The Decapod Crustaceans of the Panama Canal

LAWRENCE G. ABELE
and
WON KIM

SMITHSONIAN CONTRIBUTIONS TO ZOOLOGY · NUMBER 482

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SMITHSONIAN INSTITUTION PRESS
Washington, D.C.
1989

ABSTRACT

Abele, Lawrence G., and Won Kim. The Decapod Crustaceans of the Panama Canal. *Smithsonian Contributions to Zoology*, number 482, 50 pages, 18 figures, 3 tables, 1989.—Eighty-eight species of decapod crustaceans were collected from the Panama Canal. Seven of these were previously undescribed (*Macrobrachium crebrum*, new species, *M. digitus*, new species, *Synalpheus recessus*, new species, *S. superus*, new species, *Eurypanopeus canalensis*, new species, *Panopeus gatunensis*, new species, and *P. mirafloresensis*, new species), and another five were known only from one or a few records. Approximately 27 of the species occurred in fresh water (including one introduced from Iraq), 31 in euryhaline conditions, and 30 in almost marine conditions. Thirty species were collected from the Miraflores Third Locks Lake area and spillway (6–30 ‰), 23 species from the lower locks (10–30 ‰), and 25 species from the upper locks (0–5 ‰) of the Miraflores Locks. Twelve species were collected from the fresh water of the Pedro Miguel Locks and an equal number from freshwater streams on Barro Colorado Island. The Gatun Locks yielded four species from the freshwater upper locks, eight from the 2–8 ‰ waters of the middle locks, and 22 from the 8–15 ‰ waters of the lower locks. A typical marine assemblage of species occurred down to about 10 ‰, whereas a typical freshwater fauna occurred up to about 3 ‰; a species-minimum zone was observed from about 3 to 5 ‰.

There has been relatively little exchange between the Atlantic and Pacific regions. Seven Atlantic species (one freshwater and six euryhaline species) were collected from the Pacific side and one Pacific euryhaline species from the Atlantic side. Most of the Atlantic migrants were collected from the Miraflores Third Locks Lake area and apparently have not established breeding populations outside of the Panama Canal. Surprisingly, only one of the 27 freshwater species has spread throughout the canal. The fresh water of Gatun Lake forms an effective barrier to the distribution of stenohaline marine species, and therefore any salinization of Gatun Lake (or construction of a sea-level canal) would almost certainly result in an extensive faunal exchange and would be unconscionable given our ignorance of the biota and ecology of the communities of the Panama Canal.

OFFICIAL PUBLICATION DATE is handstamped in a limited number of initial copies and is recorded in the Institution's annual report, *Smithsonian Year*. SERIES COVER DESIGN: The coral *Montastrea cavernosa* (Linnaeus).

Library of Congress Cataloging in Publication Data
Abele, Lawrence G.
The decapod crustaceans of the Panama Canal.
(Smithsonian contributions to zoology ; no. 482)
Bibliography: p.
1. Decapod (Crustacea)—Panama—Canal Zone. 2. Crustacea—Panama—Canal Zone. I. Kim, Won, 1955–. II. Title. III. Series.
QL1.S54 no. 482 591 s 88-600342
[QL444.M33] [595.3'84'097287]

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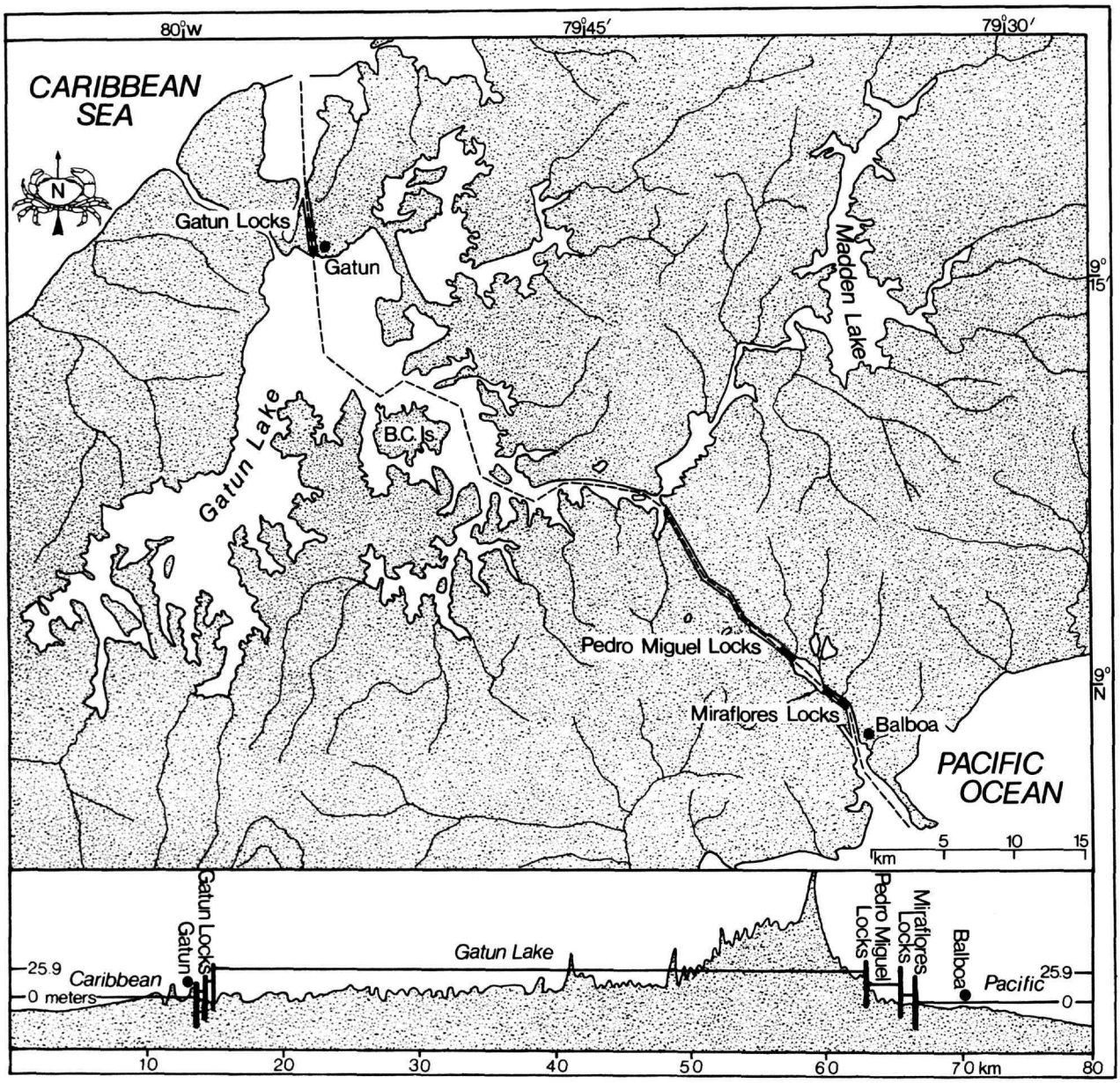

FIGURE 1.—Primary localities from which specimens of the present study were collected.

The Decapod Crustaceans of the Panama Canal

Lawrence G. Abele and Won Kim

Introduction

Interest in the biota of the Panama Canal has waxed and waned over the years since its opening in 1914. Hildebrand (1939) provided the first summary of the biota and discussed the canal as a possible passageway for organisms between the Atlantic and Pacific oceans. He generally concluded that the fresh water of Gatun Lake (Figure 1) provides a barrier to the passage of marine organisms. Other than the inclusion of material from the Panama Canal in systematic studies, there was little interest in the biota for the next 25 years. In the mid and late 1960s, discussion of the possible construction of a sea-level canal, which would remove the present freshwater barrier of Gatun Lake, resulted in a small flood of publications (see Rubinoff, 1968, 1970; Briggs, 1969; Jones, 1972, and references therein; Jones and Dawson, 1973; McCosker and Dawson, 1975; Spivey, 1976) and renewed interest.

During the time of high interest a number of individuals, primarily supported by the Smithsonian Tropical Research Institute and the Smithsonian Institution's National Museum of Natural History, made collections throughout the Panama Canal including the locks while they were drained for cleaning and repair. Here we report on the decapod crustaceans contained in those collections and provide an annotated checklist of the decapods of the Panama Canal. The list of species is restricted to those collected between the lower Miraflores Locks on the Pacific coast and the lower Gatun Locks on the Caribbean coast.

THE PANAMA CANAL.—The canal (Figure 1) is approximately 80 km in length and bisects the Isthmus of Panama, connecting the Atlantic and Pacific oceans. The water at both ends of the canal is fully saline, but the fresh water of Gatun Lake in the center of the canal effectively isolates the stenohaline marine biota of Central America (Hildebrand, 1939; Jones and Dawson, 1973; McCosker and Dawson, 1975). Gatun Lake provides a barrier to passage for the marine organism but does not provide a barrier to the distribution of freshwater organisms.

The structure of the Panama Canal is most easily understood if one follows the passage of a ship from the Pacific to the Atlantic (or vice versa). Temperature and salinity data are from Jones and Dawson (1973). From the Pacific a ship enters the Bay of Panama, where both temperature and salinity vary seasonally (see Glynn, 1972). The surface temperatures during the wet season (April–December) are about 23°–29°C, and the salinities range from 25 to 31 ‰. The temperature can drop to as low as 15°C during dry-season upwelling but is usually higher, ranging from 16° to 29°C. The salinities are higher during the dry season, ranging from about 32 to 35 ‰. (As one approaches the canal, freshwater outflow from the locks reduces the salinity.) Once in the Bay of Panama, a ship enters a dredged channel, which continues for about 13.7 km before reaching the two chambers of Miraflores Locks. The bottom waters of the lower chambers can have salinities as high as 30 ‰, whereas the waters of the upper chambers are about 5 ‰. The two chambers provide a combined lift of 16.4 m and open into Miraflores Lake, which is essentially fresh water. The lake is about 1.6 km long and ends at the single-chambered Pedro Miguel Locks, where a lift of 9.5 m into Gatun Lake is provided. Gatun Lake is large (about 430 km^2) and was created by damming of the Chagres River. Barro Colorado Island, which is surrounded by Gatun Lake, was created at the same time. The lake extends for about 51.5 km to the three chambers of Gatun Locks at the Atlantic terminus of the Canal. Here the locks provide a descent of 25.9 m to the level of the Atlantic Ocean. The ship then travels out of Gatun Locks through an 11.9 km channel in Limon Bay into the Caribbean Sea. The waters of Gatun Lake and the highest lock are fresh. The salinity in the middle lock is about 3 ‰ and in the lowest lock is about 10 ‰. From there the salinity increases to about 30 ‰ in Limon Bay.

Lawrence G. Abele and Won Kim, Department of Biological Science, Florida State University, Tallahassee, Florida 32306-2043.

MATERIALS AND METHODS.—Collections were made in the Panama Canal by one of us (LGA) intermittently during 1968–1969 and 1972–1974. Extensive additional material came from the collections of Drs. M.L. Jones and C.E. Dawson and others (see station data). Specimens were collected by hand, with dipnets, by formalin washes of substratum, and by the use of ichthyocides during the draining and cleaning of the locks.

The abbreviation "cl" in the shrimps refers to carapace length from the posterior dorsal margin to the posterior orbital margin, except for species of *Alpheus* and *Synalpheus*, in which cl refers to carapace length from the posterior dorsal margin to the tip of rostrum. In the crabs, cl refers to carapace length from the frontal margin to the posterior margin of the carapace, and "cb" refers to carapace breadth measured at the widest point, including any anterolateral teeth present.

The "Material Examined" section lists all specimens examined. Data on stations listed in the "Material Examined" section are provided in the appendix. The "Measurements" section contains data from all the present specimens except for species in which the specimens were all juveniles or broken. In those cases we provided measurement data from the literature. Some species' accounts do not contain a "Measurements" section because the present specimens are all juveniles or broken and no data were available from the literature. All material is deposited in the Smithsonian Institution's National Museum of Natural History.

ACKNOWLEDGMENTS.—We thank the following individuals for assistance with this study: Drs. C.E. Dawson, J. Graham, M.L. Jones, H. Kaufman, J. Rosewater, and I. Rubinoff, who all collected material from the Panama Canal, and Drs. F.A. Chace, Jr., B. Felgenhauer, R.B. Manning, J. Martin, and A.B. Williams, who reviewed the manuscript. Dr. J.S. Garth was kind enough to share with us a portion of his unpublished manuscript on eastern Pacific brachyurans. The Smithsonian Tropical Research Institute (STRI) and particularly its director, Dr. Ira Rubinoff, provided a great deal of support for this project. Many of the collections were made while LGA was on a STRI postdoctoral fellowship. The Smithsonian Institution's National Museum of Natural History provided space, facilities, and access to collections while WK worked at that institution—we thank F.A. Chace, Jr., B. Kensley, R.B. Manning, and A.B. Williams for their help during his visit.

List of Species

Order DECAPODA
Suborder DENDROBRANCHIATA
Superfamily PENAEOIDEA
Family PENAEIDAE
Penaeus Fabricius, 1798
1. *Penaeus brevirostris* Kingsley, 1878
2. *Penaeus stylirostris* Stimpson, 1871
Suborder PLEOCYEMATA
Infraorder CARIDEA
Superfamily ATYOIDEA
Family ATYIDAE
Atya Leach, 1816
3. *Atya innocous* (Herbst, 1792)
4. *Atya margaritacea* A. Milne Edwards, 1864
5. *Atya scabra* (Leach, 1815)
6. *Atya tenella* Smith, 1871
Micratya Bouvier, 1913
7. *Micratya poeyi* (Guérin-Méneville, 1855)
Potimirim Holthuis, 1954
8. *Potimirim glabra* (Kingsley, 1878)
9. *Potimirim mexicana* (De Saussure, 1857)
Superfamily PALAEMONOIDEA
Family PALAEMONIDAE
Leander E. Desmarest, 1849
10. *Leander paulensis* Ortmann, 1897
Macrobrachium Bate, 1868
11. *Macrobrachium acanthurus* (Wiegmann, 1836)
12. *Macrobrachium americanum* Bate, 1868
13. *Macrobrachium carcinus* (Linnaeus, 1758)
14. *Macrobrachium crebrum*, new species
15. *Macrobrachium crenulatum* Holthuis, 1950
16. *Macrobrachium digitus*, new species
17. *Macrobrachium digueti* (Bouvier, 1895)
18. *Macrobrachium heterochirus* (Wiegmann, 1836)
19. *Macrobrachium olfersii* (Wiegmann, 1836)
20. *Macrobrachium panamense* Rathbun, 1912
21. *Macrobrachium rathbunae* Holthuis, 1950
22. *Macrobrachium tenellum* (Smith, 1871)
Palaemon Weber, 1795
23. *Palaemon gracilis* (Smith, 1871)
24. *Palaemon hancocki* Holthuis, 1950
25. *Palaemon pandaliformis* (Stimpson, 1871)
Palaemonetes Heller, 1869
26. *Palaemonetes schmitti* Holthuis, 1950
Superfamily ALPHEOIDEA
Family ALPHEIDAE
Alpheus Fabricius, 1798
27. *Alpheus armillatus* H. Milne Edwards, 1837
28. *Alpheus colombiensis* Wicksten, 1988
29. *Alpheus firmus* Kim and Abele, 1988
30. *Alpheus heterochaelis* Say, 1818
Synalpheus Bate, 1888
31. *Synalpheus apioceros* Coutière, 1909
32. *Synalpheus recessus*, new species
33. *Synalpheus superus*, new species
Family HIPPOLYTIDAE
Lysmata Risso, 1816
34. *Lysmata intermedia* (Kingsley, 1878)
35. *Lysmata wurdemanni* (Gibbes, 1850)
Infraorder ANOMURA
Superfamily COENOBITOIDEA
Family DIOGENIDAE
Calcinus Dana, 1851
36. *Calcinus obscurus* Stimpson, 1859
Clibanarius Dana, 1852
37. *Clibanarius vittatus* (Bosc, 1802)
Superfamily GALATHEOIDEA
Family PORCELLANIDAE
Euceramus Stimpson, 1860
38. *Euceramus transversilineatus* (Lockington, 1878)
Petrolisthes Stimpson, 1858
39. *Petrolisthes armatus* (Gibbes, 1850)
40. *Petrolisthes galathinus* (Bosc, 1802)
41. *Petrolisthes lindae* Gore and Abele, 1974
42. *Petrolisthes robsonae* Glassell, 1945
43. *Petrolisthes zacae* Haig, 1968
Infraorder BRACHYURA

Section OXYRHYNCHA
Superfamily MAJOIDEA
Family MAJIDAE
Notolopas Stimpson, 1871
44. *Notolopas lamellatus* Stimpson, 1871
Pelia Bell, 1835
45. *Pelia mutica* (Gibbes, 1850)
46. *Pelia tuberculata* (Wicksten, 1987), new combination
Superfamily HYMENOSOMATOIDEA
Family HYMENOSOMATIDAE
Elamenopsis A. Milne Edwards, 1873
47. *Elamenopsis kempi* (Chopra and Das, 1930)
Superfamily PARTHENOPOIDEA
Family PARTHENOPIDAE
Heterocrypta Stimpson, 1871
48. *Heterocrypta colombiana* Garth, 1940
49. *Heterocrypta craneae* Garth, 1959
Section BRACHYRHYNCHA
Superfamily PORTUNOIDEA
Family PORTUNIDAE
Callinectes Stimpson, 1860
50. *Callinectes arcuatus* Ordway, 1863
51. *Callinectes danae* Smith, 1869
52. *Callinectes exasperatus* (Gerstaecker, 1856)
53. *Callinectes sapidus* Rathbun, 1896
54. *Callinectes toxotes* Ordway, 1863
Portunus Weber, 1795
55. *Portunus asper* (A. Milne Edwards, 1861)
Superfamily XANTHOIDEA
Family XANTHIDAE
Eurypanopeus A. Milne Edwards, 1878
56. *Eurypanopeus canalensis*, new species
57. *Eurypanopeus dissimilis* (Benedict and Rathbun, 1891)
Eurytium Stimpson, 1859
58. *Eurytium tristani* Rathbun, 1906
Hexapanopeus Rathbun, 1898
59. *Hexapanopeus beebei* Garth, 1961
60. *Hexapanopeus caribbaeus* (Stimpson, 1871)
61. *Hexapanopeus paulensis* Rathbun, 1930
Menippe De Haan, 1833
62. *Menippe nodifrons* Stimpson, 1859
Panopeus H. Milne Edwards, 1834
63. *Panopeus chilensis* H. Milne Edwards and Lucas, 1844
64. *Panopeus gatunensis*, new species
65. *Panopeus lacustris* Desbonne, 1867
66. *Panopeus mirafloresensis*, new species
67. *Panopeus purpureus* Lockington, 1877
68. *Panopeus rugosus* A. Milne Edwards, 1880
Pilumnus Leach, 1815
69. *Pilumnus dasypodus* Kingsley, 1879
70. *Pilumnus reticulatus* Stimpson, 1860
Rhithropanopeus Rathbun, 1898
71. *Rhithropanopeus harrisii* (Gould, 1841)
Superfamily GRAPSIDOIDEA
Family GRAPSIDAE
Glyptograpsus Smith, 1870
72. *Glyptograpsus impressus* Smith, 1870
Goniopsis De Haan, 1833
73. *Goniopsis cruentata* (Latreille, 1802)
Pachygrapsus Randall, 1840
74. *Pachygrapsus gracilis* (De Saussure, 1858)
75. *Pachygrapsus transversus* (Gibbes, 1850)
Sesarma Say, 1817
76. *Sesarma aequatoriale* Ortmann, 1894
77. *Sesarma americanum* De Saussure, 1858
78. *Sesarma angustum* Smith, 1870
79. *Sesarma occidentale* Smith, 1870
80. *Sesarma rhizophorae* Rathbun, 1906
81. *Sesarma rubinofforum* Abele, 1973
Superfamily POTAMOIDEA
Family PSEUDOTHELPHUSIDAE
Potamocarcinus H. Milne Edwards, 1853
82. *Potamocarcinus richmondi* (Rathbun, 1893)
Ptychophallus Smalley, 1964
83. *Ptychophallus goldmanni* Pretzmann, 1965
Superfamily OCYPODOIDEA
Family OCYPODIDAE
Uca Leach, 1814
84. *Uca festae* Nobili, 1902
85. *Uca oerstedi* Rathbun, 1904
86. *Uca pygmaea* Crane, 1941
87. *Uca thayeri umbratila* Crane, 1941
88. *Uca tomentosa* Crane, 1941

Systematic Account

Order DECAPODA

Suborder DENDROBRANCHIATA

Superfamily PENAEOIDEA

Family PENAEIDAE

Penaeus Fabricius, 1798

1. *Penaeus brevirostris* Kingsley, 1878

Penaeus brevirostris Kingsley, 1878:98.—Pérez Farfante, 1970:31, fig. 50p.
Penaeus (Farfantepenaeus) brevirostris.—Holthuis, 1980:39.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta 130-1: 3 juv.; sta 130-2-b: 13 juv.); Miraflores Locks (sta 1536: 2 juv.).

TYPE LOCALITY.—Realego, Nicaragua.

DISTRIBUTION.—Known in the eastern Pacific, from San Francisco Bay southward to the Pearl Islands, Panama; Peru; the Galapagos Islands.

2. *Penaeus stylirostris* Stimpson, 1871

Penaeus stylirostris Stimpson, 1871:134.
Penaeus (Litopenaeus) stylirostris.—Pérez Farfante, 1975:472, figs. 8–12.—Holthuis, 1980:45.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta 130-1: 13 juv.); Miraflores Locks (sta 1524: 2 ♂, 3 ♀; sta 1525: 1 ♂, 7 juv.; sta 1536: 1 ♂; sta 1728: 1 ♀).

MEASUREMENTS.—Males, cl 19.6–31.6 mm; females, cl 26.1–32.1 mm.

TYPE LOCALITY.—Panama.

DISTRIBUTION.—Known in the eastern Pacific, from Punta Abreojos, Territorio de Baja California, and Gulf of California, Mexico to Tumbes, Peru (Pérez Farfante, 1975).

Suborder PLEOCYEMATA

Infraorder CARIDEA

Superfamily ATYOIDEA

Family ATYIDAE

Atya Leach, 1816

3. *Atya innocous* (Herbst, 1792)

Cancer (Astacus) Innocous Herbst, 1792:62, pl. 28: fig. 3.
Atya occidentalis Newport, 1847:159.
Atya innocous.—Holthuis, 1966:237.—Chace and Hobbs, 1969:57, figs. 8, 10a–c, 14a,b.—Hobbs and Hart, 1982:56, figs. 1d,e, 2, 4a, 5–10, 12a,b, 22–30 [in part, Atlantic drainage material only].

MATERIAL EXAMINED.—Barro Colorado Island (Shannon Creek: 1 ♀, Mar 1974; LGA 69-63: 1 ♂).

MEASUREMENTS.—Males, cl 5.0–40.9 mm; females, cl 2.5–20.6 mm; ovigerous females, cl 7.9–24.9 mm (Chace and Hobbs, 1969; Hobbs and Hart, 1982).

TYPE LOCALITY.—Martinique.

DISTRIBUTION.—Known in the Atlantic watershed from Nicaragua to Panama and in the West Indies from the Greater Antilles and Virgin Islands southward to Curaçao (Hobbs and Hart, 1982); on the island of Dominica (Chace and Hobbs, 1969).

REMARKS.—See 6. *A. tenella*.

4. *Atya margaritacea* A. Milne Edwards, 1864

Atya margaritacea A. Milne Edwards, 1864:148, 149, pl. 3: fig. 2.—Holthuis, 1969:92.—Hobbs and Hart, 1982:91, figs. 1b, 9, 10, 11d,e, 37–41.
Atya rivalis Smith, 1871:94.—Chace and Hobbs, 1969:66.—Rodríguez, 1981:46.

MATERIAL EXAMINED.—Panama Canal, Rio Cocoli (LGA 73-25: 2 ♂, 3 ♀).

MEASUREMENTS.—Largest male, cl 30.0 mm, average 18.6 mm; largest female, cl 24.4 mm, average 14.3 mm; ovigerous female, cl 7.3–20.8 mm, average 12.7 mm (Hobbs and Hart, 1982).

TYPE LOCALITY.—New Caledonia (as pointed out by Holthuis, 1966:234, "evidently in error").

DISTRIBUTION.—Known from Baja California southward on the Pacific slope through Panama to Peru (Hobbs and Hart, 1982).

5. *Atya scabra* (Leach, 1815)

Atys scaber Leach, 1815:345.
Atya scabra.—Leach, 1816, pl. 21.—Hobbs and Hart, 1982:106, figs. 1k,l, 8–10, 11b,c, 45–53.

MATERIAL EXAMINED.—Barro Colorado Island (stream adjacent to shore: 8 ♂, 20 ovig. ♀, Aug 1962, coll. by H.L. Loftin).

