lateral view; b, dorsal view of anterior portion (from Rathbun, U. S. N. M.).

*Characters*.—Rostrum about two-thirds as long as the carapace, pronouncedly convex above; armed with five to seven teeth, with one or two small teeth below near the tip; behind the rostrum there is a median gastric spine. Antennal and hepatic spines of good size; suborbital angle of carapace blunt. Ocular peduncles with a minute black ocellus above, towards the outside and beyond the limit of the cornea. Antennal scale much longer than the rostrum, with blade considerably exceeding the spine.

*Dimensions*.—Type, ovigerous female: length of carapace and rostrum 6 mm., of rostrum 2.5 mm., of abdomen 15 mm.

*Type Locality*.—Gulf of California, in Concepcion Bay, Lower California ("Albatross").

*Distribution*.—San Diego Bay, California; Gulf of California (Rathbun).

## Family PONTONIIDAE

Rostrum laterally compressed and armed with teeth or depressed and unarmed. Antennules with one of the two flagella usually cleft a little distance from the tip. Mandible with incisor process but without palp. First pair of legs chelate and slender. Second pair chelate with one or both legs stouter or longer than first pair.

## KEY TO THE CALIFORNIA GENERA OF THE PONTONIIDAE

- I. Rostrum short, less than one-half length of carapace, depressed, bent downward, not dentate. One of the second pair of legs with very large chela. (Known only from off Santa Cruz Island.)
- Pontonia*, p. 38.
- II. Rostrum often about as long as carapace, compressed, usually dentate, not bent downward. Second pair of legs long, slender, and equal. (Not known north of Santa Catalina Island.)

*Periclimenes*, p. 39.

Genus *Pontonia* Latreille

Rostrum short, depressed, bent downward; not dentate; with or without a keel below at the free end. Both flagella of antennules short; thicker of the two bifid. Antennal scale of moderate length only, broad. One of the second pair of legs with very large chela.

*Pontonia californiensis* Rathbun

*Pontonia californiensis* Rathbun, Proc. U. S. Nat. Mus., 24, 902, 1902; H. A. E., 10, 33, fig. 11, 1904; Borradaile, Trans. Linn. Soc. London (Zool.), (2), 17, 389, 391, 1917.

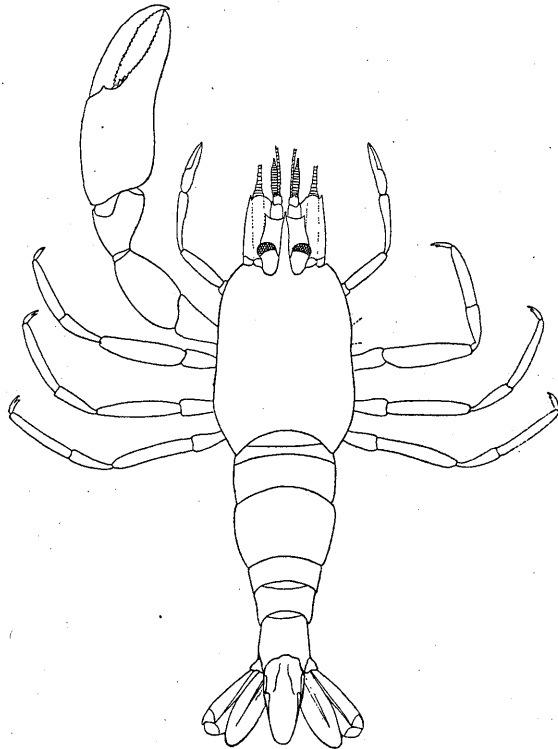


Fig. 23. *Pontonia californiensis*, ♀; dorsal view,  $\times 427$  (from Rathbun, U. S. N. M.).

*Characters*.—Rostrum more than one-third the length of the remainder of carapace, very narrow, deflexed. Right foot of second pair missing. Merus of left foot short and stout, carpus cup-shaped, palm and fingers subequal in length, palm two-thirds as broad as long, fingers gaping, prehensile edges denticulate, fringed with long hair. Telson twice as long as sixth somite, with two pairs of long lateral, appressed spines inserted on anterior half.

*Dimensions*.—Type, female: length of carapace and rostrum 6.7 mm., of rostrum 1.8 mm., of abdomen 9 mm.

*Type Locality*.—Off Santa Cruz Island, California, 30 fathoms ("Albatross" station 2945).

*Remarks*.—This is the only *Pontonia* described from the west coast of North America, the *P. margarita* of Smith being a *Conchodytes* (Rathbun).

### Genus *Periclimenes* Costa

Rostrum long, compressed, usually dentate, in side view diminishing gradually to a sharp point at the free end, not bent downward. Thicker flagellum of antennules long or moderate, bifid. Antennal scale long, usually narrow. Second pair of legs long, slender, and equal.

#### *Periclimenes tenuipes* (Holmes)

*Anchista tenuipes* Holmes, *Ocas. Papers Calif. Acad. Sci.*, 7, 216, 1900.

*Periclimenes tenuipes* Rathbun, *H. A. E.*, 10, 34, fig. 12, 1904; Borradaile, *Trans. Linn. Soc. London (Zool.)*, (2), 17, 368, 372, 1917.

*Periclimenes holmesi* Nobili, *Ann. Mus. Univ. Napoli (N. S.)*, 2, no. 21, 5, 1907; Borradaile, *ibid.*, (2), 17, 376, 1917.

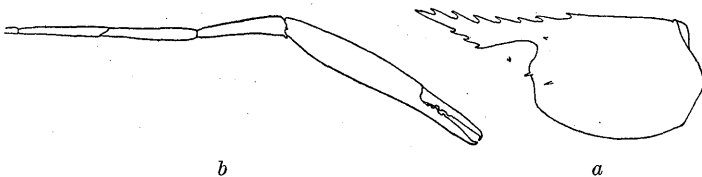


Fig. 24. *Periclimenes tenuipes*,  $\times 4$ ; a, lateral view of carapace; b, foot of second pair (from Rathbun, U. S. N. M.).

*Characters*.—Rostrum about as long as the carapace, rather deep near the middle, armed above with six or seven teeth, the last one or two on the carapace; lower side armed with three or four teeth; the last dorsal spine is near the anterior third of the carapace. A supraorbital, an antennal, and an hepatic spine present; anterolateral angle of the carapace rounded and devoid of spines. Ocular peduncles large and furnished with an ocellus between the cornea and the proximal part of the stalk. Second pair of legs slender and greatly elongated, the carpus reaching beyond the rostrum; ischium, merus, and carpus of subequal length; hand long, very narrow, subcylindrical, exceeding the length of the carpus and merus combined; fingers slender, straight, about two-thirds as long as the palm; tips hooked and crossed when fingers are closed. Telson with two pairs of dorsal spinules.

*Dimensions.*—Type: length of body 18 mm., of second chelipeds 16 mm., of hand 7 mm., of carpus 3 mm.

*Type Locality.*—Santa Catalina Island, California.

*Distribution.*—From Santa Catalina Island, California, to Gulf of California (Rathbun).

*Remarks.*—The specimens in the U. S. National Museum, collected in the Gulf of California by the "Albatross," from which the above figure was taken, "agree with Holmes's description, except that the fingers of the second pair of feet are only a little over half as long as the palm and the posterolateral angle of the sixth abdominal segment is subacute" (Rathbun). Nobili (1917, p. 5) suggests the name *holmesi* for *Periclimenes tenuipes* (Holmes) which he says is preoccupied by *P. tenuipes* (Leach), but as there does not seem to be any original description I have retained Holmes's name. Borradaile says (1917, p. 376), "I have not been able to find the original description of it [*P. tenuipes* (Leach)]."

### Family PANDALIDAE

Rostrum laterally compressed, long, and armed with teeth or spines. Mandibles with incisor process and palp of two or three segments. First pair of legs slender and usually simple, but often only apparently so, being at times microscopically chelate. Second pair long, slender, and chelate, with segmented carpus.

#### KEY TO THE CALIFORNIA GENERA OF THE PANDALIDAE

- I. Antennules not longer than the carapace. No laminate expansions on the merus of the third maxilliped and the ischium of the first legs.  
*Pandalus*, p. 40.
- II. Antennules twice the length of the carapace. Merus of third maxillipeds and ischium of first legs with a longitudinally developed laminate expansion fringed with long hairs.  
*Pandalopsis*, p. 46.

### Genus *Pandalus* Leach

Rostrum long and prominent, armed above with spines, which are for the greater part movable, and below with fixed and rigid teeth; rostrum continued backward upon the carapace as a median dorsal carina. Antennules not longer than the carapace. Mandible with a three-jointed palp. Second pair of legs unequal, with much segmented carpus.

None of the species at present known from California have median spines on the abdomen.

#### KEY TO THE CALIFORNIA SPECIES OF PANDALUS

- I. Dorsal spines not reaching behind middle of carapace; tip of rostrum acuminate, often with a small tooth behind the tip dorsally (*P. jordani* and *P. platyceros*), or trifold (*P. montagui tridens*).
  - A. Sixth segment of abdomen slender, about three times as long as wide. Carapace smooth and shining.

1. Rostrum with spines on distal half of superior margin, about one and three-fourths times as long as carapace, armed above with fourteen to seventeen spines, including four on the carapace, all movable except distal three; below with seven to ten immovable spines.

*jordani*, p. 41.

2. Rostrum unarmed on distal half of superior margin, slender, about one and one-half to one and four-fifths as long as carapace, armed above with ten to twelve movable spines, of which three to five are on the carapace, the remainder confined to the basal half of the rostrum (posterior spine just in front of middle of carapace) below with six to seven immovable spines.

*montaguvi tridens*, p. 42.

- B. Sixth segment of abdomen short and stout, about one and one-half times as long as wide. Carapace pubescent. Rostrum one and one-half to one and two-thirds times the carapace. Median crest arising half way back on the carapace, armed with fourteen to seventeen spines, extending to middle of rostrum, all movable except one to five anterior ones; usually a solitary spine not far behind acute tip; seven to eight fixed spines below.

*platyceros*, p. 43.

II. Dorsal spines extending behind middle of carapace; tip of rostrum trifid.

- A. Rostrum one and one-half times as long as carapace or more. Median dorsal spines eight to nine, all movable, rather distant; ventral spines nine to ten, immovable. Sixth segment of abdomen about one and one-half times as long as wide. (Not known north of Monterey Bay, or south of Santa Catalina Island.)

*gurneyi*, p. 46.

- B. Rostrum less than one and one-half times as long as carapace. Median dorsal spines ten to twelve, movable; about half of them on the carapace, the posterior spine a little behind the middle; terminal half of rostrum, unarmed above; lower margin six to eight spines. Sixth segment of abdomen one and two-thirds as long as wide. (Not known south of San Francisco.)

*danae*, p. 44.

### ***Pandalus jordani* Rathbun**

Plate 14, figure 1

*Pandalus jordani* Rathbun, Proc. U. S. Nat. Mus., 24, 900, 1902; H. A. E., 10, 40, pl. 2, fig. 3, 1904.

*Characters*.—Surface smooth and shining. Rostrum about one and three-fourths times as long as carapace, slightly arched above the eyes, terminal two-thirds ascending; slender; armed with fourteen to seventeen spines above, including four on the carapace, distal three immovable, others movable, closer together above the eye; seven to ten immovable spines below, extending nearer to tip than superior spines; tip acuminate; the posterior of the dorsal spines lies between the middle and the anterior third of the carapace. Antennal scale three-fourths to four-fifths as long as carapace, extremity of blade broadly

rounded, and equally produced with the spine. Right leg of second pair extends about to end of antennal scale; the left leg may be half again as long; the right carpus has nineteen to twenty-two segments, the left fifty-eight to sixty-three segments. Third segment of abdomen compressed and its posterior half carinated, the carina interrupted by a slight lobe at the posterior third of the segment; this lobe is of varying size, at no time strong, and has a tendency to disappear in large specimens, in which it may occur only as a slight unevenness in the curve, seen in profile; posterior margin well produced backward, rounded, unarmed; sixth segment of abdomen slender, about three times as long as wide.

*Dimensions.*—Type, ovigerous female: length 124.5 mm., length of carapace and rostrum 59.5 mm., of rostrum 38 mm.

*Type Locality.*—Off Santa Cruz Island, California, 155 fathoms ("Albatross" station 2949).

*Distribution.*—From Unalaska to off San Diego, California, 25 to 199 fathoms.

*Remarks.*—Distinguished from *P. borealis* (north Pacific and Atlantic), which has a similar rostrum, by the reduction of the abdominal lobe or hump and the absence of posterior median spines on third and fourth segments.

*Biological Survey of San Francisco Bay.*—Of the seventeen "outside" stations, *Pandalus jordani* was taken at seven, D 5785-5791, representing all of those at which the depth exceeded 29 fathoms. At four of the stations from one to eighteen specimens were taken, from each of the other three more than fifty were obtained. With but one exception the bottom was "very fine, green sand." From exceptional station, D 5791, very little bottom material was brought up other than "refuse and garbage." The ranges for temperature and salinity recorded at the time of making the various hauls were respectively 9.3° to 12.2° C and 33.9 to 34.4. *Crago alaskensis elongata* also occurred quite abundantly at each of these stations.

### *Pandalus montagui tridens* Rathbun

Plate 13, figure 2

*Pandalus montagui tridens* Rathbun, Proc. U. S. Nat. Mus., 24, 901, 1902; H. A. E., 10, 41, pl. 2, fig. 2, 1904.

*Characters.*—Rostrum slender, from one and one-half to one and four-fifths times the length of carapace. Dorsal spines ten to twelve in number, all movable, three to five on the carapace and the remainder on the basal half of the rostrum; posterior spine just in front of middle of carapace; inferior spines six or seven, rigid; distal two-thirds of rostrum ascending, tip trifid. Antennal scale with outer margin slightly arcuate; blade truncate at tip, spine stout, reaching to or beyond the end of blade. Right leg of second pair with carpus divided into twenty to twenty-eight segments. Left leg of second pair with carpus divided into about seventy-four segments. Sixth segment of abdomen slender, about three times as long as wide.



*Dimensions.*—Type, female: length 104 mm.; length of carapace and rostrum 48.5 mm.; of rostrum 30.2 mm. The largest specimen on the Pacific Coast was taken off Point Arena, California, in 239 fathoms ("Albatross" station 3349). It measures 110 mm. long, carapace and rostrum 53 mm., rostrum 34 mm. (Rathbun).

*Type Locality.*—Off North Head, Akutan Island, Alaska, 72 fathoms ("Albatross" station 2842).

*Distribution.*—From Bering Sea to off San Nicolas Island, California, 3 to 1084 fathoms.

*Remarks.*—Miss Rathbun says:

I have separated this form from *P. montagui* Leach of the North Atlantic on account of its somewhat longer rostrum, which varies from one and a half to one and two-thirds times the carapace, the dorsal spines terminating behind the middle of the rostrum, while in typical *P. montagui* the rostrum is from one and two-fifths to one and a half times the carapace, and its dorsal spines reach to or in front of its middle. In *P. montagui* the tip is bifid; in the subspecies usually trifid.

### ***Pandalus platyceros* Brandt**

Plate 14, figure 3

*Pandalus platyceros* Brandt in Middendorff, Reise in den äussersten Norden und Osten Sibiriens, Bd. II, Zool., Th. I, p. 123, 1851; Holmes, Occas. Papers Calif. Acad. Sci., 7, 210, 1900; Rathbun, H. A. E., 10, 44, 1904.

*Characters.*—Body stout. Carapace covered with a dense, short pubescence. Rostrum one and one-half to one and two-thirds times as long as carapace, provided with a broad, entire laminar crest on each side. Median crest arising halfway back on the carapace, armed with fourteen to seventeen spines extending to middle of rostrum, the anterior one to five spines fixed, the rest movable; usually a solitary spine not far behind the acute tip. Lower limb armed with seven or eight fixed spines, diminishing gradually in size; the basal tooth very large. Posterior part of rostrum deflexed, anterior half or two-thirds ascending, tip above level of carapace. Antennal scale four-fifths to seven-eighths as long as carapace, oblong, extremity of blade subtruncate, slightly exceeded by the spine. Right leg of second pair reaching to end of maxillipeds, carpus eight- to nine-jointed; left leg of second pair two-fifths again as long as right; carpus divided into twenty-seven or twenty-eight joints. Sixth segment of abdomen short and stout, one and one-half times as long as wide.

*Dimensions.*—Type: length of carapace 34.9 mm., of rostrum 38.1 mm., of abdomen 46.6 mm., of caudal appendages 19.1 mm.; total length 138.7 mm. Of an ovigerous female, length 214 mm., length of carapace and rostrum 113 mm., of rostrum 68 mm. (Rathbun).

*Type Locality.*—Unalaska.

*Distribution.*—Unalaska to off San Diego, California, 25 to 266 fathoms. Japan (Balss). The 25-fathom record here cited was made off Portuguese Bend, near San Pedro, California, by the Venice Marine Biological Station.

**Pandalus danae** Stimpson

Plate 13, figure 3

*Pandalus danae* Stimpson, Proc. Boston Soc. Nat. Hist., 6, 87, 1857; Jour. Boston Soc. Nat. Hist., 6, 502 (62), pl. 21, figs. 6, 7, 1857; Rathbun, R., The Fisheries and Fishery Industries of the U. S., sec. 1, p. 281, 1884; Holmes, Occas. Papers Calif. Acad. Sci., 7, 209, pl. 4, figs. 61, 62, 1900; Rathbun, H. A. E., 10, 47, fig. 13, 1904.

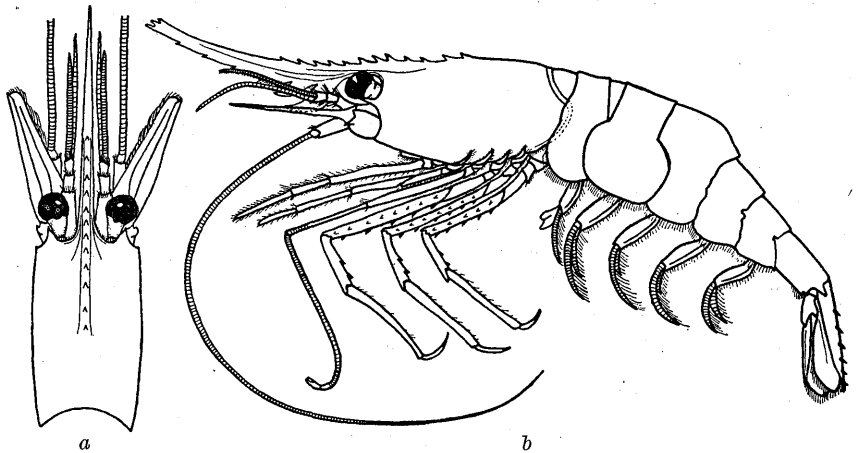


Fig. 25. *Pandalus danae*, ♂, natural size; a, dorsal view of anterior end (proportional lengths of joints of antennular peduncle are not exact in lateral view, use this view); b, lateral view.

*Characters.*—A rather stout species. Surface finely pitted. Rostrum a little longer than the carapace (from one-fifth to one-eighth longer), distal two-thirds directed obliquely upward. Median dorsal spines ten to twelve, movable, about half of them on the carapace, the posterior spine a little behind the middle; terminal half of rostrum unarmed above, apex trifid; lower margin six- to eight-spined, the spines diminishing anteriorly; lateral carinae moderately prominent. Antennal scale from three-fourths to five-sixths as long as carapace, tapering to the extremity, the laminar part of which is rounded, and much exceeded by the spine. Right leg of second pair (exceeds antennal scale) may slightly exceed or fall short of the tip of the rostrum; merus slightly annulated; carpus with from eighteen to twenty-one joints, those of the proximal half very indistinctly marked; left leg one-third or nearly half again as long as right leg; merus and distal portion of ischium faintly annulated; about sixty carpal segments. Sixth segment of abdomen one and two-thirds as long as wide.

*Dimensions.*—Type: length 63.5 mm. The specimens taken in connection with the Bay Survey ranged between 55 and 114 mm. in length, exclusive of rostrum.

*Type Locality.*—Puget Sound.

*Distribution.*—From Sitka, Alaska, to San Francisco, California, 10 to 101 fathoms.

*Biological Survey of San Francisco Bay.*—*Pandalus danae* was found almost exclusively in the deeper portions of the middle bay, the region of greatest abundance being the outer central part of Golden Gate where three (D 5738, 5808, 5809) of the six stations from which it is recorded are located, and where 97 per cent of all the specimens caught were taken. The other three stations (D 5700, 5827, 5828) were made, one off Sausalito, one just to the westward of Alcatraz, and the third in mid-channel off the southern end of the east side of Angel Island (plate 5).

A summary of the above stations indicates quite a close correspondence between the depth, character of bottom, and the number of specimens obtained:

| Station | Depth  | Character of bottom   | Number of specimens |
|---------|--------|---|---------------------|
| D 5808  | 27-43  | Coarse sand, gravel and stones, ranging up to 14 inches in length.  | 23                  |
| D 5738  | 23-60  | Large rocks with very little coarse shelly sand.  | 3                   |
| D 5809  | 21½-53 | Coarse sand, gravel and stones.   | 3                   |
| D 5700  | 17-19  | Sand, coarse and fine gravel, broken shells.  | 2                   |
| D 5827  | 6-17   | Clean, coarse sand and gravel, stones of all sizes up to width of hand and one-half inch thick at beginning, and sand and fine gravel and no stones at end of haul. | 1                   |
| D 5828  | 10-16  | Variegated mud, containing some sand and many shells at beginning, and sand and fine gravel with some shell fragments and living mollusks at end of haul.           | 1                   |

As no specimen was taken at a temperature exceeding 12.2° C and none in a salinity less than 25.7 it is apparently the combination of the effects of higher temperature, lower salinity, shoaler water together with that of the character of the bottom which restricts the range of *Pandalus danae* in the bay, except in the section from which it is here recorded.

This is graphically demonstrable on the temperature and salinity curves figured by Sumner in his report upon the physical conditions in the Bay (1914, figs. B and M): The occurrence of this species far north of the southern shore of Angel Island, or at most the head of Raccoon Strait or south of Goat Island, would be restricted from January to July (periods I, II, III, and VI of Sumner) by rapid falling of the salinity below the minimum value, 25.7, established above, and from February to October (periods I, II, III, and IV) by the rise of temperature above 12.2° C. By the process of elimination only the months of November and December (period V of Sumner)

would have conditions of temperature and salinity favoring an extension of the range of *Pandalus danae*, but at this period as well as during the remainder of the year it is no doubt the absence of sufficient areas of favorable bottom elsewhere in the bay, together with the decrease in depth, that exercises the potent influence in restricting this species to the region of its observed distribution.

It is impossible to explain why no specimens of *Pandalus danae* were taken outside, for Dr. Rathbun says (1884, p. 821):

This Prawn has been much more abundant in the San Francisco markets during the past two years than formerly, and the reason assigned is that the fishermen, driven out of San Francisco Bay by the constantly diminishing supply of fish there, have been forced to resort to the open sea between the Farallone Islands and Point Reyes, where the Prawns live in large numbers.

### *Pandalus gurneyi* Stimpson

Plate 13, figure 1

*Pandalus gurneyi* Stimpson, Ann. Lyc. Nat. Hist., N. Y., 10, 128, 1871;  
Rathbun, H. A. E., 10, 50, pl. 2, fig. 6, 1904.

*Characters*.—Very near *P. danae*. Rostrum one and one-half to one and two-thirds longer than the carapace. Median dorsal spines eight or nine, all movable, rather distant; ventral spines nine or ten, immovable. Antennal scale as long as carapace. Right leg of second pair extends to tip of acicle, carpal segments seventeen; left leg one-third longer than right, carpal segments about forty-five. Sixth segment of abdomen one and one-half times as long as wide.

*Dimensions*.—Ovigerous female: length 77.5 mm., length of carapace and rostrum 38.5 mm., of rostrum 25 mm. (Rathbun).

*Type Locality*.—Monterey, California.

*Distribution*.—Monterey to San Pedro, and Santa Catalina Island, California, 9 to 55 fathoms.

### Genus *Pandalopsis* Bate

Antennules twice the length of the carapace. Merus of third maxillipeds with inner margin longitudinally developed into a broad laminate expansion fringed with long hairs. Ischium of first pair of thoracic legs also with large laminate expansion, the lower margin of which is fringed with a row of hairs on the inner side.

### *Pandalopsis ampla* Bate

Plate 14, figure 2

*Pandalopsis ampla* Bate, "Challenger" Rept., Zool., 24, Macrura, p. 671, pl. 175, fig. 3, 1888.

*Pandalopsis ampla* Faxon, Mem. Mus. Comp. Zool., 18, 155, 1895; Rathbun, H. A. E., 10, 51, 1904.

*Characters.*—Surface remotely punctate. Rostrum one and one-third to one and nine-tenths as long as rest of the carapace (in small specimens it may be two and one-half times the carapace), slightly ascending, slightly arched above the eyes. Median crest occupying the anterior two-thirds of the carapace, armed with seven to thirteen movable spines, of which three to five are on the carapace and in front of the middle, the anterior spine considerably behind the middle of the rostrum. There is also a subterminal fixed spine; and occasionally two subterminal spines, both above, or one above and one below. Greater part of the rostrum unarmed above; lower margin armed with thirteen to sixteen slender spines, larger toward the base of the rostrum. Antennal scale four-fifths to eight-ninths as long as carapace; blade broadly rounded at the tip and exceeded by the spine. Ischium of first pair of feet is dilated in a thin, broad, laminar, inferior projection which is anteriorly lobiform. Feet of second pair equal, carpus with twenty to twenty-four segments; the right and left carpus may or may not have an equal number of segments; chela as long as the five adjacent segments of the carpus. Third segment of abdomen moderately produced backward in the middle, forming a lobe in the posterior margin; sixth segment nearly two and one-half times as long as wide, and about two-thirds as long as the telson.

*Dimensions.*—Of a specimen measured by Miss Rathbun: length 164 mm.; length of carapace and rostrum 85.7 mm.; of rostrum 87.6 mm.

*Type Locality.*—Off Monte Video, 600 fathoms ("Challenger").

*Distribution.*—From Washington to Mexico, and off Monte Video; 302 to 1084 fathoms.

### Family HIPPOLYTIDAE

Rostrum almost always a prominent feature, armed with teeth, and laterally compressed, usually well developed, sometimes, however, even shorter than the eye-stalks. Mandibles various, with incisor process and palp, or without either or both. First pair of legs chelate and moderately stout, stouter and shorter than second pair. Second pair chelate, slender, and equal, with segmented carpus.

#### KEY TO THE CALIFORNIA GENERA OF THE HIPPOLYTIDAE

- I. Carpus of second pair of legs with more than seven segments. Mandible without incisor process or palp. (Not known north of Santa Barbara.)  
*Hippolysmata*, p. 49.
- II. Carpus of second pair of legs with seven segments. Mandible with incisor process and palp of two segments.  
*Spirontocaris*, p. 50.
- III. Carpus of second pair of legs with three segments. Mandible with incisor process but without palp.  
*Hippolyte*, p. 47.

### Genus *Hippolyte* Leach

Carpus of second pair of legs consisting of three segments. Mandible with an incisor process but without a palp. Carapace with a supraorbital spine.

**Hippolyte californiensis** Holmes

*Hippolyte californiensis* Holmes, Proc. Calif. Acad. Sci., (2), 4, 576, figs. 21-26, 1895; Occas. Papers Calif. Acad. Sci., 7, 193, 1900; Rathbun, H. A. E., 10, 56, 1904.

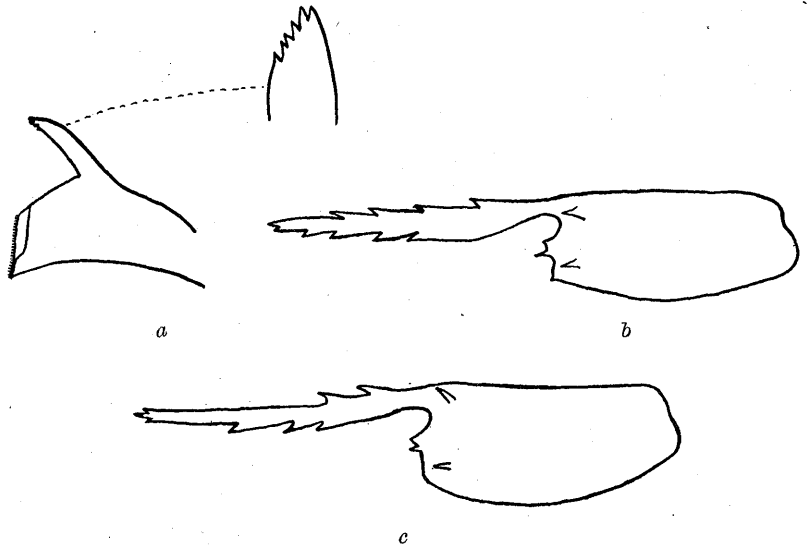


Fig. 26. *Hippolyte californiensis*; a, mandible; b, lateral view of carapace (from Holmes); c, lateral view of carapace,  $\times 8$ , showing arrangement of rostral spines most commonly met with.

*Characters*.—Rostrum slender, a little longer than the carapace, armed both above and below with three to five, exceptionally six teeth; anterior tooth of each series usually situated immediately behind the acuminate tip, giving it a more or less trifid appearance; remaining teeth of upper series usually more or less bunched over the eye and confined to the basal half of the rostrum; base of rostrum rounded and not continued upon the carapace. Antennular peduncle about one-half as long as rostrum. Abdomen not crested or carinated; telson truncated and spinulose at the tip.

*Dimensions*.—Type: length 38 mm.

*Color*.—Green (Holmes).

*Type Locality*.—Bodega Bay, California.

*Distribution*.—From Sitka, Alaska, to San Diego, California (Rathbun).

*Remarks*.—"In a lot of eleven specimens from Puget Sound, the dorsal teeth are usually two, in one case three, on the basal half of the rostrum, and one or none near the tip. In a few individuals from San Diego the rostral teeth are typical" (Rathbun). In another lot of over fifty specimens received from the Venice Marine Biological Station, Venice, California, there is only one "typical" specimen. The rostrum figured by Holmes as the type seems to be a comparatively rare variation in the arrangement of the dorsal spines. With but three exceptions the rostral extremity of the Venice specimens is trifid; the exceptional specimens have a bifid rostrum.

Genus **Hippolysmata** Stimpson

Carpus of second pair of legs consisting of more than seven segments. No supraorbital spine. Antennules with two long flagella. Mandible without incisor process or palp.

**Hippolysmata californica** Stimpson

*Hippolysmata californica* Stimpson, Proc. Chicago Acad. Sci., 1, 48, 1896; Ann. Lyc. Nat. Hist. N. Y., 10, 123, 1871; Holmes, Occas. Papers Calif. Acad. Sci., 7, 180, pl. 2, fig. 38, 1900.

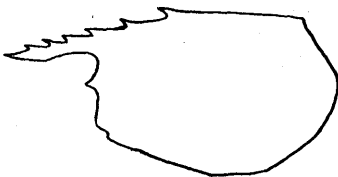


Fig. 27. *Hippolysmata californica*, lateral view of carapace (after Holmes).

*Characters*.—Rostrum slender, strongly ridged on the sides, bent downward near the base, about one-half as long as the carapace; armed above with six or seven teeth, the last tooth situated at considerably more than the usual interval from the preceding one and at about the anterior third of the carapace; below armed with three teeth. Flagella of the antennules subequal and longer than the body. Second pair of legs very long and slender; ischium stouter than the merus and about as long, more or less annulated towards the tip; merus divided into something over twenty annulations; carpus about as long as merus and ischium combined and divided into about thirty-two annulations; hand minute, oblong, the fingers scarcely as long as the palm. Telson subacute, much shorter than the uropods.

*Dimensions*.—Type: length 31.8 mm.

*Color*.—Very conspicuously marked with longitudinal stripes of drab and reddish brown (Holmes). Abdomen in life striped longitudinally with red; stripes anteriorly, on carapace, bending obliquely upward; greater part of tail-fan a deep mahogany color, with tips of uropods and telson bluish; antennules, antennae and legs light reddish brown; eggs of ovigerous female light pea-green.

*Type Locality*.—San Diego, California.

*Distribution*.—Santa Barbara to San Diego, California (Rathbun).

*Remarks*.—Found abundantly in tide pools. The teeth on the under side of the rostrum are quite inconspicuous, and are not indicated in the figure taken from Holmes, above.

Genus *Spirontocaris* Bate

Carpus of second pair of legs consisting of seven segments, mandible with incisor process, and palp of two segments.

## KEY TO THE CALIFORNIA SPECIES OF SPIRONTOCARIS

- I. One or more supraorbital spines present.
- A. Rostrum roughly subcircular; three, more rarely two, supraorbital spines. (Not known south of Monterey.) *prionota*, p. 52.
- B. Rostrum not subcircular, more or less elongate; one or two supraorbital spines.
1. One supraorbital spine.
- a. Rostrum comparatively prominent, longer than eye; supraorbital spine relatively small.
- i. Rostrum less than twice as long as the eye; armed above with four spines, two of which are on the carapace, below with three teeth on anterior third. (Known only from 448 + fathoms.) *washingtoniana*, p. 55.
- ii. Rostrum twice or more than twice as long as the eye; armed above with ten teeth, last three of which are on the carapace, below with six teeth, all of which are in front of the middle of the rostrum. (Only one specimen known, from Monterey.) *affinis*, p. 56.
- b. Rostrum inconspicuous, reduced to a spine on frontal margin, much shorter than the eye, supraorbital spines a very prominent feature; behind rostral spine anterior half of carapace is carinated and bears three spines. (Known only from Laguna Beach.) *lagunae*, p. 57.
2. Two supraorbital spines.
- a. Abdominal segments laterally acute. Rostrum shorter than remainder of carapace. Dorsal spines continued posterior to middle of carapace; spines on carapace proper four. (Not known south of Point Arena.) *lamellicornis*, p. 53.
- b. First three abdominal segments laterally rounded.
- i. Rostrum longer than remainder of carapace. Dorsal spines continued at least to or beyond middle of carapace; spines on carapace proper two or three. *bispinosa*, p. 54.
- ii. Rostrum shorter than, rarely as long as, remainder of carapace.
- a. Dorsal spines all in front of middle of carapace, spines on carapace proper two. (Known only from 211 + fathoms.) *sica*, p. 55.
- b. Dorsal spines continued posterior to middle of carapace; spines on carapace proper three or four. *snyderi*, p. 54.



## II. No supraorbital spine or spines.

## A. Rostrum as long as or longer than rest of carapace.

1. Terminal half (at least) of rostrum devoid of spines above. Sixth abdominal segment not longer than the telson.
  - a. Sixth abdominal segment less than twice as long as wide. Rostrum deep, one-fourth as deep as long. (Not known north of Monterey Bay.)
 

*carinata*, p. 62.
  - b. Sixth abdominal segment more than twice as long as wide. Rostrum more slender.
    - i. Scale at base of antennules extending beyond first segment. Third maxilliped with epipod. (Not known south of Drake's Bay.)
 

*fleza*, p. 58.
    - ii. Scale at base of antennules not reaching beyond or only slightly beyond first segment. Third maxilliped without epipod. (Not known south of Santa Catalina Island.)
 

*gracilis*, p. 59.
2. Terminal half of rostrum with spines (in part, at least).
  - a. Sixth abdominal segment longer than telson.
 

*decora*, p. 61.
  - b. Sixth abdominal segment shorter than telson.
    - i. Third maxillipeds exceeding antennal scale. Rostrum with six to eight spines above.
 

*paludicola*, p. 64.
    - ii. Third maxillipeds not exceeding antennal scale.
      - a. Rostrum with more than eight spines above. (Within California region known only from Monterey Bay.)
 

*layi*, p. 63.
      - b. Rostrum with five or six spines above.
        - i. Third maxillipeds reaching about to the middle of the antennal scale. (Not known north of San Francisco Bay or south of Laguna Beach.)
 

*franciscana*, p. 60.
        - ii. Third maxillipeds reaching nearly to end of antennal scale. (Not known south of Santa Cruz.)
 

*kincaidi*, p. 63.

## B. Rostrum shorter than rest of carapace.

## 1. Rostrum elongate, reaching beyond middle of antennal scale.

- a. Upper and lower limbs of rostrum deep and with convex margins. (Known only from 178 + fathoms.)
 

*macrophthalmia*, p. 72.
- b. Upper and lower margins of rostrum not both convex.
  - i. Upper margin of rostrum concave; rostrum armed above with six teeth, the last one of which is on the carapace; below with three teeth. (Known only from 266 + fathoms.)
 

*brachydactyla*, p. 72.
  - ii. Upper margin of rostrum straight; rostrum armed above with six to seven teeth, the last two of which are on the carapace; below with two to four teeth. (Not known north of Monterey Bay.)
 

*picta*, p. 68.

2. Rostrum short, not reaching beyond middle of antennal scale.
- a. Rostrum not reaching as far as cornea. (Not known north of San Francisco Bay.)  
*taylori*, p. 67.
  - b. Rostrum reaching as far as or beyond the cornea.
    - i. Rostrum not reaching second segment of antennular peduncle.
      - a. Antennal scale about equal in length to or shorter than the telson. (Not known south of San Francisco Bay.)  
*brevirostris*, p. 66.
      - b. Antennal scale longer than the telson. (Not known north of San Francisco Bay.)  
*palpator*, p. 65.
    - ii. Rostrum reaching second segment of antennular peduncle and usually beyond.  
*cristata*, p. 69.

As can be seen above, the species of *Spirontocaris* dealt with in this paper arrange themselves readily into four groups based on the number of supraorbital spines; the last of these groups has been subdivided for convenience, owing to the number of species included in it.

- I. Group with more than two supraorbital spines, p. 52.
- II. Group with two supraorbital spines, p. 53.
- III. Group with one supraorbital spine, p. 55.
- IV. Group with no supraorbital spines.
  - a. Rostrum as long as or longer than remainder of carapace, p. 58.
  - b. Rostrum shorter than remainder of carapace, p. 65.

*I. Group with more than two supraorbital spines.*

***Spirontocaris prionota* (Stimpson)**

*Hippolyte prionota* Stimpson, Proc. Acad. Nat. Sci. Phila., 16, 153, 1864; Kingsley, Bull. Essex Inst., 14, 127, pl. 2, fig. 9, 1883.

*Spirontocaris prionota* Walker, Trans. Liverpool Biol. Soc., 12, 277, 1898; Holmes (mis-spelled *prionota*), Occas. Papers Calif. Acad. Sci., 7, 206, 1900; Rathbun, H. A. E., 10, 61, 1904.

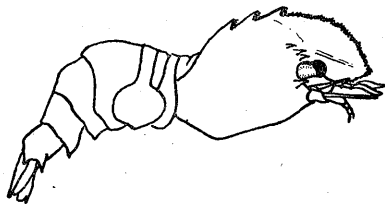


Fig. 28. *Spirontocaris prionota*, lateral view of carapace and abdomen (adapted from Kingsley).

*Characters*.—Carapace with two or three supraorbital spines in a longitudinal series; dorsally crested nearly to the posterior margin and armed with three teeth, the anterior margins of which are armed on either side with a short, transverse row of small spines. Rostrum shorter than the carapace, lamelliform, very deep though not so deep as long; general outline roughly subcircular; anterior

and dorsal margin minutely serrated, with spinuliform teeth, lower margin with four or five small simple teeth. Abdominal segments laterally rounded, except the fourth and fifth which have the posterolateral angle produced into an acute tooth. Dactyls of ambulatory legs about one-half as long as their propodi.

*Dimensions*.—Type: length about 35 mm.

*Type Locality*.—Puget Sound.

*Distribution*.—From Bering Sea to Monterey, California, to 80 fathoms (Rathbun). Japan (Balss).

*Remarks*.—To Kingsley's figure one must add two or three supraorbital spines arranged in a longitudinal series. While three seems to be the normal number the anterior one is often reduced and sometimes wanting (Rathbun). Easily distinguished from the other North Pacific lamelli-rostral species by serrate margin of dorsal teeth, and rostrum (Stimpson).

## II. Group with two supraorbital spines.

### *Spirontocaris lamellicornis* (Dana)

*Hippolyte lamellicornis* Dana, Proc. Acad. Nat. Sci. Phila., 6, 24, 1852; Crust. U. S. Expl. Exped., 1, 576, 1852, pl. 36, fig. 6, 1855.

*Spirontocaris lamellicornis* Holmes, Occas. Papers Calif. Acad. Sci., 7, 208, 1900; Rathbun, H. A. E., 10, 62, fig. 18, 1904.



Fig. 29. *Spirontocaris lamellicornis*, ♀, lateral view of carapace,  $\times 1\frac{1}{2}$  (from Rathbun, U. S. N. M.).

*Characters*.—Abdominal segments laterally acute. Rostrum with mid-rib horizontal or but slightly ascending, about three-fourths as long as the rest of the carapace, broad and lamellate, continued backward nearly to posterior margin of carapace. Median spines of carapace proper four, rather larger than the rostral teeth which number about six above; below there are two teeth, of which the anterior forms the lower of the two teeth forming the bifid tip of the rostrum. Dactyls of the last pair of ambulatory legs about half as long as their propodi.

*Dimensions*.—Types: length 38 to 50.8 mm.

*Type Locality*.—Dungeness, Straits of Fuca.

*Distribution*.—This species occurs sparingly from Unalaska to Point Arena, California, 9 to 77 fathoms (Rathbun).

*Remarks*.—The number of supraorbital spines for this species as figured by Dana is only one. This is either an error or an abnormality for an examination of all the U. S. National Museum material of this species fails to show any exception to the rule of two supraorbital spines. Dana also has the first abdominal segment laterally rounded, which is only exceptionally the case; as a rule it is acute.

**Spirontocaris bispinosa** Holmes

*Spirontocaris bispinosa* Holmes, Occas. Papers Calif. Acad. Sci., 7, 207, 1900; Rathbun, H. A. E., 10, 68, fig. 23, 1904.

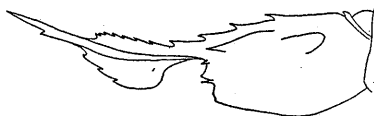


Fig. 30. *Spirontocaris bispinosa*, ♀, lateral view of carapace,  $\times 2$  (from Rathbun, U. S. N. M.).

*Characters.*—Rostrum a little longer than remainder of carapace. Distal half of rostrum a slender, styliform process, with a strong upward trend, devoid of teeth above and with a single tooth below. Basal half of rostrum high and laminate, continued backward over the anterior two-thirds of the carapace as a carina, armed above with ten to twelve teeth which decrease in size and become more closely set anteriorly, there being several small teeth crowded together where the rostrum is abruptly narrowed; the two posterior dorsal teeth are the two median spines of the carapace proper; below the basal half of the rostrum is armed with three or four low teeth. First three abdominal segments laterally rounded. Dactyls of ambulatory legs about one-half as long as their propodi.

*Dimensions.*—Of an ovigerous female, approximate length 59.5 mm., length of carapace and rostrum 25.2 mm., of rostrum 14.8 mm. (Rathbun).

*Type Locality.*—Puget Sound.

*Distribution.*—From Yes Bay, Alaska, to off San Diego, California, 13 to 211 fathoms.

**Spirontocaris snyderi** Rathbun

*Spirontocaris snyderi* Rathbun, Proc. U. S. Nat. Mus., 24, 894, 1902; H. A. E., 10, 69, fig. 24, 1904.



Fig. 31. *Spirontocaris snyderi*, ♀, lateral view of carapace,  $\times 2\frac{1}{2}$  (from Rathbun, U. S. N. M.).

*Characters.*—Median spines of the carapace proper three or four; between these spines and the small ones on the rostrum there is a considerable space; rostral teeth five or six above and three or four below. Rostrum a little shorter than remainder of the carapace, much the shape of that of *S. bispinosa* except that the mid-rib is more rapidly ascending and ends in a short point and that the upper lamina is more shallow and of rather even depth. First three abdominal segments laterally rounded. Dactyls of ambulatory legs one-third as long as their propodi or less than one-third.

*Dimensions*.—Type, ovigerous female: approximate length, 28 mm.; length of carapace and rostrum 9.4 mm., of rostrum 4.4 mm.

*Type Locality*.—Monterey Bay, California.

*Distribution*.—Puget Sound to Lower California, 44 to 77 fathoms (Rathbun).

*Remarks*.—This species bears a curious resemblance to *S. bispinosa*; in general terms it is a *bispinosa* with the slender spine of the rostrum broken off; but a closer examination shows other and more radical differences (Rathbun).

### *Spirontocaris sica* Rathbun

*Spirontocaris sica* Rathbun, Proc. U. S. Nat. Mus., 24, 894, 1902; H. A. E., 10, 69, fig. 25, 1904.



Fig. 32. *Spirontocaris sica*, ♀, lateral view of carapace,  $\times 1\frac{1}{2}$  (from Rathbun, U. S. N. M.).

*Characters*.—Near *S. bispinosa*. Posterior median tooth of carapace considerably in front of middle. Rostrum shorter than in *S. bispinosa*; upper and lower laminae narrower and extending nearer the tip; armed with nine to fourteen teeth above (in *S. bispinosa* ten to twelve), the last two of which are on the carapace; below with three to five teeth on the lamina (as in *S. bispinosa*), but none on the slender terminal portion. First three abdominal segments laterally rounded. Dactyls of ambulatory legs about one-third as long as their propodi.

*Dimensions*.—Type, female: length 58 mm.; length of carapace and rostrum 24.8 mm., of rostrum 12.8 mm.

*Type Locality*.—Santa Barbara Channel, 265 fathoms ("Albatross" station 3200).

*Distribution*.—Off the coast of California, from Point Arena to San Diego, 211 to 464 fathoms (Rathbun).

### III. Group with one supraorbital spine.

#### *Spirontocaris washingtoniana* Rathbun

*Spirontocaris washingtoniana* Rathbun, Proc. U. S. Nat. Mus., 24, 895, 1902; H. A. E., 10, 76, fig. 30, 1904.



Fig. 33. *Spirontocaris washingtoniana*, ♀, lateral view of carapace,  $\times 2\frac{1}{2}$ , (from Rathbun, U. S. N. M.).

*Characters.*—Carapace stout, carinated in its anterior half; posterior median spine situated at the anterior fourth of the carapace. Rostrum slender, half as long as the carapace, reaching just to end of first segment of the antennules, nearly horizontal, slightly sinuous; dorsal spines four, two of which are on the carapace; anterior two-fifths of rostrum unarmed above, armed below with three teeth on anterior third, one tooth close to the tip; except for the teeth the rostrum is scarcely limbed above or below. Basal scale of antennules about two-thirds as long as the first segment of the peduncle. Abdomen narrow compared with carapace; posterior margin of third segment is moderately produced; sixth segment one and one-half times as long as fifth, and a little more than one-half as long as the telson.

*Dimensions.*—Type, female: length 39 mm., of carapace and rostrum 14 mm., of rostrum 5 mm.

*Type Locality.*—Off Sea Lion Rock, Washington, 685 fathoms ("Albatross" station 3071).

*Distribution.*—Has also been taken east of San Clemente Island, California, 448 to 468 fathoms ("Albatross" station 4401; 1 ♀).

### *Spirontocaris affinis* (Owen)

*Hippolyte affinis* Owen, in *Zoology of Captain Beechey's Voyage* (in the "Blossom"), *Crustacea*, p. 90, pl. 27, fig. 4, 1839; *Holmes, Occas. Papers Calif. Acad. Sci.*, 7, 194, 1900.

*Spirontocaris affinis* Rathbun, *H. A. E.*, 10, 77, 1904.

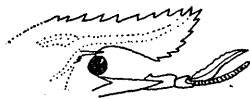


Fig. 34. *Spirontocaris affinis*, lateral view of anterior portion (after Owen).

*Characters.*—Depth of rostrum greater than one-third but not quite equal to half its length; rostrum shorter than the antennules but exceeding their peduncles; armed above with ten more or less evenly spaced, subequal teeth, the last three of which are on the carapace; armed below with about six teeth, all in front of the middle of the rostrum. The spine on the outer side of the base of the antennules exceeds the first segment of the peduncle in length. Fifth segment of abdomen laterally unarmed.

*Dimensions.*—Type: length 38 mm.

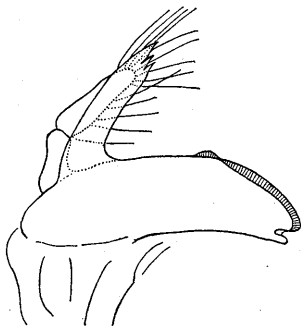
*Color.*—Red (Owen).

*Type Locality.*—Monterey, California.

*Remarks.*—Has not been reported since Owen's original description.

**Spirontocaris lagunae** sp. nov.

Plate 12, figures 10 and 11

Fig. 35. *Spirontocaris lagunae*, ♀, mandible, much enlarged.

*Description*.—Carapace about one-half as long as abdomen, exclusive of telson; surface with small, scattered tufts of setae. Rostrum very small, reduced to a mere spiniform tooth; supraorbital spine well developed, prominent, reaching beyond the frontal margin of the carapace by about half the length of the eye-stalk; behind the rostrum the carapace is more or less carinated, carina bearing three teeth on anterior half of carapace, and fading out toward posterior margin; of these teeth the median is much the largest, being about twice the size of the other two, which are subequal; posterior tooth at about the middle of the carapace; anterolateral margin with subocular, antennal and branchiostegal spines. Antennular peduncle reaching forward about half the length of the antennal scale, flagella attaining its extremity; antennal peduncle about as long as or slightly longer than antennular peduncle. Mandible with incisor process and palp of two segments. Third pair of maxillipeds exceeding the antennal peduncle but falling short of the tip of the scale. Carpus of second pair of legs with seven segments. Propodi of ambulatory legs spinulose below, dactyls with five corneous spines, increasing in size to the last or terminal one; terminal spine and the one next adjacent subequal, making the dactyl appear biunguiculate.

First three abdominal segments laterally rounded; epimera of fourth somewhat, and fifth pronouncedly drawn out into a backward pointing, acute, spine-tipped process, armed on the posterior margin with a second spine a little distance above the first; postero-ventral angle of sixth segment prolonged into a strong, stout spine, above which, on the posterior margin, there is a much shorter, weaker one; on the ventral surface of this segment there is a blunt, conical tubercle, at about the anterior fourth of the median line; dorsal surface of telson with three pairs of spinules.

*Dimensions*.—Type (Cat. No. 52711, U. S. N. M.), ovigerous female: length about 20 mm.

*Color*.—Type, “kelp color” (Hilton). The label on two other specimens also collected by Prof. W. A. Hilton reads: “Body light, legs darker, red and black on appendages.”

*Type Locality*.—Known only from two ovigerous females and one male specimen dredged at Laguna Beach, California, by Prof. W. A. Hilton. Of these the male and one female were taken August 27, 1917, in 12 to 15 fathoms.

*Remarks.*—From the great development of the supraorbital spines it would appear that this species is referable to the genus *Alope* White, from which it differs, however, in having a mandibular palp of only two segments instead of three as is characteristic of that genus.

IV. Group with no supraorbital spines.

Section a. Rostrum as long as or longer than remainder of carapace. (In this subgroup, with the exception of *S. paludicola*, the third maxillipeds do not exceed the antennal scale. In *S. gracilis*, *flexa*, *carinata*, and *franciscana* the third maxillipeds reach about to the middle of the antennal scale or only slightly beyond the middle. In *S. decora* they extend well beyond the middle and in *S. kincaidi* nearly to the end of the scale, but in neither do they quite attain its end or at all exceed it. In *S. paludicola*, mentioned above, the third maxillipeds slightly exceed the tip of the antennal scale. The length of the third maxillipeds of *S. layi* is not known.) (For section b, see p. 65.)

**Spirontocaris flexa** Rathbun

*Spirontocaris camtschatica* Rathbun, The Fur Seals and Fur-Seal Islands of the North Pacific Ocean, pt. III, p. 557, 1899, not *S. camtschatica* (Stimpson).

*Spirontocaris flexa* Rathbun, Proc. U. S. Nat. Mus., 24, 986, 1902; H. A. E., 10, 78, fig. 32, 1904.

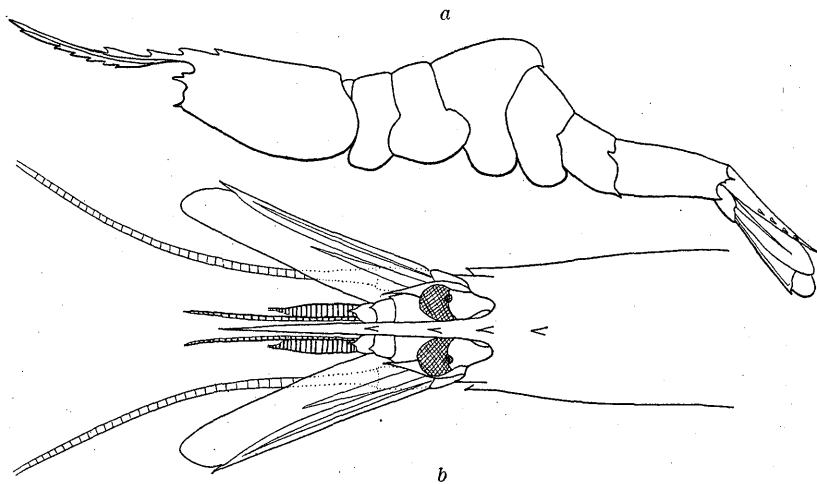


Fig. 36. *Spirontocaris flexa*, ♀; a, lateral view of carapace and abdomen,  $\times 2\frac{1}{2}$ ; b, dorsal view of anterior portion,  $\times 3\frac{3}{4}$  (from Rathbun, U. S. N. M.).

*Characters.*—Rostrum slender, armed with four or five teeth above, including one or two on the carapace, anterior tooth near middle of rostrum; anterior half of rostrum not limbed above; lower limb narrow and armed with from five to eight spines. Basal spine of the antennules extends beyond the first segment of the peduncle. The abdomen is strongly geniculated at the third segment, which is posteriorly produced and compressed, forming a smooth, rounded carina; sixth segment more than twice but not three times as long as wide, and shorter than the telson.



*Dimensions*.—Type, female: length 54 mm.; of carapace and rostrum 20 mm.; of rostrum 11.5 mm.

*Type Locality*.—North of Bird Island, Shumagins, Alaska, 21 fathoms ("Albatross" station 2850).

*Distribution*.—From Bering Sea to Drake's Bay, California, 20 to 93 fathoms (Rathbun).

*Remarks*.—This species is very near *S. gracilis*, from which it differs in the longer basal scale of the antennules, in the lower position of the pterygostomial spine, in the presence of epipods on the maxilliped and first two pairs of feet (Rathbun).

### *Spirontocaris gracilis* (Stimpson)

*Hippolyte gracilis* Stimpson, Proc. Acad. Nat. Sci. Phila., 16, 155, 1864.

*Heptacarpus tenuissimus* Holmes, Occas. Papers Calif. Acad. Sci., 7, 203, 1900.

*Heptacarpus? gracilis* Holmes, *ibid.*, 7, 205, 1900.

*Spirontocaris gracilis* Rathbun, H. A. E., 10, 77, fig. 31, 1904.

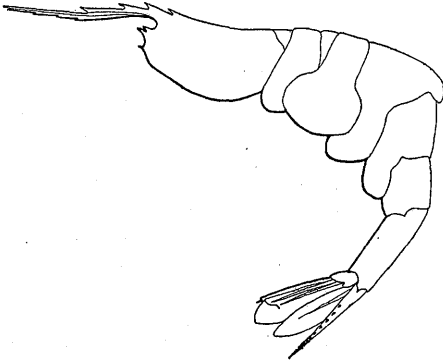


Fig. 37. *Spirontocaris gracilis*, ♀, lateral view, × 2 (from Rathbun, U. S. N. M.).

*Characters*.—Rostrum very slender, similar to that of *S. flexa*, scarcely higher than wide; armed above with four spines, the posterior on the carapace, the anterior near middle of rostrum; armed below with four or five small distant teeth. The spine on the outer side of the base of the antennules does not reach beyond, or only slightly beyond the first segment of the peduncle. Third maxilliped without an epipodite (see *Remarks*). Abdomen strongly geniculated or bent at a right angle at the third segment, which is posteriorly produced and compressed forming a smooth, rounded carina; sixth segment more than twice but not three times as long as wide, and not longer than the telson.