MEASUREMENTS.—Largest male, cl 46.3 mm; largest female, cl 29.5 mm; smallest ovigerous female, cl 7.1 mm (Hobbs and Hart, 1982).

TYPE LOCALITY.—Unknown ("Habitat ____"; Leach, 1815:345); restricted to "the area of Veracruz, Mexico" (Holthuis, 1966:234); fixed by neotype selection to Misantla, Estado de Veracruz, Mexico, 19°56′N, 96°50′W (Hobbs and Hart, 1982).

DISTRIBUTION.—Known from Liberia to northern Angola; in the islands off the west coast of Africa from the Cape Verde group southward to Annobon; in the West Indies from Cuba and Hispaniola to Curaçao and Trinidad and from Tamaulipas, Mexico, to Santa Catarina, Brazil. The species' presence on the Pacific slope perhaps resulted from an introduction (Hobbs and Hart, 1982).

6. *Atya tenella* Smith, 1871

Atya tenella Smith, 1871:94, 95.—Abele, 1975:56, 57.—Holthuis, 1986:444.
Atya innocous.—Hobbs and Hart, 1982:56, fig. 23 [not material from Atlantic drainages].—Felgenhauer and Abele, 1983:336, figs.1–13.

MATERIAL EXAMINED.—Pedro Miguel Locks (LGA 69-21: 2 juv.).

MEASUREMENTS.— Mature males, total length (tl) 26.0–58.2 mm; ovigerous females, tl 45.1–67.4 mm (Abele and Blum, 1977).

TYPE LOCALITY.—Hacienda el Polvon, Departamento Occidental, Nicaragua.

DISTRIBUTION.—Nicaragua to Colombia in Pacific drainages (Holthuis, 1986).

REMARKS.—The status of this species is unclear. Abele (1975) provided some notes on characters that distinguished the Atlantic *A. innocous* from the Pacific *A. tenella* on the basis of specimens from Panama. Hobbs and Hart (1982), in a detailed review of the genus, concluded that the Atlantic and Pacific populations were conspecific and used the older name *innocous* for both populations. Basically, they did so because they found some Antillian populations that approached the Pacific populations in morphology (spindly legs and vaulted carapace), but no Pacific populations have been found that are as robust as the Atlantic material. Thus in their key (1982:26, 27) it was necessary to note that the Atlantic and Pacific specimens differ in morphology. Holthuis (1986) argued that the name *tenella* should be retained for the Pacific material, and we have followed that recommendation.

Micratya Bouvier, 1913

7. *Micratya poeyi* (Guérin-Méneville, 1855)

Atya Poeyi Guérin-Méneville, 1855, pl. 2: figs. 7, 7a–c.
Micratya poeyi.—Schmitt, 1935:137, fig. 11.—Chace and Hobbs, 1969:70, figs. 12, 13, 14h,i.—Chace, 1972:14.

MATERIAL EXAMINED.—Barro Colorado Island (adjacent to shoreline and creek: 1 ovig. ♀, Aug 1962, coll. by H.L. Loftin).

MEASUREMENTS.—Males, cl 1.8–4.6 mm; females, cl 1.8–6.2 mm; ovigerous females, cl 3.2–6.2 mm (Chace and Hobbs, 1969).

TYPE LOCALITY.—Cuba.

DISTRIBUTION.—West Indies (Cuba, Jamaica, Puerto Rico, Dominica, Martinique). According to Chace and Hobbs (1969), the systematic status of a single ovigerous female collected from Tortuguero, Costa Rica, is questionable. The present specimen is the first published record from Panama, although the species is common in Atlantic-drainage streams of Panama.

Potimirim Holthuis, 1954

8. *Potimirim glabra* (Kingsley, 1878)

Atyoida glabra Kingsley, 1878:93.
Potimirim glabra.—Holthuis, 1954:3, fig. 1.—Smally, 1963:177, fig. 1.—Chace and Hobbs, 1969:76, figs. 15, 19b,c.—Abele and Blum, 1977:244.

MATERIAL EXAMINED.—Barro Colorado Island (LGA 69-61: 14 ♂, 4 ♀, 1 ovig. ♀; LGA 69-63: 1 ♂).

MEASUREMENTS.—Males, cl 2.0–3.6 mm; females, cl 1.9–5.1 mm; ovigerous females, cl 3.7–5.1 mm (Abele and Blum, 1977).

TYPE LOCALITY.—West coast of Republic of Nicaragua.

DISTRIBUTION.—In freshwater habitats from western Mexico to Ecuador and from eastern Mexico through the West Indies to Brazil (Abele and Blum, 1977).

9. *Potimirim mexicana* (De Saussure, 1857)

Caridina mexicana De Saussure, 1857:505.
Atyoida Mexicana.—Von Martens, 1868:49.
Potimirim mexicana.—Holthuis, 1954:4 [part].—Villalobos, 1960:295, pls. 6–9.—Chace and Hobbs, 1969:79, fig. 19d.—Chace, 1972:15.

MATERIAL EXAMINED.—Stream adjacent to Gatun Locks (LGA 71-4: 3 ♂, 7 ♀, 2 ovig. ♀); Barro Colorado Island (LGA 69-63: 1 ♀).

MEASUREMENTS.—Maximum postorbital carapace length about 6 mm (Chace and Hobbs, 1969).

TYPE LOCALITY.—Veracruz, Mexico.

DISTRIBUTION.—Known from northeastern Mexico to Republic of Panama; Cuba, Jamaica, and Puerto Rico.

Superfamily PALAEMONOIDEA

Family PALAEMONIDAE

Leander E. Desmarest, 1849

10. *Leander paulensis* Ortmann, 1897

Leander paulensis Ortmann, 1897:192, pl. 1: fig. 14.—Manning, 1961:526, figs. 1, 2a,b,e.
Palaemon paulensis.—Rathbun, 1901:125.
Leander tenuicornis.—Holthuis, 1952:155 [part, reference to *L. paulensis* only; not *Leander tenuicornis* (Say, 1818)].

MATERIAL EXAMINED.—Gatun Locks (LGA 74-4: 4 ♂, 2 ovig. ♀; sta 176, M-2-F: 1 ♂; sta 1530: 2 ♂, 5 ♀, 2 ovig. ♀); Miraflores Locks (sta 77-3: 1 ♂).

MEASUREMENTS.—Males, cl 4.0–5.7 mm; females, cl 3.5–4.2 mm; ovigerous females, cl 4.5–7.2 mm.

TYPE LOCALITY.—São Paulo, Brazil.

DISTRIBUTION.—Known from northern Florida Bay and in nearby brackish water of the extreme southern portion of the Florida peninsula; Mayaguez, Puerto Rico; Curaçao; São Paulo, Brazil. Now first recorded from the eastern Pacific at Miraflores Locks, Panama.

REMARKS.—Manning (1961) redescribed this species, which Holthuis (1952) had earlier synonymized with *Leander tenuicornis* (Say, 1818). The present specimens agree almost perfectly with the description of Manning and show similar variation in the number of rostral teeth. The number of dorsal rostral teeth ranges from 12 to 13, and the number of ventral rostral teeth ranges from 5 to 7. Five males and one female were infected with bopyrid isopods.

Macrobrachium Bate, 1868

11. *Macrobrachium acanthurus* (Wiegmann, 1836)

Palaemon acanthurus Wiegmann, 1836:150.
Macrobrachium acanthurus.—Holthuis, 1952:45, pl. 8, pl. 9: figs. a,b.—Chace and Hobbs, 1969:89, figs. 20, 25a,g.—Chace, 1972:20.—Williams, 1984:66, figs. 44–45.

MATERIAL EXAMINED.—Gatun Locks, Lower Chambers, several specimens, coll. by H. Hildebrand in 1935.

MEASUREMENTS.—Males, cl 4.0–36.5 mm; females, cl 4.0–20.6 mm; ovigerous female, cl 16.2 mm (Chace and Hobbs, 1969).

TYPE LOCALITY.—Brazilian coast.

DISTRIBUTION.—Neuse River estuary of North Carolina through Central America and the West Indies to Rio Grande do Sul, Brazil (Chace and Hobbs, 1969; Williams, 1984).

12. *Macrobrachium americanum* Bate, 1868

Macrobrachium americanum Bate, 1868:363, pl. 30.—Holthuis, 1952:128, pl. 31: figs. d,e; 1980:87.—Abele and Blum, 1977:245.—Wicksten, 1983:12.—Abele and Kim, 1984:957.
Palaemon jamaicensis Semper, 1868:585.
Macrobrachium jamaicense.—Rathbun, 1910, pl. 51: fig. 1.

MATERIAL EXAMINED.—Rio Pedro Miguel (adjacent to Locks: 1 ♂, in fish trap, 12 Apr 1969, coll. by L.G. Abele).

MEASUREMENT.—Males, cl 15.5–43.9 mm; females, cl 8.1–27.6 mm; ovigerous female, cl 27.6 mm (Abele and Blum, 1977).

TYPE LOCALITY.—Lake Amatitlan, Guatemala.

DISTRIBUTION.—Known from fresh waters of western America from Baja California, Sonora, Mexico, through Central America to northern Peru; Isla del Coco and the Galapagos Islands (Holthuis, 1952).

13. *Macrobrachium carcinus* (Linnaeus, 1758)

Cancer Carcinus Linnaeus, 1758:631.

Macrobrachium carcinus.—Hedgpeth, 1949:31, figs. 1b, 3, 5.—Holthuis, 1952:114, pl. 30, pl. 31: figs. a–c.—Chace and Hobbs, 1969:93, figs. 21, 25b,h.—Williams, 1984:68.

MATERIAL EXAMINED.—Barro Colorado Island (LGA 69-26: 1 ♂; Allee stream: 1 ♀, Jun 1969, coll. by L.G. Abele).

MEASUREMENTS.—Males, cl 10.9–92.0 mm; females, cl 12.2–64.2 mm; ovigerous females, cl 13.7–44.2 mm (Chace and Hobbs, 1969).

TYPE LOCALITY.—"in Americae fluviis" (restricted to Jamaica by Holthuis, 1952).

DISTRIBUTION.—Known from Florida and Texas to Estado de Santa Catarina, Brazil; the West Indies (Holthuis, 1952).

14. *Macrobrachium crebrum*, new species

FIGURE 2

MATERIAL EXAMINED.—*Holotype:* Male, cl 21.0 mm, Republic of Panama, Panama Canal, Miraflores Third Locks Lake, sta 1731.

Paratypes: Miraflores Third Locks Lake, sta 1731: 1 ♂, 1 ♀.

MEASUREMENTS.—Males, cl 18.8–21.0 mm; female, cl 16.0 mm.

DESCRIPTION.—Rostrum (Figure 2*a*) concave medially, ascending in distal half, reaching to or slightly beyond distal end of scaphocerite, armed dorsally with 10 teeth, including two preorbital; ventral margin convex, armed with six teeth, first arising below area between fifth and sixth dorsal teeth; distance between teeth greater in middle region; short, stiff setae present along rostral margin ventrally.

Carapace smooth; lower orbital angle rounded; strong antennal spine arising below orbital angle; hepatic spine smaller than antennal; distinct hepatic groove present; branchiocardiac groove weak; frontal region behind orbital margin slightly depressed.

Cornea rounded and broader than eyestalk.

Stylocerite acute and directed somewhat laterally at tip, extending to middle of penultimate segment of antennule; ultimate segment of antennule slightly longer than penultimate segment.

Scaphocerite overreaching distal end of antennular peduncle by sum of ultimate and half of penultimate segment of antennule; outer margin straight, ending in short spine; spine falling far short of inner blade; inner blade rounded distally.

Third maxilliped (Figure 2*b*) falling short of middle of scaphocerite; antepenultimate segment about 1.5 times as long as penultimate; penultimate segment longer than ultimate; exopod extending to distal end of antepenultimate segment.

First pereopods (Figure 2*c,d*) slender, extending beyond distal end of scaphocerite by distal half of fingers; palm of chela about 1.2 times as long as fingers; carpus about 2 times as long as chela, 1.3 times as long as merus; merus about 2 times as long as ischium.

Second pereopods (Figure 2*e*) robust; larger pereopod overreaching distal end of scaphocerite by distal half of carpus; chela slightly less than 2 times as long as carpus; palm slightly longer than densely pubescent fingers; movable finger with cutting edge bearing blunt tooth on proximal 1/4 of its length and two small teeth behind blunt tooth; immovable finger bearing larger, blunt tooth behind blunt tooth of movable finger and 3 small teeth behind blunt tooth of immovable finger; carpus about 4.0 times as long as broad at distal end, slightly longer than merus; merus slightly longer than ischium; palm, carpus, merus, and ischium armed with rows of horny spinules; spinules larger inferiorly.

Third through fifth pereopods similar, covered with very short, dense setae on all segments except dactyli.

Third pereopod (Figure 2*f*) reaching with portion of dactylus beyond distal end of scaphocerite; propodus slightly less than 2 times as long as carpus, somewhat shorter than merus; ischium almost same length as carpus.

Fifth pereopod reaching somewhat beyond middle of scaphocerite.

Abdomen smooth; pleura of first three somites broadly rounded on posterior ventral margins; pleuron of fourth with broad triangular shape; pleuron of fifth rectangular, acute on posterior ventral margin; sixth somite about 1.3 times length of fifth, about 0.6 times length of telson. First pleopod lacking appendix interna; endopod almost half as long as exopod; second pleopod with appendix masculina (Figure 2*i*) slightly less than 2 times as long as appendix interna, with strong, stiff setae on superior surface and tip.

Telson (Figure 2*g,h*) tapering regularly toward tip; dorsal surface bearing usual two pairs of spines, one pair arising about middle and other pair about 3/4 length of telson; posterior margin ending in long, narrow tip, sometimes slightly overreached by long inner pair of posterior spines.

Uropodal exopod with diaeresis; inner movable spine of diaeresis slightly overreaching outer immovable spine.

VARIATION.—The rostrum of the paratype male falls short of the outer spine of the scaphocerite and has eleven teeth dorsally and seven teeth ventrally. The third dorsal tooth rises almost above the orbital margin. The second pereopod of the female paratype is more slender than those of the holotype and paratype males; the rostrum falls short of the distal end of the inner blade of the scaphocerite and is armed with ten teeth dorsally and six teeth ventrally. The pleuron of the fifth abdominal somite is more angled and is of an elongated triangular shape rather than rectangular as in the male.

REMARKS.—The present species is morphologically similar to three other Panamanian species, *M. tenellum*, *M. panamense*, and *M. rathbunae*, though they can be distinguished by the following features. There are two pre-orbital teeth in *M. crebrum*, whereas there is only one in *M. tenellum*. The chela fingers of the second pereopod in males of *M. crebrum* are

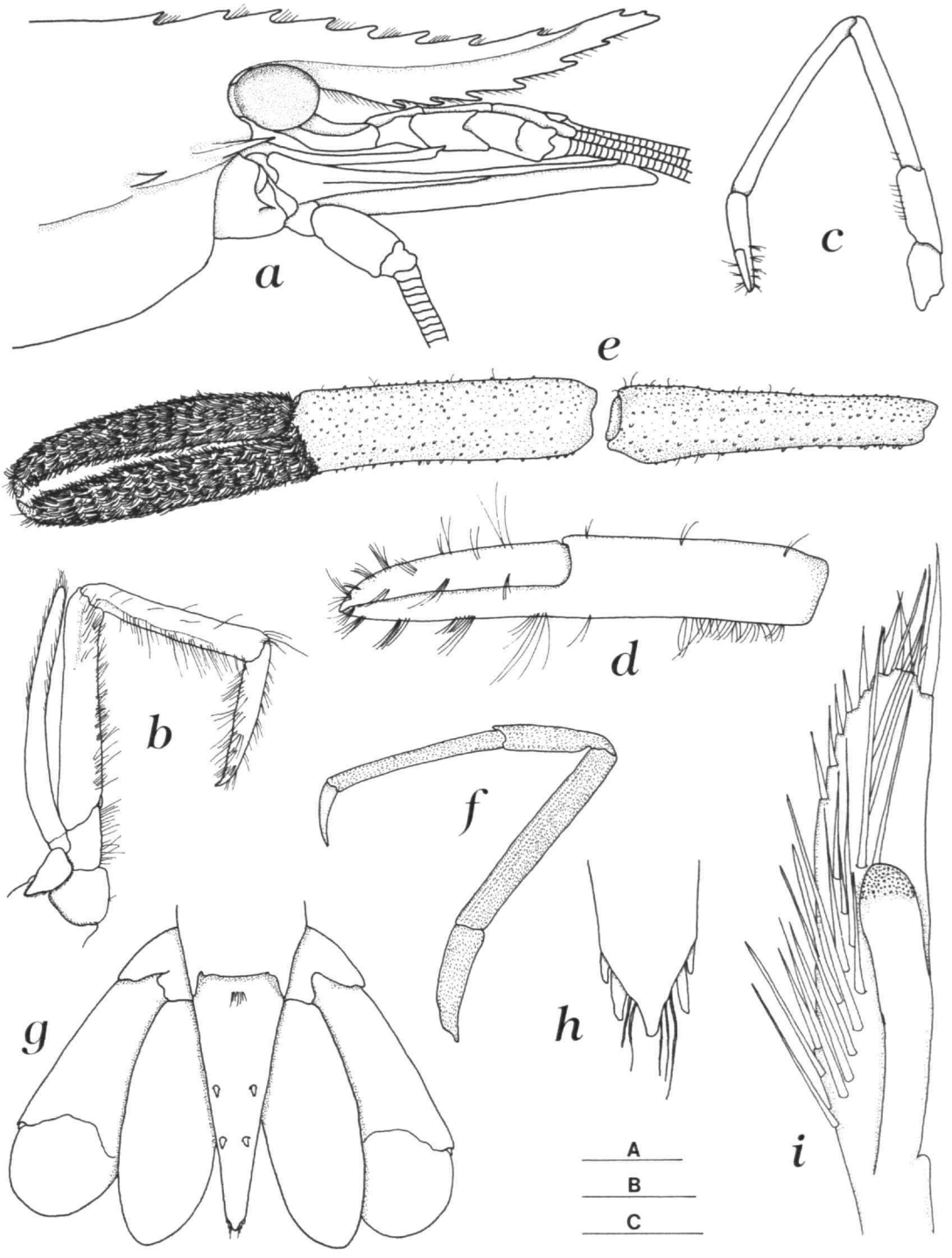

FIGURE 2.—*Macrobrachium crebrum*, new species: *a*, anterior region, lateral view; *b*, right third maxilliped; *c*, left first pereopod; *d*, same, chela; *e*, chela and carpus of left second pereopod; *f*, left third pereopod; *g*, telson and uropods; *h*, posterior end of telson; *i*, left appendix masculina (*a,e,g,h*, holotype male, cl 21.0 mm; *b–d,f,i*, male, cl 18.8 mm, from sta 1731). (Scale A, 5 mm, *b*, 1 mm, *d,h*, 0.5 mm, *i*; scale B, 5 mm, *a*; scale C, 5 mm, *c,e–g*.)

thickly pubescent, whereas they are naked in *M. panamense*. In addition, the rostrum of *M. crebrum* is shorter than that of *M. panamense*, and the second pereopod of *M. crebrum* is more robust than that of *M. panamense* (compare Figures 2 and 5).

The present species can be distinguished from *M. rathbunae* by the following features. The second pereopod extends beyond the scaphocerite by the distal half of the merus in *M. crebrum* but by the entire merus in *M. rathbunae*. The fingers of the second pereopod are slightly shorter than the palm in *M. crebrum*, whereas they are about 0.7 times the length of the palm in *M. rathbunae* (Table 2).

ETYMOLOGY.—The specific name is from the Latin *crebrum* (thick), referring to the thick pubescence on the fingers of the chela of the second pereopod.

15. *Macrobrachium crenulatum* Holthuis, 1950

Macrobrachium crenulatum Hothuis, 1950a:95; 1952:107, pl. 27: figs. a–d, pl. 28.—Chace and Hobbs, 1969:99, figs. 22, 25c,i.—Chace, 1972:20.

MATERIAL EXAMINED.—Barro Colorado Island (LGA 69-63: 12 spec.; stream adjacent to dock: 18 spec., Aug 1962, coll. by H.L. Loffin).

MEASUREMENTS.—Males, cl 2.9–29.7 mm; females, cl 3.0–25.3 mm; ovigerous females, cl 8.7–19.0 mm (Chace and Hobbs, 1969).

TYPE LOCALITY.—Rio Peje Bobo, Panama.

DISTRIBUTION.—West Indies, Panama, and Venezuela.

16. *Macrobrachium digitus*, new species

FIGURES 3, 4

Macrobrachium panamense.—Holthuis, 1952, pl. 3 [not *M. panamense* Rathbun, 1912].

MATERIAL EXAMINED.—*Holotype:* Male, cl 41.9 mm, Republic of Panama, Panama Canal, Miraflores Locks, sta 1524.

Other Material: Upper Miraflores Locks, sta 1719: 1 ♂, cl 29.0 mm.

MEASUREMENTS.—Males, cl 29.0–41.9 mm.

DESCRIPTION.—Rostrum (Figure 3) slightly convex posteriorly, concave medially, overreaching distal end of scaphocerite by about 1/4 of length from orbital margin to apex, armed dorsally with 10 teeth, including two postorbital, first placed in anterior 1/5 length of carapace; distance between seventh and eighth teeth about 2.4 times as long as distance from eighth to rostral tip; ventral margin convex, armed with eight teeth, first arising below fifth dorsal tooth; distance between teeth decreasing anteriorly; short, dense setae present on ventral rostral margin; lateral ridge oblique, merging with orbital margin.

Carapace smooth, anterolateral angle with very short setae; lower orbital angle rounded rather than truncated; strong antennal spine arising below lower orbital angle; hepatic spine present, smaller than antennal; distinct hepatic and branchiocardiac grooves present; frontal region behind orbital margin slightly depressed.

Cornea rounded and broader than eyestalk.

Stylocerite acute and directed somewhat laterally at tip, extending beyond middle of penultimate segment of antennule; ultimate segment of antennule longer than penultimate segment.

Scaphocerite falling far short of tip of rostrum and almost reaching to ventral fifth tooth of rostrum, about 3 times as long as broad; outer margin almost straight, ending in short spine falling far short of distal margin of inner blade.

Third maxilliped (Figure 4*a*) falling slightly short of middle of scaphocerite; antepenultimate segment with numerous very small spinules on outer surface, about 1.7 times as long as penultimate; penultimate segment about 1.3 times as long as ultimate; exopod extending to distal end of antepenultimate segment.

First pereopods (Figure 4*b*) slender, smallest of all pereopods, extending beyond distal end of scaphocerite by 1/2 length of palm; fingers of chela about as long as palm; carpus 2.6 times as long as merus; merus about 2.2 times as long as ischium; merus and ischium with dense small spinules on outer surfaces.

Second pereopods (Figures 3, 4*c*) slightly unequal in both length and width; larger (left) pereopod overreaching distal end of scaphocerite by distal 1/3 of merus; chela about 1.3 times as long as carpus; fingers of chela subequal to palm, covered with thick coat of brown, short setae and curving downwards; movable finger with cutting edge bearing small, blunt tooth on proximal 1/5 of its length and large, blunt tooth present on cutting edge of immovable finger behind blunt tooth of movable finger; two small proximal teeth on cutting edges of each finger; palm somewhat swollen and highest in middle, armed with blunt, horny, brown spinules; carpus about 1.4 times as long as merus, widening distally, 7 times as long as broad, armed with dark spinules; merus 1.4 times as long as ischium; merus and ischium armed with spinules.

Third through fifth pereopods similar, covered with very short, dense spinules on all segments except dactyli.

Third pereopod (Figure 4*d*) overreaching distal end of scaphocerite by part of propodus; propodus almost 3.4 times as long as dactylus; carpus somewhat more than half as long as propodus.

Fifth pereopod weaker than fourth; propodus slightly over 4.2 times as long as dactylus, provided with transverse, long tuft of setae on inferior distal region; carpus about 2/3 length of propodus; merus somewhat shorter than propodus.