*Dimensions*.—Type: length 31.8 mm.

*Type Locality*.—Puget Sound.

*Distribution*.—From the Shumagins, Alaska, to Santa Catalina Island, California, 21 to 47 fathoms.

*Remarks*.—This is, so far as known, the only *Spirontocaris* from the west coast of America in which the third maxilliped lacks an epipodite.

*Biological Survey of San Francisco Bay*.—*Spirontocaris gracilis* was taken at three outside stations, D 5785, 5786, 5791, which were

made at a depth of 29 to 40 fathoms, in close correspondence with its known bathymetric range (see *Distribution* above). The bottom at the first two of these stations was "very fine, dark green sand," at the last one practically nothing but "refuse and garbage." The range of bottom temperature at these stations was 9.6° to 9.8° C; the range of salinity, 34.2 to 34.3.

### *Spirontocaris franciscana* sp. nov.

Plate 12, figures 8 and 9

*Description*.—Rostrum about one-fourth longer than the carapace, only slightly exceeding the antennal scale; armed above with five teeth, the last of which is situated on the carapace, while the most anterior is slightly more than one-third, about two-fifths, the length of the rostrum from the tip; armed below with six to seven teeth, the most anterior of which is the smaller and is situated immediately behind the acute tip, thus giving the rostral extremity a bifid appearance. The suborbital angle of the carapace is prominent and the antennal spine is well developed, but there is no trace of a pterygostomial spine.

Thinner flagellum of the antennules exceeds the blade of the antennal scale by as much as the blade exceeds the spine; thicker flagellum extends four-fifths the length of the antennal scale; basal scale of antennules not reaching beyond proximal margin of the first segment of the peduncle. Antennal peduncle reaching about as far forward as the antennular peduncle; antennal scale (measured along outer margin) about equal to the carapace in length.

The maxillipeds about reach or just fall short of the middle of the antennal scale. First pair of feet reach as far forward as the eyes, the second exceed the maxillipeds by the length of the hand, the third pair by about one-third the length of their propodal joints, and the fourth pair by the length of their dactyli, while the last or fifth extend only as far forward as the tips of the maxillipeds. This species, like *S. stylus*, has an epipod but no exopod on the third maxilliped, and has all the thoracic feet without epipods.

Abdomen strongly geniculated at the third segment, which is more or less evenly rounded above; sixth segment shorter than the telson; telson with four to six pairs of lateral spinules.

*Dimensions*.—Type (Cat. No. 50439, U. S. N. M.), ovigerous female: length 46 mm., of carapace and rostrum 17 mm., of rostrum 10 mm.

*Color*.—"Plain reddish brown (pale)." Taken from the label of a specimen collected by Prof. W. A. Hilton at Laguna Beach.

*Type Locality*.—San Francisco Bay ("Albatross" station D 5770).

*Distribution*.—San Francisco Bay and Laguna Beach, California, 2¼ to 7½ fathoms.

*Remarks*.—This species is close to *Spirontocaris stylus* of Stimpson (see Rathbun, 1904a, p. 84, for description), and like it lacks a pterygostomial spine, but differs, however, in that the teeth of the dorsal margin of the rostrum extend forward onto its distal half; the rostrum too, is shorter, and the antennal peduncle longer in *S. franciscana*, which also, withal, is the stouter and more robust species of the two.

One of the San Francisco Bay specimens (the single one taken at D 5778) has the anterior dorsal tooth at the middle of the rostrum, and did it not coincide so closely in all other points, I should be inclined to doubt its identity.

*Biological Survey of San Francisco Bay.*—Only four specimens of this species were taken in the bay; three in 5 to 7½ fathoms, from the “rough, rocky bottom” to the eastward of Point Bonita (D 5770); and one also from a hard bottom of “fine clean gray sand, and medium sized rounded stones” in 2½ to 3½ fathoms on the bay side of Fort Point (D 5778).

### *Spirontocaris decora* Rathbun

*Spirontocaris decora* Rathbun, Proc. U. S. Nat. Mus., 24, 896, 1902; H. A. E., 10, 79, fig. 33, 1904.

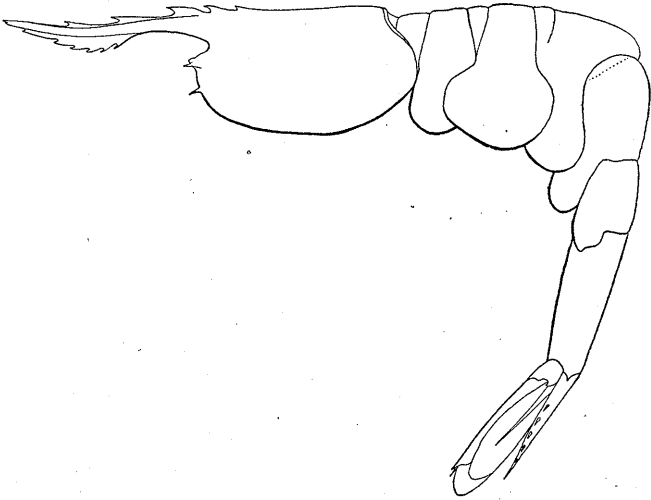


Fig. 38. *Spirontocaris decora*, ♀, lateral view, × 3 (from Rathbun, U. S. N. M.).

*Characters.*—Sixth abdominal segment longer than the telson, nearly three times as long as wide. Rostrum longer than the carapace, armed above with four or five teeth, of which one or two are on the carapace, anterior tooth in front of middle of rostrum. Rostrum not deep, but less slender than in *S. gracilis* and *S. flexa*, a little concave above, but nearly horizontal; lower limb narrowing distally from near posterior end, armed with six to eight teeth; tip acuminate. Basal spine of antennules reaching about to end of first segment of the peduncle. Posterior margin of third segment of abdomen is produced backward in the middle, and the segment itself is posteriorly prominent but not laterally pinched or carinated as in allied species.

*Dimensions.*—Type, female: approximate length 47 mm., length of carapace and rostrum 16.4 mm., of rostrum 9 mm.

*Type Locality.*—Off Santa Cruz Island, California (“Albatross” station 2946).

*Distribution.*—From Straits of Fuca to San Diego, California, 50 to 171 fathoms (Rathbun).

**Spirontocaris carinata** (Holmes)

*Heptacarpus carinatus* Holmes, Occas. Papers Calif. Acad. Sci., 7, 202, pl. 3, fig. 60, 1900.

*Spirontocaris carinata* Rathbun, H. A. E., 10, 84, 1904.

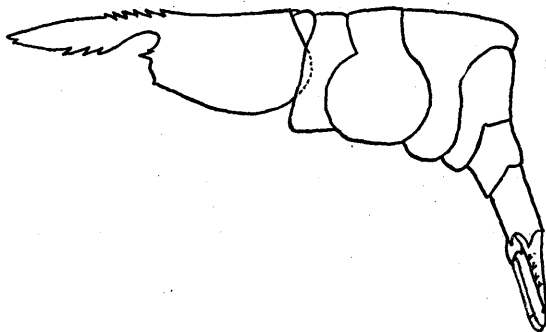


Fig. 39. *Spirontocaris carinata*, lateral view of carapace and abdomen (after Holmes).

*Characters*.—Rostrum deep, one-fourth as deep as long; armed above with four to six small teeth, the posterior one on the carapace, the anterior one a little behind the middle of the rostrum, below with four to six teeth, the anterior of which is commonly near the tip. Basal spine of the antennules reaches about to the tip of the first segment of the peduncle. Third segment of abdomen is posteriorly produced and crested; sixth less than twice as long as wide, and shorter than the telson.

*Dimensions*.—Single specimen in the U. S. National Museum: length from tip of rostrum to end of telson 48 mm., of rostrum 9 mm., of carapace 9 mm., of telson 6 mm.

*Color*.—Varies with surroundings. Specimens among bright green seaweeds are of a uniform bright green color, while the specimens living only a few yards away among the red seaweeds imitate almost exactly the color of the algae that surround them (Holmes).

*Type Locality*.—Monterey Bay, California.

*Distribution*.—From Monterey Bay, shallow water (Holmes), to Point Loma, California ("Albatross" one specimen) (Rathbun). I have also seen a specimen dredged at Laguna Beach by Prof. W. A. Hilton in 10 to 15 fathoms.

*Remarks*.—The eyes of this species are very slender. The antennular peduncles extend about one-third the length of acicle (Rathbun).

**Spirontocaris kincaidi** Rathbun

*Spirontocaris kincaidi* Rathbun, Proc. U. S. Nat. Mus., 24, 899, 1902;  
H. A. E., 10, 95, fig. 43, 1904.

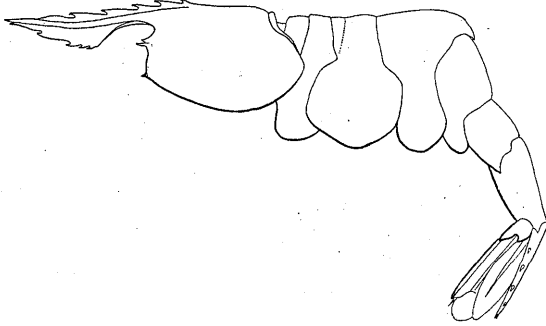


Fig. 40. *Spirontocaris kincaidi*, ♀, lateral view,  $\times 2\frac{1}{2}$  (from Rathbun, U. S. N. M.).

*Characters*.—Carapace short in relation to the abdomen. Rostrum one-third longer than the carapace, not reaching tip of antennal scale, slightly concave above, horizontal; armed above with five, occasionally six teeth, two of which are on the carapace, anterior dorsal tooth a little in front of the middle of the rostrum; tip acute; lower limb tapering from a point in front of the eye to the tip, armed with five teeth, one subterminal. Basal spine of the antennules reaching distal margin of the second segment of the peduncle. Posterior margin of the third abdominal segment is produced backward into a pronounced lobe; the abdomen is strongly bent at this point; the fourth segment is spineless; the sixth is barely twice as long as wide or high, and a little shorter than the telson.

*Dimensions*.—Type, ovigerous female: approximate length 36.5 mm., length of carapace and rostrum 13.6 mm., of rostrum 7.7 mm.

*Type Locality*.—Off Santa Cruz, California, 21 fathoms (“Albatross” station 3124).

*Distribution*.—Puget Sound to San Pedro, California, 21 to 100 fathoms.

**Spirontocaris layi** (Owen)

*Hippolyte layi* Owen, in *Zoology of Captain Beechey’s Voyage* (in the “Blossom”), *Crustacea*, p. 90, pl. 27, fig. 3, 1839; Bate in *Lord’s Naturalist in British Columbia*, 2, 279, 1866; Lockington, *Bull. Essex Inst.*, 10, 161, 1878.

*Spirontocaris layi* Rathbun, H. A. E., 10, 96, 1904.



Fig. 41. *Spirontocaris layi*, lateral view of anterior portion (after Owen).

*Characters*.—Rostrum armed above with about ten unequally spaced teeth, the last three of which are on the carapace; below with four or five nearly equal teeth in front of the middle of the rostrum.

*Dimensions*.—Type: length, 63.5 mm.

*Color*.—Red (Owen).

*Type Locality*.—Monterey, California.

*Distribution*.—Monterey, California (Owen), Esquimalt Harbor, Vancouver Island (Bate).

### *Spirontocaris paludicola* (Holmes)

*Heptacarpus paludicola* Holmes, Occas. Papers Calif. Acad. Sci., 7, 201, pl. 3, figs. 56, 57, 1900.

*Spirontocaris paludicola* Rathbun, H. A. E., 10, 101, 1904.

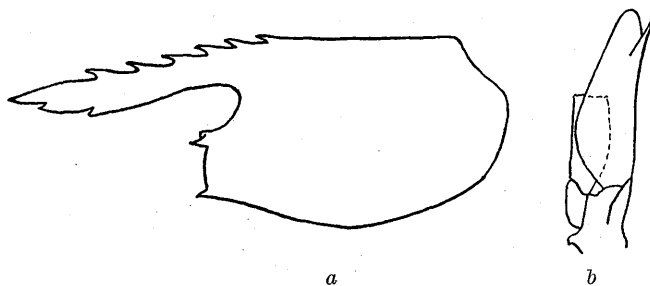


Fig. 42. *Spirontocaris paludicola*; a, lateral view of carapace; b, acicle (after Holmes).

*Characters*.—Third maxillipeds exceeding the antennal scale. Rostrum slender, about as long as carapace, reaching nearly to or slightly beyond the end of the antennal scale, armed above with six to eight evenly spaced teeth, the last tooth on the anterior fourth of the carapace; armed below with two to four teeth on the distal third or two-fifths of the rostrum. Third segment of the abdomen smoothly rounded above, not carinate or with posterior margin produced; sixth segment about one and one-third or one-half times as long as wide and shorter than the telson, which is shorter than the antennal scale.

*Dimensions*.—Length of the specimens taken in San Francisco Bay ranged from 22 to 32 mm., from tip of rostrum to end of telson.

*Color*.—Uniform green (Holmes).

*Type Locality*.—Humboldt Bay, California.

*Distribution*.—British Columbia to San Diego, California.

*Remarks*.—Occasional specimens of this species have been found with the rostrum shorter than the carapace and antennal scale as well, a rare and apparently abnormal condition. In such cases, in preserved material, it is quite difficult to distinguish the species from *S. picta*. However, the rostrum always reaches about to the middle of the thicker flagellum of the antennules or beyond, while in *S. picta* the rostrum only slightly exceeds the antennular peduncle, if at all. On the whole, *S. paludicola* runs larger in size. In specimens of relatively the same size the rostrum and acicle are comparatively longer in *S. paludicola*; the teeth on the lower side of the rostrum are apparently not quite so bunched near the tip as in *S. picta*, but are more widely and evenly separated; the sixth abdominal segment is longer and comparatively not quite so stout; and the posterior ambulatory legs are much more slender than in *S. picta*.

*Biological Survey of San Francisco Bay.*—*Spirontocaris paludicola* was found in shallow water, in patches of eel grass along the Raccoon Strait's shore of Angel Island, where one specimen was taken by means of a boat-dredge in 2 to 5½ fathoms (D 5763), and among the algal growths in pools on the tidal flats north of the Standard Oil pier, Richmond, where also only a single specimen was obtained.

IV. Group with no supraorbital spines—(Continued)

Section b. Rostrum shorter than the carapace, not exceeding three-fourths its length. (In this subgroup the third maxillipeds exceed the antennal scale except in occasional specimens of *S. picta*, in which the maxillipeds attain but fail to reach beyond the tip of the antennal scale, and in *S. macrophthalma*, in which they fall short of the tip of the antennal scale. In *S. taylori*, *palpator* and *brevirostris* the third maxillipeds exceed the tip of the antennal scale by the whole, or the greater part of the terminal joint, and occasionally in some adults of the two latter species by the two last joints of the maxillipeds. In *S. cristata* and the greater number of specimens of *S. picta* the third maxillipeds only slightly exceed the antennal scale. In *S. brachydactyla* the third maxillipeds exceed the antennal scale by half the length of the last joint. The basal spine of the antennules in all the above species usually reaches to about the middle of the second segment of the peduncle, except in *S. macrophthalma* and *S. brachydactyla*; in the former it does not quite reach the end of the first segment, while in the latter it varies from being slightly shorter to slightly longer than the first segment of the antennular peduncle.) (For section a, see p. 58.)

*Spirontocaris palpator* (Owen)

*Hippolyte palpator* Owen, in Zoology of Captain Beechey's Voyage (in the "Blossom"), Crustacea, p. 89, pl. 28, fig. 3, 1839.

*Heptacarpus palpator* Holmes, Occas. Papers Calif. Acad. Sci., 7, 196, pl. 3, figs. 48, 49, 1900.

*Spirontocaris palpator* Rathbun, H. A. E., 10, 98, 1904; Hilton, Jour. Ent. Zool., Pomona Coll., 8, 69, 1916; *ibid.*, 10, 54, 1918.

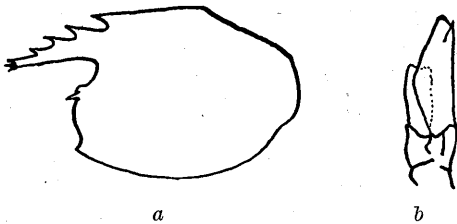


Fig. 43. *Spirontocaris palpator*; a, lateral view of carapace; b, acicle (after Holmes).

*Characters.*—Antennal scale longer than the telson; antennal peduncle reaching about to the middle of the scale. Rostrum reaching cornea or beyond, but not exceeding first segment of antennular peduncle; armed above with four to seven teeth, the last two or three of which are on the carapace; below without teeth or a small one near the tip; tip of rostrum usually simple, sometimes bifid or trifid.

*Dimensions.*—Type: length 46.6 mm.

*Color.*—Red (Owen). Almost transparent; red on the thorax in one case, body streaked with brownish in another; still another with body violet and appendages deep pink; in a fourth instance the body had a light pink tinge.

*Type Locality.*—Monterey, California.

*Distribution.*—San Francisco Bay, California, to Magdalena Bay, Lower California.

*Remarks.*—This species and the one following (*S. brevisrostris*) are very similar in general appearance and are undoubtedly closely related. They can always be distinguished by the length of the antennal scale as compared with the telson; it is always longer than the telson in *S. palpator*; it may be equal, but never exceeds the telson in *S. brevisrostris*, often falling short of it. *S. brevisrostris* is relatively the much stouter and more robust species of the two, attaining also a much greater size. To emphasize these differences the following table, based on four of the largest specimens of each species in the U. S. National Museum collections, is inserted.

| All measurements in mm. | Locality          | Length of carapace | Length of abdomen (over all) | Length of third maxillipeds | Length of antennal scale | Length of telson |
|-------------------------|-------------------|--------------------|------------------------------|-----------------------------|--------------------------|------------------|
| <i>S. palpator</i>      | San Pedro         | 8                  | 17                           | 12                          | 4                        | 3.5              |
| <i>S. palpator</i>      | Pacific Grove     | 9                  | 19                           | 15                          | 5                        | 4.0              |
| <i>S. palpator</i>      | San Diego         | 9                  | 19                           | 20                          | 5                        | 4.5              |
| <i>S. palpator</i>      | San Diego         | 10                 | 21                           | 20                          | 6                        | 5.0              |
| <i>S. brevisrostris</i> | San Francisco Bay | 14                 | 28                           | 37                          | 7                        | 7.0              |
| <i>S. brevisrostris</i> | Kadiak, Alaska    | 14                 | 30                           | 25                          | 7                        | 8.0              |
| <i>S. brevisrostris</i> | San Francisco Bay | 15                 | 32                           | 31                          | 7                        | 8.0              |
| <i>S. brevisrostris</i> | Unalaska, Alaska  | 17                 | 35                           | 43                          | 8                        | 8.0              |

In eleven of a series of fourteen specimens of *S. palpator*, the tip of the rostrum had a simple ending, tip in one bifid and in two trifid.

### *Spirontocaris brevisrostris* (Dana)

*Hippolyte brevisrostris* Dana, Proc. Acad. Nat. Sci. Phila., 6, 24, 1852;

Crust. U. S. Expl. Exped., 1, 566, 1852, pl. 36, fig. 5, 1855.

*Heptacarpus brevisrostris* Holmes, Occas. Papers Calif. Acad. Sci., 7, 198, pl. 3, figs. 50, 51, 1900.

*Spirontocaris brevisrostris* Rathbun, H. A. E., 10, 99, 1904.

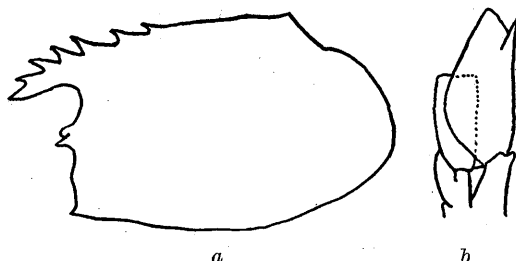


Fig. 44. *Spirontocaris brevisrostris*; a, lateral view of carapace; b, acicle (from Holmes).



*Characters.*—Antennal scale about the same length or shorter than the telson; antennal peduncle reaching about two-thirds the length of the scale. Rostrum reaching cornea or beyond, but not exceeding first segment of antennular peduncle; armed above with five or six teeth, the last three or four of which are on the carapace; below without teeth; tip of rostrum simple, very exceptionally bifid.

*Dimensions.*—Types: length of body 31.8 to 38 mm.

*Color.*—Uniform light crimson or scarlet (Stimpson).

*Type Locality.*—Dungeness, Straits of Fuca.

*Distribution.*—Attu, Aleutian Islands, to San Francisco Bay, California (Rathbun).

*Remarks.*—I have examined a series of about seventy specimens of this species and find that practically all have the antennal scale about as long as the telson; ten had the antennal scale shorter than the telson. In all but one the tip of the rostrum ended simply; in this single exception it was clearly bifid, owing to the fact that the first rostral spine was situated immediately above the acute tip.

*Biological Survey of San Francisco Bay.*—Only two specimens of *Spirontocaris brevirostris* were taken in the bay; one along the southern shore of Golden Gate in  $2\frac{1}{4}$  to  $3\frac{1}{2}$  fathoms, in company with *S. taylori* at D 5778, and one near the head of Raccoon Strait in 13 to 19 fathoms at D 5795. The bottom in both cases was more or less rocky, characterized by considerable algal growth in the case of the former.

### *Spirontocaris taylori* (Stimpson)

*Hippolyte taylori* Stimpson, Jour. Boston Soc. Nat. Hist., 6, 500, 1857.

*Heptacarpus taylori* Holmes, Occas. Papers Calif. Acad. Sci., 7, 199, pl. 3, figs. 52, 53, 1900.

*Spirontocaris taylori* Rathbun, H. A. E., 10, 101, 1904.

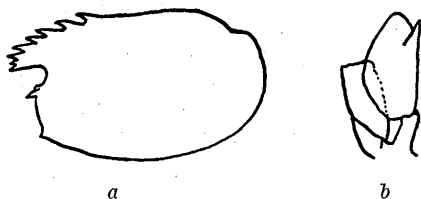


Fig. 45. *Spirontocaris taylori*; a, lateral view of carapace; b, acicle (after Holmes).

*Characters.*—Rostrum very short, not reaching even to the cornea, extending very little beyond the anterior margin of the carapace, armed above with five or six teeth, the last three or four situated on the carapace; anteriorly the teeth become more inclined forward, the end of the rostrum appearing curved downward although the lower margin is horizontal; unarmed below. Antennal scale about as long as telson.

*Dimensions.*—The Biological Survey specimens listed below ranged between 11 and 28 mm. in length, from tip of rostrum to end of telson.

*Type Locality.*—Monterey, California.

*Distribution.*—San Francisco Bay, California, to Magdalena Bay, Lower California (Rathbun).

*Remarks.*—Distinguished by the extreme shortness of the rostrum (Stimpson). *S. taylora* though approaching *S. brevisrostris* never attains so large a size and always retains its characteristic rostrum in which the last two teeth, immediately following the acute tip, are above rather than behind it.

*Biological Survey of San Francisco Bay.*—The localities at which *Spirontocaris taylora* was taken were always characterized by an abundant growth of algae. This species was dredged from among the rocks, in 2 to 5 and possibly 7 fathoms along both shores of Golden Gate: two specimens at D 5770, on the north side east of Point Bonita, and two and six specimens respectively, at D 5777 and 5778 on the south side, east of Fort Point. Five other specimens were washed from bunches of seaweed stripped from the piles of the Sausalito Ferry building.

### *Spirontocaris picta* (Stimpson)

*Hippolyte picta* Stimpson, Ann. Lye. Nat. Hist., N. Y., 10, 125, 1871.

*Heptacarpus pictus* Holmes, Occas. Papers Calif. Acad. Sci., 7, 200, pl. 3, figs. 54 and 55, 1900.

*Spirontocaris picta* Rathbun, H. A. E., 10, 101, 1904.

*Heptacarpus pictus* Baker, Rep. Laguna Mar. Lab., 1, 106, 1912.

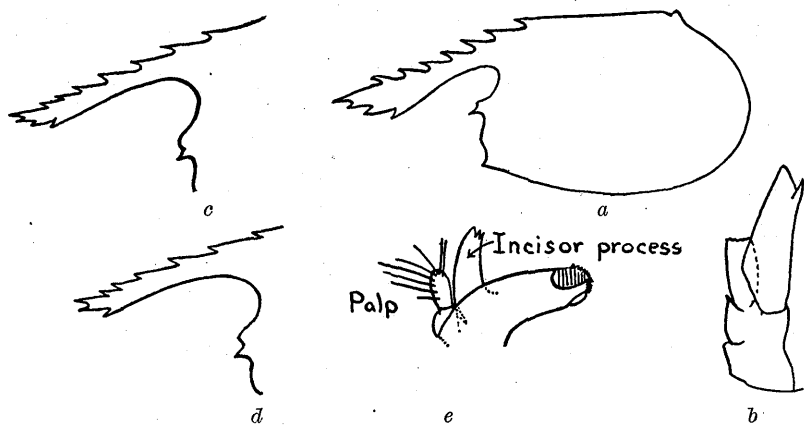


Fig. 46. *Spirontocaris picta*; a, lateral view of carapace; b, acicle (after Holmes); c and d, variations in spining of rostrum; e, mandible (after Baker).

*Characters.*—Rostrum reaches beyond the middle of the antennal scale but does not exceed three-fourths its length, about equals or slightly exceeds the antennular peduncle; armed above with six or seven quite evenly spaced teeth, the last two of which are on the carapace; armed below with two to four teeth near the tip. Antennal scale about as long as the telson.

*Dimensions.*—Type: length 33.8 mm.

*Color*.—Thorax obliquely streaked with crimson (Stimpson). Greenish, semi-transparent, with oblique reddish marks on carapace (Baker).

*Type Locality*.—Monterey, California.

*Distribution*.—Monterey Bay to San Diego, California (Rathbun).

*Remarks*.—Abundant in tide pools (Baker). The rostrum is more slender over the eyes and the teeth on the under side appear to be closer together than seems to be the case in *S. paludicola*.

### *Spirontocaris cristata* (Stimpson)

*Hippolyte cristata* Stimpson, Proc. Acad. Nat. Sci. Phila., 12, 33, 1860; not *H. cristatus* de Haan, 1849.

*Heptacarpus cristatus* Holmes, Occas. Papers Calif. Acad. Sci., 7, 202, pl. 3, figs. 58, 59, 1900.

*Spirontocaris cristata* Rathbun, H. A. E., 10, 102, fig. 45, 1904.

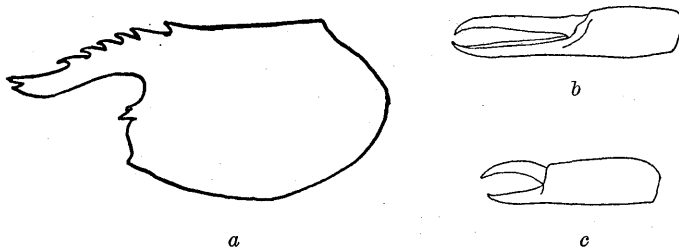


Fig. 47. *Spirontocaris cristata*; a, lateral view of carapace (after Holmes); b, chela, ♂,  $\times 10\frac{2}{3}$ ; c, chela, ♀,  $\times 10\frac{2}{3}$  (from Rathbun, U. S. N. M.).

*Characters*.—Rostrum reaching second segment of the antennular peduncle and beyond, usually to the tip of the peduncle, only rarely reaching beyond the middle of the antennal scale; nearly straight above, but slightly arched over the eye where the dorsal teeth are most thickly set; dorsal teeth five to eight, the last two or three of which are on the carapace, the most anterior tooth situated at some distance from the tip; below there are one, two, or three teeth near the tip. Antennal scale longer than the telson. Dactyls of ambulatory legs very long and slender, more than one-third, about one-half the length of their propodi. This character will serve to distinguish *S. cristata* from all the other species given in this subgroup.

*Dimensions*.—Type: length 25.4 mm. The Bay specimens were from 8 to 32 mm. in length over all.

*Type Locality*.—San Francisco, California.

*Distribution*.—From Sitka, Alaska, to San Diego, California, 3 to 33 fathoms (Rathbun).