Abdomen not smooth to touch, covered with very small spinules except dorsal portions of first three somites; pleura of first three somites broadly rounded on posterior ventral margins; pleuron of fourth more angularly rounded; pleuron

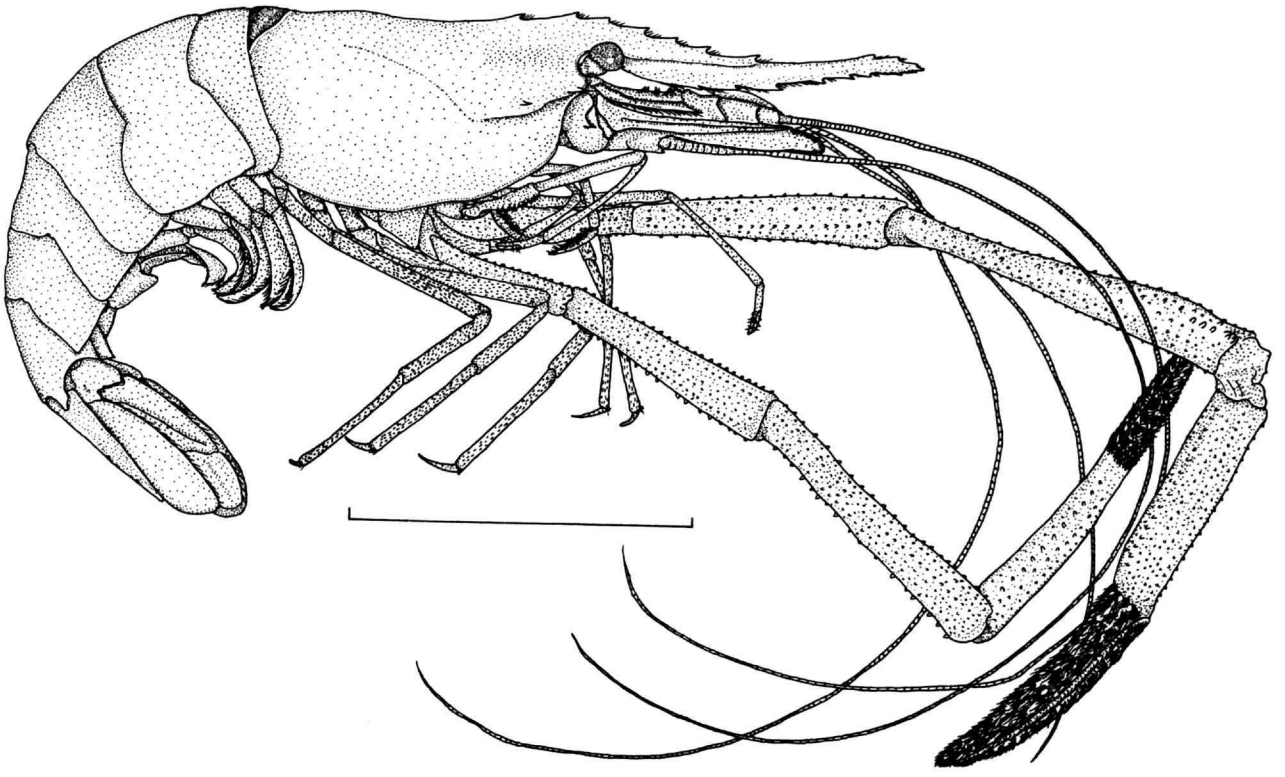

FIGURE 3.—*Macrobrachium digitus*, new species, holotype male, cl 41.9 mm, lateral view. (Scale, 50 mm.)

of fifth subrectangular on posterior ventral margin; sixth somite about 1.6 times as long as fifth. Arch in front of basis of uropod semicircular in shape. First pleopod lacking appendix interna; endopod less than half as long as exopod. Appendix masculina (Figure 4*g*) present on second pleopod, about 2 times as long as appendix interna, with strong, stiff setae on superior surface and tip.

Telson (Figure 4*e*) covered with very small spinules on dorsal surface, armed with two pairs of spines, one pair in middle and other pair slightly closer to first pair than to posterior end; posterior end broken in present specimens.

Uropods (Figure 4*f*) ovate, extending well beyond posterior end of telson; posterior lateral tip of basis of uropod short, rounded rather than acute, elongate in shape; exopod extending beyond endopod; diaeresis present; very small spine just medial to outer margin; number of very small spinules present on dorsal surface.

REMARKS.—The present species is similar to both *M. panamense* and *M. tenellum*. It can be easily distinguished from *M. panamense* by the following features: the fingers of the chela of the second pereopod of *M. panamense* are naked and longer than the palm, whereas the fingers of the present species are covered with thick pubescence and are slightly shorter than or subequal to the palm. The present species can be distinguished from *M. tenellum* by the following: the carpus of the second pereopod of *M. tenellum* is slender (length 13–15 × breadth), whereas that of the present species is robust (length 6–8 × breadth). In *M. tenellum* there is always only one pre-orbital rostral tooth, whereas there are two pre-orbital teeth in the present species.

During the course of this study we examined the holotype and paratypes of *M. panamense* (see remarks under that species). On the basis of our examination of the types and Rathbun's (1912) original description, we believe that the illustration of *M. panamense* by Holthuis (1952, pl. 3) is not that species. The illustration appears to be very close to the present species, and we tentatively refer that illustration to the present species.

ETYMOLOGY.—The specific name is from the Latin *digitus* (finger), referring to the pubescent, long fingers of the chela of the second pereopod.

17. *Macrobrachium digueti* (Bouvier, 1895)

Palaemon Digueti Bouvier, 1895:159, fig. 2.
Macrobrachium digueti.—Holthuis, 1950b:13; 1952:103, pl. 26: figs. a-e.—Méndez, 1981:73, fig. 225.—Wicksten, 1983:12.

MATERIAL EXAMINED.—Pedro Miguel Locks (LGA 69-21: 43 spec. (including ovigerous females)); Pacific coast adjacent to Panama Canal on west bank near Miraflores (2 ♂, 1 ♀, 9

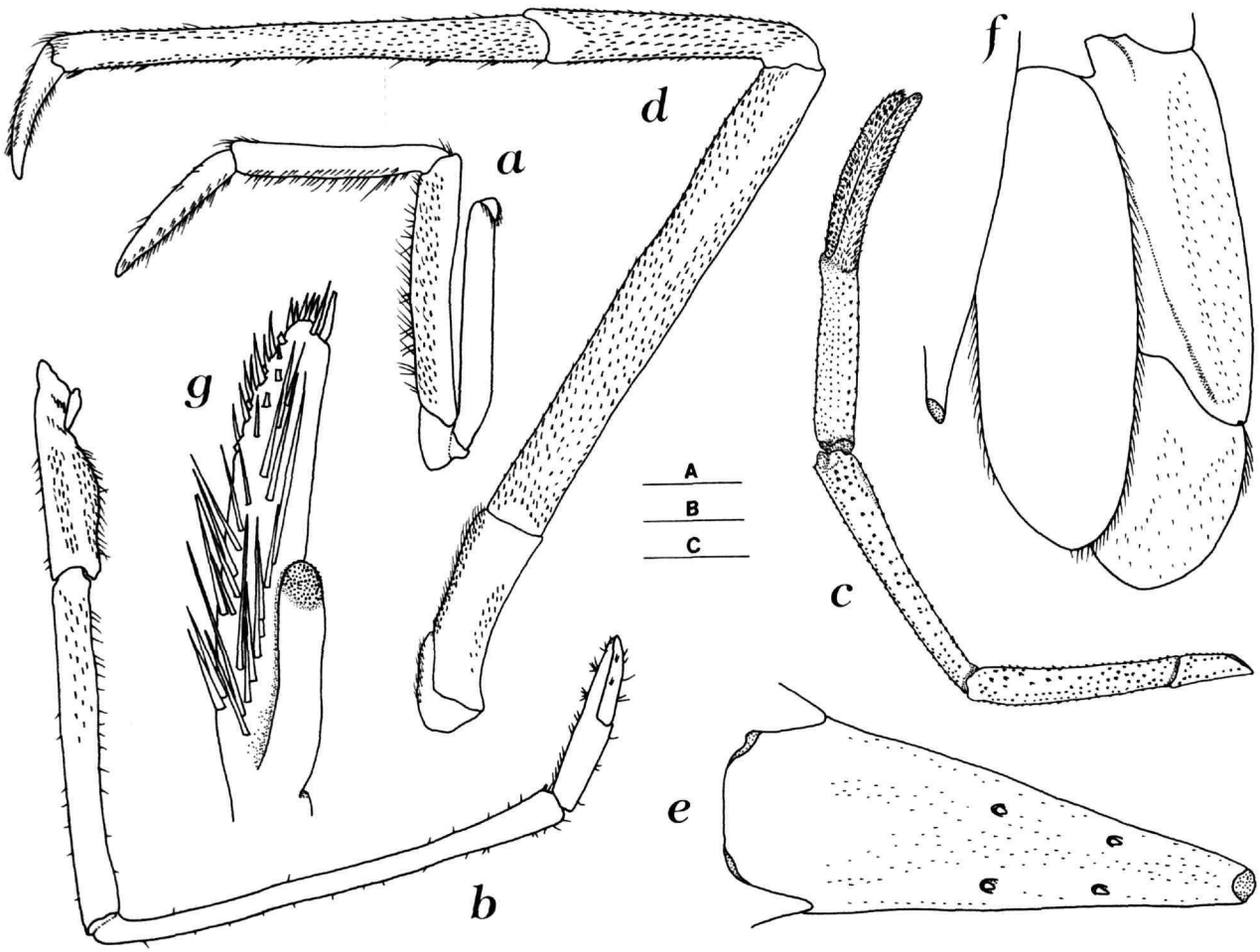

FIGURE 4.—*Macrobrachium digitus*, new species: *a*, left third maxilliped; *b*, left first pereopod; *c*, left second pereopod; *d*, left third pereopod; *e*, telson; *f*, right uropods; *g*, left appendix masculina (*a–f*, holotype male, cl 41.9 mm; *g*, male, cl 29.0 mm, from sta 1719). (Scale A, 1 mm, *g*; scale B, 20 mm, *c*; scale C, 5 mm, *a,b,d–f*.)

Mar 1973, coll. by L.G. Abele).

MEASUREMENTS.—Males, cl 4.1–6.4 mm; female, cl 4.5 mm.

TYPE LOCALITY.—Mulege River, Baja California.

DISTRIBUTION.—Known from fresh water of the Pacific drainage, from Baja California to Peru (Holthuis, 1952).

18. *Macrobrachium heterochirus* (Wiegmann, 1836)

Palaemon heterochirus Wiegmann, 1836:149.

Macrobrachium heterochirus.—Holthuis, 1950b:14; 1952:69, pl. 15: figs. a,b, pl. 16: figs. a–c.—Chace and Hobbs, 1969:106, figs. 24, 25e,k.—Holthuis, 1980:92.

MATERIAL EXAMINED.—Barro Colorado Island (shoreline and creek: 28 spec., Aug 1962, coll. by H.L. Loffin).

MEASUREMENTS.—Males, cl 6.8–33.3 mm; females, cl 5.2–24.0 mm; ovigerous females, cl 10.0–24.0 mm (Chace and Hobbs, 1969).

TYPE LOCALITY.—"East coast of Mexico."

DISTRIBUTION.—Known from fresh water of eastern Central and South America from Mexico to south Brazil; the West Indies (Holthuis, 1952).

19. *Macrobrachium olfersii* (Wiegmann, 1836)

Palaemon Olfersii Wiegmann, 1836:150.

Macrobrachium olfersii.—Pearse, 1911:111.—Holthuis, 1952:95, pl. 24, pl. 25: figs. a,b.—Williams, 1984:70, figs. 47, 48.

MATERIAL EXAMINED.—Middle Gatun Lock (mid to lower part before entering small chamber: 1 ♂, 4 Mar 1974); "Esclusa de Gatun Atlantico" (17 ♂, 2 ♀, 11 ovig. ♀, 5 Oct 1973, coll. by S.B. DeRosario).

MEASUREMENTS.—Males, cl 5.8–12.7 mm; females, cl 8.2–9.7 mm; ovigerous females, cl 4.2–8.8 mm.

TYPE LOCALITY.—"Brazilian Coast."

DISTRIBUTION.—Lower Cape Fear River near Southport, North Carolina; Florida; Louisiana; Texas; Veracruz, Mexico, to Santa Catarina, Brazil (Williams, 1984).

REMARKS.—The present specimens have the rostral tooth formula 13–16/2–5 (13/3 most common). One female is infected with a bopyrid isopod.

20. *Macrobrachium panamense* Rathbun, 1912

FIGURE 5; TABLE 1

Macrobrachium acanthurus panamense Rathbun, 1912:1.

Macrobrachium panamense.—Holthuis, 1950b:17; 1952: 23 [not pl. 3: figs. a–e].

MATERIAL EXAMINED.—Miraflores Locks (sta 77-3: 1 ♀; sta 87-3: 5 ♂, 3 ♀; sta 1524: 1 ♂; sta 1525: 2 ♂; sta 1718: 8 ♂, 2 ovig. ♀; sta 1719: 17 ♂, 14 ♀, 6 ovig. ♀; sta 1729: 3 ♂, 6 juv.).

MEASUREMENTS.—Males, cl 8.0–41.9 mm; females, cl 11.5–23.5 mm; ovigerous females, cl 13.0–29.2 mm.

TYPE LOCALITY.—Rio Calabre, Panama.

DISTRIBUTION.—Known from Honduras to Ecuador, on the Pacific slope.

REMARKS.—In her original description of *M. panamense*, Rathbun (1912) noted the following diagnostic characters: (1) second legs smooth to the touch, (2) palm of the second chela definitely shorter than the fingers, (3) fingers slender, almost naked, taken together narrower than the palm, (4) telson continuing posteriorly in an elongated triangular tooth and this tooth twice as long as the inner of the lateral spines, except in juveniles.

Holthuis (1952) used the last characters in a key distinguishing the American *Macrobrachium* species. However, his figures of this species (1952, pl. 3: figs a–e) show a second pereopod quite different in form from that described by Rathbun (see 1–3 above and comments under "16. *M. digitus*").

We examined a total of 62 specimens (36 males, 26 females) that we identified as *M. panamense*. There is considerable sexual as well as size-related variation (compare Figure 5*b,c* with Figure 5*a*). The fingers of the second chela in small males (cl 8.0–15.5 mm) tend to be very long, with an average finger/palm ratio of 1.75 (range, 1.4–1.97). This ratio tends to be about 1.16 in large males and approximately 1.0 in females (Figure 5*d,e*) of all sizes. Small specimens of both sexes have almost no pubescence on the second pereopod and no tubercles on the cutting edge of the fingers, whereas large specimens, particularly males, have some pubescence on the fingers. Three small specimens (2 males and a female) have the inner spines of the posterior margin of the telson overreaching its tip. Two males have only a single postorbital tooth on the rostrum, and the rostra of two others do not extend beyond the tip of the scaphocerite. In males the average chela/carpus ratio of the second pereopod is 1.40, whereas in females it is 1.05.

21. *Macrobrachium rathbunae* Holthuis, 1950

FIGURE 6; TABLE 2

Macrobrachium rathbunae Holthuis, 1950b:94; 1952:42, pl. 7: figs. a–f.

MATERIAL EXAMINED.—Miraflores Locks (sta 87-3: 1 ♂, 7 ♀; sta 130-2-b: 3 ♂, 2 ♀).

MEASUREMENTS.—Males, cl 5.9–8.1 mm; females, cl 5.7–9.5 mm.

TYPE LOCALITY.—Hog Creek Valley, San Jose Island, Archipelago de las Perlas, Gulf of Panama.

DISTRIBUTION.—Panama; Ecuador; Colombia.

REMARKS.—The present specimens agree with the description of Holthuis (1952) with the few exceptions noted below. According to Holthuis (1952:42), the fingers of the chela of the second pereopod are 0.5 to 0.6 times as long as the palm. He also noted that the fingers are relatively longer in young (= smaller) specimens. We examined and measured the paratypes of *M. rathbunae* (see Table 2). The fingers are about 0.7 times as long as the palm in the paratypes, whereas, in the

TABLE 1.—Measurement data and mean ratios of segments of the second pereopods for the type series of *Macrobrachium panamense* Rathbun, 1912.

Character	Male (6 ♂)		Nonovigerous female (8 ♀)	
Carapace length	17.8–22.7 mm		11.3–19.5 mm	
Number of rostral teeth (dorsal/ventral)	9–11/6–9		8–10/5–8	
Ratio	Right (n=5)	Left (n=5)	Right (n=6)	Left (n=6)
Fingers/palm	1.13	1.20	1.05	0.95
Chela/carpus	1.32	1.33	1.07	0.95
Carpus/merus	1.31	1.27	1.40	1.46
Length/breadth of palm	2.97	3.36	3.81	3.86
Breadth of palm/carpus	1.27	3.36	1.05	1.06

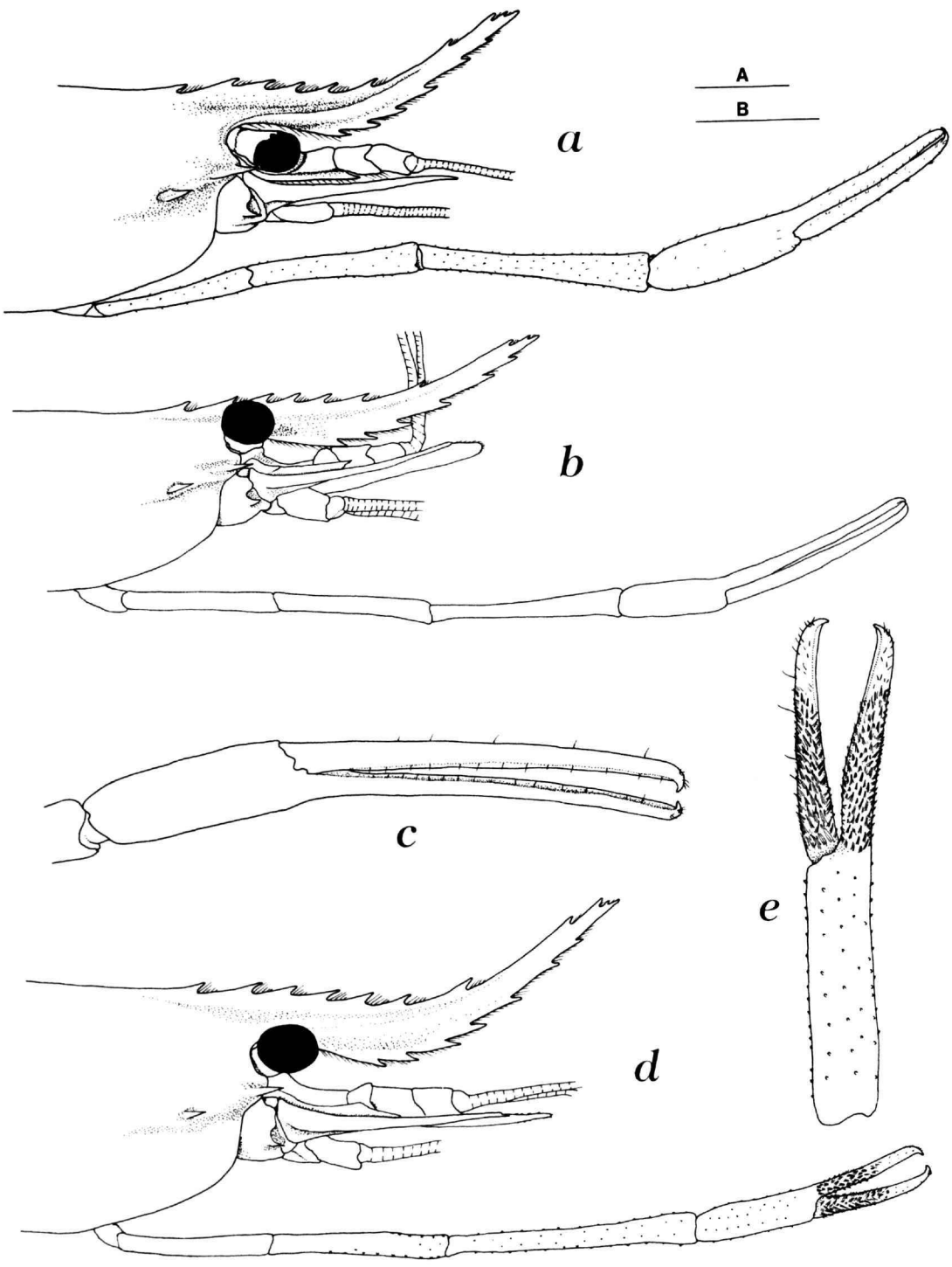

FIGURE 5.—*Macrobrachium panamense: a,* anterior region and right second pereopod, lateral view; *b,* anterior region and right second pereopod, lateral view; *c,* chela of right second pereopod; *d,* anterior region and right second pereopod, lateral view; *e,* chela of right second pereopod (*a,* holotype male; *b,c,* male, cl 13.3 mm, from sta 1718; *d,e,* female, cl 16.8 mm, from sta 1719). (Scale A, 5 mm, *b,d,* 2.5 mm, *c,e;* scale B, 10 mm, *a.*)

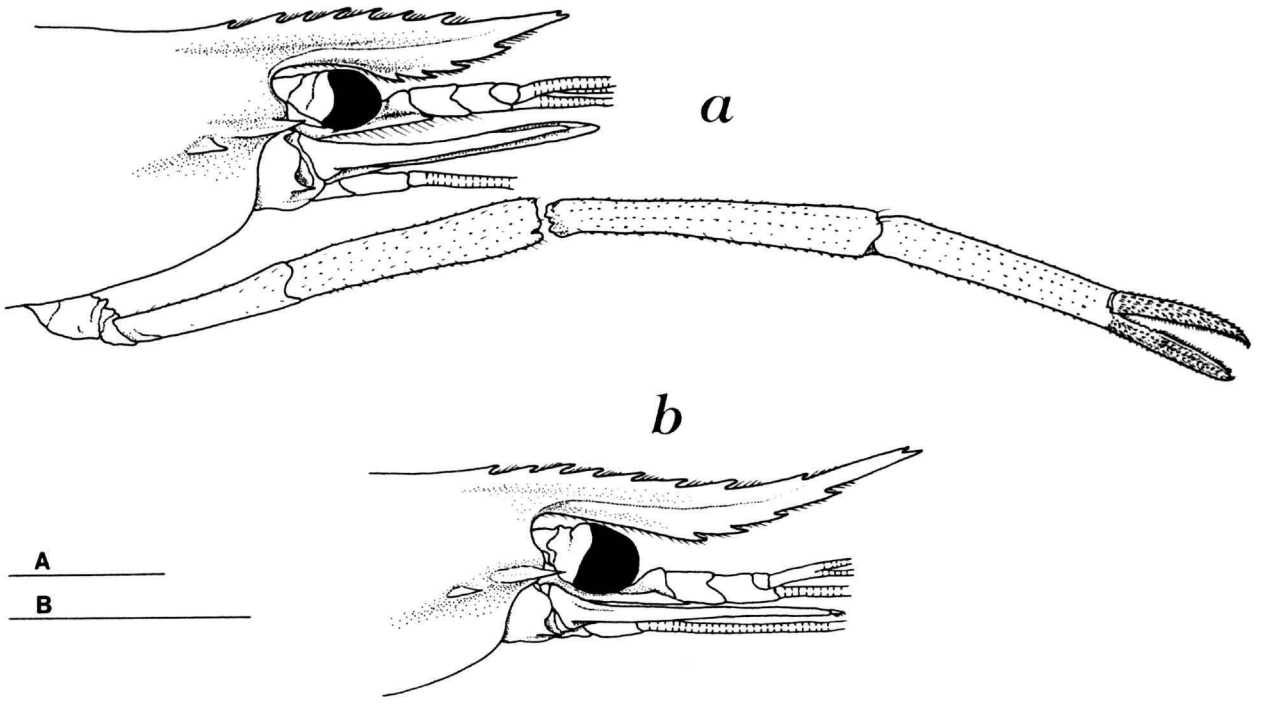

FIGURE 6.—*Macrobrachium rathbunae: a,* anterior region and right second pereopod; *b,* anterior region, lateral view (*a,* paratype male; *b,* paratype male, cl 12.9 mm). (Scale A, 10 mm, *a;* scale B, 10 mm, *b.*)

TABLE 2.—Measurement data and mean ratios of segments of the second pereopods for the paratypes of *Macrobrachium rathbunae* Holthuis, 1950.

Character	Male (4 ♂)		Female				Detached chelae
			1 Nonovigerous		1 Ovigerous		
Carapace length	10.2–24.1 mm		20 mm		20.0 mm		
Number of rostral teeth (dorsal/ventral)	9–12/4–6		11/5		10/4		
Ratio	Right (n=3)	Left (n=1)	Right (n=1)	Left (n=1)	Right*	Left (n=1)	
Fingers/palm	0.67	0.77	0.69	0.73	–	0.73	0.72
Chela/carpus	1.04	0.84	0.97	0.95	–	1.00	1.06
Carpus/merus	1.04	1.54	1.40	1.41	–	1.35	1.36
Length/breadth of palm	5.48	5.0	5.80	5.5	–	5.0	5.03
Breadth of palm/carpus	0.97	1.0	0.83	0.83	–	0.86	1.06

*Right leg absent.

present specimens, the fingers are relatively longer (0.98 times the length of the palm) probably because the present specimens (cl 5.7–9.5 mm) are smaller than the paratypes (cl 10.2–24.1 mm). Below are the measurement data for the present specimens. The average ratio of finger to palm of the second chela for 4 male specimens is 0.98, the average ratio of chela to carpus is 1.12, and the rostral tooth formula is 9–10/5–6. The average ratio of finger to palm of the second chela for 9 female specimens is 0.94, the average ratio of chela to carpus is 1.07, and the rostral tooth formula is 9–10/6–7 (see Table 2 for comparison to paratypes).