*Remarks*.—The male differs peculiarly from the female. It has the customary points of difference: It is smaller and more slender; the rostrum is more slender and slightly overlaps the second antennular segment instead of reaching to the end of it. The most striking character is the unusual length of the fingers which exceed the palm in length and are rather slender, giving the chelae a *Palaemon*-like appearance; in the female, on the contrary, the fingers are considerably shorter than the palm, as in most species of the genus (Rathbun).

*Biological Survey of San Francisco Bay.*—*Spirontocaris cristata* is essentially a middle and lower bay form (see plate 6). It was taken at somewhat over one-fourth of the dredging stations in both of these sections (21 middle and 10 lower, or 29% and 26% respectively) and at from one-ninth to one-seventh of the hydrographic stations made in the same divisions (12 middle and 15 lower or 11% and 14% respectively). In the upper bay it was taken at but one of twenty-two dredging stations (D 5715; 4%) and at only one of eighty hydrographic stations (H 5264; 1%). Outside the bay *Spirontocaris cristata* was taken only at three of the seventeen dredging stations made there (D 5731, 5791, and 5807; 18%).

The range of distribution within the region covered by the bay survey may be briefly stated, as, from Pinole Point (H 5264) in the upper bay to Point San Mateo in the lower bay (D 5748) and outside to about the 30-fathom line (D 5791).

From the percentages given above this species is apparently more of a bottom dweller than an inhabitant of the upper water layers, being taken about twice as frequently in the dredge as in the tow-net hauls. With respect to the character of bottom preferred there seems to be little choice as the dredging stations are about equally divided between those with a more or less hard bottom, sand, gravel, shells or rocks, and mud. However, when the average number of specimens per catch is considered, the lower bay with its quite uniformly muddy bottom seems to be the region of greatest abundance. In the lower bay an average of fourteen and four-tenths specimens per dredge haul were taken as compared with two and two-tenths for the middle bay, two for the single haul made in the upper bay, and two per haul for both of the outside stations. This is also shown, though not so strikingly, when the tow-net hauls for each region are treated in a like manner, in the lower bay the average number of specimens per catch being four and eight-tenths, for the middle bay three and five tenths, for the upper bay one, outside, none.

Furthermore, aside from showing that *Spirontocaris cristata* is found more abundantly near the bottom than near the surface, the averages just given corroborate in another way what has just been brought out, that the muddy bottom of the lower bay seems to be preferred by this species. In the lower bay the highest average per catch is with the dredge hauls while in the middle bay, where the bottom is not so uniformly muddy or not at all muddy in some parts, this relation is reversed, although only to a slight degree, the average

number of specimens per catch with the dredge being two and two-tenths and for the tow-net three and five-tenths. The upper bay is muddy like the lower bay and its single dredge and tow-net catches exhibit a relation corresponding to that shown in the lower bay.

The highest temperature prevailing at the time of making any particular catch was 19.4° C (H 5216, upper bay); the lowest, 7.6° C (H 5311, lower bay). The highest salinity recorded, 34.3, was naturally outside (D 5791); the lowest, 22.5, was in the upper bay (D 5715). It seems hardly necessary to state that owing to the character of the collecting apparatus employed the figures given above represent surface readings in the case of the hydrographic stations and bottom readings in the case of the dredging stations.

At only three hydrographic stations, one in each of the major portions of the bay, was *Spirontocaris cristata* taken alone. Usually it was associated with one species of *Crango*, frequently with two or three, and rarely with four. Some species of *Cancer* were found in all but three of the dredge hauls, and "crab megalopa" were obtained in sixteen of the twenty-eight tow-net hauls (H stations). Three specimens of *Spirontocaris cristata* were obtained in company with *S. taylori* from algae stripped from the piles of the Sausalito Ferry building.

There are three specimens of juvenile *Spirontocaris* taken from as many hydrographic stations (H 4996, 5122, 5217) which I shall briefly refer to here under *Spirontocaris cristata* as most probably belonging to this species. The last one was taken in the tow-net just off the north end of Raccoon Strait; the other two in mid-channel off the southeastern shore of Angel Island. The surface temperatures of these stations, taking the time of making the haul into consideration, ranged from 13.8° to 14.6° C, the surface salinity from 20.82 to 32.29. The first of these hauls was made in February, the second in May, and the last in October. In view of the great lapse of time between all three of these records, February to October, it is surprising that the young stages of *Spirontocaris* were not represented more often in the bay collections.

The following is a complete list of the stations at which *Spirontocaris cristata* was taken: D 5702, 5705, 5715, 5723, 5726, 5730, 5732, 5739, 5743-5748, 5754, 5755, 5762, 5766-5768, 5772, 5773, 5778, 5779, 5791, 5795, 5799, 5802, 5803, 5807, 5809, 5828, 5829, 5847, 5848; H 4996, 5005, 5010, 5015, 5091, 5094, 5098, 5099, 5101, 5102, 5112, 5115, 5117, 5120, 5123, 5128, 5134, 5138, 5163, 5165, 5186, 5188, 5216, 5264, 5298, 5299, 5311, 5317, 5319; and Sausalito, March 19, 1912.

**Spirontocaris brachydactyla** Rathbun

*Spirontocaris brachydactyla* Rathbun, Proc. U. S. Nat. Mus., 24, 898, 1902;  
H. A. E., 10, 93, fig. 41, 1904.

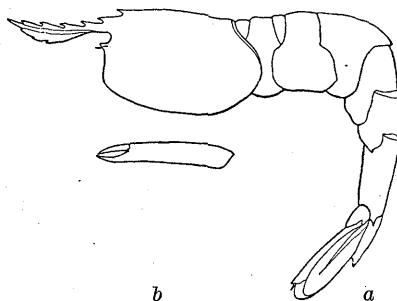


Fig. 48. *Spirontocaris brachydactyla*, ♀; a, lateral view of carapace and abdomen,  $\times 3$ ; b, chela of first pair,  $\times 5$  (from Rathbun, U. S. N. M.).

*Characters*.—Rostrum distinctly shorter than the carapace; armed above with six teeth, the last of which is on the carapace; armed below with three. Fingers of chelae of first pair of legs very short, not more than one-third as long as the palm. No spine on fourth segment of abdomen. Telson broken.

*Dimensions*.—Of type, ovigerous female: length, exclusive of rostrum and telson 24.8 mm.; length of carapace 7.7 mm.

*Type Locality*.—Off Santa Cruz Island, 266 fathoms ("Albatross" station 2948).

*Distribution*.—Southern California, 266 to 417 fathoms (Rathbun).

**Spirontocaris macrophthalmalma** Rathbun

*Spirontocaris macrophthalmalma* Rathbun, Proc. U. S. Nat. Mus., 24, 900,  
1902; H. A. E., 10, 105, fig. 48, 1904.

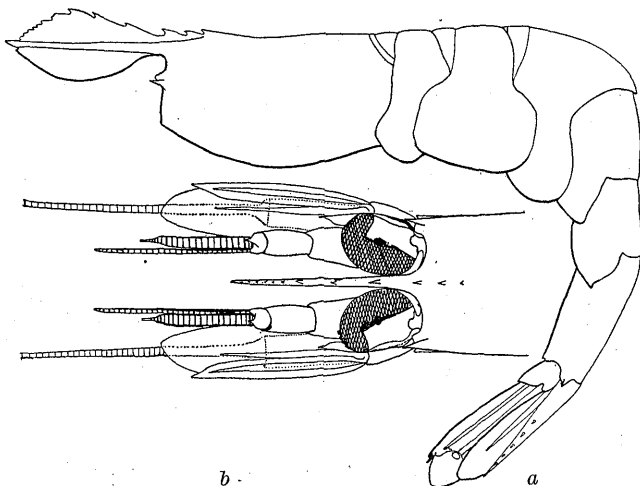


Fig. 49. *Spirontocaris macrophthalmalma*; a, lateral view of carapace and abdomen, ♂,  $\times 2$ ; b, dorsal view of anterior portion, ♀,  $\times 2\frac{1}{2}$  (from Rathbun, U. S. N. M.).

*Characters*.—Carapace carinated in its anterior half, posterior spine at the anterior fifth; upper line of carapace and mid-rib of rostrum nearly horizontal; rostrum about three-fourths or five-sixths as long as the carapace, upper and lower limbs with convex margins and widest at about the middle of their length; armed above with ten to fourteen teeth, the last two or three of which are on the carapace; armed below with one to three spines; tip acute. Eyes large, pyriform; cornea extending on inner side almost to the base of the peduncle. Blade of antennal scale exceeding the spine considerably, most advanced toward its inner margin.

*Dimensions*.—Type, female: length 62.6 mm.; length of carapace and rostrum 24 mm.; of rostrum 11 mm.

*Type Locality*.—Off Tawhit Head, Washington, 178 fathoms ("Albatross" station 3076).

*Distribution*.—From the north coast of Unalaska eastward and southward to Point Sur, California, 178 to 636 fathoms (Rathbun).

*Remarks*.—The males exhibit the usual differences from the females (described above) in being more slender, in the longer antennular flagella, and in the abdominal appendages (Rathbun).

#### Family CRANGONIDAE (ALPHEIDAE)

Rostrum very small or wanting. Eyes covered by the carapace. Mandibles with incisor process and palp of two segments. First pair legs chelate, with one or both chelae powerfully developed. Second pair of legs minutely chelate, long, slender, and equal, with segmented carpus. Telson broad and rounded.

As the genera of Weber (*Nomenclator entomologicus*, 1795) complying with the International Code of Zoological Nomenclature are to be accepted as valid (vide Smithsonian Publ. 1938, 1910) I have followed Miss Rathbun's findings (Proc. Biol. Soc., Washington, 17, 170, 1904*b*) and have given *Crangon* precedence over *Alpheus* Fabricius. Hence the name of the family to which this genus belongs becomes Crangonidae and the family formerly bearing that name must needs be changed. For it Miss Rathbun (*op. cit.*) has supplied Crangonidae (p. 81), based on the genus *Crago*, in place of the former genus *Crangon*.

#### KEY TO THE CALIFORNIA GENERA OF THE CRANGONIDAE

- I. Rostrum present, short and pointed; hands normal, dactyl of larger hand opening either vertically or horizontally; front either unispinose or trispinose.
  - A. No pterygostomian spine. Thoracic feet with epipods; dactyli simple. (Not known north of the Farallon Islands.)  
*Crangon*, p. 74.
  - B. Pterygostomian spine present. Thoracic feet without epipods; dactyli bifid. (Not known north of Santa Monica Bay and Santa Catalina Island.)  
*Synalpheus*, p. 77.
- II. Rostrum wanting; hands inverted so that dactyls are on lower side; front not spined, either emarginate between the eyes or evenly rounded. (Not known north of Point Arena.)  
*Betaeus*, p. 79.

Genus **Crangon** Weber

Rostrum short and usually spiniform. Antennules with basal article and spine reduced. Distal joint of third maxillipeds drawn out to a point and almost unarmed. No pterygostomial spine on carapace. Thoracic legs with epipods; dactyli simple.

## KEY TO THE CALIFORNIA SPECIES OF CRANGON

## I. Front trispinose; rostrum present, orbital hoods armed with spines.

## A. Basal joint of antennae with a spine.

1. Merus joints of third and fourth pair of legs with a spine below at inferodistal angle. A sulcus between eye-shields and rostrum. Large hand sculptured, dactyl closing horizontally. Smaller hand with a superior spine above articulation of dactyl only, no external spine. (Not known north of Farallon Islands.)

*dentipes*, p. 74.

2. No spines on merus joints of third and fourth pairs of legs; no sulcus between eye-shields and rostrum.

- a. Dactyl of larger hand closing horizontally, laminate. Large hand sculptured; smaller hand spined. (Not known north of Monterey.)

*bellimanus*, p. 75.

- b. Dactyl of larger hand closing vertically. Large hand smooth; smaller hand without spines. (From Monterey to Santa Barbara.)

*equidactylus*, p. 76.

- B. Basal joint of antennae without a spine. Smaller hand with a superior spine above articulation of dactyl, no external spine. As no specimen, only the original description, has been seen it is not known how the dactyl of the larger hand opens. (Known only from Santa Barbara.)

*barbara*, p. 76.

- II. Front unispinose; rostrum present, but no spines on orbital hoods. A deep sulcus between eye-shields and rostrum. Smaller hand smooth without spines; dactyl of larger hand opening vertically. (Not known north of San Pedro.)

*californiensis*, p. 76.

**Crangon dentipes** (Guérin)

*Alpheus dentipes* Guérin, Exp. Sci. Morée, Zool., p. 39, pl. 27, fig. 3, 1832.

*Alpheus clamator* Holmes, Occas. Papers Calif. Acad. Sci., 7, 182, pl. 2, figs. 39, 40, 1900; Baker, Rep. Laguna Mar. Lab., 1, 106, 1912.

*Alpheus dentipes* Rathbun, H. A. E., 10, 108, 1904; Hilton, Jour. Ent. Zool., Pomona Coll., 8, 67, fig. 6, 1916.



Fig. 50. *Crangon dentipes*; a, small hand; b, large hand (after Holmes).



*Characters.*—Merus joints of third and fourth pairs of legs with a spine below at the inferodistal angle. Front trispinose; rostrum present and orbital hoods each armed with a spine; a sulcus between the eye-shields and the rostrum. Large hand sculptured, dactyl closing horizontally; small hand with a superior spine above the articulation of the dactyl only, no external spine. Basal spine of antennules shorter than first joint of peduncle. Carpus of second pair of legs with first and second segments equal.

*Dimensions.*—Length of an ovigerous female in the collection of the U. S. National Museum from tip of rostrum to end of telson 35 mm.; length of carapace and rostrum 11 mm.; length of large hand 19 mm.

*Color.*—In alcohol a light flesh tint, much deeper on the large hand. A darker spot on the upper surface of the carapace, also on the anterior edge of the first two abdominal segments (Lockington).

*Type Locality.*—"Sapience, et au cap Tenare; golfe de Genes" (Guérin).

*Distribution.*—Farallon Islands, California, to San Bartholome Bay, Lower California. Mediterranean; Cape Verde Islands; Bermudas; Porto Rico; Cuba; Key West (Rathbun).

*Remarks.*—This species lives in pools on rocky reefs at low tide level, and is capable of producing, by clapping together the fingers of the larger hand, a snapping noise like that which can be made with the finger nail (Lockington). Common in sponge masses and kelp holdfasts (Baker).

### *Crangon bellimanus* (Lockington)

*Alpheus bellimanus* Lockington, Proc. Calif. Acad. Sci., 7, 34, 1877; Holmes, Occas. Papers Calif. Acad. Sci., 7, 184, pl. 2, fig. 41, 1900; Rathbun, H. A. E., 10, 108, 1904.

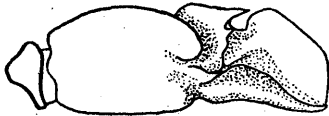


Fig. 51. *Crangon bellimanus*, large hand (after Holmes).

*Characters.*—Front trispinose; rostrum present and orbital hoods each armed with a spine; no sulcus between eye-shields and rostrum. Large hand sculptured, dactyl laminate, closing horizontally. Small hand with a superior spine on upper margin at articulation of dactyl and an external spine on outer surface at base of dactyl. Basal spine of antennules short, not reaching second joint of peduncle. Carpus of second pair of legs with first segment about as long as the next two combined.

*Dimensions.*—Type: length from point of rostrum to end of abdomen 30.3 mm.; length of larger hand 12.7 mm., of smaller 9.7 mm.

*Color.*—The present species may be easily recognized by the beautiful coloring of its hands, which in a dried specimen are orange, with various spots and workings of black and white. The carapace presents similar coloration to that of the hands (Lockington).

*Type Locality.*—San Diego, California, found among the kelp.

*Distribution.*—From Monterey to San Diego, California (Rathbun); Chile (Coutière).

**Crangon barbara** (Lockington)

*Alpheus clamator* Kingsley (not Lockington), Bull. U. S. Geol. Surv., 4, no. 1, p. 197, 1878.

*Alpheus barbara* Lockington, Ann. Mag. Nat. Hist. (5), 1, 471, 1878; Rathbun, H. A. E., 10, 108, 1904.

*Characters*.—Basal joint of antennae without a spine. Small hand with a superior spine above articulation of dactyl, no external spine. Basal spine of antennules short, stout, not reaching second joint of peduncle. Carpus of second pair of legs with first and second segments equal.

*Type Locality*.—Santa Barbara, California.

*Remarks*.—According to Coutière probably the same as *A. macrocheles* (Hailstone) (Rathbun). Kingsley did not give any measurements of his type, which was an imperfect specimen. The species has not been seen since the original description.

**Crangon californiensis** (Holmes)

*Alpheus californiensis* Holmes, Occas. Papers Calif. Acad. Sci., 7, 186, pl. 2, fig. 42, pl. 3, figs. 43, 44, 1900.

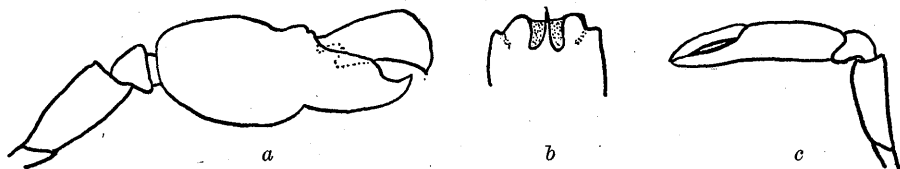


Fig. 52. *Crangon californiensis*; a, large hand; b, dorsal view of anterior portion of carapace; c, small hand (after Holmes).

*Characters*.—Front unispinose; rostrum present, but orbital hoods without spines; a deep sulcus between eye-shields and rostrum. Small hand smooth. Basal spine of antennules broadly ovate, acuminate, scarcely reaching tip of first joint of peduncle. Carpus of second pair of legs with first segment long, exceeding second.

*Dimensions*.—Type: length 37 mm.; length of carapace 12.5 mm., of large hand 15 mm., of small hand 9 mm.

*Type Locality*.—San Pedro, California.

*Distribution*.—Also found at Magdalena Bay, Lower California, by C. R. Orcutt.

**Crangon equidactylus** (Lockington)

*Alpheus equidactylus* Lockington, Proc. Calif. Acad. Sci., 7, 35, 1877; Holmes, Occas. Papers Calif. Acad. Sci., 7, 187, pl. 3, figs. 45, 46, 1900; Rathbun, H. A. E., 10, 108, 1904.



Fig. 53. *Crangon equidactylus*; a, large hand; b, small hand (after Holmes).

*Characters*.—Front trispinose; rostrum present and orbital hoods each armed with a spine; no sulcus between eye-shields and rostrum. Hands oblong, narrow, compressed, smooth, without spines; a transverse sulcus crossing the upper edge of the hand behind the dactyl, from which a longitudinal sulcus extends backward on the upper edge of the larger hand almost to the posterior margin, but about two-thirds as far in the smaller one; dactyl of large hand closing vertically. Basal spine of the antennules stout, extending to end of second joint of peduncle. Carpus of second pair of legs with first segment as long as the next four combined.

*Dimensions*.—Type, length 19.1 mm.

*Type Locality*.—Monterey, California.

*Distribution*.—Monterey to Santa Barbara, California.

*Remarks*.—According to Coutière this is *Alpheopsis trispinosus* of Stimpson (Rathbun).

### Genus *Synalpheus* Bate

Rostrum short and usually spiniform. Antennules with basal joint longest; basal spine wide, equal to sum of first two joints. Distal joint of third maxillipeds elongate, armed with strong spinules at tip. Carapace with a pterygostomial spine. Thoracic legs without epipodites; dactyli bifid.

#### *Synalpheus lockingtoni* Coutière

Plate 12, figure 1

*Alpheus leviusculus* Lockington, Ann. Mag. Nat. Hist. (5), 1, 479, 1878, not *A. edwardsi* var. *leviusculus* Dana, 1852.

*Alpheus lockingtoni* Coutière, Proc. U. S. Nat. Mus., 36, 21, fig. 1, 1909.

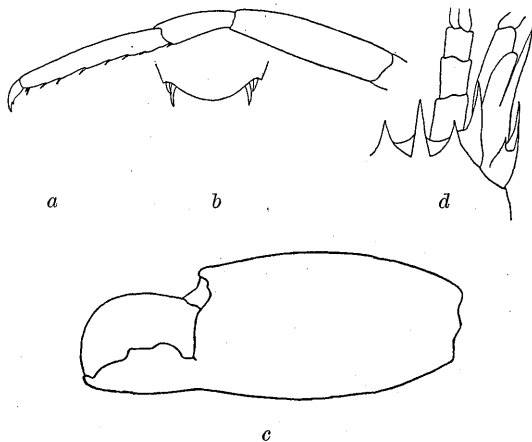


Fig. 54. *Synalpheus lockingtoni*; a, third leg,  $\times$  about 10; b, end of telson,  $\times$  about 10; c, large chela,  $\times$  about  $7\frac{1}{2}$ ; d, frontal margin and right side of antennal region,  $\times$  about 10.

*Characters.*—Rostrum a little longer than lateral spines, reaching extremity of basal joint of antennules. Second joint of antennules slightly longer than third; first joint only about one and a-half times longer than second; basal spine reaching at least to middle of the second joint, usually attaining its distal third. Lateral spine of basal joint of antennae about as long or slightly longer than the rostrum; spine of antennal scale about as long as or slightly longer than terminal joint of antennal peduncle. Anterior margin of palm of large chela terminates in a conical tubercle, which is short and always destitute of a spine. Carpus of second pair of legs with first segment slightly shorter than sum of next four; merus shorter than the carpus. Merus of third pair of legs approximately equal to carpus of second pair and about three and three-quarters to four times as wide; dorsal hook of dactyl about twice as long as ventral. Telson with posterior angles right angles not prolonged into a triangular prominence.

*Dimensions.*—Type, largest female: length 30 mm., carapace 10 mm., larger hand 11 mm. Of largest specimen examined by Coutière: length of carapace and rostral spine 7 mm., of rostral spine about 1 mm., of abdomen 10.2 mm.

*Type Locality.*—Gulf of California.

*Distribution.*—Also taken off eastern point of San Nicolas Island, California, 229 to 298 fathoms ("Albatross" station 4421) (Coutière); from Venice Beach, Santa Monica Bay, in roots of *Neriocystis*, and west shore of Catalina Harbor, littoral, received from Venice Marine Biological Station.

*Remarks.*—In introducing his description, from which the above characters have been drawn in part, Coutière says:

I believe I have rediscovered the species described by Lockington, although the specimens which represent it differ in slight details. . . . The description of Lockington—very explicit as to the length of the antennal spines, the form of the chela of the first pair, the carpus of the second pair, the dactyl of the third pair, and the telson—appears to permit identification of the specimens of *S. leviusculus* with those which I have studied. The differences bear upon two points: Lockington says the spine of the scaphocerite [antennal scale] does not reach the extremity of the peduncle and that the movable finger of the large chela projects beyond the pollex. The first character hardly exists on the specimens I have seen, the spine being approximately equal to the carpocerite [the terminal joint of the antennal peduncle] and the fingers of the large chela equal.

In turn, the specimens received from the Venice Marine Biological Station which I assign to this species differ slightly from Coutière's figures and descriptions, but his figures differ in a few minor points from the specimens on which they were based. The slender dactyl of the larger chela as figured by him is not so apparent in his specimens. In them the outline approximates more nearly the one figured above; in it, however, the palm is somewhat stouter. Further, the inferodistal angle of the propodus of the third pair of legs bears a pair of juxtaposed spines, both in his specimens and ours, while his figures show but one; similarly, the inferodistal angle of the carpus of the same pair of legs which he figured as unarmed carries a spine in both lots of specimens. The second legs, on the other hand, are in very close agreement. In general the Venice specimens are proportionally somewhat stouter throughout, but structurally they are so nearly like Coutière's that in spite of the great discrepancy in the depths at which they were obtained I feel convinced that they represent the same species (cf. *Crago variabilis*, *Remarks*, p. 99).

Genus *Betaeus* Dana

Hands inverted so that dactyls are on lower side. Rostrum wanting; front not spined, either emarginate between the eyes or evenly rounded.

## KEY TO THE CALIFORNIA SPECIES OF BETAEUS

- I. Front emarginate between the eyes. Hands subequal, oval; fingers with but slight gape. (From Point Arena to Laguna Beach.)  
*harfordi*, p. 79.
- II. Front rounded. Hands similar, long and narrow; fingers with a more or less wide gape. (Not known north of San Pedro.)  
*longidactylus*, p. 80.

*Betaeus harfordi* (Kingsley)

*Alpheus harfordi* Kingsley, Bull. U. S. Geol. Surv., 4, 198, 1878; Bull. Essex. Inst., 14, 124, pl. 2, fig. 4, 1883.

*Betaeus aequalis* Lockington, Ann. Mag. Nat. Hist. (5), 1, 479, 1878.

*Alpheus aequalis* Holmes, Occas. Papers Calif. Acad. Sci., 7, 189, pl. 3, fig. 47, 1900.

*Betaeus harfordi* Rathbun, H. A. E., 10, 108, 1904; Hilton, Jour. Ent. Zool., Pomona Coll., 8, 67, 1916.

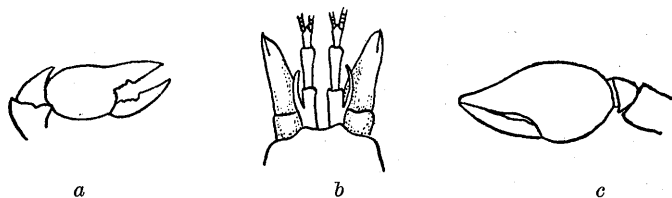


Fig. 55. *Betaeus harfordi*; a, hand; b, dorsal view of anterior portion (after Kingsley); c, hand (after Holmes).

*Characters*.—Front emarginate between the eyes. Hands oval, vertical, smooth, strongly compressed; dactyl slender, the inner margin straight or somewhat concave near the base; fixed finger much wider than the dactyl, the entire inner margin may be straight, or there may be a deep, rounded notch near the base; tips of the fingers curved and crossed when closed; inner margins pubescent, the rest of the hand naked. Basal spine of the antennules long and slender, reaching beyond middle of the second joint of peduncle, second joint about twice the length of the third.

*Dimensions*.—Types: length 19 and 24 mm., length of carapace 6 and 8 mm., length of larger hand 6 and 8 mm., respectively.

*Color*.—When fresh dark purple, in alcohol a light flesh tint (Lockington). Pale olive green, eggs translucent green (Hilton).

*Type Locality*.—Santa Catalina Island, California.

*Distribution*.—Point Arena to Laguna Beach, California.

*Remarks*.—This species lives under the mantle of *Haliotis rufescens* Swains. (Lockington). "...but it is not confined to that habitat, for I found several specimens upon sea-urchins that were brought up from several feet of water at Catalina Island. Their color was a dark purple like the specimens described by

Lockington and resembled the color of the sea-urchins in whose spines they were entangled when captured. At Point Arena I captured from under a rock at low tide a single specimen which was nearly white." (Holmes.) Found in kelp hold-fasts (Hilton).

### **Betaeus longidactylus** Lockington

Plate 12, figure 2

*Betaeus longidactylus* Lockington, Proc. Calif. Acad. Sci., 7, 35, 1877;  
Ann. Mag. Nat. Hist. (5), 1, 480, 1878.

*Alpheus longidactylus* Holmes, Occas. Papers Calif. Acad. Sci., 7, 190,  
1900.

*Betaeus longidactylus* Rathbun, H. A. E., 10, 108, 1904; Baker, Rep.  
Laguna Mar. Lab., 1, 106, 1912.

*Characters*.—Front rounded, scarcely notched at the center even rarely. Hands large, oblong, compressed, scabrous, the margins rounded, their length much exceeding that of all the preceding joints combined; fingers slender, widely gaping, longer than the palm, the tips furnished with small, curved, corneous claws, which are crossed when the fingers are closed; fixed finger with a large tooth a little behind the middle of the inner margin and a small, round tooth at the base. Basal spine of the antennules long and slender, about reaching the tip of the second joint of peduncle, second and third joints subequal.

*Dimensions*.—Type: length 38.4 mm., length of larger hand 14.2 mm., of smaller hand 9.1 mm.