22. *Macrobrachium tenellum* (Smith, 1871)

Palaemon tenellum Smith, 1871:98.

Macrobrachium tenellum.—Holthuis, 1950b:18; 1952:54, pl. 10, pl. 11: figs. a,b.—Méndez 1981:73, fig. 233.—Wicksten, 1983:12.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta

110: 4 ♂, 3 spec.) Miraflores Locks (sta 1719: 1 ♂, 1 ♀).

MEASUREMENTS.—Males, cl 6.2–14.6 mm; female, cl 18.1 mm.

TYPE LOCALITY.—Polvon, western Nicaragua.

DISTRIBUTION.—Known from the Mulege River, Baja California, Mexico; Panama; Ecuador to northwestern Peru.

REMARKS.—One male has a tooth in the typically smooth interval between the eighth and ninth dorsal teeth of the rostrum.

Palaemon Weber, 1795

23. *Palaemon gracilis* (Smith, 1871)

Leander gracilis Smith, 1871:97.
Palaemon (Palaemon) gracilis.—Holthuis, 1950b:7; 1952:183, pl. 45: figs. f–l.
Palaemon gracilis.—Wicksten, 1983:11.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta 130-1: 7 ♂, 5 ♀); Miraflores Locks (sta 1719: 1 ♀, 1 ovig. ♀; sta 1720: 1 ♀).

MEASUREMENTS.—Males, cl 4.8–5.9 mm; females, cl 5.3–10.2 mm; ovigerous female, cl 10.3 mm.

TYPE LOCALITY.—Estero at Realejo, western Nicaragua.

DISTRIBUTION.—Caimanero Lagoon; western America from Nicaragua to southern Panama.

24. *Palaemon hancocki* Holthuis, 1950

Palaemon hancocki Holthuis, 1950a:97.
Palaemon (Palaemon) hancocki.—Holthuis, 1950b:7; 1952:185, pl. 46: figs. a–f.

MATERIAL EXAMINED.—Miraflores Locks (sta 1719: 1 ovig. ♀).

MEASUREMENTS.—Ovigerous female, cl 10.0 mm.

TYPE LOCALITY.—Guayas.

DISTRIBUTION.—Colombia and Ecuador; now from Miraflores Locks, Panama.

25. *Palaemon pandaliformis* (Stimpson, 1871)

Leander pandaliformis Stimpson, 1871:130.
Palaemon (Palaemon) pandaliformis.—Holthuis, 1950b:7; 1952:187, pl. 46: figs. g–l.—Chace and Hobbs, 1969:111, figs. 26, 28a.—Chace, 1972:21.

MATERIAL EXAMINED.—Pedro Miguel Locks (LGA 69-21: 4 juv.); Barro Colorado Island (Shannon Creek: 3 ovig. ♀, 5 Feb 1969, coll. by T. Zaret).

MEASUREMENTS.—Maximum postorbital carapace length about 7 mm (Chace and Hobbs, 1969).

TYPE LOCALITY.—Barbados or Trinidad.

DISTRIBUTION.—Known from the West Indies and Guatemala to Estado de Santa Catarina, Brazil.

Palaemonetes Heller, 1869

26. *Palaemonetes schmitti* Holthuis, 1950

Palaemonetes schmitti Holthuis, 1950a:99; 1950b:10.
Palaemonetes (Palaemonetes) schmitti.—Holthuis, 1952:229, pl. 54: figs. a–e.

MATERIAL EXAMINED.—Miraflores Locks (sta 77-2: 7 juv.; sta 77-3: 3 ♂, 1 ♀, 6 ovig. ♀, 10 juv.; sta 77-8: 1 juv.; sta 77-9: 1 juv.; sta 203, U-M-1-F: 2 juv.; U-M-3-W: 1 juv.; sta 204, L-M-3-F: 2 ♀; sta 1524: 23 ♂, 10 ♀, 11 ovig. ♀, 71 juv.; sta 1525: 12 ♂, 21 ♀, 27 ovig. ♀, about 400 juv.; sta 1718: 218 ♂, 237 ♀, 34 ovig. ♀, 213 juv.; sta 1719: 3 ♂, 52 ♀, 61 ovig. ♀, about 350 juv.; sta 1720: 46 ♂, 59 ♀, 23 ovig. ♀, about 250 juv.; sta 1728: 113 ♂, 168 ♀, 41 ovig. ♀, about 1450 juv.; sta 1729: 68 ♂, 47 ♀, 7 ovig. ♀, about 850 juv.; sta 1730: 94 ♂, 132 ♀, 19 ovig. ♀, about 600 juv.); Miraflores Locks spillway (sta 130-2-b: 14 ♂, 12 ♀, 15 ovig. ♀, 4 juv.); Upper Miraflores Locks (2 ♀, 1 ovig. ♀).

MEASUREMENTS.—Males, cl 2.7–4.9 mm; females, cl 3.4–5.3 mm; ovigerous females, cl 4.0–5.9 mm.

TYPE LOCALITY.—Upper chamber, east side, Miraflores Locks, Panama.

DISTRIBUTION.—Venado Beach, Canal Zone, east of the Panama Canal; San Francisco Beach (near Panama City) and Miraflores Locks, Panama.

REMARKS.—The rostral tooth formula is 9–11/2–4. Several aberrant specimens have the rostrum reaching the distal end of the basal segment of the antennular peduncle and no tooth on the ventral margin of the rostrum.

Superfamily ALPHEOIDEA

Family ALPHEIDAE

Alpheus Fabricius, 1798

27. *Alpheus armillatus* H. Milne Edwards, 1837

Alpheus armillatus H. Milne Edwards, 1837: 354.—Williams, 1965:67, fig. 55; 1984:92, fig. 63.—Chace, 1972:62.

MATERIAL EXAMINED.—Gatun Locks (LGA 74-4: 45 ♂, 18 ♀, 16 ovig. ♀, 12 juv.; sta 81-2: 6 ♂, 3 ovig. ♀, 1 juv.; sta 177, L-1-W: 2 ♂, 1 ♀, 1 juv.; L-3-W: 2 ♂, 1 ♀, 4 juv.; L-4-F: 2 ♂, 2 ♀; L-4-W: 4 ♂, 1 ♀, 1 ovig. ♀, 7 juv.; L-5-W: 4 ♂, 1 ♀, 2 juv.; sta 1530: 2 ♂, 2 ovig. ♀).

MEASUREMENTS.—Males, cl 4.9–12.2 mm; females, cl 5.3–10.0 mm; ovigerous females, cl 5.3–13.1 mm.

TYPE LOCALITY.—Antilles, West Indies.

DISTRIBUTION.—Known from North Carolina, the Gulf of Mexico, and Bermuda to Estado de São Paulo, Brazil.

REMARKS.—This highly variable species can be distinguished from related Atlantic species by its rostrum, which has sharply defined borders. Of the material examined, one aberrant female has no rostral carina in the middle portion between the tip and the broadened posterior base of the

rostrum. The second abdominal pleuron of *A. armillatus* is sexually dimorphic; females have a broader pleuron than males.

28. *Alpheus colombiensis* Wicksten, 1988

Alpheus colombiensis Wicksten, 1988:1, fig. 1.
Alpheus hamus Kim and Abele, 1988:91, fig. 38.

MATERIAL EXAMINED.—West side of Panama Canal in mangrove (1 ♂, 1 ovig. ♀, 5 Nov 1972, coll. by J.B. Graham); Miraflores Locks (sta 87-3: 1 ♂, 1 ♀).

MEASUREMENTS.—Males cl 14.1–16.0 mm; female, cl 9.7 mm; ovigerous female cl 13.6 mm.

TYPE LOCALITY.—Bahía Malaga, Pacific coast of Colombia (4°0'N, 77°15'W).

DISTRIBUTION.—Golfito, Costa Rica; Panama, Pacific drainage of Panama Canal; Bahía Malaga, Colombia.

REMARKS.—We are tentatively synonymizing *A. hamus* Kim and Abele published in February 1988 with *A. colombiensis* Wicksten published in January of 1988. The synonymy is tentative because Wicksten stated that the telson of *A. colombiensis* lacks distolateral spines (and none are shown in her figure), while there are small distolateral spines present on the telson of *A. hamus*. In addition, Kim and Abele (1988:93) described considerable variation, including sexual variation, in this species, while no variation is noted by Wicksten. However, the presence of immovable spines on the outer margin of the protopodites of the pleopods is such a unique feature among alpheids that it is probable that Wicksten simply overlooked the small distolateral spines of the telson.

29. *Alpheus firmus* Kim and Abele, 1988

Alpheus firmus Kim and Abele, 1988:93, fig. 39.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta 130-2-b: holotype male, cl 9.2 mm, paratypes, 25 ♂, 4 ♀, 13 ovig. ♀); Miraflores Locks (sta 77-3: 1 ovig. ♀, 1 juv.; sta 87-3: 2 ♂, 2 ♀; sta 203, U-M-5-F: 1 ♂, 2 ovig. ♀).

MEASUREMENTS.—Males, cl 5.1–10.5 mm; females, cl 8.9–9.9 mm; ovigerous females, cl 7.3–12.5 mm.

TYPE LOCALITY.—Miraflores Locks, Panama.

DISTRIBUTION.—Pacific side of Panama: Miraflores Locks, Punta Paitilla.

30. *Alpheus heterochaelis* Say, 1818

Alpheus heterochaelis Say, 1818:243.—Williams, 1965:66, fig. 54; 1984:95, fig. 65.—Chace, 1972:67.—Christoffersen, 1984:200, figs. 5–7.

MATERIAL EXAMINED.—Gatun Locks (LGA 74-4: 3 ♂, 1 ♀; sta 177, L-1-W: 1 ♂, 2 ♀; L-3-W: 1 ♂, 1 ♀, 3 ovig. ♀).

MEASUREMENTS.—Males, cl 3.4–7.5 mm; females, cl 5.5–8.1 mm; ovigerous females, cl 7.9–8.9 mm.

TYPE LOCALITY.—Amelia Island, Nassau County of Florida.

DISTRIBUTION.—North Carolina to the State of Paraíba, Brazil.

REMARKS.—In all specimens, the dactyli of the third and fourth pereopods are subspatulate in shape and show sexual dimorphism in the second abdominal pleuron, females having a broader pleuron than males.

Synalpheus Bate, 1888

31. *Synalpheus apioceros* Coutière, 1909

Synalpheus apioceros Coutière, 1909:27, fig. 9.—Chace, 1972:86.—Felder and Chaney, 1979:8.

MATERIAL EXAMINED.—Gatun Locks (sta 81-1: 1 ♂, 1 ♀, 2 ovig. ♀, 6 juv.; sta 81-2: 1 ovig. ♀).

MEASUREMENTS.—Male, cl 3.9 mm; female, cl 4.1 mm; ovigerous females, cl 3.9–4.5 mm.

TYPE LOCALITY.—Marco, Florida.

DISTRIBUTION.—Known from southern Florida to Surinam, westward to the Yucatan Peninsula; Panama.

REMARKS.—All our specimens lack the major cheliped, making identification difficult. They agree in other respects with the description and illustrations of Coutière (1909).

32. *Synalpheus recessus*, new species

FIGURES 7, 8

MATERIAL EXAMINED.—*Holotype:* Male, cl 7.8 mm; Republic of Panama, Panama Canal, Miraflores Locks, sta 1720.

Paratypes: Miraflores Locks, sta 1720: 27 ♂, 10 ♀.

Other Material: Miraflores Locks (sta 78: 9 ♂, 4 ovig. ♀, 8 juv.; sta 78-2: 1 ♂, 1 ovig. ♀, 1 juv.).

MEASUREMENTS.—Males, cl 4.1–8.4 mm; females, cl 6.1–9.5 mm; ovigerous females, cl 5.9–7.4 mm.

DESCRIPTION.—Rostrum (Figures 7, 8*a,b*) short, not exceeding lateral ocular teeth, arising from anterior slope far behind anterior margin of carapace, directed upward distally above level of ocular teeth; tip bearing several setae. Ocular hoods separated from rostrum by broad, depressed anterior slope of carapace, with narrowly acute teeth at tips and overreaching tip of rostrum; ocular teeth bearing several setae at tips. Pterygostomial margin produced as narrowly rounded lobe below basicerite.

Stylocerite narrowly elongate, reaching to middle of second antennular segment; first antennular segment nearly as long as sum of second and third segments; second segment almost 1.4 times as long as third segment.

Scaphocerite with lateral spine falling short of distal end of carpocerite; inner blade well developed, not extending to tip of lateral spine; cleft between inner blade and lateral spine deep, arising from proximal 1/3 of scaphocerite. Basicerite (Figure 8*c*) without spine dorsally; lateral spine reaching to proximal 1/4 of scaphocerite. Carpocerite overreaching distal

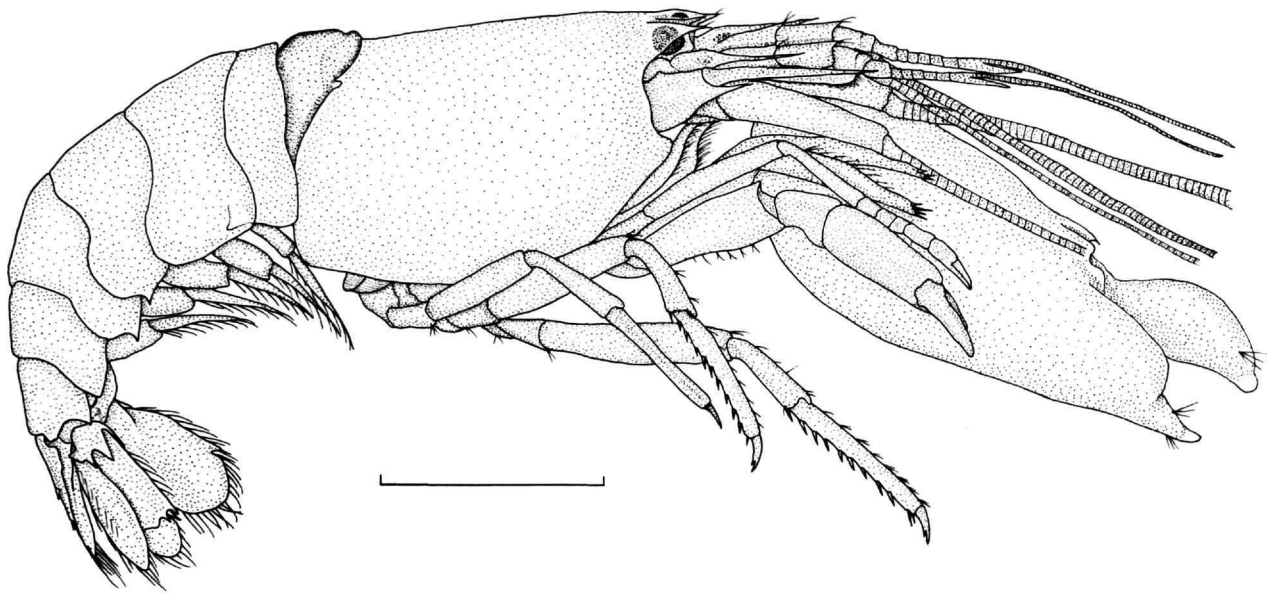

FIGURE 7.—*Synalpheus recessus*, new species, holotype male, cl 7.8 mm, lateral view. (Scale, 5 mm.)

end of antennular peduncle by 2/3 length of third antennular segment.

Third maxilliped (Figure 8*d*) reaching distal end of carpocerite by distal 1/3 of ultimate segment.

Major first pereopod (Figure 8*e–g*) overreaching distal end of carpocerite by almost 2/3 length of entire chela. Major chela about 2.7 times as long as broad; palm about 1.6 times as long as fingers, terminating in sharp downward-directed tooth on superior distal margin. Carpus short and broad, with almost invisible minute tooth (visible under high magnification) on superior distal margin. Merus about half as long as palm, with almost invisible minute tooth (visible under high magnification) at distal end of superior margin.

Minor first pereopod (Figure 8*h*) overreaching distal end of carpocerite by 2/3 length of entire chela. Palm of chela about 1.5 times as long as fingers. Carpus just half as long as palm, armed with almost invisible minute, acute tooth (visible under high magnification) on superior distal margin. Merus almost 2.5 times as long as broad, armed with almost invisible minute tooth (visible under high magnification) at distal end of superior margin.

Second pereopod (Figure 8*i*) overreaching distal end of carpocerite by length of entire chela and carpus. Fingers of chela longer than palm. Carpus slightly more than 2.5 times as long as chela and composed of five segments; first segment slightly longer than sum of distal four segments; second slightly longer than third; third and fourth subequal; fifth almost same length as sum of third and fourth segments. Merus shorter than carpus. Ischium slightly shorter than merus.

Third, fourth, and fifth pereopods with dactyli biunguiculate and base of lower process almost as broad as base of upper process.

Propodus of third pereopod (Figure 8*j,k*) about 4.7 times as long as dactylus; inferior margin armed with eight to 10 movable spines throughout length in addition to distal one. Carpus more than half as long as propodus with one movable spine at distal end of inferior margin. Merus of third pereopod (Figure 8*j*) about 5 times as long as broad.

Carpus of fourth pereopod with one movable spine at distal end of inferior margin. Merus about 4.2 times as long as broad.

Carpus of fifth pereopod with no movable spine.

Pleuron (Figure 7) of first abdominal somite of male with sharp tooth on ventral margin posteriorly; pleura of third and fourth each with acute tooth on posterior half of ventral margin; pleuron of fifth broadly triangular posteriorly.

Telson (Figure 8*m*) subtriangular, with middle of lateral margins slightly convex and with posterior margin convex; dorsal surface with slight longitudinal median depression, armed typically with two pairs of prominent spines; anterior pair situated slightly more than 1/3 length of telson; posterior pair located at about 2/3 length of telson; posterior margin with two pairs of strong outer spines; inner pair slightly less than twice as long as outer pair.

Uropodal exopod with lateral margin convex anteriorly; diaeresis with two immovable spines laterally; outer spine larger; one movable spine between these two immovable spines.

VARIATIONS.—This species shows sexual dimorphism in the form of the pleura of the abdominal somites. The pleuron of the first abdominal somite of males (Figure 7) has a sharp tooth

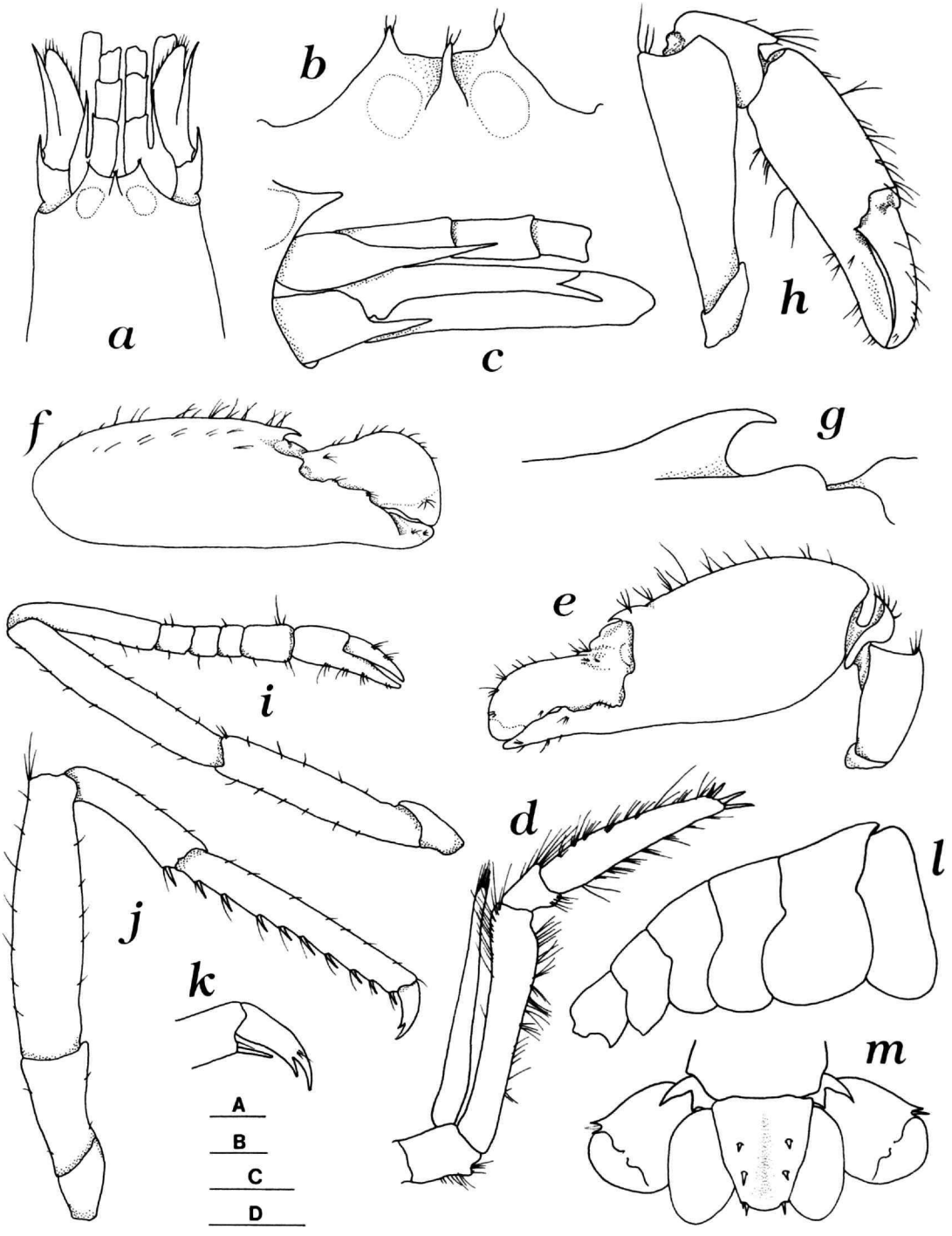

FIGURE 8.—*Synalpheus recessus*, new species, ovigerous female, cl 5.9 mm, from sta 78: *a*, anterior region, dorsal view; *b*, anterior margin of carapace, dorsal view; *c*, stylocerite and basicerite, lateral view; *d*, right third maxilliped; *e*, left (major) first pereopod, ventral outer view; *f*, same, chela, dorsal inner view; *g*, same, superior palmar spine; *h*, right (minor) first pereopod, dorsal outer view; *i*, right second pereopod; *j*, right third pereopod; *k*, same, dactylus; *l*, abdomen; *m*, telson and uropods. (Scale A, 2 mm, *l,m;* scale B, 1 mm, *d;* scale C, 0.5 mm, *g,k;* scale D, 1 mm, *b,c,h–j*, 2 mm, *a,e,f.*)

on the ventral margin posteriorly; the pleura of the third and fourth abdominal somites each bear an acute tooth on posterior half of the ventral margin. There are no teeth on the pleura of the abdominal somites of females (Figure 8*l*).

REMARKS.—This species belongs to the Paulsoni group, which includes species of *Synalpheus* having supraocular spines at least equal to the rostrum in importance, the dactylus of the third pereopod with two hooks approximately equal in width at the base, a stylocerite longer than the first segment of the antennule, ocular teeth always longer than wide and spinous, and a rostrum armed with a vertical prolongation that embraces the ocellary beak (Coutière, 1909). The present species is most closely related to *S. townsendi* in the absence of a dorsal spine on the basicerite, in the presence of a distal spine on the superior margin of the palm of the major chela, and in the similar shape of the dactylus of the third pereopod. The present species can be distinguished from *S. townsendi* by the following characters: (1) the present species has the rostrum arising from the anterior slope far behind the anterior margin of the carapace, directing upward distally; (2) the rostrum of the present species never exceeds the lateral ocular tooth. In his description of *S. townsendi*, Coutière (1909) noted that "on some specimens the frontal teeth are longer and more slender," but the frontal teeth of the present species are wider than the rostrum. In addition, the spine on the superior margin of the palm of the major chela in *S. recessus* is directed downward distally, whereas it is straight in *S. townsendi*.

ETYMOLOGY.—The rostrum of the species arises from the anterior slope far behind the anterior margin of the carapace. The specific name is from the Latin *recessus* (withdrawal).

33. *Synalpheus superus*, new species

FIGURES 9, 10

MATERIAL EXAMINED.—*Holotype:* Male, cl 5.0 mm; Republic of Panama, Panama Canal, Miraflores Locks, sta 1720.

Paratypes: Miraflores Locks, sta 1720: 16 ♂, 17 ♀, 2 juv.

Other Material: Miraflores Locks (sta 77-2: 1 ovig. ♀; sta 78: 21 ♂, 9 ♀, 3 juv.; sta 78-2: 9 ♂, 1 ovig. ♀).

MEASUREMENTS.—Males, cl 2.8–5.6 mm; females, cl 3.1–5.5 mm; ovigerous females, cl 3.5–3.7 mm.

DESCRIPTION.—Rostrum (Figures 9, 10*a*) slender, reaching to middle of first antennular segment, arising from anterior slope far behind anterior margin of carapace, bearing two or three setae at tip, directed upward distally. Ocular hood separated from rostrum by broad, depressed anterior slope, forming narrowly acute tooth at tip; tooth not reaching to tip of rostrum, bearing two or three setae at tip. Pterygostomial margin produced as rather acute lobe below basicerite.

Stylocerite narrowly acute, falling short of middle of second antennular segment; first antennular segment about 1.5 times as long as second segment and about 2 times as long as third segment.

Scaphocerite with inner blade well developed; cleft between inner blade and lateral spine deep, arising from less than proximal 1/3 of scaphocerite; lateral spine far overreaching distal margin of inner blade; blade reaching to distal end of carpocerite. Basicerite with spine dorsally; lateral spine reaching to distal end of proximal 1/3 of scaphocerite. Carpocerite overreaching distal end of antennular peduncle by length of third antennular segment.

Third maxilliped (Figure 10*b*) with ultimate segment bearing several movable spines at tip, about 4 times as long as penultimate segment.

Major first pereopod (Figure 10*c,d,e*) overreaching distal end of carpocerite by 2/3 length of chela. Chela slightly less than 3 times as long as broad; palm 2.1 times as long as fingers, terminating in slender spine on superior distal margin, spine preceded by tubercle. Carpus short and broad with almost invisible minute tooth (visible under high magnification) on superior distal margin. Merus less than half as long as palm, with almost invisible minute tooth (visible under high magnification) at distal end of superior margin.

Minor first pereopod (Figure 10*f*) overreaching distal end of carpocerite by length of entire fingers and small part of palm. Palm of chela 1.2 times as long as fingers. Carpus distinctly less than 1/3 length of palm, armed with almost invisible minute tooth (visible under high magnification) on distal end of superior margin. Merus with almost invisible minute tooth (visible under high magnification) on distal end of superior margin.

Second pereopod (Figure 10*g*) overreaching distal end of carpocerite by distal half of carpus. Fingers of chela 1.4 times as long as palm. Carpus 2 times as long as chela and composed of five segments; first segment slightly longer than sum of distal four segments; second slightly longer than third; third and fourth subequal; fifth longer than sum of third and fourth. Merus about same length as carpus, more than 1.2 times as long as ischium.

Third, fourth, and fifth pereopods with dactyli biunguiculate and base of lower process almost as broad as base of upper process.

Propodus of third pereopod (Figure 10*h,i*) 3.8 times as long as dactylus, inferior margin armed with eight movable spines throughout length in addition to distal one. Carpus more than half as long as propodus, with one movable spine at distal end of inferior margin. Merus unarmed, about 4.5 times as long as broad, less than 1.2 times as long as propodus.

Fourth pereopod with carpus bearing one movable spine at distal end of inferior margin.

Fifth pereopod with carpus bearing no movable spine.

Pleuron (Figures 9, 10*j*) of first abdominal somite of male with sharp tooth on ventral margin posteriorly; pleura of second and third broadly rounded, those of fourth and fifth obscurely angulate posteriorly.

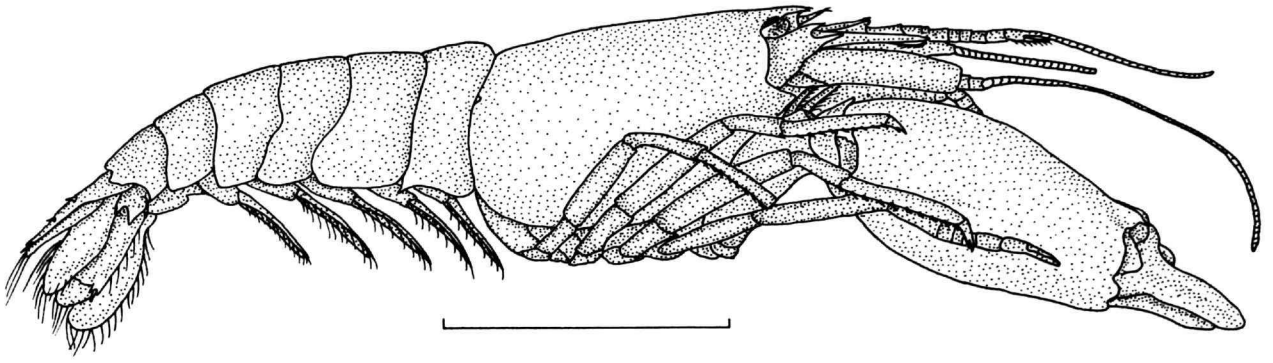

FIGURE 9.—*Synalpheus superus*, new species, holotype male, cl 5.0 mm, lateral view. (Scale, 5 mm.)

Telson (Figure 10*k*) trapezoidal with sinuous lateral margins and broadly convex posterior margin; dorsal surface with slight longitudinal median depression and bearing two pairs of prominent spines; anterior pair located at almost 1/3 length of telson; posterior pair closer to anterior pair than to posterior margin; posterior margin armed with two pairs of strong spines; inner pair almost twice as long as outer pair.

Uropodal exopod with lateral margin convex anteriorly; diaeresis with two immovable spines laterally; outer spine larger; one movable spine between these two immovable spines.

VARIATIONS.—This species exhibits sexual dimorphism in the pleura of the abdominal somites. The pleuron (Figure 10*j*) of the male first abdominal somite has a sharp tooth on the ventral margin posteriorly; there are no teeth on the pleura of the female abdominal somites (Figure 10*l*).

REMARKS.—This species belongs to the Paulsoni group and seems to be most closely related to the *S. apioceros* complex in the presence of a dorsal spine on the basicerite and the presence of a spine on the superior margin of the palm distally. According to Coutière (1909) *S. apioceros desterroensis* is more distinctly separated from *S. apioceros* than are the other *S. apioceros* subspecies. The rostrum of *S. apioceros desterroensis* is separated from the lateral spines by wide intervals with sinuous bases. The present species is very similar to *S. apioceros desterroensis* in this respect. However, the shape of the spine on the superior distal margin of the palm of the present species is more similar to those of *S. apioceros*, *S. apioceros sanjosei*, and *S. apioceros leiopes* than to that of *S. apioceros desterroensis* in the presence of a preceding tubercle. The present species is also similar to *S. apioceros leiopes* in having a deep cleft between the inner blade and lateral spine of the scaphocerite.

ETYMOLOGY.—The basicerite of this species has a long spine on the dorsal as well as the lateral surface. The specific name is from the Latin *superus* (upper).

Family HIPPOLYTIDAE

Lysmata Risso, 1816

34. *Lysmata intermedia* (Kingsley, 1878)

Hippolysmata intermedia Kingsley, 1878:90.
Lysmata intermedia.—Sivertsen, 1933:5, pl. 2: figs. 9–15.—Chace, 1972:128.—Wicksten and Méndez, 1983:86, figs. 35, 36.—Wicksten, 1983:28.

MATERIAL EXAMINED.—Gatun Locks (sta 81-2: 1 ♂).

MEASUREMENTS.—Male, cl 5.6 mm.

TYPE LOCALITY.—Dry Tortugas, Florida.

DISTRIBUTION.—Known in the western Atlantic from the Florida Keys to Tobago and Curaçao; in the eastern Pacific from the Gulf of California, Mexico, and Panama to Peru; the Galapagos Islands.

35. *Lysmata wurdemanni* (Gibbes, 1850)

Hippolyte Wurdemanni Gibbes, 1850:197.
Hippolysmata wurdemanni.—Hay and Shore, 1918:392, pl. 26: fig. 12.
Hippolysmata (Hippolysmata) wurdemanni.—Williams, 1965:84, fig. 68.
Lysmata wurdemanni.—Chace, 1972:129.—Williams, 1984:127, fig. 90.

MATERIAL EXAMINED.—Gatun Locks (sta 1530: 1 ♂, 1 ovig. ♀).

MEASUREMENTS.—Male, cl 14.9 mm; ovigerous female, cl 16.3 mm.

TYPE LOCALITY.—Key West, Florida.

DISTRIBUTION.—Great Egg Harbor, New Jersey, to Port Aransas, Texas; Surinam; French Guiana; Mamanguape, São Paulo, Brazil (Williams, 1984).

REMARKS.—The present male specimen has a rostrum with 7 dorsal teeth and 4 ventral teeth that reaches to the distal end of the antennular peduncle. The ovigerous female has a rostrum with 5 dorsal teeth and 2 ventral teeth that reaches to the distal end of the penultimate segment of the antennular peduncle.

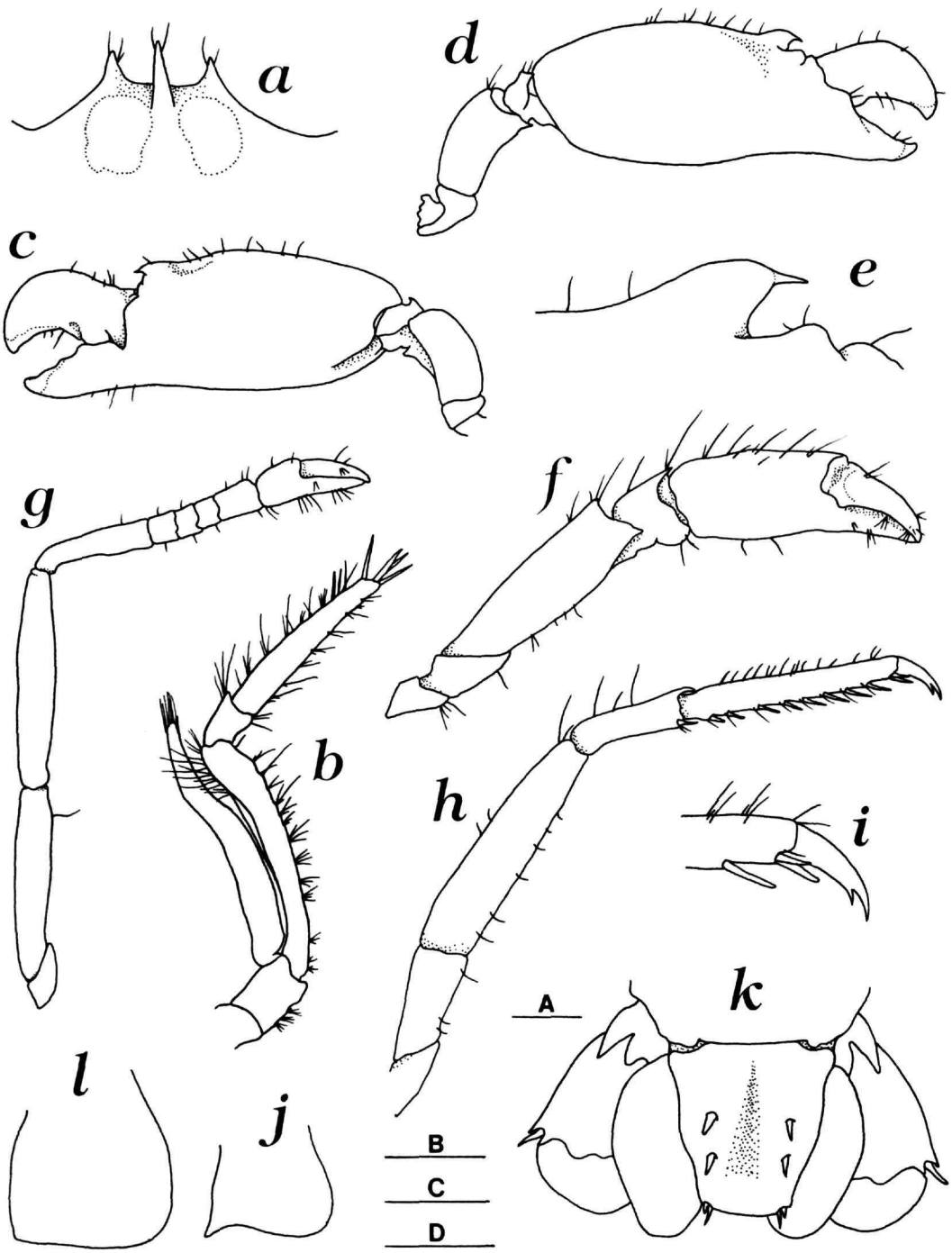

FIGURE 10.—*Synalpheus superus*, new species: *a*, anterior margin of carapace, dorsal view; *b*, right third maxilliped; *c*, left (major) first pereopod, dorsal outer view; *d*, same, ventral inner view; *e*, same, superior palmar spine; *f*, right (minor) first pereopod; *g*, right second pereopod; *h*, right third pereopod; *i*, same, dactylus; *j*, right first abdominal pleuron; *k*, telson and uropods; *l*, right first abdominal pleuron (*a*, holotype male, cl 5.0 mm; *b–k*, male, cl 5.4 mm, from sta 1720; *l*, female, cl 4.9 mm, from sta 1720). (Scale A, 1 mm, *b*, *l*; scale B, 2 mm, *c*, *d*; scale C, 1 mm, *a*,*f–h*,*j*,*k*; scale D, 0.5 mm, *e*,*i*.)

Infraorder ANOMURA

Superfamily COENOBITOIDEA

Family DIOGENIDAE

Calcinus Dana, 1851

36. *Calcinus obscurus* Stimpson, 1859

Calcinus obscurus Stimpson, 1859:83.—Holthuis, 1954:20, figs. 5, 6.—Ball and Haig, 1974:101.

MATERIAL EXAMINED.—Miraflores Locks (sta 78-1: 2 ♂, 3 ovig. ♀).

MEASUREMENTS.—Males, cl 10.0–12.5 mm; ovigerous females, cl 5.2–10.4 mm.

TYPE LOCALITY.—Panama.

DISTRIBUTION.—Known from the west American coast, from southern California through Panama to Ecuador.

Clibanarius Dana, 1852

37. *Clibanarius vittatus* (Bosc, 1802)

Pagurus vittatus Bosc, 1802:78, pl. 12: fig. 1.
Clibanarius vittatus.—Hay and Shore, 1918:410, pl. 30: fig. 9.—Holthuis, 1959:141, figs. 26, 27.—Williams, 1984:194, fig. 135.

MATERIAL EXAMINED.—Gatun Locks (sta 81-9: 6 ♂, 1 ♀, 3 ovig. ♀; sta 177, L-5-F: 2 ♂, 3 ♀; L-5-W: 2 ♂, 2 ♀; sta 1530: 1 ♂); Gatun Lower Locks (2 ♂, 2 ♀, 5 ovig. ♀, 5 Mar 1974).

MEASUREMENTS.—Males, cl 3.8–12.5 mm; females, cl 4.8–7.8 mm; ovigerous females, cl 4.9–6.0 mm.

TYPE LOCALITY.—"Les côtes de la Caroline."

DISTRIBUTION.—This species has a broad range along the western Atlantic, being known in the west Atlantic from the Potomac River, Gunston, Virginia, through Panama and Surinam to Florianopolis, Santa Catarina, Brazil.

Superfamily GALATHEOIDEA

Family PORCELLANIDAE

Euceramus Stimpson, 1860

38. *Euceramus transversilineatus* (Lockington, 1878)

Porcellana transversilineata Lockington, 1878:396.
Euceramus transversilineatus.—Glassell, 1938:426, pl. 30.—Haig, 1960:190, fig. 7(2), pl. 36: fig. 2.

MATERIAL EXAMINED.—Miraflores Locks (sta 78-1: 2 ♂, 1 ovig. ♀, 1 juv., 17 Jan 1972).

MEASUREMENTS.—Males, cb 2.4–2.9 mm; ovigerous female, cb 4.0 mm.

TYPE LOCALITY.—Boca de las Piedras and Bahia de los Angeles, Gulf of California.

DISTRIBUTION.—Bahia de Santa Maria and Bahia de la Magdalena, Baja California; Punta Penasco and San Felipe, Gulf of California, south to Isla Taboga, Panama (Haig, 1960).

REMARKS.—The present specimens have wider carapaces than those of northern forms. The ratio of carapace length to carapace width is about 1.33.

Petrolisthes Stimpson, 1858

39. *Petrolisthes armatus* (Gibbes, 1850)

Porcellana armata Gibbes, 1850:190.
Petrolisthes armatus.—Stimpson, 1858:227.—Haig, 1960:50, pl. 19: fig. 2.—Gore and Abele, 1976:21.—Gore, 1982:11.—Coen and Heck, 1983:213.

MATERIAL EXAMINED.—Miraflores Locks (sta 203, U-M-4-W: 1 ♂; sta 77-8: 2 ♂); Gatun Locks, lower chamber (sta 81-1, 2, 4, 9: 27 ♂, 29 ♀, 6 ovig. ♀).

MEASUREMENTS.—Males, cb 3.0–5.9 mm.

TYPE LOCALITY.—Florida.

DISTRIBUTION.—Bermuda; Georgia; central eastern Gulf coast of Florida to Brazil; western Africa and eastern Pacific (Gulf of California to Peru) (Coen and Heck, 1983).

40. *Petrolisthes galathinus* (Bosc, 1802)

Porcellana galathina Bosc, 1802:233, pl. 6: fig. 2.
Petrolisthes galathinus.—Gore, 1982:13.—Williams, 1984:243, fig. 178.

MATERIAL EXAMINED.—Gatun Locks, lower chamber (sta 81-2: 1 ovig. ♀).

MEASUREMENTS.—Males, cl 7–17 mm; females cl 7–14 mm (Williams, 1984).

TYPE LOCALITY.—Unknown.

DISTRIBUTION.—Cape Hatteras, North Carolina, through the Gulf of Mexico and Caribbean Sea to Rio de Janeiro, Brazil; Pacific Ocean from Isla San Lucas, Costa Rica, to off La Libertad, Ecuador.

41. *Petrolisthes lindae* Gore and Abele, 1974

Petrolisthes lindae Gore and Abele, 1974:564, figs. 2, 3D,G; 1976:22.

MATERIAL EXAMINED.—Miraflores Locks (sta 203, U-M-1-F: 1 ♂, 1 ♀; U-M-2-W: 1 ♀; U-M-3-W: 24 ♂, 15 ♀, 10 juv.; U-M-4-W: 3 ♂, 9 juv.; U-M-5-F: 3 ♂, 1 ♀, 3 juv.; U-M-5-W: 8 ♂, 11 ♀, 4 juv.; sta 204, L-M-1-W: 2 ♀, 3 ovig. ♀, 1 juv.; L-M-2-F: 6 ♂, 1 ♀, 3 ovig. ♀, 5 juv.; L-M-2-W: 2 ♂; L-M-3-F: 2 ♂; L-M-3-W: 6 ♂, 1 ♀, 2 ovig. ♀, 3 juv.; L-M-4-F: 1 ♂, 1 ♀, 2 ovig. ♀, 7 juv.; L-M-5-W: 2 ♂, 1 ♀; sta 77-2: 4 ♀, 1 ovig. ♀, 6 juv.; sta 77-3: 11 ♂, 7 ♀, 23 juv.; sta 77-8: 86 ♂, 55 ♀, 113 ovig. ♀, 89 juv.; sta 77-9: 3 ♂, 4 juv.; sta 78: 5 ♂, 4 ovig. ♀, 4 juv.; sta 78-1: 6 ♂, 1 ♀, 9 ovig. ♀, 21 juv.; sta 78-2: 3 ovig. ♀, 2 juv.; sta 78-3: 1 ♀; sta 1720: 1 ovig. ♀); east bank of the Panama Canal (4 ♂, 1 ♀, 3 ovig. ♀, 25 Aug 1972); Miraflores Locks (door between upper and lower chambers: 8 ♂, 4 ♀, 4 ovig. ♀, 5 juv., 26 Aug 1974); Miraflores Upper Lock (3 ♂, 8 ♀, 26 Aug 1974).

MEASUREMENTS.—Males, cb 3.9–8.8 mm; females, cb

3.0–6.7 mm; ovigerous females, cb 3.6–8.4 mm.

TYPE LOCALITY.—Republic of Panama, Panama Province, Pacific coast.

DISTRIBUTION.—Known only from the vicinity of the Pacific entrance to the Panama Canal.

REMARKS.—This species is quite variable. Variation includes the presense or absence of serration and a fringe of setae on the anterior part of the manus. It is very difficult to distinguish this species from *P. robsonae* when *P. lindae* has the serration and a fringe of setae on the anterior part of the manus. In juveniles and even adult specimens without appendages, it is not easy to distinguish this species from *P. armatus* or *P. robsonae*. Therefore the juveniles among the present specimens may belong to *P. armatus* or *P. robsonae*. Some specimens show very small but distinct epibranchial spines.

42. *Petrolisthes robsonae* Glassell, 1945

Petrolisthes robsonae Glassell, 1945:227, fig. 3.—Haig, 1960:57, pl. 18: fig. 2.—Gore and Abele, 1974:567, fig. 3c; 1976:24.

MATERIAL EXAMINED.—Gatun Locks (sta 177, L-5-F: 3 juv.; L-5-W: 1 juv.); Miraflores Locks (sta 203, U-M-2-W: 2 ♂, 1 ♀; sta 204, L-M-1-W: 1 ♀, L-M-2-W: 1 ♂; L-M-5-W: 1 ♀; sta 77-8: 5 ♂; sta 78-1: 1 ♂; sta 78-3: 1 ♂); Miraflores Locks spillway (sta 130-5: 1 ♂).

MEASUREMENTS.—Males, cb 3.6–5.8 mm; females, cb 3.2–6.9 mm.

TYPE LOCALITY.—Miraflores Locks, Panama Canal, Panama.

DISTRIBUTION.—Mexico, El Salvador, Panama, and Guayaquil, Ecuador; Gatun Locks, the Atlantic side of Panama.

REMARKS.—Haig (1960) noted a single specimen of *P. robsonae* from the Gatun Lock. The present material confirms the presence of this species on the Atlantic coast of Panama.

43. *Petrolisthes zacae* Haig, 1968

Petrolisthes zacae Haig, 1968:63, fig. 2.—Gore and Abele, 1974:567; 1976:25.

MATERIAL EXAMINED.—Miraflores Lock spillway (sta 130: 1 ♂); Pacific side, east bank of Panama Canal (3 ♂, 3 ovig. ♀, 1 juv., 25 Aug 1972).

MEASUREMENTS.—Males, cb 5.1–8.4 mm; ovigerous females, cb 6.7–7.8 mm.

TYPE LOCALITY.—Ballenas Bay, Gulf of Nicoya, Costa Rica.

DISTRIBUTION.—Costa Rica; Pacific side of Panama.

REMARKS.—Of the material examined, one ovigerous female has two anterior carpal spines and four posterior carpal spines; the other ovigerous females have three anterior and three posterior carpal spines; one male has two anterior and two posterior carpal spines.

Infraorder BRACHYURA

Section OXYRHYNCHA

Superfamily MAJOIDEA

Family MAJIDAE

Notolopas Stimpson, 1871

44. *Notolopas lamellatus* Stimpson, 1871

Notolopas lamellatus Stimpson, 1871:97.—Rathbun, 1925:287, fig. 95, pl. 81, pl. 238: fig. 1.—Garth, 1958:295, pl. Q: fig. 8, pl. 33: fig. 1.

MATERIAL EXAMINED.—Miraflores Locks (sta 77-2: 1 ♂, 2 ovig. ♀, 1 juv., 2 spec.; sta 78-1: 10 ♂, 1 ♀, 11 ovig. ♀, 2 juv., 1 spec.; sta 78-2: 1 juv.; sta 204, L-M-5-F: 1 ♂; sta 1525: 2 ♂; sta 1720: 2 ♂, 1 ♀, 1 ovig. ♀, 1 juv.; sta 1730: 1 ♂, 1 juv.).

MEASUREMENTS.—Males, cb 5.0–15.5 mm; females, cb 6.2–6.9 mm; ovigerous females, cb 4.7–10.8 mm.

TYPE LOCALITY.—Panama and Manzanillo, Mexico.

DISTRIBUTION.—Known in the eastern Pacific from Mexico, Nicaragua, Costa Rica, Panama, and Colombia to Ecuador; in the Atlantic, off Beaufort, North Carolina.

REMARKS.—This species has considerable variation that apparently has a geographical basis (Garth, 1958). In the present specimens, the gape of the fingers of the cheliped occurs in males but not in females. The size of the chela is variable; a male with cb 8.8 mm has a chela smaller than that of a male with cb 8.1 mm.

Pelia Bell, 1835

Pelia Bell, 1835:170.
Nicoya Wicksten, 1987:691. [New synonymy.]

Five species of *Pelia* were known previously. Three species (*P. tumida, P. pacifica,* and *P. pulchella*) have been reported from the eastern Pacific and two species (*P. mutica* and *P. rotunda*) from the Atlantic. The following key can be used for distinguishing the six species of *Pelia* including *P. tuberculata,* new combination.