*Color*.—Color of carapace of dried (type) specimen green, with nuances of russet and olive; fingers of larger hand light red, the tips green (Lockington). The color varies in living specimens from olive green to olive brown; the legs are reddish, and in many specimens there is a light colored dorsal stripe along the middle of the body (Holmes). Blackish, bluish green in life, with whitish stripe on median dorsal line of abdomen, and a white fleck above each of the points of articulation of the epimera; tail-fan of darker color, almost black-green; antennules and antennae brownish green, antennal scale blue with white markings; legs purplish brown with extreme distal portions of propodus and dactylus clear white.

*Type Locality*.—San Diego, California, on a sandy mud flat, between tides.

*Distribution*.—San Pedro to San Diego, California.

*Remarks*.—

The unequal size of the chelipeds (of the type) is exceptional. I have collected numerous specimens of this species at San Pedro, California, where it is found in abundance in tide pools on a rocky ledge near the entrance to the harbor. The hands are similar, generally equal, and very much larger in adult males than in young males and females. The anterior margin of the carapace in some specimens is slightly convex, in others straight, while in a few it is slightly concave. In many adult females, and to a less extent in adult males also, the dorsal surface of the carapace is bulged upward, owing, doubtless, to the enlargement of the ovaries or testes. Many of the specimens were infested with a parasitic isopod attached to the under side of the abdomen (Holmes).

### Family LYSMATIDAE (PROCESSIDAE)

Rostrum horizontal with dorsal surface of carapace. Mandibles without incisor process and without palp. First pair of legs more or less chelate. Second pair, minutely chelate, slender, with segmented carpus.

Genus *Processa* Leach

One of the first pair of legs chelate and the other simple; rarely both chelate. Second pair of legs unequal, carpus multiarticulate. Rostrum short.

*Processa canaliculata* Leach

Plate 12, figure 6

*Processa canaliculata* Leach, Mal. Podoph. Brit., pl. 41 and corresponding text, July 1, 1815; Rathbun, Bull. U. S. Fish Comm., 20, pt. 2, 104, 1900 (1901); H. A. E., 10, 110, 1904.

*Characters*.—Rostrum slender, about half as long as eye-stalks, unarmed except at apex, which is obscurely bifid and furnished with a few long hairs. First pair of feet rather stout, reaching a little beyond the antennal scale; right, or chelate foot with palm a little longer than carpus or fingers; left or simple foot of first pair with dactylus about one-fourth the length of propodus; remaining feet slender; second pair unequal.

*Dimensions*.—See *Remarks*.

*Type Locality*.—Torcross, southern coast of Devon, England.

*Distribution*.—Europe; Madeira; Bermudas; from North Carolina to Trinidad, including Gulf of Mexico and West Indies; from San Diego, California, to Panama Bay; Japan; Amboina. Shallow water to 111 fathoms (Rathbun).

*Remarks*.—From Miss Rathbun (1904a, p. 110), I take the following:

Two specimens of unusual interest were taken at San Diego, California, by D. S. Jordan, in 1880. They are about 22 mm. long, and differ from typical specimens in having the left foot of the first pair similar to the right, or chelate. One specimen is a female and has both chelipeds present. The other is so mutilated that the sex is indeterminate; it has a left cheliped, the right is missing. This form might perhaps be deemed a distinct species or genus were it not that among a lot of specimens from Cedar Keys, Florida, both forms occur. From this locality they are small (12 to 15 mm. long), and five specimens are bichelate while four have only a right cheliped, the left foot being simple, as in typical *P. canaliculata*. These two forms from the same locality present no other appreciable difference.

Aside from this remarkable dimorphism in the left first foot the species is a most variable one. The rostrum may be half as long as the eye. The eyes while always of good size are not uniform, in some cases larger and more reniform, with the cornea extending on the outer side almost back to the carapace. The second joint of the antennulae varies from one and one-fourth to twice the length of the third joint. The antennal scale may be a little more than half as long as the carapace (rostrum excluded) or even two-thirds as long as the carapace; it may be just as long as the antennular peduncle or distinctly longer. Of the specimens examined, those from the west coast of Mexico and Panama Bay have the largest eyes; they agree fairly well with the description and figure of Bate's *P. processa* from Amboina, 15 fathoms.

## Family CRAGONIDAE (CRANGONIDAE)

(CRANGONIDAE OF AUTHORS, NOT CRANGONIDAE PAGE 73.)

Rostrum generally small, usually dorsally flattened, and not toothed, or wanting; in *Paracrangon* only it is a suberect, elongated, laterally compressed spine. Eyes generally free, in *Nectocrangon* only are they covered by the carapace. Mandibles without incisor and palp. First pair of legs subchelate and stouter than the second. Second pair slender and equal, with unsegmented carpus, either minutely chelate or simple.

## KEY TO THE CALIFORNIA GENERA OF THE CRAGONIDAE

- I. Rostrum present. Eyes free. Dactyls of fourth and fifth pairs of feet long, acuminate, and more or less flattened.
- A. Rostrum short, more or less dorsally flattened. All five pairs of legs present. *Crago*, p. 82.
- B. Rostrum elongate; a laterally compressed, suberect spine. Second pair of legs wanting. *Paracrangon*, p. 103.
- II. Rostrum wanting. Eyes nearly concealed or hidden by carapace. Dactyls of fourth and fifth pairs of legs dilated, adapted for swimming. *Nectocrangon*, p. 102.

Genus *Crago* Lamarck

Rostrum very short and more or less dorsally flattened. Eyes free. Dactyls of fourth and fifth pairs of legs more or less flattened.

## KEY TO THE CALIFORNIA SPECIES OF CRAGO

- I. Gastric region not depressed below general level of the carapace. Antennal scale with very oblique inner margin and narrow extremity; spine exceeding blade except in *C. nigricauda*, in which it is variable, longer or shorter than the blade.
- A. Carapace without a median gastric spine. *stylirostris*, p. 90.
- B. Carapace with one or more median spines.
1. Carapace with one median spine.
- a. Sixth segment of abdomen sulcate beneath.
- i. Hand of first pair of feet very slender, four or more times as long as wide; dactylus when flexed almost longitudinal. Fifth abdominal segment not carinate. *franciscorum*, p. 92.
- ii. Hand of first pair of feet not slender, less than three and one-half times as long as wide; anterior margin against which dactylus closes usually more transverse than longitudinal, never forming an angle of less than 45° with lengthwise margin.
- a. Fifth segment of abdomen not carinate. Blade of antennal scale having its anterior margin more advanced at inner than at outer angle. Sixth abdominal segment with a large circular spot, characteristic only of this species, on either side at its posterior end. *nigromaculata*, p. 86.
- b. Fifth segment of abdomen furnished with a superior median carina.
- i. Antero-internal angle of antennal scale advanced, reaching nearly as far as or farther than the spine. Hands of first pair of feet little over twice as long as wide; anterior margin against which dactylus closes more nearly transverse than longitudinal. *nigricauda*, p. 84.



- ii. Antero-internal angle of antennal scale not produced, the spine reaching much beyond the blade. Hands of first pair of feet two and one-half to three times as long as wide; anterior margin, against which dactylus closes, oblique, forming an angle of about 45° with lengthwise margins.

*alaskensis elongata*, p. 88.

- b. Sixth segment of abdomen not sulcate, convex beneath.

- i. Hands very stout, only two and one-quarter times as long as wide; anterior margin more longitudinal than transverse. Antepenultimate segment of outer maxillipeds greatly dilated.

*alba*, p. 89.

- ii. Hands elongate, about three times as long as wide, anterior margin more longitudinal than transverse. Antepenultimate segment of outer maxillipeds not dilated. (Not known north of San Pedro.)

*holmesi*, p. 90.

- 2. Carapace with two median spines.

- a. Rostrum slightly ascending, rounded at the tip; not exceeding the eyes. Abdominal sulci filled with a thin, short pubescence, easily rubbed off. Hands over three times as long as their average width; anterior margin obliquely transverse. Second segment of antennular peduncle twice as long as third. Antennal scale about two-thirds length of carapace.

*communis*, p. 95.

- b. Rostrum ascending at an angle of 45°; tip pointed, usually exceeding the eyes. Abdominal sulci without pubescence. Hands shorter than preceding species, about three times as long as wide; anterior margin more longitudinal.

- i. Eyes of moderate size. Second segment of antennular peduncle about three times as long as third. Antennal scale about four-fifths as long as the carapace exclusive of the rostrum. (Not known north of San Francisco.)

*resima*, p. 96.

- ii. Eyes very large. Second segment of antennular peduncle about one and one-half times as long as third. Antennal scale three-fourths as long as the carapace exclusive of the rostrum. (Known only from 685 + fathoms.)

*abyssorum*, p. 97.

- II. Gastric region depressed below general level of the carapace. Antennal scale with spine shorter than the blade, except in *C. variabilis*, in which the spine equals or exceeds the blade, and in *C. lomae*, in which the spine exceeds the blade.

- A. Second lateral carina of the carapace (counting from the middle) unarmed.

- 1. First to fourth abdominal segments, inclusive, smooth.

- a. Anterior median spine of the carapace not advanced as far as the line of the orbits. Hands of first pair of legs oblong, narrowing a little distally, or presenting a slight constriction at the base of the spine, three times as long as wide.

*munita*, p. 98.

- b. Anterior median spine projecting in front of the line of the orbits. Hands much as in preceding species, but with anterior margin of hand more longitudinal. *acclivis*, p. 98.
2. First to fourth abdominal segments more or less carinated. Hands about three times as long as wide.
- a. First to third abdominal segments armed laterally with one or two spines each.
- i. First to third segments armed laterally with one spine each; spine of third segment obsolescent in the male. (Known only from 525 + fathoms.) *lomae*, p. 100.
- ii. First to third segments armed laterally with two spines each. (Not known south of Point Conception.) *spinosissima*, p. 100.
- b. First to third abdominal segments laterally unarmed. (Known off California only from 158 + fathoms.) *variabilis*, p. 99.
- B. Second lateral carina of the carapace armed with a spine a little behind the superior lateral spine. First to fourth abdominal segments smooth. Hands of first pair of feet are two and one-half times as long as wide, swollen; the anterior margin more longitudinal than transverse. (Not known south of Laguna Beach.) *munitella*, p. 101.
- I. Group with gastric region not depressed below the general level of the carapace. Antennal scale with spine exceeding blade except in *C. nigricauda*, in which it is variable, usually longer but sometimes shorter than the blade.

Section a. Carapace with one or no median spines. (*C. stylirostris* is the only species in this section which lacks the median gastric spine, although with a lens one can discern a scabrous granule where the spine usually occurs in the other members of this group.) (For section b, see p. 95.)

### *Crago nigricauda* (Stimpson).

*Crangon nigricauda* Stimpson, Proc. Calif. Acad. Sci., 1, 97, 1856; Jour. Boston Soc. Nat. Hist., 6, 496, pl. 22, fig. 6, 1857; Holmes, Occas. Papers Calif. Acad. Sci., 7, 170, pl. 2, fig. 31, 1900 (in part); Rathbun, H. A. E., 10, 112, fig. 50, 1904.

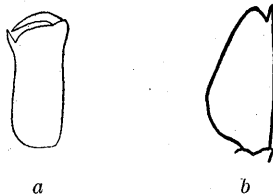


Fig. 56. *Crago nigricauda*; a, chela,  $\times 2\frac{1}{2}$  (from Rathbun, U. S. N. M.); b, acicle (after Holmes).

*Characters*.—Antennal scale about two-thirds the length of the carapace; antero-internal angle rounded and produced, reaching nearly as far forward as the spine at the outer angle, sometimes farther than the spine. Hands oblong,

a little more than twice as long as wide, with edges subparallel; the margin against which the dactylus closes more nearly transverse than longitudinal. Fifth segment of abdomen with a distinct median carina.

*Dimensions.*—The specimens taken in San Francisco Bay ranged up to 58 mm. in length from tip of rostrum to end of telson; the greater number averaged between 30 and 35 mm. in length.

*Color.*—A very dark gray, or blackish, becoming entirely black at the tail. Hands tinted with lilac (Stimpson).

*Type Locality.*—Tomales Bay, California.

*Distribution.*—According to Holmes, who includes here *C. alaskensis*, this species ranges from Alaska to Lower California. I have seen specimens only from Comox, British Columbia, southward (Rathbun). Japan (Bals). Littoral to 31 fathoms.

*Biological Survey of San Francisco Bay.*—Except for *Crago franciscorum*, *C. nigricauda* is the most abundant and widely distributed species found in the bay and as compared with that species, although taken at seven more dredging stations, was only obtained at about half as many, or 69 out of 137, hydrographic (tow-net) stations.

*Crago nigricauda* was taken in the upper bay at 82% (18) of dredging and 22% (18) of the hydrographic stations; in the middle bay at 77% (56) of the dredging and 16% (18) of the hydrographic stations; in the lower bay at 50% (19) of the dredging and 31% (33) of the hydrographic stations; and outside at 53% (9) of the dredging stations only.

A summary of these figures indicates that this species, although constituting one of the principal returns of the tow-net, is rather an inhabitant of the lower or bottom strata of water than of the upper layers. It was taken, in all, at three-fourths (75%) of the total number of dredging stations, while it is recorded at less than a fourth (23%) of the total number of hydrographic (tow-net) stations, and of these only seven contained more than ten examples.

With respect to the character of the bottom preferred, little choice is displayed. There seems to be a tendency for the greater number of specimens to frequent the more or less muddy bottoms rather than those of a harder composition, predominantly sand, gravel, or rock; but this indication is possibly the result of using a highly effective piece of apparatus on the former type of bottom and not on the latter, the so-called "sledge trawl" (Sumner, 1914, p. 5, and pl. 8). Of the twenty-seven dredging stations, which returned fifty or more specimens, 74% (20) were made with the sledge trawl.

Although in the bay, i.e., Golden Gate, a considerable number of specimens were taken at stations having a maximum depth of 43 to 53 fathoms (D 5808, 5809) and two possibly at 60 fathoms (D 5738,

23 to 60 fathoms), not a single individual was taken at any station outside at which the depth exceeded 26 fathoms. This is, however, quite in keeping with the *Distribution*, under which the maximum depth for this species is 31 fathoms, recorded in 1897 by the "Albatross" on the Flattery Bank. It is highly probable that the specimens from the deeper bay stations listed above were obtained at or near the shallower end of each of the hauls, for which the minimum depths are 27,  $21\frac{1}{2}$ , and 23 fathoms, respectively.

In view of its wide distribution within and outside the bay practically all of the temperature and salinity readings observed during the survey (Sumner, 1914) are applicable to this species.

A complete list of stations at which *Crago nigricauda* was taken is given below: D 5700, 5702, 5705, 5707-5709, 5711-5717, 5719-5723, 5727, 5729-5733, 5735-5739, 5742-5751, 5754, 5755, 5757, 5758, 5762-5768, 5770-5774, 5776-5784, 5792-5809, 5815-5830, 5833, 5847-5849; H 4987, 4989, 4994-4996, 4998, 5004, 5013, 5014, 5082-5084, 5091, 5092, 5094, 5098, 5101, 5103-5107, 5109-5118, 5120, 5122, 5124, 5125, 5127, 5138, 5143, 5144, 5146, 5158, 5161, 5163-5165, 5168, 5169, 5172, 5186, 5187, 5193, 5196, 5199, 5250-5252, 5272, 5274, 5276, 5298, 5299, 5303, 5308, 5311, 5319, 5320; "fishing grounds," July, 1912; W. of Blunt Point, Angel Island, March 27, 1913; Fort Baker, April 19, May 13, 1913; Tiburon, April 29, 1913.

### *Crago nigromaculata* (Lockington)

*Crangon nigromaculata* Lockington, Proc. Calif. Acad. Sci., 7, 34, 1877;  
Holmes, Occas. Papers Calif. Acad. Sci., 7, 173, pl. 2, fig. 32, 1900;  
Rathbun, H. A. E., 10, 114, fig. 51, 1904.

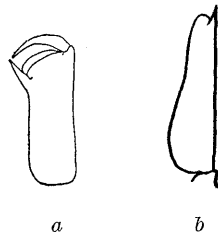


Fig. 57. *Crago nigromaculata*; a, chela, ♀,  $\times 2\%$  (after Rathbun, U. S. N. M.); b, acicle (after Holmes).

*Characters*.—Sixth segment of abdomen with a large circular spot on either side of its posterior end; bluish in life and when fresh. Hands similar to but a little longer than those of *C. nigricauda*. Antennal scale also like that of

*C. nigricauda*, but longer and narrower; blade with anterior margin more advanced at inner than at outer angle. Fifth segment of abdomen not carinate.

*Dimensions*.—Type: from tip of antennal scale to tip of tail 63.5 mm., of body from tip of rostrum 52.3 mm. The largest specimen taken in San Francisco Bay, an ovigerous female, measured 69 mm. from tip of rostrum to end of telson; the general average was between 40 and 45 mm.

*Color*.—Readily distinguished from all others by the black spot on each side of the tail (Lockington).

*Type Locality*.—San Diego, California, 6 fathoms.

*Distribution*.—From northern California to Lower California, 3 to 33 fathoms (Rathbun).

*Biological Survey of San Francisco Bay*.—*Crago nigromaculata* is a bottom-dwelling form, rather scatteringly distributed in the middle and upper lower bay, and outside within the 30-fathom curve. With few exceptions all our specimens were taken on a muddy sand, sandy mud, or mud bottom, in 5 to 16 fathoms by means of the sledge trawl. Not a single specimen was taken in any of the tow-net hauls.

In the middle bay out of a return of seventy-eight specimens from thirteen stations (18% of the total number) only four hauls of one specimen each were not made with the sledge trawl (D 5705, 5-foot Tanner trawl; D 5778 and 5779, 19-inch boat dredge and 3-foot Tanner trawl, and D 5795, oyster dredge), and only three (D 5778, 5779, 5795 included in the four just mentioned) had a bottom of sand and stones or boulders. These three were also the only middle bay records not made in the upper and eastern portions of that division. Eighteen specimens, all told, were obtained in two seine hauls on the Fort Baker Beach.

In the lower bay fourteen specimens were taken at three stations (D 5803–5805; 8% of the total number), all of which were made with the sledge trawl off Hunter's Point, on a soft mud bottom containing worm tubes in two instances (D 5804, 5805).

Outside at three stations (D 5736, 5792, 5806, 17% of the total number), made with the 9 and 12-foot beam trawls in 9 to 26 fathoms, on a fine gray to greenish sand bottom, twenty specimens were obtained.

The ranges of temperature and salinity correlated with the stations from which this species is recorded are, respectively, 8.8° to 17.2°C, and 27.8 to 34.1.

The middle bay stations at which *Crago nigromaculata* was taken are: D 5705, 5778, 5779, 5795, 5797, 5799, 5821, 5823–5826, 5828, 5830; Fort Baker, April 19 and May 13, 1913.

***Crango alaskensis elongata* (Rathbun)**

*Crangon alaskensis elongata* Rathbun, Proc. U. S. Nat. Mus., 24, 888, 1902;  
H. A. E., 10, 115, fig. 54, 1904.

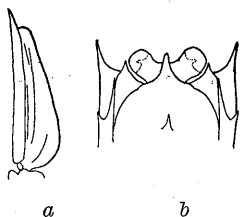


Fig. 58. *Crango alaskensis elongata*, ♀; a, acicle,  $\times 2$ ; b, anterior portion of carapace,  $\times 2\frac{1}{2}$  (from Rathbun, U. S. N. M.).

*Characters*.—Antennal scale as long as the carapace, exclusive of the rostrum; antero-internal angle of blade rounded and not produced; spine extending considerably beyond the blade. Hands from two and a half to three times as long as wide; anterior margin, against which dactylus closes obliquely forming an angle of about  $45^\circ$  with the lengthwise margin. Fifth segment of abdomen with superior median carina.

*Dimensions*.—Type, ovigerous female: length from tip of rostrum to tip of telson 55.7 mm., length of carapace, 13.5 mm., of antennal scale 11.6 mm. The San Francisco Bay material ranged in length, from tip of rostrum to end of telson, for the smallest specimen, a male, 11 mm., to 55 mm. for the largest, an ovigerous female; the greater number of the specimens averaged about 44 mm. in length.

*Type Locality*.—Off Santa Barbara, California, 29 fathoms ("Albatross" stations 2970, 2971).

*Distribution*.—British Columbia to United States Mexican boundary line.

*Remarks*.—This subspecies is a form of *C. alaskensis*, which is found from Puget Sound northward. It differs from the typical *C. alaskensis* in that the rostrum is longer and narrower; the outer flagellum of the antennules falls considerably short of the antennal scale; the antennal scale is much longer, about equaling the length of the carapace exclusive of the rostrum.

*Biological Survey of San Francisco Bay*.—*Crango alaskensis elongata* was taken in numbers of twenty or more at all outside stations at which the depth exceeded 19 fathoms, D 5785–5792 except D 5788, 60 to 68 fathoms, where only two specimens were obtained. *Pandalus jordani* was taken at all but the most shoal of these stations, D 5792. 19 to 26 fathoms, the others being all over 29 fathoms in depth. The bottom uniformly was very fine green sand except at D 5791, where little else than refuse and garbage was brought up. For these stations the observed temperature and salinity ranges are respectively  $9.3^\circ$  to  $12.2^\circ$  C, and 33.8 to 34.3.

***Crago alba* (Holmes)**

*Crangon alba* Holmes, Occas. Papers Calif. Acad. Sci., 7, 174, 1900; Rathbun, H. A. E., 10, 117, figs. 56, 57, 1904; Hilton, Jour. Ent. Zool., Pomona Coll., 10, 54, 1918.

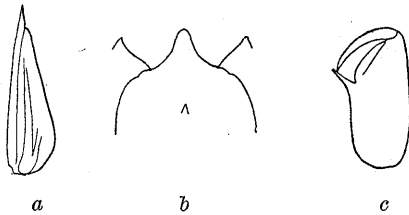


Fig. 59. *Crago alba*, ♀; a, acicle,  $\times 2$ ; b, dorsal view of orbital region of carapace,  $\times 4$ ; c, chela,  $\times 2\frac{2}{3}$  (from Rathbun, U. S. N. M.).

*Characters.*—Sixth segment of abdomen rounded beneath, not grooved. Third maxillipeds reaching the end of the blade; antepenultimate segment much expanded. Hands very stout, only two and one-fourth times as long as the width measured from the inner base of the immovable spine; the anterior margin is more longitudinal than transverse. Antennal scale about three-fourths the length of the carapace; blade with very oblique inner margin, the tip scarcely wider than the adjacent portion of the spine; spine extending considerably beyond the blade.

*Dimensions.*—The specimens taken in connection with the Survey ranged from 32 to 45 mm. in length, the average being about 36 mm. in length, from tip of rostrum to end of telson.

*Color.*—Nearly white (Holmes). White dotted with black (Hilton).

*Type Locality.*—Monterey Bay, California.

*Distribution.*—From Vancouver Island, British Columbia, to San Diego, California, to a depth of 47 fathoms (Rathbun).

*Biological Survey of San Francisco Bay.*—*Crago alba* was dredged only once in the course of the survey, eight specimens at D 5790, outside, in 33 to 35 fathoms; bottom very coarse, variegated sand, with a small proportion of fine sand; temperature  $9.7^{\circ}$  to  $11.5^{\circ}$  C; salinity 33.9. Over fifty specimens of *Crago alaskensis elongata* were also taken at this station.

***Crago holmesi* (Rathbun)**

*Crangon holmesi* Rathbun, Proc. U. S. Nat. Mus., 24, 888, 1902; H. A. E., 10, 118, fig. 58, 1904.

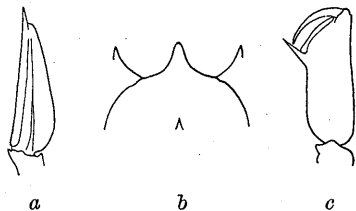


Fig. 60. *Crago holmesi*, ♀; a, acicle,  $\times 4$ ; b, dorsal view of rostral region of carapace,  $\times 8$ ; c, chela,  $\times 8$  (from Rathbun, U. S. N. M.).

*Characters*.—Sixth segment of abdomen rounded beneath, not grooved. Third maxillipeds exceeding the antennal scale a little; antepenultimate segment not dilated. Hands elongate, about three times as long as wide; the anterior margin against which the dactyl folds is more longitudinal than transverse. Antennal scale either as long as or nearly as long as the carapace, exclusive of the rostrum; blade very narrow at the extremity; spine much exceeding blade.

*Dimensions*.—Type, ovigerous female: length 23 mm., length of carapace 5.3 mm., of antennal scale 4.2 mm.

*Type Locality*.—Wilmington, California, 27 fathoms ("Albatross" station 2939).

*Distribution*.—From San Pedro and Santa Catalina Island, California, to Cerros Island, Lower California, 15 to 58 fathoms.

***Crago stylirostris* (Holmes)**

*Crangon stylirostris* Holmes, Occas. Papers Calif. Acad. Sci., 7, 174, pl. 2, figs. 33–35, 1900; Rathbun, H. A. E., 10, 118, fig. 59, 1904.

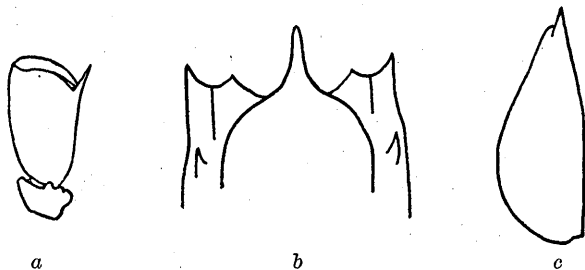


Fig. 61. *Crago stylirostris*; a, chela; b, dorsal view of anterior portion of carapace; c, acicle (after Holmes).

*Characters*.—Carapace without a median gastric spine. Rostrum long, narrow, grooved above, tapering to a narrow, acute tip, which is curved strongly downward and much compressed laterally. Sixth segment of abdomen not sulcated



below. Third maxillipeds with antepenultimate segment outwardly dilated, as in *C. alba*. Hands slightly widened distally, shorter and broader than in *C. alba*, the length being barely twice the width; anterior margin more transverse than longitudinal. Antennal scale shaped as in *C. alba* but much shorter, being only a little over half as long as the carapace.

*Dimensions*.—Type: length 55 mm.; length of carapace 15 mm., of antennal scale 10 mm. The Bay specimens range up to 54 mm. in length, the largest taken an ovigerous female; the general average is between 34 and 47 mm.

*Type Locality*.—Trinidad, Humboldt County, California.

*Distribution*.—Chirikof Island, Alaska, to Santa Cruz, California, to a depth of 26 fathoms.

*Biological Survey of San Francisco Bay*.—*Crago stylirostris* is primarily a bottom-dweller, living on a more or less hard, sand or sandy bottom, occurring principally in that portion of the middle bay lying west of Alcatraz, Angel Island, and the head of Raccoon Strait, exclusive of Richardson Bay (see plate 7), as well as outside, where, however, it was not found beyond the 26 fathom line. *Crago stylirostris* was taken at only three hydrographic stations (H 4996 middle bay; H 5005, 5015 lower bay, only one specimen at each).

In the upper bay this species was taken at but 9% (2) of the dredging stations at the extreme lower end between Points San Pedro and San Pablo; in the middle bay at 38% (28) of the stations, of which 75% (21) were in the western section defined above, inclusive of Golden Gate; in the lower bay at only 5% (2); and outside at 47% (8) of the stations. Of the eleven eastern middle, upper, and lower bay stations, only 9% (1) returned more than eleven specimens and then only a total of thirty-three, while on the other hand not less than 47% (17) of the thirty-six western middle bay and outside stations returned more than twelve, 22% (8) returned more than thirty-three specimens. At five (62%) of these eight stations, fifty and more specimens were obtained.

With respect to the character of the bottom as stated above, we find that thirty-one (77%) of the stations at which *Crago stylirostris* was dredged had a more or less hard, predominantly sandy bottom, of which eighteen (58%) were purely sand bottoms, while thirteen (42%) contained a considerable admixture of gravel, rock, or stones; six (15%) of the stations were made on a muddy sand or sandy mud bottom; and only two (5%) on a purely mud bottom; the bottom at one (2%) of the stations was not characterized.

The extremes of temperature and salinity to which the distribution of this species subjects it, ranged, respectively, from 8.7° to 16° C, and from 17.5 to 34.1.