See "Remarks" under discussion of *P. tuberculata.*

Key to the Species of *Pelia*

1. Rostrum long, nearly half as long as remainder of carapace; basal article of antenna almost wholly exposed in dorsal view . . . . . ***P. pulchella***
   Rostrum not long, or not more than two-fifths (nearly half in *P. tuberculata*) of remaining carapace length; basal article of antenna not more than half exposed in dorsal view 2
2. Carapace elongate, its greatest width about two-thirds its greatest length 3
   Carapace broad, its greatest width about three-fourths its greatest length 5
3. Only extremity bearing spine or tooth of basal article of antenna exposed in dorsal view . . . . . ***P. tumida***
   Basal article of antenna half or nearly half exposed in dorsal view 4
4. Carapace moderately high on median line, rostrum less deflexed, carapace narrower at hepatic regions than in *P. rotunda* . . . . . ***P. mutica***
   Carapace very high on median line; rostrum more deflexed, carapace wider at hepatic regions than in *P. mutica* . . . . . ***P. rotunda***
5. Basal article of antenna nearly half exposed in dorsal view; posterior margin of carapace produced and truncated with granular margin . . . . . ***P. tuberculata,*** new combination
   Basal article of antenna only slightly visible from dorsal view; posterior margin of carapace rounded, and not granulate . . . . . ***P. pacifica***

45. *Pelia mutica* (Gibbes, 1850)

Pisa mutica Gibbes, 1850:171.

Pelia mutica.—Hay and Shore, 1918:455, pl. 38: fig. 7.—Rathbun, 1925:278, fig. 94, pl. 98: figs. 2, 3.—Williams, 1965:250, figs. 229, 233E; 1984:321, figs. 255, 259a.—Powers, 1977:65.—Lemaitre, 1981:246.

MATERIAL EXAMINED.—Gatun Locks (sta 81-2: 1 ovig. ♀).

MEASUREMENTS.—Ovigerous female, cb 5.8 mm.

TYPE LOCALITY.—Charleston Harbor, off White Point Battery, South Carolina.

DISTRIBUTION.—Buzzards Bay and Vineyard Sound, Massachusetts, and the Gulf of Mexico to the west coast of Florida; Cuba, Puerto Rico, and St. Thomas, West Indies; north coast of South America; now from Gatun Locks, Panama.

46. *Pelia tuberculata* (Wicksten, 1987), new combination

FIGURES 11, 12

Nicoya tuberculata Wicksten, 1987:691, figs. 1-2.

MATERIAL EXAMINED.—Miraflores Locks (sta 77-2: 1 ♂, 1 ♀, 4 ovig. ♀, 1 juv.; sta 78: 1 ♂; sta 78-2: 1 ♂; sta 1525: 1 ♂, 1 ovig. ♀, 1 juv.; sta 1720: 5 ♂, 3 ♀, 5 ovig. ♀, 1 juv.).

MEASUREMENTS.—Males, cb 3.0–10.4 mm; females, cb 2.9–5.8 mm; ovigerous females, cb 3.0–6.7 mm.

DESCRIPTION.—Carapace (Figure 11*a*) pyriform, rounded, broad, granular along margins, covered with short pubescence; gastric region rounded and elevated with scattered granules at summit; hepatic regions with many small granules laterally; branchial regions inflated with few scattered granules; cardiac region highest, with small rounded elevation; posterior margin truncate, produced, upturned slightly, with granules. Rostrum depressed, nearly 1/2 length of carapace and bifurcated; horns narrow, divergent anteriorly or almost straight and slightly upturned at tips. Postorbital tooth small. Anterior inner margin of orbital lobe with granules. Basal antennal segment elongate, nearly half visible in dorsal view, with anterior outer tooth; tip of peduncle extending almost to middle of bifurcated portion of rostrum in adult male.

Inner margin of merus of third maxilliped denticulate.

Chelipeds (Figure 12*a–d*) almost devoid of setae, sexually dimorphic; those of female weak and more slender; scattered granules present on surfaces of merus and carpus; palm of chela oblong, inflated laterally; fingers widely gaping, denticulate on cutting edge of distal half; molar-like tubercle or few small teeth on cutting edges of movable finger near base in adult male; no gape or slight gape at proximal end in adult female and juvenile; margins of merus granulate; rows of longitudinal granules present on surface of carpus.

Walking legs (Figure 12*e–h*) compressed, pubescent, with rows of stiff setae on margins and with scattered granules on surfaces. First pair of walking legs much longer than others. Last pair of walking legs very short; dactylus strongly curved; corneous tip long and sharp.

Abdomen in male seven-jointed, becoming smaller from third to seventh.

Male gonopod (Figure 12*i,j*) slender, gradually narrowing distally, curving slightly outward in distal portion, with pouch-like longitudinal depression on distolateral angle. Female gonopore (Figure 12*k*) with opening on rounded dome-like elevation.

VARIATIONS.—Remarkable size and sex variation (Figure

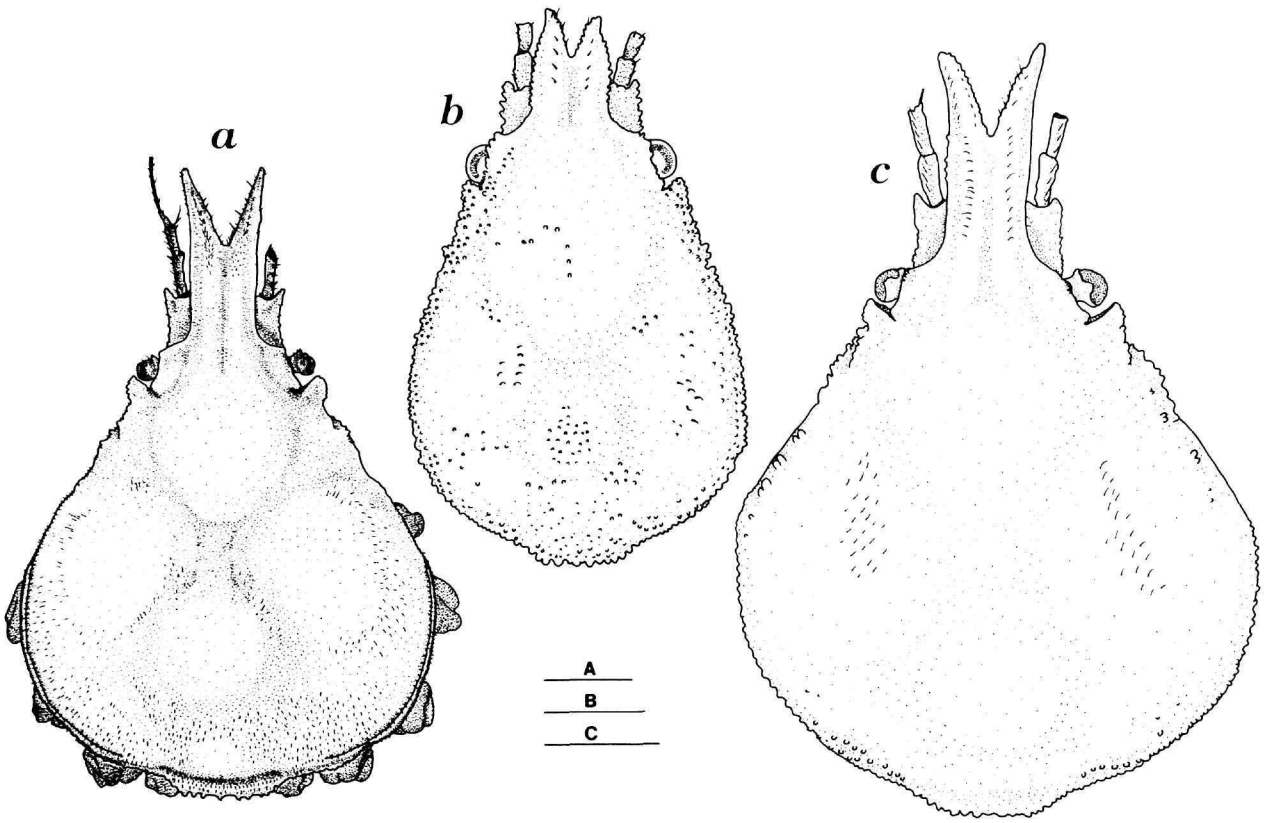

FIGURE 11.—*Pelia tuberculata*, new combination: *a*, carapace and rostrum, dorsal view ; *b*, same; *c*, same (*a*, male, cb 10.4 mm, from sta 78-2; *b*, male juvenile, cb 2.1 mm, from sta 77-2; *c*, male, cb 6.2 mm, from sta 78-1). (Scale A, 1 mm, *c;* scale B, 2.5 mm, *a;* scale C, 0.5 mm, *b*.)

11*a–c*) exists in this species. The general shape of the carapace of adult males is more rounded than that of adult females and juveniles because the hepatic regions in adult males are broader than those of adult females and juveniles. Granules on the carapace are more prominent and numerous in adult females and juveniles than in adult males: the lateral margin of the rostrum, basal antennal segment and orbital lobe are furnished with small granules in adult females and juveniles, but these granules are almost lacking in adult males. The rostral horns are divergent anteriorly, narrow and bifurcated at about half the rostral length in adult males, but these horns are not distinctly divergent anteriorly, more or less stout and bifurcate at about $^1/_3$ rostral length in adult females and juveniles. The gape of the fingers in adult males is very wide; a single adult male has a molar-like tubercle on the cutting edge of the movable finger near the base, but another adult male has a few small teeth; there is no gape at the proximal end in adult females and juveniles.

REMARKS.—Wicksten (1987) established the genus *Nicoya* (subfamily Pisinae) to accommodate this species, which was based on a single ovigerous female. She indicated that *Nicoya* resembled *Pelia* but differed from the latter in having a tuberculate carapace, broad meri of the walking legs, and a third maxilliped without a deep notch at the anteroexternal angle of the merus (1987:691). The large series of specimens available to us suggests that the genus *Nicoya* Wicksten, 1987, is a junior synonym of *Pelia* Bell, 1836, for the following reasons. First, the presence of tubercles on the carapace varies with the size and sex of the specimen. Second, most species of *Pelia*, including the type species *P. pulchella* Bell, have the meri of the walking legs broad (Garth, 1958). Third, the difference in the form of the anteroexternal angle of the merus of the third maxilliped between the present species and members of the genus *Pelia* is one of degree. This region is notched in *P. mutica*, for example, whereas it is sloping only, without a distinct notch, in the present species. Fourth, the gonopods of this species are very similar to those of species of *Pelia*. Thus, on the basis of the examination of much more material than was available to Wicksten, we conclude that the species *tuberculata* should be placed in the genus *Pelia*.

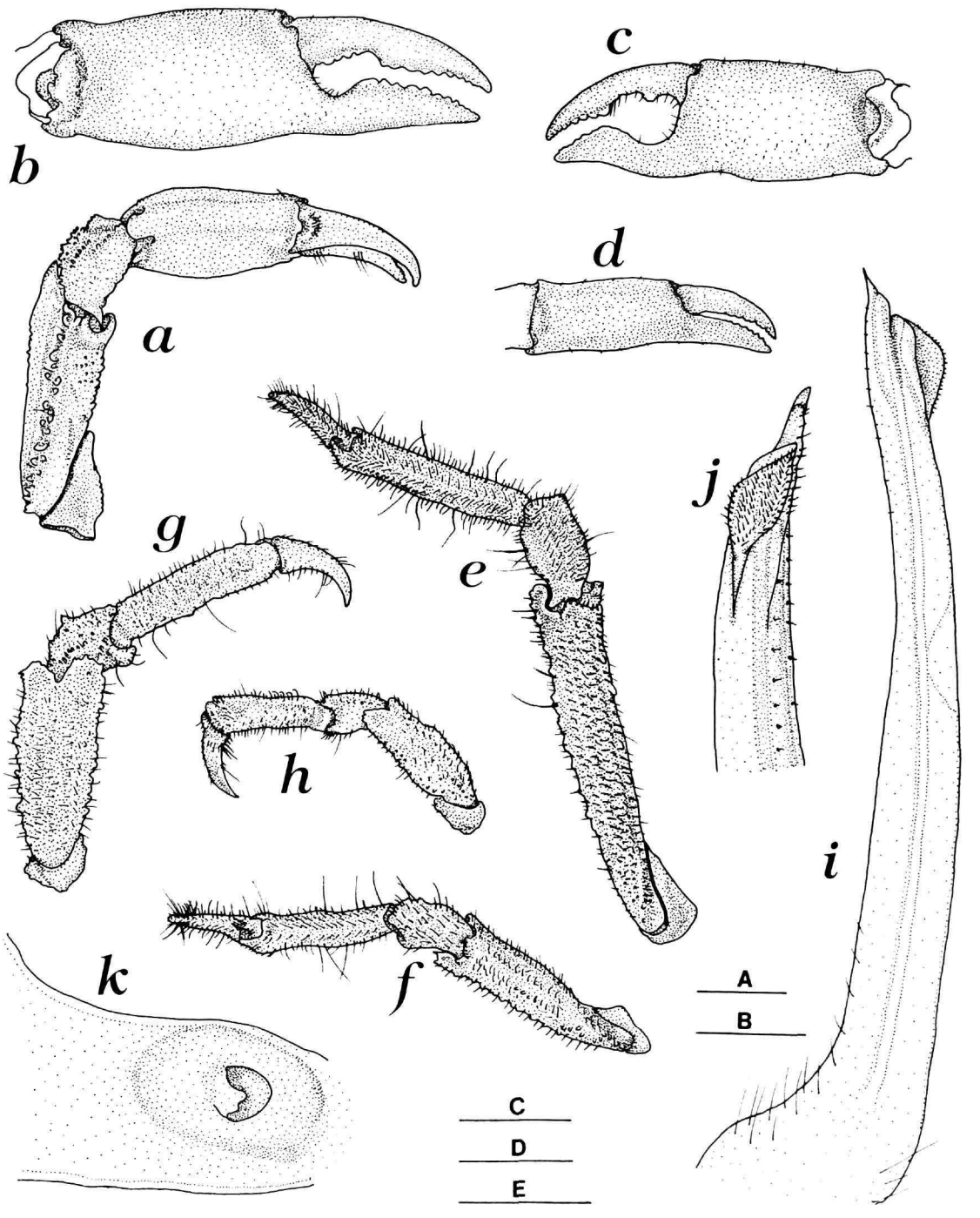

FIGURE 12.—*Pelia tuberculata*, new combination: *a*, left first pereopod (cheliped), dorsal view; *b*, chela of right first pereopod, external view; *c*, chela of left first pereopod, external view; *d*, chela of right first pereopod, external view; *e*, left second pereopod (first walking leg); *f*, left third pereopod; *g*, right fourth pereopod; *h*, left fifth pereopod; *i*, right gonopod, mesial view; *j*, same, distal portion, lateral view; *k*, right gonopore (*a,c,e–h*, male, cb 8.4 mm from sta 78-1; *b*, male, cb 2.1 mm, from sta 77-2; *d,i,j*, male, cb 10.4 mm, from sta 78-2; *k*, female, cb 4.8 mm, from sta 78-1). (Scale A, 0.1 mm, *k;* scale B, 2.0 mm, *a,c,e–h;* scale C, 0.5 mm, *j;* scale D, 0.2 mm, *b;* scale E, 4 mm, *d*, 0.1 mm, *i*.)

Superfamily HYMENOSOMATOIDEA

Family HYMENOSOMATIDAE

Elamenopsis A. Milne Edwards, 1873

47. *Elamenopsis kempi* (Chopra and Das, 1930)

Rhynchoplax kempi Chopra and Das, 1930:416, figs. 2-5.
Neorhynchoplax kempi.—Sakai, 1938:200.—Holthuis, 1968:111.—Abele, 1972a:211, fig. 1.
Elamenopsis kempi.—Lucas, 1980:190.

MATERIAL EXAMINED.—Miraflores Locks (sta 203, U-M-1-W: 2 ovig. ♀; U-M-2-F: 2 ♂, 2 ovig. ♀; U-M-2-W: 1 ovig. ♀; U-M-3-W: 1 ovig. ♀; U-M-4-F: 1 ovig. ♀); Pedro Miguel Locks (sta 209, 3-F: 1 ovig. ♀, 1 juv.; 3-W: 1 juv.; 4-F: 4 ♂, 2 juv.; 4-W: 1 ♂, 1 juv.; 5-F: 9 ♂, 2 juv.; 5-W: 1 ovig. ♀); Miraflores Upper Lock (1 ovig. ♀, 26 Aug 1974).

MEASUREMENTS.—Males, cb 2.8–5.1 mm; ovigerous females, cb 3.3–4.5 mm.

TYPE LOCALITY.—Basra (Shat-al-Arab), Iraq (Mesopotamia).

DISTRIBUTION.—Known from the fresh waters at Shat-al-Arab, the confluence of the Euphrates and Tigis River, near Basra, Iraq; Panama Canal.

REMARKS.—This species probably has been introduced into the Panama Canal and seems to have established a permanent population there (Abele, 1972a).

Superfamily PARTHENOPOIDEA

Family PARTHENOPIDAE

Heterocrypta Stimpson, 1871

48. *Heterocrypta colombiana* Garth, 1940

Heterocrypta colombiana Garth, 1940:71, pl. 18: figs. 1, 2; 1948:23; 1958:479, pl. Z_4: figs. 13, 13a, pl. 54: fig. 3.

MATERIAL EXAMINED.—Miraflores Locks (sta 78-1: 1 ♂).

MEASUREMENTS.—Male, cb 15.7 mm.

TYPE LOCALITY.—Port Utria, Choco, Colombia.

DISTRIBUTION.—Salinas Bay of Costa Rica; Port Utria, Choco, Colombia; off Esmeraldas of Ecuador; now from Miraflores Locks, Panama.

REMARKS.—This is a very rare species. Only four specimens (three males and one female) were known previously. The present specimen increases to five the known representatives of this species and connects its range between Costa Rica and Colombia.

49. *Heterocrypta craneae* Garth, 1959

Heterocrypta craneae Garth, 1959:123, pl. 1.

MATERIAL EXAMINED.—Miraflores Locks (sta 204, L-M-3-F: 1 ♀).

MEASUREMENTS.—Female, cb 30.0 mm.

TYPE LOCALITY.—La Union, Gulf of Fonseca, El Salvador, 10.97 m, mud and mangrove leaves.

DISTRIBUTION.—Known from the type locality; now from Miraflores Locks, Panama.

REMARKS.—The species was previously known only from the female holotype and female paratype. The present specimen increases to three the known representatives of this rare species and extends its range to the Pacific side of Panama.

Section BRACHYRHYNCHA

Superfamily PORTUNOIDEA

Family PORTUNIDAE

Callinectes Stimpson, 1860

50. *Callinectes arcuatus* Ordway, 1863

Callinectes arcuatus Ordway, 1863:578.—Garth and Stephenson, 1966:43, pl. 5: fig. A, pl. 8: fig. A, pl. 10: fig. A, pl. 12: fig. D.—Williams, 1974:752, figs. 8, 18f, 20g–h, 22f, 24.

MATERIAL EXAMINED.—Miraflores Locks (sta 77-1: 1 juv.; sta 77-4: 4 juv.; sta 204, L-M-1-F: 1 ♀; L-M-3-F: 2 juv.; L-M-4-F: 1 juv.; sta 1524: 6 juv.; sta 1719: 6 juv.; sta 1728: 10 juv.; sta 1729: 7 juv.); Miraflores Locks Spillway (sta 130-2-b: 2 ♂, 14 juv.).

MEASUREMENTS.—Males, cb 76.9–81.5 mm; female, cb 82.8 mm.

TYPE LOCALITY.—Cape San Lucas, Baja California.

DISTRIBUTION.—Known in the eastern Pacific from Los Angeles Harbor, California, and Panama to Mollenda, Peru; the Galapagos Islands.

51. *Callinectes danae* Smith, 1869

Callinectes Danae Smith, 1869:7.
Callinectes danae.—Rathbun, 1896:357, pl. 16, pl. 24: fig. 4, pl. 25: fig. 3, pl. 26: fig. 3, pl. 27: fig. 3.—Williams, 1974:746, figs. 7, 18e, 20e–f, 22e, 24; 1984:367, figs. 293d, 295.—Powers, 1977:76.—Coen and Heck, 1983:219.

MATERIAL EXAMINED.—Gatun Locks (sta 81-2: 1 ♀; sta 81-9: 4 ♂, 5 juv.; sta 1687: 1 juv.).

MEASUREMENTS.—Males, cb 88.0–95.0 mm; female, cb 64.1 mm.

TYPE LOCALITY.—Recife [= Pernambuco, Estado de Pernambuco], Brazil.

DISTRIBUTION.—Bermuda; New Hanover County, North Carolina, near Cape Fear; southern Florida and eastern side of Yucatan Peninsula, through Panama to Estado de Santa Catarina, Brazil.

52. *Callinectes exasperatus* (Gerstaecker, 1856)

Lupea exasperata Gerstaecker, 1856:129.
Callinectes exasperatus.—Rathbun, 1897a:150.—Williams, 1974:757, figs. 9,

18g, 20i, 22g, 26; 1984:369, figs. 293e, 296.—Powers, 1977:76.

MATERIAL EXAMINED.—Miraflores Locks (sta 87-3: 1 ♂, 8 juv.).

MEASUREMENTS.—Male, cb 54.8 mm.

TYPE LOCALITY.—Puerto Cabello, Venezuela.

DISTRIBUTION.—Duval County, east of Jacksonville, Florida (rarely), to Santa Catarina, Brazil; Veracruz, Mexico; Bermuda; also reported from extreme southern Texas (Williams, 1984); now first reported from the eastern Pacific at Miraflores Locks.

53. *Callinectes sapidus* Rathbun, 1896

Callinectes sapidus Rathbun, 1896:352, pl. 12, pl. 24: fig. 1, pl. 25: fig. 1, pl. 26: fig. 1, pl. 27: fig. 1.—Williams, 1974:778, figs. 1, 16, 17, 19d, 21, 23b, c, 26; 1984:376, figs. 293g, 299.—Powers, 1977:78.—Lemaitre, 1981:248.

MATERIAL EXAMINED.—Gatun Locks (LGA 74-3: 2 ♂, 6 juv.; LGA 74-4: 1 ♂, 1 juv.; sta 81-2: 1 juv.; sta 176, M-1-F: 6 juv.; M-5-F: 1 juv.; sta 177, L-5-F: 1 ♂, 1 ♀; sta 1530: 1 juv.; sta 1685: 1 juv.; sta 1686: 6 juv.; sta 1687: 1 juv.).

MEASUREMENTS.—Males, cb 98.3–175.5 mm; female, cb 87.1 mm.

TYPE LOCALITY.—East coast of United States.

DISTRIBUTION.—Occasionally Nova Scotia, Maine, and northern Massachusetts to northern Argentina, including Bermuda and the Antilles; Øresund, Denmark; the Netherlands and adjacent North Sea; northwest and southwest France; Golfo di Genova; northern Adriatic; Aegean, western Black, and eastern Mediterranean Sea; Lake Hamana-ko, central Japan (Williams, 1984).

REMARKS.—This highly variable, well-known species was described by Williams (1974) in detail. The present specimens have three to four anterior spines on the merus of the cheliped.

54. *Callinectes toxotes* Ordway, 1863

Callinectes toxotes Ordway, 1863:576.—Garth and Stephenson, 1966:50, pl. 5: fig. C, pl. 8: fig. C, pl. 10: fig.C, pl. 12: fig. F.—Williams, 1974:764, figs. 11, 18i, 20l, 22i, 27.

MATERIAL EXAMINED.—Miraflores Locks (sta 77-3: 11 juv.; sta 77-4: 2 juv.; sta 78-3: 3 juv.; sta 203, U-M-5-F: 1 juv.; sta 1536: 10 juv.; sta 1718: 4 juv.; sta 1730: 1 ♂, 4 juv.; sta 1731: 2 juv.); upper east chamber of Miraflores Locks (2 ♂, 17 Jan 1972); Miraflores Upper Lock (1 juv.).

MEASUREMENTS.—Males, cb 89.8–105.0 mm.

TYPE LOCALITY.—Cape San Lucas, Baja California.

DISTRIBUTION.—Known in the eastern Pacific from Cabo de San Lucas, Baja California, to extreme northern Peru.

Portunus Weber, 1795

55. *Portunus asper* (A. Milne Edwards, 1861)

Neptunus asper A. Milne Edwards, 1861:325, pl. 30: figs. 3–3c.

Portunus (Portunus) asper.—Rathbun, 1930:56, pl. 20: figs. 2, 3, pl. 21, pl. 22: figs. 1, 2.

Portunus asper.—Garth and Stephenson, 1966:19, pl. 3: fig. A, pl. 7: fig. A, pl. 9: fig. D, pl. 11: fig. A.

MATERIAL EXAMINED.—Miraflores Locks (sta 78-1: 8 juv.; sta 78-2: 1 juv.; sta 1730: 3 juv.).

TYPE LOCALITY.—Shore of Chile.

DISTRIBUTION.—Known from Gulf of California, Mexico, to Chile.

REMARKS.—Rathbun (1930) described this species as having frontal teeth with triangular tips. The present specimens have frontal teeth with distinctly rounded tips.