A complete list of stations at which *Crango stylirostris* was taken includes: D 5700, 5702, 5707, 5708, 5710-5713, 5715, 5729, 5731-5733, 5735-5737, 5741, 5742, 5745, 5746, 5765, 5769, 5776-5778, 5792, 5795, 5796, 5798-5802, 5806-5809, 5820, 5826, 5828, 5829; H 4996, 5005, 5015; "fishing grounds," July, 1912; west of Blunt Point, Angel Island, March 27, 1913.

### *Crango franciscorum* (Stimpson)

*Crangon franciscorum* Stimpson, Proc. Calif. Acad. Sci., 1, 97, 1859; Jour. Boston Soc. Nat. Hist., 6, 495, pl. 22, fig. 5, 1857; Rathbun, R., The Fisheries and Fishery Industries of the U. S., sec. 1, p. 818, 1884; Holmes, Occas. Papers Calif. Acad. Sci., 7, 172, 1900; Rathbun, H. A. E., 10, 120, fig. 61, 1904.

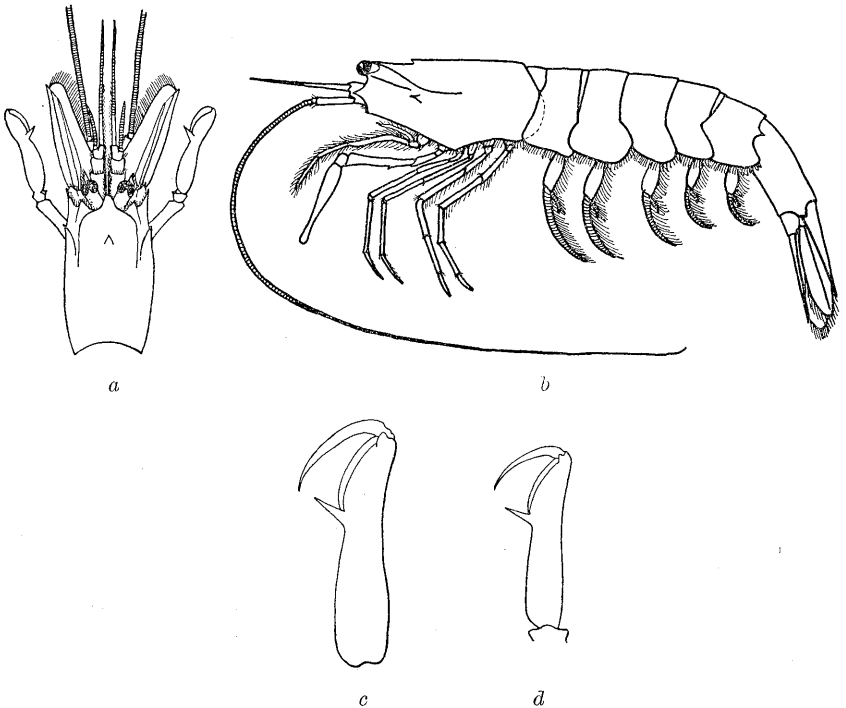


Fig. 62. *Crango franciscorum*, ♀, natural size; a, dorsal view of anterior portion; b, lateral view; c, chela of ♂,  $\times 2\frac{1}{2}$ ; d, chela of ♀,  $\times 2\frac{1}{2}$  (last two from Rathbun, U. S. N. M.).

*Characters*.—Hands very long and narrow from four to four and a half times longer than wide (longer in the male than in the female), inflated near the base, outer margin concave for most part, inner convex, dactyl when flexed, almost longitudinal. Antennal scale about three-fourths as long as carapace, blade

broad and slightly rounded at extremity, spine exceeding blade. Fifth segment of abdomen not carinate.

*Dimensions.*—Type: about 76.2 mm. The Bay specimens ranged up to 82 mm. in length from tip of rostrum to end of telson for the largest female; the average for the greater number of specimens taken is between 47 and 62 mm.

*Color.*—Dark and light yellowish gray mottled. Eyes salmon-colored in life (Stimpson).

*Type Locality.*—San Francisco Bay, California.

*Distribution.*—Southeastern Alaska to San Diego, California, to a depth of 29 fathoms.

*Biological Survey of San Francisco Bay.*—*Crago franciscorum* is universally distributed throughout the bay, extending well up into Suisun Bay, from which it is the only decapod recorded, down into the lower bay as far as suitable collecting apparatus was employed (D 5847, south of which only oyster tongs were used), and outside to the fourteen fathom line.

It was taken in the upper bay at twenty (91%) of the dredging and thirty-five (44%) of the hydrographic stations; in the middle bay at fifty-one (70%) of the dredging and thirty-three (30%) of the hydrographic stations; in the lower bay at fifteen (39%) of the dredging and sixty-nine (64%) of the hydrographic stations; and outside at eight (47%) of the dredging stations, only.

Although taken at seven less dredging stations than *Crago nigricauda*, as compared with that species *Crago franciscorum* is preponderantly an inhabitant of the upper water layers, being an abundant and oft recurring catch of the tow-net. It was taken, in all, at one hundred and thirty-seven (45%) of the total number of hydrographic stations, of which eighty-six (63%) returned more than ten specimens each.

As Stimpson remarked, this species "is found very abundantly in sandy coves around the Bay." We found it even more abundant in the more or less muddy regions of the bay, principally in the upper, lower, and the eastern and upper portions of the middle bay as can readily be seen in a review of the tow-net hauls. These were all made with the same gear, at approximately the same depth and are therefore fairly comparable. From these hydrographic (tow-net) stations, fifty or more specimens were taken at fourteen (40%) of the upper bay stations; at nineteen (28%) of the lower bay stations; and at only six (18%) of the middle bay stations, all of which were in the upper and eastern portions, lying east of Alcatraz, and east and north of Angel Island. No specimens were taken in the tow-net outside.

Somewhat similar relations are shown between the dredge hauls in the various divisions of the bay, but they are much less reliable owing to employment of several different types of collecting apparatus, i.e., boat dredge, beam trawl, sledge trawl, and bucket dredge. Considering only the dredging stations, fifty or more specimens were returned by nine (45%) of the upper bay stations; by eight (53%) of the lower bay stations; by fourteen (27%) of the middle bay stations, of which all but one (93%) are in the upper and eastern portions; and by three (37%) of the outside stations.

At only two of the dredging stations did the depth exceed 19 fathoms: D 5742 in Raccoon Strait, 20 to 30 fathoms (thirty-five specimens); and D 5808 in Golden Gate, 27 to 43 fathoms (two specimens). Outside, however, no specimens were taken at a depth exceeding 14 fathoms.

The ranges of temperature and salinity as observed for the entire bay, as in the case of *Crago nigricauda*, are applicable to this species also; but it must be remembered that the occurrence of *Crago franciscorum* in Napa Creek, above Mare Island, as well as in Suisun Bay, indicates a range of salinity much below any recorded during the survey. Unfortunately we are unable to cite this range here as no hydrographic observations were made above Carquinez Strait.

The list of stations at which *Crago franciscorum* was taken includes: D 5700, 5702, 5705-5716, 5719-5721, 5723, 5725, 5726, 5729-5733, 5735-5737, 5739, 5741-5761, 5763, 5764, 5766-5768, 5771-5773, 5777, 5779, 5780, 5784, 5793-5800, 5802-5808, 5815-5828, 5830, 5847, 5848; H 4986, 4987, 4989, 4993-4996, 4998, 4999, 5002-5008, 5010, 5012-5017, 5082-5096, 5098, 5101-5107, 5109-5117, 5120, 5122-5128, 5131, 5134, 5137, 5138, 5143, 5144, 5146, 5149, 5150, 5155, 5156, 5158-5169, 5171-5173, 5176, 5178-5183, 5185-5188, 5190, 5193, 5196, 5199, 5200, 5218, 5228, 5250-5255, 5257, 5262, 5266, 5267, 5269-5276, 5288, 5298, 5299, 5302, 5306, 5308, 5311, 5313, 5315, 5316, 5319, 5320, 5330; North of Key Route pier, August 2, 1912; Fort Baker, April 19, 1913; Tiburon, April 29, 1913; electric light, ship's side, Sausalito, April 3, 1913.

I. Group with gastric region not depressed below the general level of the carapace.  
 Antennal scale with spine exceeding blade—(Continued)

Section b. Carapace with two median spines. (For section a, see p. 84.)

***Crago communis* (Rathbun)**

*Crangon communis* Rathbun, The Fur Seals and Fur-Seal Islands of the North Pacific Ocean, pt. 3, p. 556, 1899; H. A. E., 10, 123, fig. 64, 1904.

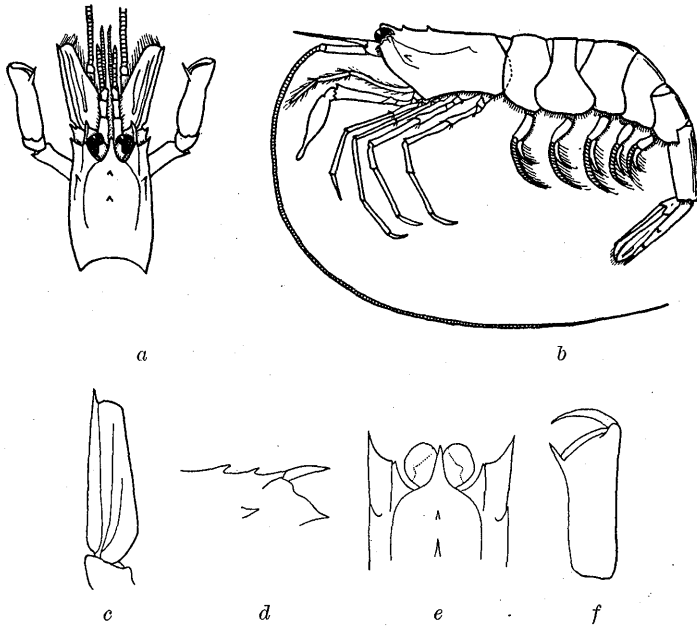


Fig. 63. *Crago communis*, ♀; a, dorsal view of anterior portion, natural size; b, lateral view, natural size; c, acicle,  $\times 2$ ; d, lateral view of anterior portion of carapace; e, dorsal view of same,  $\times 2$ ; f, chela,  $\times 2\frac{1}{2}$  (last four from Rathbun, U. S. N. M.).

**Characters.**—Third to fifth abdominal segments with a blunt median carina; first and second segments with a transverse sulcus; the third and fourth each with two transverse sulci, which are connected either side of the median carina; sixth segment furnished with two prominent longitudinal carinae, a median sulcus, and a sulcus on the outer side of each carina; the telson with a deep median sulcus. The abdominal sulci are filled with a short, thin pubescence, easily rubbed off. Second segment of antennular peduncle about twice as long as the third. Rostrum slender, tapering, ascending, having a median sulcus, tip rounded, not extending beyond the eyes. Hands over three times as long as their average width, anterior margin obliquely transverse. Antennal scale about two-thirds the length of the carapace; spine exceeding blade.

**Dimensions.**—Type, female: length 64 mm., length of carapace 16 mm., length of antennal scale 10.5 mm. The Survey specimens ranged between 33 and 65 mm. in length; the average of the twenty-five specimens taken being about 40 mm.

*Type Locality.*—Off Pribilof Islands, Bering Sea, 51 fathoms ("Albatross" station 3441).

*Distribution.*—Bering Sea to San Diego, California, 9 to 309 fathoms.

*Remarks.*—The rostrum in normal individuals does not extend beyond the eyes; in many cases, however, it is evident that the rostrum has been broken off or injured and later renewed, the new rostrum having a narrow, elongated, and ascending tip, exceeding the eyes but of variable length. In other respects these abnormal forms do not differ from the types (Rathbun).

*Biological Survey of San Francisco Bay.*—*Crago communis* was taken only at the most distant as well as the deepest of the outside stations, D 5788; twenty-five specimens in 60 to 68 fathoms; temperature 9.3° to 11.3° C; salinity 34.0 to 34.2. *Crago resima* also was recorded from this station only; both *C. alaskensis elongata* and *C. spinosissima* were also taken here.

#### *Crago resima* (Rathbun)

*Cragon resima* Rathbun, Proc. U. S. Nat. Mus., 24, 889, 1902; H. A. E., 10, 124, fig. 65, 1904.

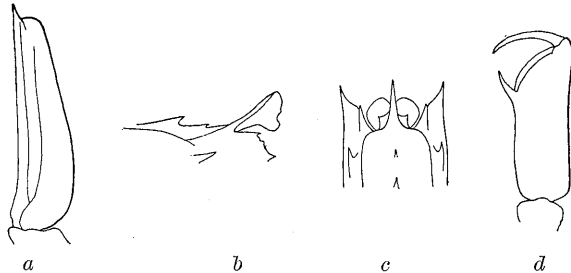


Fig. 64. *Crago resima*, ♀; a, acicula,  $\times 3\frac{1}{2}$ ; b, lateral view of anterior portion of carapace,  $\times 2\frac{1}{2}$ ; c, dorsal view of same,  $\times 2$ ; d, chela,  $\times 4$  (from Rathbun, U. S. N. M.).

*Characters.*—The first five abdominal segments are smooth, the first and second segments have a thickened band along the posterior margin, in front of which there is a slight transverse depression; the fifth segment has an obscure median carina, with a short depression on either side at the anterior end; the sixth segment has two prominent carinae and a corresponding median depression; the telson has a slight median sulcus. Eyes of moderate size. Second segment of antennular peduncle three times as long as the third. Rostrum long, narrow, pointed, advanced beyond the eyes, ascending at an angle of about forty-five degrees, slightly curved, and prolonged downward in a thin, compressed plate, which appears spatulate in a side view. The development of this plate is dependent on age; specimens 20 mm. long show no evidence of it. Hands shorter than in *C. communis*, about three times as long as wide, anterior margin also more longitudinal than in *C. communis*. Antennal scale about four-fifths the length of the carapace exclusive of the rostrum, spine exceeding blade.

*Dimensions*.—Type, ovigerous female: length 48.3 mm., length of carapace 12.2 mm., of antennal scale 8.2 mm. The three specimens taken in connection with the Survey averaged 38.5 mm. in length from tip of rostrum to end of telson.

*Type Locality*.—Off San Diego, California, 124 fathoms ("Albatross" station 2935).

*Distribution*.—From off San Francisco, California, to San Domingo Point, Lower California, 15 to 266 fathoms.

*Biological Survey of San Francisco Bay*.—Three specimens of *Crago resima* were taken at D 5788, associated with *Crago communis*, *C. alaskensis elongata* and *C. spinosissima* (see *C. communis*, above).

### *Crago abyssorum* (Rathbun)

*Cragon abyssorum* Rathbun, Proc. U. S. Nat. Mus., 24, 890, 1902; H. A. E., 10, 125, fig. 66, 1904.

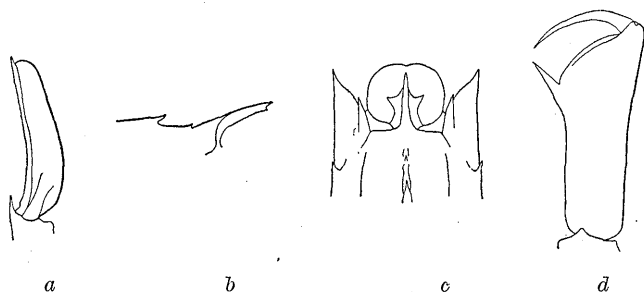


Fig. 65. *Crago abyssorum*, ♀; a, antennal scale,  $\times 2$ ; b, lateral view of rostrum and dorsal spines,  $\times 2$ ; c, dorsal view of anterior part of carapace,  $\times 2$ ; d, chela,  $\times 3\frac{3}{4}$ .

*Characters*.—The fifth abdominal segment has a long, blunt carina; the sixth has two prominent dorsal carinae and a low lateral carina on each side near the dorsal, but extending only half the length of the segment; the telson has a median furrow on its anterior fourth. Eyes very large, hemispherical, their inner faces flat and contiguous; cornea covering nearly all the outer face. Second segment of antennular peduncle about one and a half times as long as the third. Rostrum linear, flattened above, acute, ascending at an angle of about thirty degrees with the carapace, and slightly curved, a little higher than wide, the lower part laterally compressed; length about one-fourth the remainder of the carapace. Hands widening a little distally, their length three times the width, measured at the inner base of the spine; the dactylus is more longitudinal than transverse. The antennae have a slender spine at the outer base of the scale, which is narrow-oblong and three-fourths as long as the carapace, rostrum excluded.

*Dimensions*.—Type, female: length 61 mm., of carapace and rostrum 17 mm., of carapace, exclusive of rostrum, 13.5 mm., of antennal scale 10.3 mm.

*Type Locality*.—Bering Sea, southwest of Pribilof Islands, 1771 fathoms ("Albatross" station 3603).

*Distribution*.—Bering Sea to the southern extremity of California, 685 to 1771 fathoms (Rathbun).

II. Group with gastric region depressed below the general level of the carapace. Antennal scale with the blade exceeding the spine, except in *C. variabilis*, in which the spine equals or exceeds the blade, and in *C. lomae*, in which the spine exceeds the blade. (The second lateral carina of the carapace counting from the middle, is unarmed in all the species in this group except *C. munitella*, in which it is armed with a spine situated a little behind the superior lateral spine.)

### *Crago munita* (Dana)

*Crangon munitus* Dana, Crust. U. S. Expl. Exped., 1, 536, 1852, pl. 33, fig. 5, 1855.

*Crangon munita* Rathbun, H. A. E., 10, 127, fig. 67, 1904.

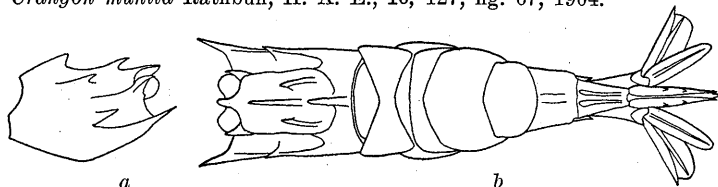


Fig. 66. *Crago munita*, ♂,  $\times 2$ ; a, lateral view of carapace; b, dorsal view of carapace and abdomen (from Rathbun, U. S. N. M.).

*Characters*.—First to fourth abdominal segments inclusive, smooth. Carapace less than two-fifths the length of the abdomen; anterior median spine of the carapace not advanced as far as the line of the orbits. Rostrum short, reaching to a line between the tips of the orbital and the anterolateral spines, nearly horizontal, medially sulcate, tip rounded. Hands oblong, narrowing a little distally or presenting a slight constriction at the base of the spine, three times as long as wide.

*Dimensions*.—Type: length of body 46.6 mm., of carapace 12.7 mm.

*Type Locality*.—Puget Sound.

*Distribution*.—Port Etches, Alaska, to San Miguel Island, California, 12 to 114 fathoms.

*Remarks*.—Dana described the abdomen as smooth. The carina of the fifth segment is very indistinct in the female, while Dana in his figure indicates two carinae on the sixth segment (Rathbun).

### *Crago acclivis* (Rathbun)

*Crangon acclivis* Rathbun, Proc. U. S. Nat. Mus., 24, 890, 1902; H. A. E., 10, 129, fig. 68, 1904.

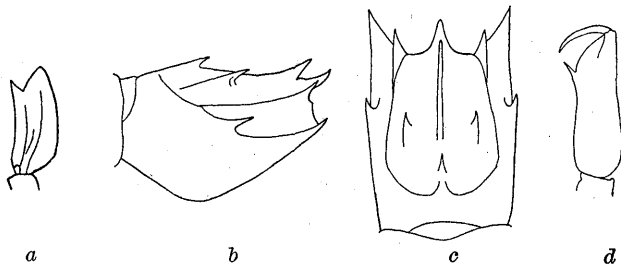


Fig. 67. *Crago acclivis*; a, acicle, ♀,  $\times 8$ ; b, lateral view of carapace, ♂,  $\times 3\frac{1}{2}$ ; c, dorsal view of carapace, ♂,  $\times 4$ ; d, chela, ♀,  $\times 8$  (from Rathbun, U. S. N. M.).



*Characters*.—First to fourth abdominal segments, inclusive, smooth. Anterior median spine of the carapace projecting in front of the line of the orbits. Rostrum narrower than in *C. munita*, and ascending at an angle of about forty-five degrees. Hands much as in *C. munita*, but with anterior margin of hand more longitudinal.

*Dimensions*.—Type, male: length 24.8 mm., length of carapace 7.4 mm., of scale 3 mm.

*Type Locality*.—Off Santa Cruz Island, California, 266 fathoms ("Albatross" station 2948).

*Distribution*.—Also off Trinity Islands, Alaska, 159 fathoms; Santa Catalina Island, California, 80 fathoms; southwest of San Nicolas Island, California, 158 fathoms. One specimen taken at each locality (Rathbun).

### *Crago variabilis* (Rathbun)

*Crangon variabilis* Rathbun, Proc. U. S. Nat. Mus., 24, 890, 1902; H. A. E., 10, 129, fig. 69, 1904.

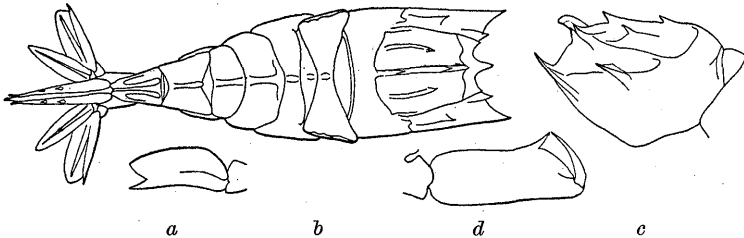


Fig. 68. *Crago variabilis*, ♀; a, antennal scale,  $\times 4$ ; b, dorsal view of carapace and abdomen,  $\times 2$ ; c, lateral view of carapace,  $\times 2$ ; d, chela,  $\times 4$  (from Rathbun, U. S. N. M.).

*Characters*.—Second, third, fourth, and fifth (sometimes the first) abdominal segments carinated, and except on the first two the carina is usually high, laterally compressed, and blunt. Carapace much as in *C. munita*, but nearly half as long as the abdomen. Rostrum short, convex from behind forward, the tip rounded and thickened. Hands vary from two and a half to three times as long as wide.

*Dimensions*.—Type, female: length 32.2 mm., length of carapace 9.2 mm., of hand 5.6 mm.; width of hand 2 mm. Of male, also measured by Miss Rathbun: length 24.6 mm., length of carapace 7 mm., of hand 4.1 mm.; width of hand 1.5 mm.

*Type Locality*.—Off North Head, Akutan Island, Alaska, 72 fathoms ("Albatross" station 2842).

*Distribution*.—Bering Sea, Alaska Peninsula, and Aleutian Islands; California (southwest of San Nicolas Island, 158 fathoms); 50 to 695 fathoms (Rathbun).

*Remarks*.—Miss Rathbun remarks:

There is more variation in this species than is usual in this genus, perhaps owing to the great bathymetrical range.

The rostrum is often much thickened and elevated, the median sulcus being almost obliterated.

The hand is not of uniform proportion. It is longer in the male than in the female, and varies in specimens of the same sex from different localities. The median abdominal carina is in general less strong on specimens from deeper water.

These differences are not sufficiently constant to warrant the division of the species.

***Crago spinosissima* (Rathbun)**

*Crangon spinosissima* Rathbun, Proc. U. S. Nat. Mus., 24, 891, 1902;  
H. A. E., 10, 130, fig. 70, 1904.

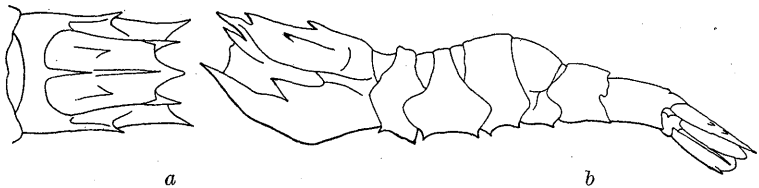


Fig. 69. *Crago spinosissima*, ♀,  $\times 2$ ; a, dorsal view of carapace; b, lateral view of carapace and abdomen (from Rathbun, U. S. N. M.).

*Characters*.—First to fourth abdominal segments more or less carinated. Anterior median spine of the carapace reaching forward to a line in front of the rear line of the orbits. Rostrum narrow and acute, ascending at an angle equal to that of the spine directly behind it. Hands about three times as long as wide. This species differs from all allied species in having the first to third abdominal segments, inclusive, armed laterally with two spines each.

*Dimensions*.—Type, female: length 36 mm., length of carapace 10.5 mm. The Survey specimens range between 28 and 48 mm. in length from tip of rostrum to end of telson.

*Type Locality*.—Off Point Arena, California, 51 fathoms ("Albatross" station 3351).

*Distribution*.—Off Oregon and California, 15 to 96 fathoms. So far as known Point Fermin is the southern limit of this species. I have seen specimens collected there by the Venice Marine Biological Station, at a depth of about 15 fathoms.

*Biological Survey of San Francisco Bay*.—*Crago spinosissima* was taken at two of the outside stations: two specimens at D 5788, 60 to 68 fathoms, and three specimens at D 5789, 33 to 46 fathoms. The bottom of both stations was "fine, green sand"; the temperature range was  $9.3^{\circ}$  to  $11.4^{\circ}$  C; and that of the salinity 33.8 to 34.3. At the deeper of these stations, D 5788, at which, in fact, the greatest depth recorded in the course of the survey, 68 fathoms, was attained, the species in question was found associated with both *C. communis* and *C. resima*, as well as *C. alaskensis elongata*.

***Crago lomae*, sp. nov.**

Plate 12, figures 3 and 4

*Description*.—Near *C. spinosissima*, with spines of carapace similarly placed, anterior median spine equaling or exceeding rostrum in prominence, more acutely pointed, and more nearly erect, at an angle of about sixty-five degrees with the carapace, while the rostrum meets the carapace at an angle nearer forty-five degrees; midway between anterior and posterior spine there is a small denticle on the median carina; surface of the carapace is roughened with minute

granulations. Antennal scale with spine noticeably exceeding blade and separated from it by a deep incision for about the distal fourth of its length. First two abdominal segments obsolescently carinate dorsally, third carinate on anterior half, fourth on anterior two-thirds, and fifth throughout its length; sixth abdominal segment with a median sulcus formed by two nearly parallel carinae, diverging somewhat anteriorly; these carina are paralleled on each side by another carina which anteriorly diverges even more from the median line; abdominal segments one and two are each armed laterally with a single spine, while the third segment has a subacute downward projection near the anterolateral angle; in the male this projection is obsolescent or entirely lacking; fourth and fifth segments with posterolateral angle acute. Telson exceeding inner branch of uropods, which in turn exceeds the outer branch; tip acute and armed in the male with three pairs of lateral spinules and in the female with four.

Ventrally the thoracic sternum of the male has an anteriorly directed spine between the bases of the second pair of legs, and a thin, laterally compressed keel between the bases of the following three pairs of legs. In the female there is a low, blunt tubercle between the bases of the second pair of legs. The first, second, and third abdominal segments of the male are armed below with a prominent, acute median spine; the fourth has a less prominent blunt spine; and the fifth has only a low tubercle; the sixth segment is ventrally unarmed. The abdomen of the female ventrally unarmed except for a small obsolescent tubercle between the pleopods of fifth segment.

*Dimensions*.—Type male, holotype (Cat. No. 52714, U. S. N. M.): length from tip of rostrum to end of telson 35 mm., length of carapace and rostrum 11 mm., of hand about 6 mm.; of female, total length 44 mm., of carapace and rostrum 13 mm., of hand 7 mm.

*Type Locality*.—Off Point Loma, California, 525 to 541 fathoms, 1 male ("Albatross" station 4334).

*Distribution*.—The only other specimen of this species, a female, was also taken off Point Loma, 628 to 640 fathoms ("Albatross" station 4353).

*Remarks*.—In this species the tip of the rostral spine reaches only about to the middle of the ocular peduncle; in *C. spinosissima* it reaches to the cornea but does not exceed it; and in *C. spinirostris* (Rathbun, 1904a, p. 131), another closely related species, the tip of the rostral spine exceeds the eyes.

### *Crago munitella* (Walker)

*Crangon munitellus* Walker, Trans. Liverpool Biol. Soc., 12, 275, pl. 16, fig. 1, 1898; Holmes, Occas. Papers Calif. Acad. Sci., 7, 176, 1900.

*Crangon munitella* Rathbun, H. A. E., 10, 132, 1904.