Superfamily XANTHOIDEA

Family XANTHIDAE

Eurypanopeus A. Milne Edwards, 1878

56. *Eurypanopeus canalensis*, new species

FIGURES 13, 14

Eurypanopeus sp.—Martin and Abele, 1986:189, fig. 2c.

MATERIAL EXAMINED.—*Holotype:* Male, cl 4.7 mm, cb 7.3 mm; Republic of Panama, Panama Canal, Miraflores Locks, sta 77-3.

Paratype: Miraflores Locks, sta 77-3: 1 ♀.

Other Material: Sta 77-7: 3 ♀; sta 77-8: 1 juv.; sta 203, U-M-2-W: 1 juv.; U-M-3-W: 2 ♂, 3 ♀, 1 juv.; U-M-4-W: 4 ♂, 2 ♀, 2 juv.; sta 1719: 1 ♂; sta 1728: 1 ♂.

MEASUREMENTS.—Males, cb 7.3–12.3 mm; females, cb 8.0–11.0 mm.

DESCRIPTION.—Carapace (Figure 13) with dorsal surface very convex along anterior-to-posterior axis, highest on anterior 1/3, about 1.6 times as broad as long; regions very slightly delimited by indistinct furrows; surface rough with scattered short setae, granules, and transverse granulated lines (scattered granules on frontal and protogastric regions; scattered granules or granulated line on hepatic region; one granulated line on metagastric region interrupted in middle; one long, round epibranchial line ending in front of inner end of ridge extending inward from fifth lateral tooth; one faint mesobranchial line on level with anterior cardiac border; few small granules on cardiac region). Frontal region deflexed anteriorly; granulated, single-edged frontal margin very slightly arched to nearly straight with median V-shaped furrow; outer end not distinctly produced. Inner supraorbital lobe well separated from front by deep notch; no distinct notches on supraorbital border; inner suborbital tooth with obtuse, granulated tip; otherwise suborbital border almost straight. Anterolateral teeth with granulated margins, well separated; compound first-second tooth with very shallow, sinuous margin; second not much produced, broadly rounded; third with short anterior margin and long arcuate lateral margin, forming round arch from first tooth; fourth projecting more outward than third, separated from third by broad notch, with

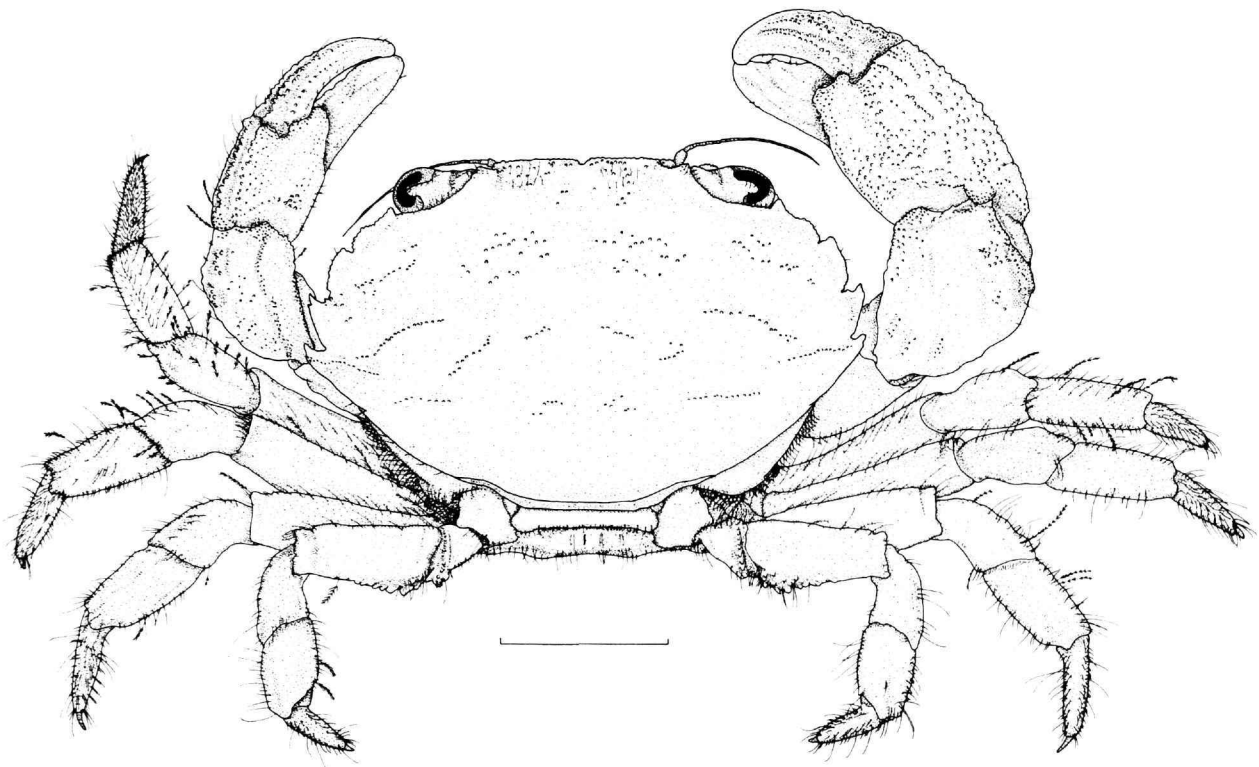

FIGURE 13.—*Eurypanopeus canalensis*, new species, holotype male, cb 7.3 mm, dorsal view. (Scale, 2.0 mm.)

small tubercles on inner anterior margin and just behind tip; fifth smaller than fourth, directed more outward than fourth, with tubercles behind tip; carapace widest between tips of fourth or fifth teeth.

Third maxilliped with red spot on inner surface in both sexes.

Chelipeds (Figures 13, 14*a,b*) markedly unequal in both sexes; palm of minor chela 2/3 as high as palm of major chela; upper borders of both palms densely granulated with shallow longitudinal grooves; minor palm more densely granulated and with deeper groove than major palm; granules continued part way down fingers; minor palm forming longitudinal granulated lines on outer surface. Major chela with movable finger bearing no large basal tooth on cutting edge; dark color of immovable finger continuing slightly onto palm, ending in oblique line, not spreading upward; palm inflated, coarsely granulated on surface. Minor chela with finger spoon-shaped; tips of fingers of both chelae white; carpus granulated and rugose, with marginal groove shallow.

Walking legs (Figure 13) pubescent. Merus of last leg (Figure 14*c*) broadened proximally with tubercles on interior margin from distal 1/3 to proximal border; ischium with tubercles along distal margin.

Male gonopod (Figure 14*d*) with long, pointed accessory process, elongate median process and one strong lateral tooth, no spines on median process. Female gonopore (Figure 14*e*) rounded, white on posterior rounded margin.

REMARKS.—This species can be easily distinguished from other *Eurypanopeus* species having spoon-shaped minor chelae by the very convex, wide carapace and the presence of tubercles on the merus and ischium of the last walking leg.

ETYMOLOGY.—The specific name is from the Panama Canal, the type locality.

57. *Eurypanopeus dissimilis* (Benedict and Rathbun, 1891)

Panopeus dissimilis Benedict and Rathbun, 1891:366, pl. 20: fig. 4, pl. 23: fig. 1.

Eurypanopeus dissimilis.—Rathbun, 1897b:19; 1930:411, fig. 66, pl. 173: figs. 1, 2.—Powers, 1977:92.

MATERIAL EXAMINED.—Miraflores Locks (sta 87-1: 7♂, 2♀, 1 ovig. ♀, 5 juv.); Gatun Locks (sta 81-2: 1♂, 1 ovig. ♀; sta 81-8: 3 juv.; sta 176, M-2-F: 1 juv.; M-2-F: 1♂; M-4-F: 3 juv.; M-5-F: 3 juv.; sta 177, L-1-W: 1♀; L-2-F: 2♂, 1 juv.; L-2-W: 2♂, 2♀, 2 juv.; L-3-W: 1♂, 1♀, 2 juv.; L-4-F: 1 juv.; L-4-W: 2♀, 1 ovig. ♀, 5 juv.; L-5-F: 1 juv.; LGA 74-4: 2♂, 1♀); Gatun Locks–Middle Locks (upper to middle portion:

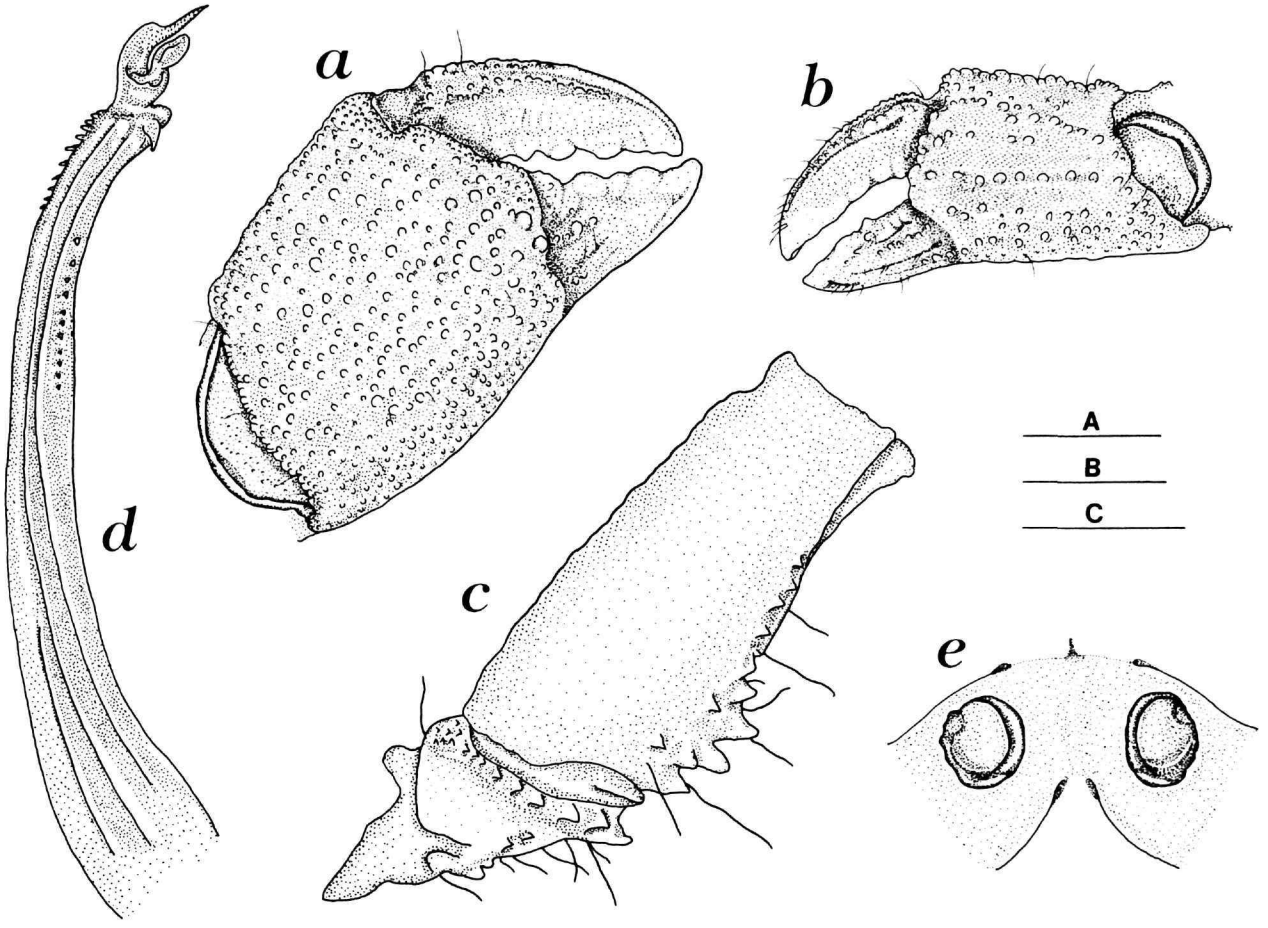

FIGURE 14.—*Eurypanopeus canalensis*, new species: *a*, chela of right (major) first pereopod (cheliped), external view; *b*, chela of left (minor) first pereopod, external view; *c*, merus and ischium of right fifth pereopod (last walking leg), external view; *d*, right gonopod, mesial view; *e*, gonopore (*a–c*, holotype male, cb 7.3 mm; *d*, male, cb 8.3 mm, from sta 203, U-M-3-W; *e*, female, cb 10.9 mm, from sta 203, U-M-3-W). (Scale A, 0.25 mm, *c*; scale B, 1 mm, *a*, *b*; scale C, 1 mm, *d*, 0.5 mm, *e*.)

1 ♀, 4 Mar 1974); Gatun Middle Lock (lower chamber: 2 ♂, 1 ♀, 4 Mar 1974).

MEASUREMENTS.—Males, cb 6.7–17.6 mm; females, cb 5.8–15.8 mm; ovigerous females, cb 8.4–12.0 mm.

TYPE LOCALITY.—Trinidad.

DISTRIBUTION.—Known in the western Atlantic from the Gulf of Mexico (west coast of Florida), Cuba, Jamaica, Nicaragua, and Trinidad to Santa Catarina, Brazil; now first reported from the eastern Pacific at Miraflores Locks, the Pacific side of Panama.

REMARKS.—Of the material examined, two males and all juveniles lack a red spot on the surface of the third maxilliped. Of these, one male has the abdomen with seven free segments. Small specimens might be confused with *Panopeus lacustris* because of the similar shape of the carapace. The round lateral extremities of the third abdominal segment of this species can be used as a diagnostic character to distiguish it from *P. lacustris*.

Eurytium Stimpson, 1859

58. *Eurytium tristani* Rathbun, 1906

Eurytium tristani Rathbun, 1906:100; 1930:425, pl. 176: fig. 3, pl. 177: fig. 3.—Garth, 1961:149.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta 110: 1 ♂; sta 110-1: 2 ♂).

MEASUREMENTS.—Males, cb 10.9–20.5 mm.

TYPE LOCALITY.—Boca del Jesus Maria, Costa Rica.

DISTRIBUTION.—Known in the eastern Pacific from Costa Rica; Panama to Peru.

Hexapanopeus Rathbun, 1898

59. *Hexapanopeus beebei* Garth, 1961

Hexapanopeus beebei Garth, 1961:148, pl. 1.—Martin and Abele, 1986: 185, fig. 2D.

MATERIAL EXAMINED.—Miraflores Locks (sta 77-2: 25 ♂, 36 ♀, 9 juv.; sta 77-3: 6 ♂, 4 juv.; sta 77-4: 1 ♂; sta 77-7: 1 ♂, 1 ♀; sta 77-8: 3 ♂, 2 ♀, 2 juv.; sta 77-9: 1 ♂; sta 78-1: 2 ♂; sta 78-3: 1 ♂, 1 ♀, 2 ovig. ♀; sta 78-4: 3 juv.; sta 203: 2 juv.; U-M-1-F: 10 ♂, 5 ♀, 3 juv.; U-M-1-W: 6 ♂, 2 ♀, 2 juv.; U-M-2-F: 7 ♂, 7 ♀, 7 juv.; U-M-2-W: 1 ♀, 2 juv.; U-M-3-F: 19 ♂, 22 ♀; U-M-3-W: 6 ♂, 3 ♀, 9 juv.; U-M-4-F: 17 ♂, 12 ♀; U-M-4-W: 1 ♂, 2 ♀, 3 juv.; U-M-5-F: 20 ♂, 13 ♀; U-M-5-W: 5 ♂, 1 juv.; sta 204, L-M-1-F: 2 ♂, 1 ♀, 7 ovig. ♀; L-M-3-F: 3 ♂, 1 ovig. ♀; L-M-3-W: 1 ♂, 1 ovig. ♀; L-M-4-F: 3 ♂, 1 ♀, 1 ovig. ♀; sta 1718: 1 ♂, 2 ♀; sta 1719: 1 ♂; sta 1728: 1 ♂, 1 ♀, 1 ovig. ♀; sta 1730: 1 ♂); Miraflores Locks spillway (sta 130-2-b: 10 ♂, 4 ♀, 1 ovig. ♀, 1 juv.); Miraflores Upper Lock (1 ♂, 1 ♀, 26 Aug 1974); Miraflores Lower Lock (mid to lower part: 1 ♂, 26, 27 Aug 1974).

MEASUREMENTS.—Males, cb 5.2–11.5 mm; females, cb 5.6–9.5 mm; ovigerous females, cb 6.6–10.0 mm.

TYPE LOCALITY.—Corinto, Nicaragua.

DISTRIBUTION.—Corinto, Nicaragua; now from the Pacific side of Panama.

REMARKS.—There are no records since the original description. Of the material examined, two males have the major chelae with no large teeth on the base of the movable fingers, apparently as a result of regeneration of a major cheliped. This species is most closely allied to *Hexapanopeus caribbaeus* (Stimpson, 1871), from which it differs in having white fingers (the whitened portion not running backward and upward on the palm), the front not especially narrowed, and the fingers of the major chela of the male conspicuously gaping (Garth, 1961).

60. *Hexapanopeus caribbaeus* (Stimpson, 1871)

Micropanope caribbaea Stimpson, 1871:108.

Hexapanopeus caribbaeus.—Rathbun, 1898:273; 1930:399, pl. 171: figs. 3–5.—Lemaitre, 1981:251.

MATERIAL EXAMINED.—Gatun Locks (LGA 74-4: 8 ♂, 1 ♀, 2 ovig. ♀; sta 81-9: 1 ♀; sta 176, M-2-F: 6 juv.; M-1-F: 8 juv.; M-2-W: 3 ♂, 2 ♀, 2 juv.; M-3-F: 4 ♂, 2 ♀, 9 juv.; M-3-W: 6 juv.; M-4-F: 1 ♂, 3 juv.; M-4-W: 1 juv.; M-5-F: 1 ♂, 2 juv.; sta 177, L-1-F: 2 ♂, 1 juv.).

MEASUREMENTS.—Males, cb 3.7–9.5 mm; females, cb 4.3–8.6 mm; ovigerous females, cb 4.3–5.1 mm.

TYPE LOCALITY.—St. Thomas, Virgin Islands.

DISTRIBUTION.—Jamaica, Puerto Rico, St. Thomas; coast of South America from Colombia and Trinidad to Santa Catarina, Brazil.

61. *Hexapanopeus paulensis* Rathbun, 1930

Hexapanopeus paulensis Rathbun, 1930:395, pl. 170: figs. 5–6.—Williams, 1984:416, figs. 328, 331o.—Powers, 1977:94.

MATERIAL EXAMINED.—Gatun Locks (LGA 74-4: 7 ♂, 3 ♀, 5 juv.; sta 81-2: 1 ♂, 3 ovig. ♀).

MEASUREMENTS.—Males, cb 8.8–16.6 mm; females, cb 9.5–14.7 mm; ovigerous females, cb 10.0–17.6 mm.

TYPE LOCALITY.—Santos, São Paulo, Brazil.

DISTRIBUTION.—Known from South Carolina, through Gulf of Mexico to Uruguay (Williams, 1984).

Menippe De Haan, 1833

62. *Menippe nodifrons* Stimpson, 1859

Menippe nodifrons Stimpson, 1859:53.—Rathbun, 1930:479, pl. 198: fig. 3, pl. 199.—Powers, 1977:97.—Lemaitre, 1981:252.

MATERIAL EXAMINED.—Gatun Locks (LGA 74-4: 20 ♂, 14 juv.; sta 81-1: 6 ♂, 4 ♀, 3 juv.; sta 81-2: 7 ♂, 9 ♀, 12 juv.; sta 81-4: 2 ♂; sta 81-9: 1 ♂; sta 1530: 1 ♂, 2 ♀, 3 juv.; sta 1687: 2 ♂, 3 ♀).

MEASUREMENTS.—Males, cb 12.5–60.0 mm; females, cb 18.5–35.0 mm.

TYPE LOCALITY.—Indian River, Florida.

DISTRIBUTION.—Known in the western Atlantic from Indian River, Florida, and Gulf of Mexico (questionable according to Felder, 1973), Panama to State of Santa Catarina, Brazil; the West Indies; in the eastern Atlantic, in Gabon, west Africa.

Panopeus H. Milne Edwards, 1834

63. *Panopeus chilensis* H. Milne Edwards and Lucas, 1844

Panopeus chilensis H. Milne Edwards and Lucas, 1844:16.—Rathbun, 1930:346, fig. 54, pl. 158: fig. 3, pl. 160.—Hildebrand, 1939:23.—Martin and Abele, 1986:188, fig. 1E.

MATERIAL EXAMINED.—Miraflores Locks (sta 78-1: 4 ♂, 1 ♀, 3 ovig. ♀, 1 juv.; sta 78-2: 1 ♂; sta 203, U-M-5-F: 1 ♂, 1 ♀, 1 juv.; U-M-3-W: 1 ♀; sta 204, L-M-2-F: 1 ♀; L-M-5-F: 1 ♂; sta 1525: 1 ♂, 1 ♀; sta 1728: 3 ♂, 1 ♀, 1 ovig. ♀, 1 juv.; sta 1730: 1 ♂).

MEASUREMENTS.—Males, cb 25.6–51.5 mm; females, cb 17.1–33.7 mm; ovigerous females, cb 19.3–37.1 mm.

TYPE LOCALITY.—Chile.

DISTRIBUTION.—Known in the eastern Pacific from Sinaloa (Mexico), Nicaragua, Costa Rica, Panama, and Peru to Chile.

REMARKS.—The color of the immovable finger of the major chela runs well back on the palm in males, but is more restricted in females. Of the material examined, males, but not females, have a red spot on the inner surface of the third maxillipeds.

64. *Panopeus gatunensis*, new species

FIGURE 15

Panopeus species 2.—Martin and Abele, 1986:189, fig. 2B.

MATERIAL EXAMINED.—*Holotype:* Male, cl 6.9 mm, cb 9.1 mm, Republic of Panama, Panama Canal, Gatun Locks, sta 74-4.

DESCRIPTION.—Carapace (Figure 15*a*) convex in both longitudinal and transverse directions, very round in shape (ratio cb/cl, 1.35), devoid of pubescence and distinct granules; surface smooth, regions well defined by rather deep furrows; each region convex; very finely granulated lines present on hepatic and epibranchial regions; short line on metagastric and several rugae on protogastric region; longitudinal furrow on frontal region very deep. Frontal margin nearly 1/3 carapace width, not much produced, divided into two lobes by shallow notch; each lobe oblique, sinuous with finely granulated single edge; outer frontal lobule not produced, rounded. Supraorbital border finely granulate with two minute notches; margin between two notches slightly produced; inner supraorbital border slightly elevated, swollen, spreading inward with granules, separated by deep furrow from outer frontal lobule. Suborbital border slightly concave with strong inner tooth produced almost to level of tip of outer frontal lobule; outer suborbital notch small and V-shaped. Subhepatic tubercle indistinct, with only few fine granules. Anterolateral margin of carapace slightly shorter than posterolateral; posterolateral margin slightly arcuate. First anterolateral tooth conical, smaller than second; second tooth arcuate, not much produced; sinus of coalesced first-second tooth shallow; third tooth with anterior inner margin almost straight; anterior half of lateral margin directed inward; fourth tooth with triangular tip; lateral margin slightly arcuate; fifth tooth small, with lateral margin much longer than anterior margin.

Third maxilliped with no red spot on inner surface.

Chelipeds (Figure 15*b,c*) similar in shape and size; minor palm slightly smaller than major palm; carpus with more or less deep anterior transverse groove; small tubercle behind groove and obtuse inner distal tooth; surface of carpus with fine granules; merus with transverse groove behind distal margin and with small, obtuse inner tooth; palms of both chelae with two longitudinal, distinct ridges above; groove between these ridges rather deep; outer surface almost smooth; fingers of both chelae elongate, narrow, much deflexed below with no large teeth on bases of cutting edges of movable fingers and with faint longitudinal grooves at outer surfaces; tips of fingers hooked, markedly crossing and not gaping when closed; dark colors of immovable fingers of both chelae continuing back on palm, also spreading upward.

Walking legs (Figure 15*d*) rather slender; dactylus long and setose; carpus with faintly defined longitudinal groove below superior margin.

Male abdomen (Figure 15*e*) with third, fourth, and fifth segments fused; proximal end of fused segments narrower than first; lateral end rounded; sixth segment slightly wider than long; terminal (seventh) segment triangular in shape with rounded tip.

Male gonopod (Figure 15*f–h*) with accessory process ending in narrow tip, exceeding median process bearing one oblique inner spine; lateral two teeth present.