*Crago munitella* Hilton, Jour. Ent. Zool., Pomona Coll., 10, 54, 1918.

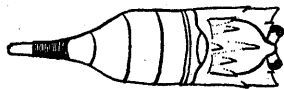


Fig. 70. *Crago munitella*, ♀, dorsal view of carapace and abdomen,  $\times 1\frac{1}{2}$  (adapted from Walker).

*Characters*.—Second lateral carina of the carapace (counting from the middle) armed with a spine a little behind the superior lateral spine. First to fourth abdominal segments smooth. Hands two and one-half times as long as wide, swollen, the anterior margin more longitudinal than transverse.

*Dimensions*.—Type, ovigerous female: length 25 mm.

*Color*.—Abdomen with sixth segment darker colored than the others; a dark transverse band on the caudal appendages (Walker). One specimen was mottled brown with bright red markings along the back; the whole body of another was a dark slate color; another was banded with slate color, with center of body red; and still another had bands of slate and red alternating (Hilton).

*Type Locality*.—Puget Sound.

*Distribution*.—Puget Sound to Laguna Beach and Santa Catalina Island, California,  $3\frac{1}{2}$  to 40 fathoms.

*Biological Survey of San Francisco Bay*.—*Crago munitella* was dredged in  $3\frac{1}{2}$  to 7 fathoms, from a bottom consisting of angular rock fragments of various sizes, at two adjacent stations, D 5773 and 5775, on each side of Yellow Bluff, south of Sausalito. At the latter station, *C. munitella* was in company with *Scleroplax granulata*, while at the former it was associated with *Spirontocaris cristata*, *Crago nigricauda*, *C. franciscorum*, and *Cancer productus*. The range of temperature and the salinity of the hydrographic stations which may be correlated with the above dredge stations (as given in appendix III, p. 354) are respectively  $11.0^{\circ}$  to  $13.5^{\circ}$  C and 26.6 to 31.6.

### Genus *Nectocrangon* Brandt

Rostrum wanting. Eyes nearly concealed or hidden by the carapace. Dactyls of fourth and fifth pairs of legs dilated and more or less adapted for swimming.

#### *Nectocrangon californiensis* Rathbun

*Nectocrangon californiensis* Rathbun, Proc. U. S. Nat. Mus., 24, 892, 1902; H. A. E., 10, 140, figs. 80, 81, 1904.

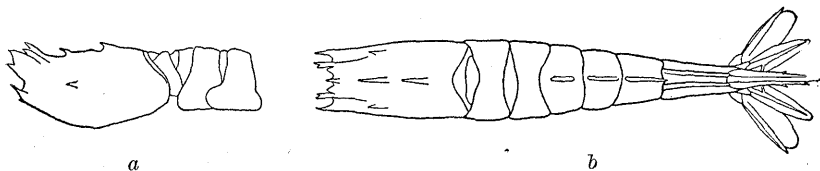


Fig. 71. *Nectocrangon californiensis*, ♂; a, lateral view of carapace and anterior portion of abdomen,  $\times 2$ ; b, dorsal view of carapace and abdomen,  $\times 2$  (from Rathbun, U. S. N. M.).

*Characters*.—First and second abdominal segments not carinated; third and fourth segments only feebly carinated; each carina of the sixth segment terminating in a small, sharp tooth or spine. Carapace with only two median spines behind spine on anterior margin which, outside of orbital fissure, is furnished with two spines close together instead of one as in the allied species. Antennal scale with spine extending only slightly beyond the blade. Hands from three and a half to four times as long as wide.

*Dimensions*.—Type, male: length 31 mm., length of carapace 8.6 mm.

*Type Locality*.—Off Santa Catalina Island, California, 80 fathoms ("Albatross" station 3664).

*Distribution*.—Santa Cruz and Santa Catalina Islands, California, 59 to 155 fathoms.

### Genus *Paracrangon* Dana

Rostrum elongate, a laterally compressed, suberect spine. Eyes free. Second pair of legs wholly absent.

#### *Paracrangon echinata* Dana

*Paracrangon echinatus* Dana, Proc. Acad. Nat. Sci. Phila., 6, 20, 1852;

Crust. U. S. Expl. Exped., 1, 538, 1852, pl. 33, fig. 6, 1855; Holmes,

Oceas. Papers Calif. Acad. Sci., 7, 176, pl. 2, figs. 36, 37, 1900.

*Paracrangon echinata* Rathbun, H. A. E., 10, 143, 1904.

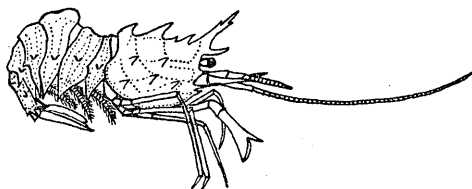


Fig. 72. *Paracrangon echinata*; lateral view,  $\times \frac{3}{4}$  (after Dana).

*Characters*.—Rostrum long, obliquely erect; posterior margin with one tooth near the middle; anterior margin with one tooth near the tip, and at base a long curved spine. Carapace with a median carina unequally four-toothed; sides carinated in such a way as to form irregular quadrangular spaces, with spines at most of the angles; on the anterior margin there is a spine at the outer angle of the orbit and another at the anterolateral angle. First pair of legs about as long as the maxillipeds; upper margin of merus terminates distally in a tooth; hands narrow, elongate, about four times as long as wide; digital spine very long and slender, directed in an obliquely longitudinal direction; anterior margin more longitudinal than transverse. Third pair of legs (the second are lacking) very slender, barely reaching to end of first pair; fourth and fifth pairs of about equal length and slightly exceeding first pair in length. Abdomen carinate behind second segment, carina of third being especially high; on sixth segment and telson it is medially sulcate; abdominal pleura of male much more spiniform than in female.

*Dimensions*.—Type: length 45 mm.

*Type Locality*.—Puget Sound.

*Distribution*.—Port Etches, Alaska, to off La Jolla, California; Japan (Balss).

*Remarks*.—Heretofore *P. echinata* had not been definitely recorded south of Puget Sound. In the "Albatross" collections, however, there are three specimens which had been taken off the Californian coast; two, an ovigerous female and an

immature specimen, from a depth of 38 to 45 fathoms, off Santa Rosa Island ("Albatross" station 4431), and one, a male from 46 to 56 fathoms, in Monterey Bay ("Albatross" station 4551). Still another California specimen is contained in the collection of the Scripps Institution; it was taken July 11, 1905, in 110 fathoms, off La Jolla (haul 998).

## Suborder REPTANTIA

### KEY TO THE TRIBES OF THE REPTANTIA

- I. Third pair of legs like the first. Abdomen *macrurous*, straight, symmetrical, well armored, with good pleura and strong tail-fan, lobes of first segment clipping the carapace.
- A. Rostrum small or wanting, third pair of legs simple and subcylindrical, carapace fused at sides to the epistome. Exopodites of last pair of abdominal appendages without sharp suture. (Not known north of San Luis Obispo.)
- Palinura*, p. 105.
- B. Rostrum of good size; third legs chelate. Carapace free from the epistome. Exopodites of last pair of abdominal appendages divided by a suture. (Except for the crayfishes, fresh-water forms, not dealt with in this paper, not found in California waters.)
- Astacura*.
- II. Third pair of legs unlike the first, abdomen rarely *macrurous*.
- A. Abdomen fairly large, *anomurous*; reduced in some of its features, but showing clear traces of some function other than that of reproduction, and almost always carrying biramous limbs on the sixth segment. Tail-fan usually present, uropods biramous, absent only in the Lithodidae. Carapace not fused with epistome. Antennae situated external to the eye, with long flagellum, often with movable antennal scale. Last thoracic sternum free, its legs always differing clearly from the third pair in size and position and nearly always in size and shape.
- Anomura*, p. 109.
- B. Abdomen comparatively small, *brachyurous*; small, straight, symmetrical, bent under the thorax, showing no traces of other function than reproduction, and without biramous limbs on the sixth segment. Tail-fan not developed, uropods rarely present, never biramous, only in the Dromiidae are they present and then only in a rudimentary condition. Carapace fused with epistome at sides and nearly always in the middle. Antennae situated internal to the eye, seldom with long flagella, and never with a movable scale. Last thoracic sternum fused with the rest, its legs often like the others.
- Brachyura*, p. 182.

## Tribe PALINURA

## KEY TO THE SUPERFAMILIES AND FAMILIES OF THE PALINURA

- I. All of the legs chelate, except sometimes the last pair; the first larger than the rest. First joint of antennae not fused with the epistome; an antennal scale present. Pleopods present on first abdominal somite; tail-fan not softer behind than before, without sutures; telson pointed (Superfamily *Eryonidea*).
- Eryontidae*, p. 105.
- II. None of the legs chelate, except sometimes the first pair; none much longer than the rest. First joint of antennae fused with the epistome; no antennal scale present. Pleopods absent from first abdominal somite: tail-fan divided by indistinct sutures into a soft hinder part and a harder front half; telson roughly square behind (Superfamily *Scyllaridea*).
- A. Carapace subcylindrical. Eyes not enclosed in separate orbits formed by the edge of the carapace. Antennae with flagella.
- Palinuridae*, p. 107.
- B. Carapace depressed. Eyes enclosed in separate orbits formed by the edge of the carapace. Antennae with flat scales in place of flagella. (Not found off California.)
- Scyllaridae*.

## Family ERYONTIDAE

Carapace either depressed with very sharply defined lateral borders or subglobose; rostrum wanting, or represented by a small spine or pair of spines. Eyes rudimentary and eye-stalks immovably fixed in the orbital notches of the anterior margin of the carapace. Antennal peduncle five-jointed, basal joint not fused with the epistome; flagellum lash-like; the renal tubercle of the basal joint of the peduncle is remarkably prominent. Telson pointed.

Genus *Eryonicus* Bate

Carapace subglobose, much inflated, and larger than the abdomen; integument almost membranous. Antennules and antennae shorter than the carapace; renal tubercle on basal segment of antennae nearly equaling the peduncle in length.

*Eryonicus agassizi* Bouvier

Plate 15, figures 1 and 2

*Eryonicus caecus*? Faxon, Bull. Mus. Comp. Zool., 24, 197, 1893; Mem. Mus. Comp. Zool., 18, 110, pl. B, fig. 2, pl. xxix, figs. 2-2f, pl. xxx, 1895 (not *Eryonicus caecus* Bate); Selbie, Sci. Invest. Fisheries Ireland, 1, 26, 1914; Sund, *Nature*, 95, 372, 1915.

*Eryonicus Agassizi* Bouvier, Bull. Inst. Oceanog. Monaco, 309, 2, 1915.

*Characters*.—Rostrum represented by a pair of small spinules. Median ridge of carapace armed with small spines, arranged as follows: Rostrum + 1, 2, 1, 1, or

none; cervical groove, 2, 2, 1, 2. Otherwise the principal spines of the carapace are situated as follows: subdorsal or branchial ridge, five; one on branchial area between median and branchial carinae; lateral carina, running from external angle of the orbit to the posterior margin of the carapace, with sixteen spines arranged six-three-seven, of which the last four are the largest; upper of two ridges, below the lateral carina, running from the outer side of the base of the antenna almost to the hinder border of the carapace, spinulose along the anterior third of its course; the lower ridge, beginning on the margin of the pterygostomial region, one-third of the way from the anterior end of the carapace and curving outward and backward to the posterior margin of the carapace, with five spines which decrease in length from the first to the fifth, followed by small denticles; the anterior spines in this last series are the largest on the body.

Eyes rudimentary, without corneae; eyestalks consisting of a large lobe, immovably fixed in a deep sinus in the anterior border of the carapace. This lobe sends forth an elongated, cylindrical process, directed outward and downward below the antero-lateral angle of the carapace; the anterior margin of the lobe bears a prominent papilla, or tubercle.

Abdomen with five longitudinal rows of spines, one median and two pairs of lateral; median row with one spine on the first abdominal somite, one or two on the second, two or one on the third, two or three on the fourth, two on the fifth, one on the sixth, and two on the base of the telson.

*Dimensions.*—Type, male: length from rostrum to end of telson 62.5 mm., of carapace 34.5 mm., of abdomen 30 mm.; specimen taken off California by the "Albatross": length from rostrum to end of telson 75 mm.

*Color.*—Of Faxon's specimens in life, "purplish red, the branchial regions livid." California specimen: "extremities shaded with pale rose, body parts flesh color."

*Type Locality.*—Off Malpelo Island, vicinity Gulf of Panama, 1201 fathoms ("Albatross" station 3375).

*Distribution.*—Gulf of Panama and vicinity; surface to 1832 fathoms (Faxon). Also taken off San Nicolas Island, California in 654 to 704 fathoms ("Albatross" station 4405).

With respect to the great depth recorded for some of the captures of *Eryonicus* Faxon says (1895, p. 110):

The huge spherical carapace of *Eryonicus* perhaps serves as a hydrostatic apparatus, by means of which the animal is enabled to lead a free-swimming life at some distance above the ocean bottom. The great depths of the soundings at some of the stations where *Eryonicus* has come up in the trawl may be delusive, as in the case of swimming *Hoplophoridae* and *Sergestidae*, which are often found in the trawl that has been lowered to great depths. At station 3388 ["Albatross," Gulf of Panama], twenty-five miles from the nearest land, where the depth was 1168 fathoms, the Tanner self-closing net [described in Agassiz, 1892, pp. 46-48] was lowered to 400 fathoms and towed for seventeen minutes. The net was hauled up to the surface after the lower part had been securely closed by the messenger at 400 fathoms. The lower part of the net was found to contain absolutely no life, while the upper part, which had remained open all the way from 400 fathoms to the surface, contained four specimens of *Eryonicus*, 19-29 mm. long, together with other swimming forms [Agassiz, 1892, pp. 48, 49]. At stations 3375 and 3383 ["Albatross," Gulf of Panama and vicinity], although captured in the trawl which had been lowered to depths of 1201 and 1832 fathoms, *Eryonicus* was found associated with several swimming forms. At station 3403 ["Albatross"], a specimen of *Eryonicus spinulosus* [Faxon, 1895, p. 116] was brought up in the trawl where the bottom was only 384 fathoms.

From these facts it is possible, if not probable, that *Eryonicus* leads a free-swimming existence at depths moderate compared with those frequented by truly



abyssal species. On the other hand, the structure of its visual organs and its absence from collections made with the surface tow-net preclude the thought of its living at or very near the surface.

*Remarks.*—There seems to be some variation in the number of spines before the cervical groove. The formula above in the “*Characters*” adapted from Faxon gives one more spine just before the cervical groove than appears in the “*Albatross*” California specimen, for which the formula reads: Rostrum + 1, 2, 1; cervical groove 2, 2, 1, 2. That this is no more than variation seems borne out by an examination of several of the juvenile specimens identified by Faxon and deposited in the U. S. National Museum. For three of these the formulas are:

1. (Length 37 mm.): Rostrum + 1, 2, 1, 1, denticle; cervical groove, 2, 2, 1, 2.
2. (Length 20 mm.): Rostrum + 1, 2, 1, denticle; cervical groove, 2, 2, 1, 2.
3. (Length 19 mm.): Rostrum + 1, 2, 1, denticle; cervical groove, 2, 2, 1, 2.

There are also some slight variations in the number of median abdominal spines, as well as slight discrepancy between Faxon’s colored figure (Faxon, 1895, pl. B) and his published description, as follows:

| Abdominal somite                               | 1 | 2 | 3 | 4 | 5 | 6 | Telson |
|--|---|---|---|---|---|---|--------|
| Faxon’s description .....                      | 1 | 2 | 2 | 2 | 2 | 1 | 2      |
| Faxon’s colored figure .....                   | 1 | 1 | 2 | 2 | 1 | 2 | 3      |
| Faxon’s juvenile No. 1 .....                   | 1 | 1 | 2 | 3 | 2 | 1 | 2      |
| Faxon’s juvenile No. 2 .....                   | 1 | 1 | 2 | 2 | 2 | 1 | 2      |
| Faxon’s juvenile No. 3 .....                   | 1 | 1 | 2 | 2 | 2 | 1 | 2      |
| “ <i>Albatross</i> ” California specimen ..... | 1 | 1 | 1 | 3 | 2 | 1 | 2      |

In Bouvier’s paper cited in synonymy above, the name *agassizi* for Faxon’s *cæcus* is introduced without comment: “. . . *E. Agassizi* (= *E. cæcus* Faxon) . . .”

Owing to the fact that Bate had only one immature specimen it is not easy to point out a number of valid differences between his species and that described by Faxon; but one which seems to be of prime importance is the presence of only one median spine on the base of the telson in Bate’s material whereas all of Faxon’s specimens and my own have two, a character which would immediately separate them in the key given by Selbie (1914, p. 28) for the species of *Eryonicus*.

#### Family PALINURIDAE

Carapace longitudinally subcylindrical, with rostrum wanting or represented by a tooth. Orbits only partially excavated; the eyes may be protected by a spine above or below, or both, but are never lodged in true orbits. Antennal peduncle four-jointed, the basal joint fused with the epistome; with a long, cylindrical, quite rigid, multiarticulate flagellum. Telson roughly square behind.

#### Genus *Panulirus* White

No central rostriform tooth. The ocular segment exposed and membranous, ocular peduncles small and free. Flagella of antennules long and slender, their segment produced considerably in advance of the frontal margin, and generally armed with strong teeth.

**Panulirus interruptus** (Randall)

*Panulirus interruptus* Randall, Jour. Acad. Nat. Sci. Phila., 8, 137, 1839.

*Panulirus interruptus* Stimpson, Jour. Boston Soc. Nat. Hist., 6, 491, 1854;

Rathbun, R., The Fisheries of the U. S., sec. 1, p. 780, pl. 270, 1884;

Holmes, Occas. Papers Calif. Acad. Sci., 7, 168, 1900; Rathbun, H. A. E.,

10, 148, 1904; Allen, Univ. Calif. Publ. Zool., 16, 139, 1916; Hilton,

Jour. Ent. Zool., Pomona Coll., 8, 67, 1916.

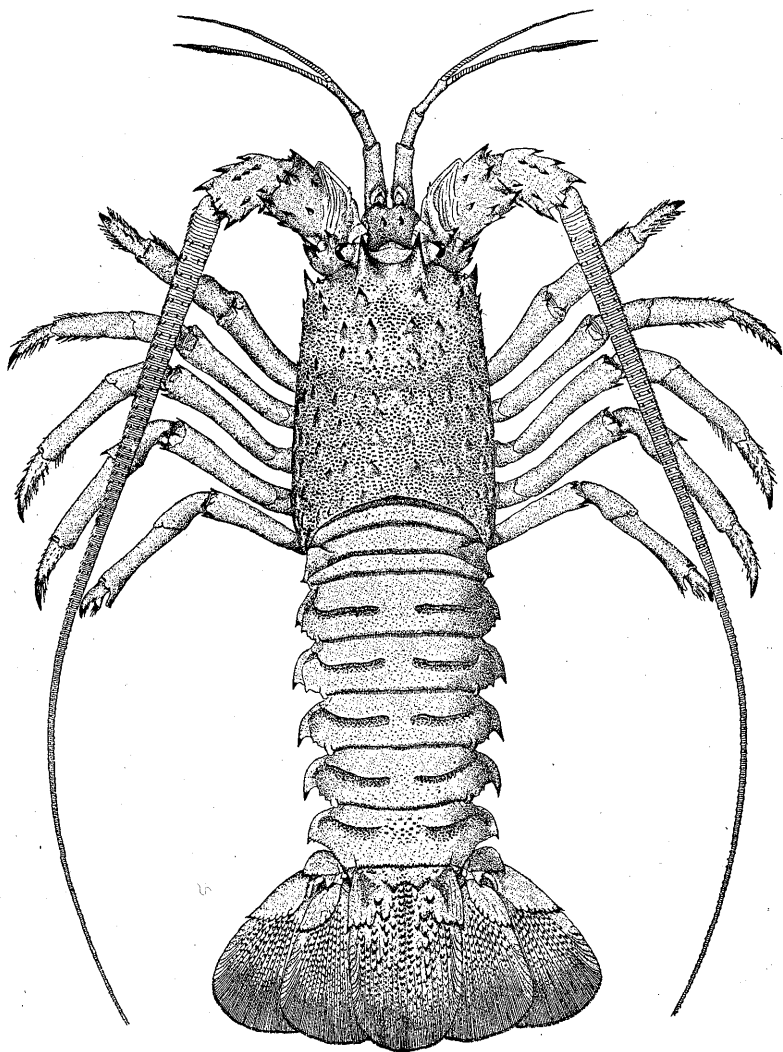


Fig. 73. *Panulirus interruptus* (from Rathbun, U. S. N. M.).

*Characters*.—Peduncle of the antennules slightly exceeds that of the antennae; first joint about as long as the next two; second joint about three-fourths as long as the third; flagella longer than the peduncle, the outer setose on one side

except near the base. Peduncle of the antennae armed with short, stout spines, flagellum spinulose, compressed at the base, and exceeding the body in length. Abdominal segments furnished with a pair of transverse dorsal setose sulci, which do not meet in the middle line except indistinctly on the sixth segment.

*Dimensions.*—Types: 127 mm.—228.6 mm., ranges up to 60.9 cm. in length (Randall).

*Color.*—Feet vittate alternately with red and olivaceous (Randall). There is a large range of color variation, from almost black, through shades of dark mahogany, reddish purple, to a light red color. Fishermen speak of albino specimens. . . . In examining traps laid among the kelp all shades were found in the same trap (Allen).

*Type Locality.*—California.

*Distribution.*—San Luis Obispo, California, to Rosalia Bay, Lower California. To a depth of 35 fathoms (Allen). Mexico (Ortmann, Streets). Except for one immature specimen in the collection of the National Museum, labeled Monterey Bay, this species has never been recorded north of San Luis Obispo, California.

*Remarks.*—This is the common "lobster" of the Pacific coast. It inhabits rocky ledges in rather deep water, and is taken in considerable numbers by the fishermen at Santa Barbara and other ports on the coast south of San Francisco. North of this point it is never found. The traps, or "pots," used in their capture are similar to those in which lobsters are taken on the New England coast, consisting of a strong wooden basket, with a funnel shaped entrance projecting inward (Stimpson). The young of the lobster are often found in the tide pools at Laguna Beach (Hilton).

## Tribe ANOMURA

### KEY TO THE SUPERFAMILIES AND THE CALIFORNIA FAMILIES OF THE ANOMURA

I. Second to fourth legs with last joint curved and flattened. First pair styliform or subchelate. Tail-fan not adapted for swimming. Abdomen bent under thorax (Superfamily *Hippidea*).

A. First pair of legs simple; carapace subcylindrical, evenly rounded, with wings which cover legs, anterolateral angles unarmed.

*Hippidae*, p. 173.

B. First pair of legs subchelate; carapace flattened, with longitudinal median ridge, without wings to cover legs, anterolateral angles spined.

*Albuneidae*, p. 171.

II. Second to fourth legs with last joint not curved and flattened. First pair of legs chelate.

A. Uropods present, adapted for swimming, tail-fan well developed. Abdomen symmetrical, pleura well developed.

1. Body depressed, abdomen bent under, folded upon itself or against thorax, often with a transverse suture on telson (Superfamily *Galatheidea*).

a. Abdomen bent upon itself, but not folded against thorax; body shrimp-like; first legs greatly elongated, slender.

*Galatheidae*, p. 162.

b. Abdomen folded against thorax, body crab-like, first legs only moderately elongate, stout.

*Porcellanidae*, p. 174.

2. Body compressed, abdomen extended, straight, no transverse suture on telson (Superfamily *Thalassinidea*).

a. Abdominal pleura large.

*Axiidae*, p. 110.

b. Abdominal pleura small or absent.

*Callianassidae*, p. 114.

B. Uropods either present or absent; when present not adapted for swimming but for holding the body in hollow objects; abdomen nearly always asymmetrical (Superfamily *Paguridea*).

1. Carapace firm in fore part and soft in hinder part. Rostrum much reduced. Uropoda present, adapted for holding body in hollow objects. Abdomen soft, showing no trace of segmentation, straight or twisted, some of the appendages lost, remaining ones much reduced. Penultimate pair of thoracic legs much shorter than those in front of them (the true hermit crabs).

*Paguridae*, p. 121.

2. Carapace firm all over, body crab-like. Rostrum spiniform or tuberculiform. Uropoda wanting. Abdomen more or less firm, sometimes quite soft, often segmented, bent under thorax. Penultimate pair of thoracic legs at least as well developed as those in front.

*Lithodidae*, p. 146.

### Family AXIIDAE

Body shrimp-like. Abdomen extended, abdominal pleura large, tail-fan well developed, adapted for swimming. First pair of legs chelate and subequal; second pair small, chelate and equal; last three pairs simple. Antennal peduncle five-jointed; antennal scale present as a movable, at times microscopic, thorn-like structure between the second and third joints of the peduncle; an immovable (antennal) thorn also present outside the scale on the second joint.

#### KEY TO THE CALIFORNIA GENERA OF THE AXIIDAE

I. Eyes pale, without pigment.

*Calastacus*, p. 112.

II. Eyes pigmented.

*Axiopsis*, p. 110.

### Genus *Axiopsis* Borradaile

Carapace in front of cervical groove laterally compressed, forming dorsally a well marked flat area or platform; without a median dorsal keel behind the cervical groove, except sometimes a mere suggestion just before the posterior border. Eyes well pigmented. Antennal "thorns" long or of middle size. Exopodite of uropods with a suture.

***Axiopsis spinulicauda* (Rathbun)**

*Axiopsis spinulicauda* Rathbun, Proc. U. S. Nat. Mus., 24, 886, 1902; H. A. E. 10, 149, fig. 90, 1904.

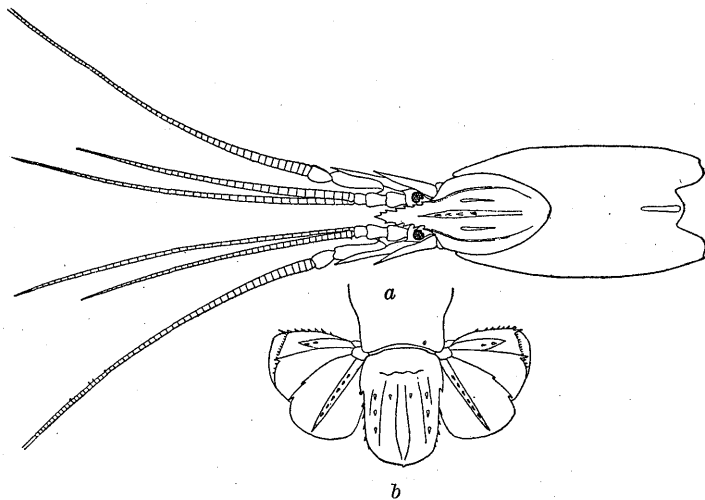


Fig. 74. *Axiopsis spinulicauda*, ♀, × 2; a, dorsal view of anterior portion; b, tail-fan (from Rathbun, U. S. N. M.).

*Characters*.—Rostrum reaches the middle of the second joint of antennular peduncle, slightly deflexed, longitudinally channeled; armed on either side with five to six teeth. Gastric region of carapace traversed by five carinae, all of which fade out before reaching the cervical groove; the median one extends along the basal third of the rostrum, and is armed with four spines just behind the line of the orbits; outer carinae are a continuation of the side margins of the rostrum; outer and intermediate carinae unarmed; in front of the narrow median posterior lobe of the carapace, the surface is compressed or pinched to form a short smooth ridge. Eyes black, of same diameter as the stalk, not reaching middle of basal antennular segment. Outer maxillipeds reach the end of the antennal peduncle. Abdomen smooth above; pleura sculptured and pubescent.

*Dimensions*.—Type, female: length of carapace and rostrum along the median line 19.6 mm., length of rostrum 3.5 mm., of abdomen 31.5 mm.

*Type Locality*.—Off Bodega Head, California, 62 fathoms (“Albatross” station 3172).

*Remarks*.—This species apparently belongs to the genus *Axiopsis* Borradaile (1903, p. 538). The exopodite of the uropods shows a suture and the eyes are well pigmented, but as there is a suggestion of a keel at the posterior end of the median line of the carapace that portion of Borradaile’s definition regarding “no keel on the carapace behind the cervical groove” must needs be modified to include this species. Except for the well pigmented eyes it fits almost as well under *Calastacus* below, as does *C. quinqueseriatus* Rathbun.

Genus **Calastacus** Faxon

Carapace subcylindrical, back arched, dorsally carinate; cervical groove distinct. Eyes almost or quite without pigment. Antennal "thorns" both of good size. Exopodite of uropods with a suture.

## KEY TO THE CALIFORNIA SPECIES OF CALASTACUS

- I. Carapace granulate; no spines behind those at the base of rostrum. (Known only from 345 + fathoms.) *investigatoris*, p. 112.
- II. Carapace not granulate; five rows of spines behind the rostrum. (Known only from 200 + fathoms.) *quinqueseriatus*, p. 113.

**Calastacus investigatoris** Anderson

*Calastacus investigatoris* Anderson, Jour. Asiatic Soc. Bengal, 65, pt. 2, p. 97, 1896; Illus. Zool. "Investigator," Crust., pt. 4, pl. 25, fig. 1, 1896; Alcock, Descr. Cat. Indian Deep Sea Crust. Dec. Macr. Anom. Indian Mus., p. 191, 1901; Rathbun, H. A. E., 10, 151, 1904.

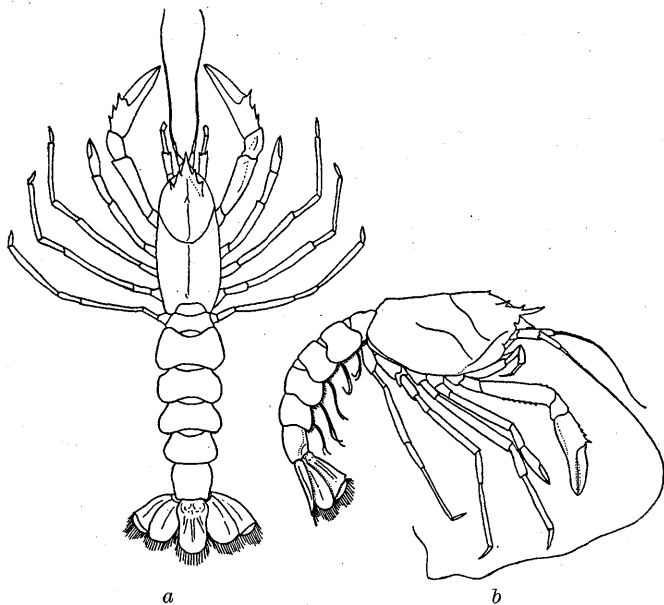


Fig. 75. *Calastacus investigatoris*; a, dorsal view; b, lateral view (after Alcock).

*Characters*.—Carapace (rostrum included), measured in the middle line, as long as the first five and a half abdominal somites; surface studded with sharpish, vesiculous granules; finely carinated in the middle line, carina terminating in a vesiculous tubercle and having a similar tubercle in the middle of its gastric course; cervical and branchial grooves very conspicuous. Rostrum not quite reaching end of second joint of antennular peduncle, its sides prolonged onto the gastric region as two sharp ridges, each of which carries two spines. In the

female the chelipeds are just over half the total length of the body, the hand comprising more than two-fifths their total length; the lower border of the ischium and merus, the upper border of the palm, and the distal half of the merus are spinose; a salient serrulate ridge runs along the lower border of the outer surface of palm and fixed finger, and there are some scattered miliary granules on both surfaces of the palm; the palm is a little longer than the carpus and a little shorter than the fingers; the fingers are slender and sharp, and do not meet at base, the cutting edge of the fixed finger is finely serrulate; there are a few setae on the fingers and palm.

*Color*.—In life: abdomen light brown, carapace very pale pink, fading to slate color on the sides (Alcock).

*Dimensions*.—Type, female: length of carapace and rostrum 22 mm., of abdomen 32.5 mm.

*Type Locality*.—Arabian Sea, off the coast of Sind, 947 fathoms.

*Distribution*.—Also taken by the "Albatross," south of the Sannak Islands, Alaska, 483 fathoms; off Cascade Head, Oregon, 345 fathoms; off San Diego, California, 417 fathoms (Rathbun).

### *Calastacus quinqueseriatus* Rathbun

*Calastacus quinqueseriatus* Rathbun, Proc. U. S. Nat. Mus., 24, 887, 1902; H. A. E., 10, 151, fig. 91, 1904.

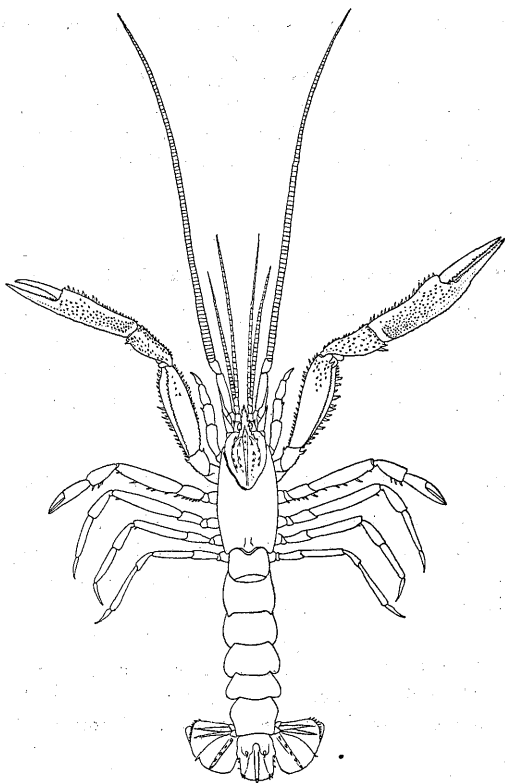


Fig. 76. *Calastacus quinqueseriatus*, ♂, × about  $\frac{3}{4}$  (from Rathbun, U. S. N. M.).

*Characters.*—Carapace (rostrum included), measured in the middle line, as long as the first five abdominal somites; its surface pitted, especially on the inferolateral portions, a few feeble setae springing from the pits; cervical groove deep, branchial grooves indistinct. The rostrum reaches to the end of the second joint of the antennular peduncle and is tipped with a spine; its lateral margins are armed with three to seven spines; the prolongations of these margins are armed with five to six spines, and form a horseshoe on the carapace which is open behind and outlined in front by a groove a little posterior to the orbit. The median carina extends from the middle of the rostrum to the rear of the horseshoe and is from two- to six-, usually three-spined at its middle. Between the median carina and the sides of the horseshoe is another row of three to five spines. The chelipeds are unequal, the longer one in the male nearly as long as the body; setose; its inner surface and also the outer surface of carpus and hand covered with sharp granules or short spines; upper margin spinose, also lower margin of merus; lower outer margin of merus outlined with very short, blunt spines and a single longer distal spine; lower margins of propodus armed with dentiform granules, margins subparallel. Fingers shorter than palm in adult males, just as long as palm in smaller males and females; usually slightly gaping at base; occludent edges finely and irregularly dentate. The stouter cheliped may be longer or shorter than the slender one. In the female the chelipeds are two-thirds as long as the body.

*Dimensions.*—Type, male: length of carapace and rostrum 28 mm., of abdomen 41 mm.

*Type Locality.*—Off San Luis Obispo Bay, 200 fathoms ("Albatross" station 3196).

*Distribution.*—Also taken by the "Albatross," off Point Sur, 298 fathoms; off San Simeon Bay, 160 fathoms; off San Luis Obispo Bay, 252 fathoms; off Point Conception, 233 to 284 fathoms; Santa Barbara Channel, 205 to 280 fathoms; off Anacapa Island, 388 fathoms, and off San Nicolas Island, California, 1084 to 1100 fathoms.

### Family CALLIANASSIDAE

Body shrimp-like. Abdomen extended; abdominal pleura small or absent; tail-fan well developed and adapted for swimming. First pair of legs unequal or subequal, perfectly or imperfectly chelate; third and fourth pairs simple, others variable. Antennal peduncle five-jointed; antennal scale quite vestigial; no antennal thorn.

#### KEY TO THE CALIFORNIA GENERA OF THE CALLIANASSIDAE

- I. Rostrum of good size, though short, tridentate, rough and hairy. First pair of legs subequal, with very small pollex, tending to become subchelate; none of remaining pairs chelate. Eye peduncles cylindrical. External maxillipeds pediform.

*Upogebia*, p. 115.

- II. Rostrum small, reduced to a small point or absent. First pair of legs very unequal, with well developed chelae; second pair small and chelate; fifth pair subchelate. Eye peduncles flattened. External maxillipeds operculiform.

*Callianassa*, p. 116.



Genus *Upogebia* Leach

First pair of legs subequal and subchelate; remaining pairs simple. Eye-stalks cylindrical; cornea terminal. Rostrum short, stout, tridentate.

*Upogebia pugettensis* (Dana)

*Gebia pugettensis* Dana, Proc. Acad. Nat. Sci. Phila., 6, 19, 1852; Crust. U. S. Expl. Exped., pt. 1, p. 510, 1852, pl. 32, fig. 1, 1855; Stimpson, Jour. Boston Soc. Nat. Hist., 6, 488, pl. 21, fig. 2, 1857; Lockington, Ann. Mag. Nat. Hist. (5), 2, 299, 1878.

*Upogebia pugettensis* Holmes, Occas. Papers Calif. Acad. Sci., 7, 157, 1900; Rathbun, H. A. E., 10, 153, 1904.

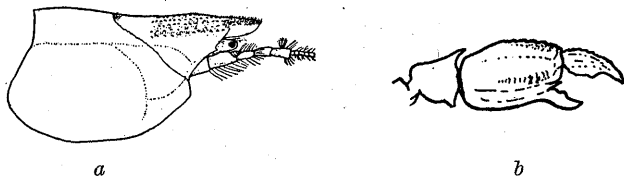


Fig. 77. *Upogebia pugettensis*; a, lateral view of carapace,  $\times 2$  (after Dana); b, hand with setae removed,  $\times \frac{4}{5}$  (after Stimpson).

*Characters*.—Upper portion of carapace in front of cervical groove flattened, scabrous, and hairy; marked with three longitudinal grooves, median groove the shortest; front tridentate, with median tooth large, horizontal, and triangular, lateral teeth short. Eye-stalks short, reaching very little farther forward than lateral teeth of front.

*Dimensions*.—Type: length 50.8 mm. The length of the carapace of the Bay specimens ranges from 11 to 14 mm.

*Type Locality*.—Puget Sound.

*Distribution*.—From southeastern Alaska to San Quentin Bay, Lower California (Rathbun).

*Remarks*.—This species excavates its subterranean burrows in the sand and mud of beaches, near low water marks, preferring that which is more or less indurated (Stimpson).

*Biological Survey of San Francisco Bay*.—Although only three specimens were taken in the course of the survey, one at Sausalito, February 8, and two at Tiburon, April 29, 1913, Lockington says:

This species is exceedingly abundant in San Francisco and Tomales bays, and frequently attains a length of six inches or even more.

The subterranean passages made by it are usually nearly perpendicular, about an inch across, and very neatly rounded in section, with the walls smooth as if plastered, the smoothness resulting entirely from the pressure of the animal's body as it pushes itself upwards and downwards by the action of its terminal abdominal segments.

The burrows are not confined to strata of sand but are abundant also in mud, in sandy shingle, and even among rocks, ranging upwards almost to high-water

mark, and downwards to at least three or four fathoms, since large specimens were brought up in abundance by the dredging machines in Oakland Harbor.

Almost every specimen collected in Tomales Bay, in the month of May, bore upon its abdominal feet either the curious Isopod *Phyllocladurus abdominalis* [see Stimpson, in synonymy above, p. 511] or a small bivalve mollusk, *Pythina rugifera* Carpenter.

While most of the smaller individuals are accompanied by a pair of *P. abdominalis*, the larger specimens were free from this crustacean but in many cases bore the mollusk above mentioned.

In only one case, out of over a hundred specimens dug up in Tomales Bay, were the mollusk and the Isopod found in company upon the same *Gebia*; and in this case the *Gebia* was of middling size and the mollusk very small. On specimens collected July 4, I did not find the bivalve, and the *Phyllocladurus* was less common than in May.

In San Francisco Bay I have not as yet detected *Pythina rugifera*, but *Phyllocladurus* is sufficiently common.

### Genus *Callianassa* Leach

First pair of legs very unequal, with well developed chelae; second pair small and chelate; fifth pair subchelate. Eye-stalks triangular or oblong, flattened; cornea dorsal, median, small or absent. Rostrum short, triangular, rudimentary, or absent.

#### KEY TO THE CALIFORNIA SPECIES OF CALLIANASSA

I. Front with median tooth either obscure or not prominent. Eyes pigmented.

A. Eye-stalks with acute and divergent extremities.

1. Median prominence of front rounded; cornea at middle of eye-stalk; large cheliped of male very broad, the carpus very little longer than wide, but considerably longer than palm, almost twice as long.

*californiensis*, p. 117.

2. Median prominence of front subacute; cornea just behind middle of eye-stalk; large cheliped of male elongate, carpus from one and one-half to twice as long as wide, carpus and palm subequal.

*longimana*, p. 117.

B. Eye-stalks oblong, their inner extremities tuberculiform and not diverging; cornea in front of middle of eye-stalk; carpus of large cheliped of male very little longer than wide, and very little longer, sometimes even shorter than palm. (Not known north of Catalina Harbor.)

*affinis*, p. 119.

II. Front with a sharp and prominent median tooth.

A. Eyes not pigmented, eye-stalks oblong; large cheliped of male with carpus much shorter than wide. (Known only from 278 + fathoms.)

*goniophthalma*, p. 122.

B. Eyes pigmented, eye-stalks with tips acute and divergent; large cheliped of male with carpus a little longer than wide. (Not known south of the Gulf of the Farallones).

*gigas*, p. 119.

**Callianassa californiensis Dana**

*Callianassa californiensis* Dana, Proc. Acad. Nat. Sci. Phila., 7, 175, 1854; Stimpson, Jour. Boston Soc. Nat. Hist., 6, 489, pl. 21, fig. 4, 1857; Holmes, Occas. Papers Calif. Acad. Sci., 7, 159, pl. 2, fig. 27, 1900; Rathbun, H. A. E., 10, 154, 1904; Hilton, Jour. Ent. Zool., Pomona Coll., 8, 63, 1916.

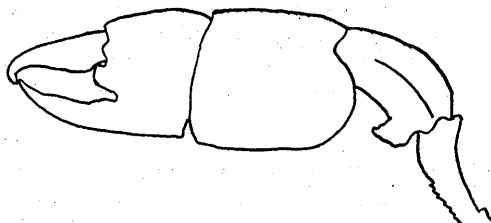


Fig. 78. *Callianassa californiensis*, large cheliped, ♂ (after Holmes).

*Characters*.—Median tooth of front very short and rounded. Eye-stalks with acute and divergent extremities; pigmented cornea at middle of eye-stalk. Large cheliped of male very broad, the carpus very little longer than broad, but considerably longer than palm.

*Dimensions*.—Length of male specimen 61 mm., length of larger cheliped 50 mm., of smaller cheliped 32 mm.; length of larger cheliped of female 31 mm., of smaller cheliped 28 mm. (Holmes).

*Color*.—Of body a delicate orange; anterior feet rose-colored (Stimpson).

*Type Locality*.—"California."

*Distribution*.—From Mutiny Bay, Alaska (Lockington), to mouth of Tia Juana River, San Diego County, California (Rathbun).

**Callianassa longimana Stimpson**

*Callianassa longimana* Stimpson, Proc. Boston Soc. Nat. Hist., 6, 86, 1857; Jour. Boston Soc. Nat. Hist., 6, 490, pl. 21, fig. 5, 1857; Holmes, Occas. Papers Calif. Acad. Sci., 7, 161, pl. 2, fig. 28, 1900; Rathbun, H. A. E., 10, 154, 1904; Hilton, Jour. Ent. Zool., Pomona Coll., 8, 63, fig. 14, 1916.

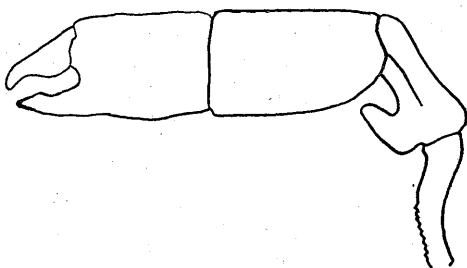


Fig. 79. *Callianassa longimana*, large cheliped, ♂ (after Holmes).

*Characters*.—Median tooth of front small and subacute. Eye-stalks with acute and divergent extremities; pigmented cornea just behind middle of eye-stalk. Large cheliped of male elongate, the carpus twice, or nearly twice as long as broad.

*Dimensions.*—Length of a male specimen 39 mm., length of large cheliped 39 mm., of small cheliped 22.5 mm. (Holmes). Often grows to be 101.6 mm. in length (Stimpson). The specimens taken in the course of the Bay Survey ranged from 15 to 97 mm. in length, mostly 48 mm. and over.

*Type Locality.*—Puget Sound.

*Distribution.*—From Vancouver Island, British Columbia to San Quentin Bay, Lower California.

*Remarks.*—This species and *C. californiensis* are very similar in practically all other characters except the large chelipeds of the adult males. The females apparently can only be distinguished by the differences in the rostrum and the relative stoutness of the smaller chelipeds, which though very similar also seem to have proportionately a somewhat narrower hand and carpus in *longimana* than in *californiensis*.

*Biological Survey of San Francisco Bay.*—The *Callianassas* are soft bodied crustaceans which “generally burrow in sand or mud either in the littoral zone or in deeper waters; at the same time they can swim with considerable activity by means of the pleopods” (Smith, 1909, p. 167).

Within the bay *Callianassa longimana* runs very true to type, having been dredged only at stations having a sandy or a purely mud bottom; two specimens were captured by means of the tow-net (H 4996, 5124). The dredging stations ranged from Pinole Point in the upper bay down through the eastern or muddy portion of the middle bay, to Point San Bruno in the lower bay. All told, this species was taken at seventeen dredging stations, distributed as follows: upper bay three, D 5716, 5717, 5820; middle bay nine, D 5708, 5709, 5714, 5740, 5756, 5822–5825; lower bay five, D 5724, 5727, 5730, 5766, 5835. The two hydrographic stations were made at approximately the same position (Primary hydrographic station 4971, just north of the head of Raccoon Strait (see plate 8).

In view of the great extent of the mud and sandy mud area in the bay (see Sumner, 1914, pls. 5, 6) our limited number of records, which represent only 11% of the total number of dredging stations, must be explained on the ground of the burrowing habits of this crustacean rather than the scarcity of specimens. It is interesting to note, in this connection, that the greater number of specimens per haul were obtained with the “orange-peel bucket” dredge (Sumner, 1914, p. 7, pl. 10). From the six stations at which it was employed an average of eight specimens per haul was returned as compared with one and six-tenths specimens per haul at the eleven at which the ordinary types of dredge or trawl were used. The relative efficiency of the two kinds of apparatus probably accounts for the absence of material from localities in the bay where it can reasonably be expected and

where only the latter types of gear were used. The ranges of temperature and salinity based on the survey observations which we are able to record for *Callianassa longimana* are, respectively, 8.2° to 13.9° C. and 18.3 to 31.7.

**Callianassa gigas Dana**

*Callianassa gigas* Dana, Proc. Acad. Nat. Sci. Phila., 6, 19, 1852; Crust. U. S. Expl. Exped., pt. 1, p. 512, 1852, pl. 32, fig. 3, 1855; Stimpson, Jour. Boston Soc. Nat. Hist., 6, 489, pl. 21, fig. 3, 1857; Holmes, Occas. Papers Calif. Acad. Sci., 7, 162, 1900; Rathbun, H. A. E., 10, 154, 1904.

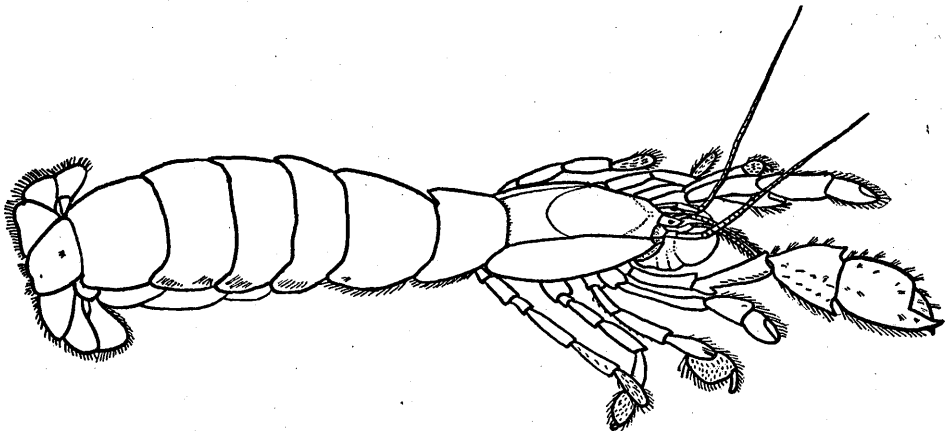


Fig. 80. *Callianassa gigas*, × 4/5 (after Dana).

*Characters*.—Front with a sharp and prominent median tooth. Eye-stalks with acute and divergent extremities; pigmented cornea behind the middle of the stalk. Large cheliped of male with carpus a little longer than wide.

*Dimensions*.—Of type: length 114 mm.

*Type Locality*.—Puget Sound.

*Distribution*.—Puget Sound (Dana, Calman), Gulf of the Farallones, California, 21 fathoms (“Albatross” station 3150) (Rathbun).

*Remarks*.—The larger hand of this species is remarkably short and stout (Stimpson).

**Callianassa affinis Holmes**

*Callianassa affinis* Holmes, Occas. Papers Calif. Acad. Sci., 7, 162, pl. 2, figs. 29–30, 1900; Rathbun, H. A. E., 10, 154, 1904.



Fig. 81. *Callianassa affinis*, ♂; a, small cheliped; b, large cheliped (after Holmes).

*Characters.*—Median tooth of front obscure, not prominent. Eye-stalks oblong, with inner extremities tuberculiform, and not diverging; pigmented cornea in front of middle of eye-stalk. Carpus of large cheliped of male very little longer than broad, and very little longer, sometimes even shorter than the palm.

*Dimensions.*—Of a male specimen from Point Loma, in the collection of the National Museum: length from tip of rostrum to end of telson 61 mm., of cara-

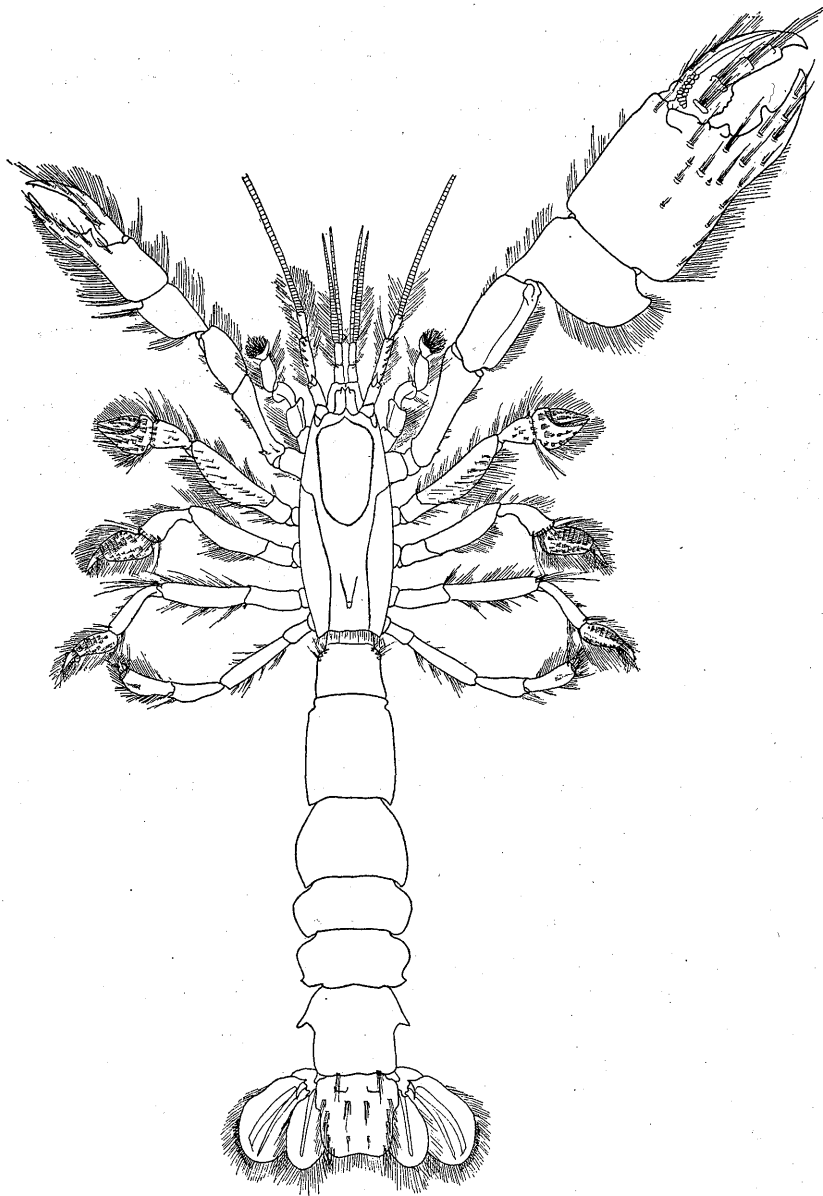


Fig. 82. *Callinassa goniophthalma*, ♂, about natural size (from Rathbun, U. S. N. M.).

pace 17 mm., of large cheliped 50 mm., of hand and fingers 16 mm., of carpus 8.5 mm., greatest width of hand 8 mm., and of carpus 9.5 mm.

*Type Locality*.—Point Loma, California.

*Distribution*.—From Santa Monica Bay to San Diego, California (Rathbun).

### *Callianassa goniophthalma* Rathbun

*Callianassa goniophthalma* Rathbun, Proc. U. S. Nat. Mus., 24, 886, 1902;  
H. A. E., 10, 154, pl. 8, 1904.

*Characters*.—Front with a sharp and prominent median tooth which reaches barely one-third the length of the eye-stalks. Eye-stalks reaching nearly to end of first antennular segment, oblong, more than twice as long as wide; sides subparallel; antero-internal angle produced in a tuberculiform tooth, these teeth being slightly divergent from each other; eyes without pigment. Large cheliped of male with carpus much shorter than wide, nearly twice as deep as long, and one-half as long as palm.

*Dimensions*.—Type, male: length of carapace 30.5 mm., of abdomen 67.5 mm.; of female: length of carapace 22.2 mm., of abdomen 52 mm.

*Type Locality*.—Off Point Conception, California, 278 fathoms ("Albatross" Station 3198).

*Distribution*.—Also taken by the "Albatross" in Clarence Strait, Alaska, 322 fathoms, and off Harris Point, San Miguel Island, California, 264 to 271 fathoms.

### Family PAGURIDAE

The "hermit crabs." Abdomen soft, showing no trace of segmentation, straight, twisted, or spirally coiled; some of the appendages lost, the remainder much reduced; tail-fan not adapted for swimming, adapted for holding body into hollow objects. Carapace firm in fore part and soft in hinder part. First pair of legs chelate; fourth pair unlike the third.

The Paguridae fall naturally into two groups (Bouvier, 1896*b*, p. 126; Alcock, 1905, p. 21) and for convenience are here so arranged.

- I. External maxillipeds approximated at the base. Chelipeds equal or subequal, or left larger than right, p. 122.
- II. External maxillipeds widely separated at the base. Right cheliped larger than the left, p. 128.

In the keys and diagnoses below reference is made to abdominal segments; although the abdomen is typically soft and unsegmented the somites can, as a rule, be approximately determined by the number and arrangement of the abdominal appendages when these are present. The abdomen is spirally coiled in all the representatives of the genera here listed except *Pylopagurus minimus* and *P. holmesi*, in which it is quite straight.

#### KEY TO THE CALIFORNIA GENERA OF THE PAGURIDAE

- I. External maxillipeds approximated at base. Chelipeds equal or subequal, or left larger than the right.
  - A. Paired appendages present on the first two abdominal segments of male and first abdominal segment of female. Chelipeds equal or subequal. Fourth pair of legs not chelate. *Paguristes*, p. 122.