REMARKS.—This species is very similar to *Hexapanopeus angustifrons* and *H. schmitti*, but can be distinguished from those species by the following characters. The carapace of this species is convex in both longitudinal and transverse directions and much narrower than those of *H. angustifrons* and *H. schmitti*. The posterolateral margin of the carapace is slightly arcuate, so the general shape of the carapace is much more rounded than those of *H. angustifrons* and *H. schmitti*. The furrows defining each region are deeper than those of *H. angustifrons* and *H. schmitti;* notably the longitudinal furrow on the frontal region is very deep. Futhermore the male gonopod is quite different from those of *H. angustifrons* and *H. schmitti* because of the presence of a rather long accessory process that exceeds the median process. The present species is also very similar to *Panopeus mirafloresensis* as described in the present work and to *P. bermudensis* in the shape of gonopod. The following characters are useful for distinguishing the present species from *P. mirafloresensis* and *P. bermudensis*. In *P. gatunensis*, the surface of each region of the carapace is smooth, and the furrow defining each region is deep, whereas in *P. mirafloresensis* and *P. bermudensis*, the surface of each region bears granulated transverse lines, and the furrows are rather shallow. The frontal margin of *P. gatunensis* consists of two single-edged lobes, but in *P. mirafloresensis* and *P. bermudensis* the two lobes are double-edged. In the major chela, there is no tooth on the base of the movable finger in *P. gatunensis*, but there is one large tooth there in most specimens of *P. mirafloresensis* and *P. bermudensis*. The general shape of the gonopods among these three species is almost identical. However, there are two lateral teeth and one spine on the median process in *P. gatunensis*, whereas there are one lateral tooth and two or three spines on the median process in *P. mirafloresensis* and *P. bermudensis*. The present species may belong to the genus *Hexapanopeus*, as it has the carapace without prominent, broken, transverse, raised, granulated lines on the anterior half. However, in the present species, the front of the carapace is not much produced, and the carapace is narrower than those of the existing species of *Hexapanopeus*. Therefore, we tentatively place the present species in the genus *Panopeus* because the general outline of the carapace is closer to those of existing species of *Panopeus* than to those of *Hexapanopeus*, even though the general shape of the male gonopod is very atypical for *Panopeus* (See Martin and Abele, 1986).

ETYMOLOGY.—The specific name is from the Gatun Locks, Panama Canal, the type locality of the present species.

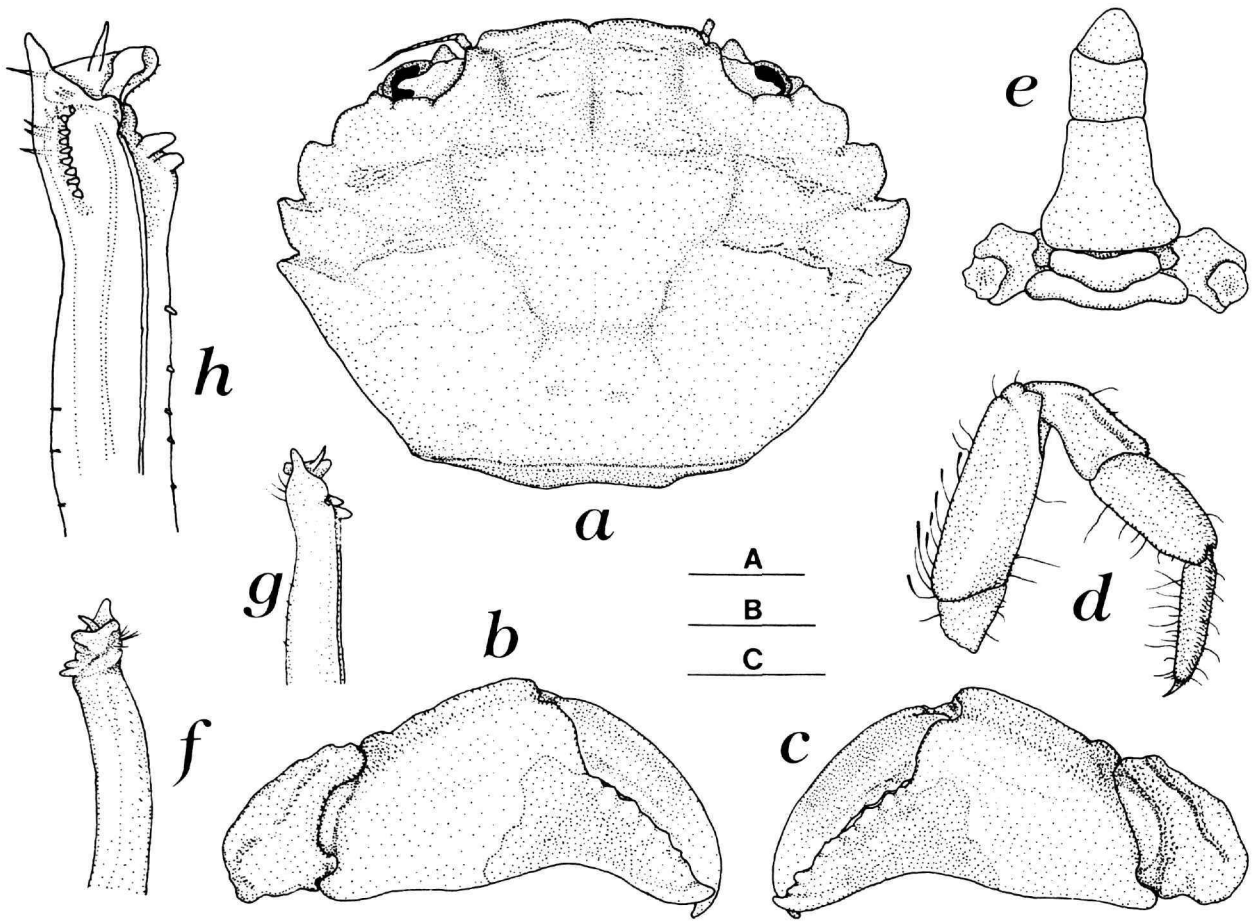

FIGURE 15.—*Panopeus gatunensis*, new species, holotype male, cb 9.1 mm: *a*, carapace, dorsal view; *b*, chela of right first pereopod (cheliped), external view; *c*, chela of left first pereopod, external view; *d*, right second pereopod (first walking leg); *e*, abdomen; *f*, right gonopod, internal view; *g*, same, external view; *h*, same, mesial view. (Scale A, 0.5 mm, *f,g;* scale B, 2 mm, *a–e;* scale C, 2.0 mm, *h.*)

65. *Panopeus lacustris* Desbonne, 1867

Panopeus lacustris Desbonne, 1867:28.—Williams, 1983:868, fig. 4.

MATERIAL EXAMINED.—Gatun Locks (LGA 74-4: 8 ♂, 7 ♀, 1 ovig. ♀, 9 juv.; sta 81-1: 1 ♂; sta 81-2: 1 ♂; sta 81-4: 2 juv.; sta 81-9: 1 ♂; sta 176; M-4-F: 1 ♂; sta 177, L-1-W: 3 ♂, 2 ♀, 2 ovig. ♀, 2 juv.; L-2-W: 3 ♂, 1 juv.; L-3-F: 1 juv.; L-3-W: 3 ♂, 1 ♀, 2 juv.; L-4-F: 1 ♀, 1 juv.; L-4-W: 3 ♂, 2 ♀, 2 ovig. ♀; L-5-W: 3 ♂, 3 juv.; sta 1530: 2 ♂, 3 ♀, 1 ovig. ♀, 2 juv.; sta 1686: 1 ♂).

MEASUREMENTS.—Males, cb 14.2–33.5 mm; females, cb 19.6–30.8 mm; ovigerous females, cb 15.4–23.5 mm.

TYPE LOCALITY.—The lagoons of Guadeloupe, hiding under rocks.

DISTRIBUTION.—Known from Bermuda and extreme southern Florida, through the West Indies, and along the Caribbean Sea and South America to Cabo Frio, Brazil. The species has been introduced in Hawaii and has been known on the Califonia coast for a number of years (Williams, 1983).

REMARKS.—Williams (1983) rediagnosed as four full species the "forms" of the mud crab *Panopeus herbstii* recognized by Rathbun (1930). The present specimens belong to *Panopeus lacustris*. Of the material examined, one male has a red spot on the inner surface of the third maxilliped.

66. *Panopeus mirafloresensis*, new species

FIGURES 16–18

Panopeus species 1.—Martin and Abele, 1986:189, fig. 2A.

MATERIAL EXAMINED.—*Holotype:* Male, cl 3.7 mm, cb 5.1 mm; Republic of Panama, Panama Canal, Miraflores

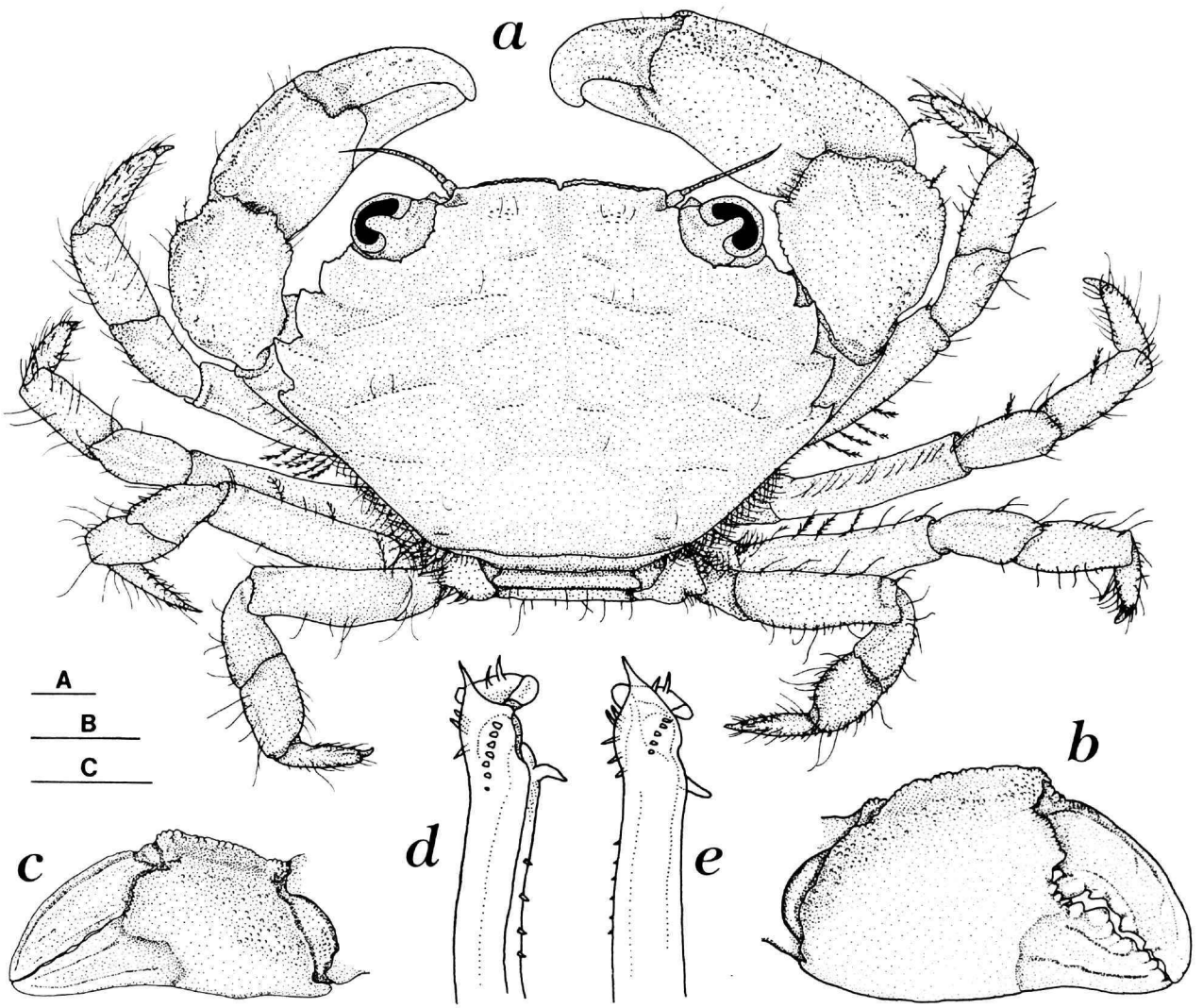

FIGURE 16.—*Panopeus mirafloresensis*, new species, holotype male, cb 5.1 mm: *a*, dorsal view; *b*, chela of right (major) first pereopod (cheliped), external view; *c*, chela of left (minor) first pereopod, external view; *d*, right gonopod, mesial view; *e*, same, external view. (Scale A, 1 mm, *d,e;* scale B, 1 mm, *b,c;* scale C, 1 mm, *a.*)

Locks, sta 77-8.

Paratypes: Miraflores Locks, sta 77-8: 60 ♂, 32 ♀, 28 ovig. ♀, 101 juv.

Other Material: Miraflores Locks (sta 77-2: 7 ♂, 4 ♀, 4 ovig. ♀; sta 78: 7 ♂, 2 ♀, 5 ovig. ♀, 15 juv.; sta 78-1: 7 ♂, 5 ♀, 1 ovig. ♀; sta 78-2: 6 ♂, 2 ♀; sta 78-4: 3 ♂, 4 ♀; 78-5: 5 ♂, 3 ovig. ♀, 12 juv.; sta 203, U-M-2-W: 1 ♂; U-M-5-F: 2 ♂, 1 ♀; sta 204, L-M-1-F: 2 ♂, 4 ovig. ♀; L-M-1-W: 4 ♂, 4 ♀, 2 juv.; L-M-2-F: 9 ♂, 3 ♀, 8 ovig. ♀, 1 juv.; L-M-2-W: 2 ♂, 3 ♀, 3 ovig. ♀, 1 juv.; L-M-3-F: 10 ♂, 7 ♀, 7 ovig. ♀; L-M-3-W: 8 ♂, 2 ♀, 3 ovig. ♀; L-M-4-F: 5 ♂, 2 ♀, 15 ovig. ♀; L-M-4-W: 6 ♂, 4 ♀, 5 ovig. ♀, 1 juv.; L-M-5-F: 3 ♂, 5 ♀, 12 ovig. ♀; L-M-5-W: 5 ♂, 6 ♀, 7 ovig. ♀, 1 juv.; sta 1525: 22 ♂, 20 ♀, 25 ovig. ♀, 2 juv.; sta 1718: 2 ♂; sta 1720: 14 ♂, 3 ♀, 9 ovig. ♀; sta 1730: 12 ♂, 13 ♀, 3 ovig. ♀, 5 juv.).

MEASUREMENTS.—Males, cb 2.8–9.1 mm; females, cb 3.0–8.9 mm; ovigerous females, cb 3.0–9.1 mm.

DESCRIPTION.—Carapace (Figure 16*a*) slightly convex in longitudinal direction, about 1.4 times as broad as long, almost devoid of pubescence; surface divided by shallow furrows into regions surmounted by one or more granulated, raised lines (one short postfrontal; two protogastric (anterior one longer than posterior); one oblique hepatic, in line with anterior protogastric; one metagastric; one very short line on inner

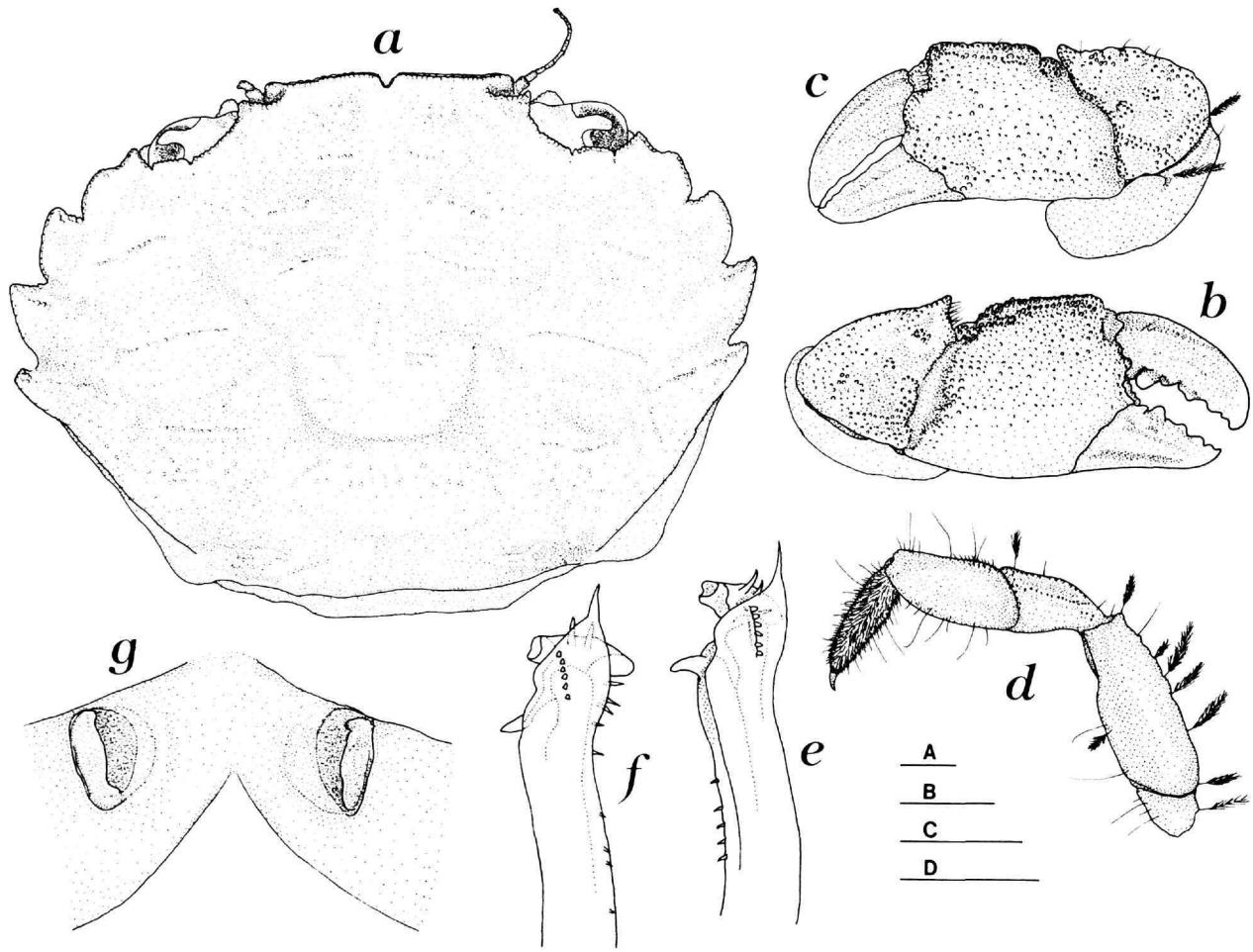

FIGURE 17.—*Panopeus mirafloresensis*, new species: *a*, carapace, dorsal view; *b*, right (major) first pereopod (cheliped), external view; *c*, left (minor) first pereopod, external view; *d*, left third pereopod (second walking leg); *e*, left gonopod, mesial view; *f*, same, external view; *g*, gonopore; (*a,e,f*, male, cb 7.8 mm, from sta 204, L-M-1-W; *b–d*, female, cb 6.4 mm, from sta 204, L-M-5-W; *g*, female, cb 6.7 mm, from sta 204, L-M-1-W). (Scale A, 1 mm, *e,f;* scale B, 1 mm, *a,d;* scale C, 1 mm, *g;* scale D, 1 mm, *b,c.*)

branchial region, in line with metagastric; one long oblique epibranchial, ending in front of inner end of ridge spreading inward from lateral fifth tooth; or one almost transverse metabranchial); in addition to these granulated lines, carapace with few scattered granules on frontal region, short granulate ridge in front of base of last walking leg, and number of scattered granules on lateral branchial region.

Frontal margin slightly produced, divided into two lobes by shallow, distinct V-shaped notch; each lobe slightly sinuous, consisting of two granulate edges; outer frontal lobule slightly produced anteriorly, subrectangular. Supraorbital border granulate, with two small distinct notches; lobe between notches almost straight, not produced; inner supraorbital tooth spreading inward with granules, separated by deep furrow from outer frontal lobule. Suborbital border granulate, slightly concave, with strong elongate inner suborbital tooth, almost reaching to tip of outer frontal lobule. Subhepatic region with no distinct tubercle, with only scattered fine granules. First anterolateral tooth small, conical, fused with second one; second tooth with lateral margin slightly arcuate; sinus between first and second teeth slightly concave; third tooth with rectangular tip, anterior margin almost straight, anterolateral margin slightly directed forward, and posterolateral margin directed inward; fused first-second tooth slightly broader than third; fourth tooth with triangular tip; anterior margin slightly concave, and lateral margin directed outward in 45° angle; fifth tooth with tip acute;

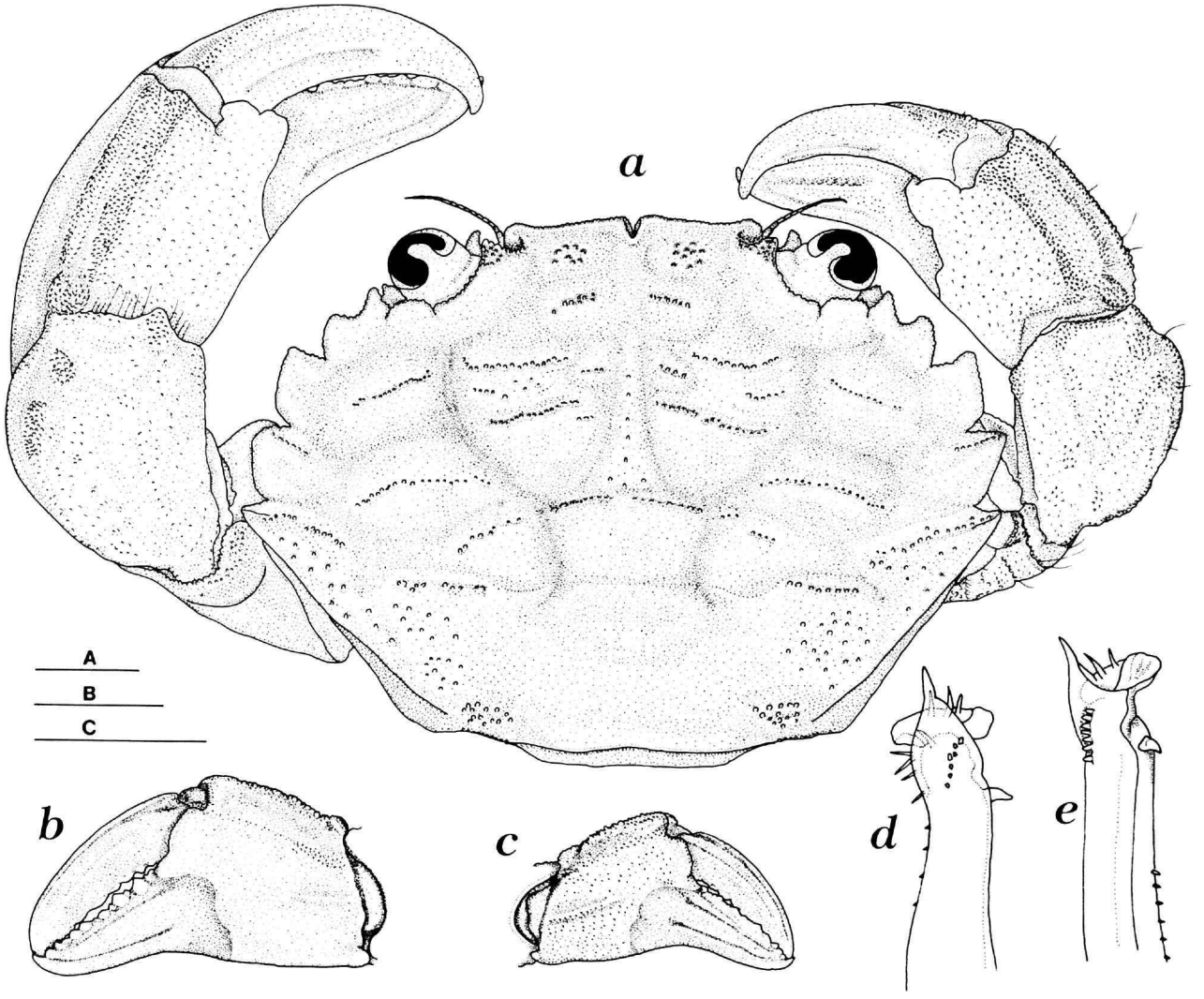

FIGURE 18.—*Panopeus mirafloresensis*, new species, male, cb 8.7 mm, from sta 204, L-M-3-F: *a*, carapace and first pereopods, dorsal view; *b*, chela of left first pereopod, external view; *c*, chela of right first pereopod, external view; *d*, right gonopod, external view; *e*, same, mesial view. (Scale A, 2 mm, *d,e;* scale B, 2 mm, *b,c;* scale C, 2 mm, *a*.)

carapace widest between tips of fourth teeth; posterior margin of carapace slightly concave.

Third maxilliped with no red spot or structure on inner surface in either sex.

Chelipeds (Figure 16*b,c*) very unequal; carpus rugose with fine granules; distal groove distinct but not deep, with superior tooth inside; palm of major chela inflated, finely granulate on upper 1/3 of outer surface, with very shallow longitudinal groove above; palm of minor chela more coarsely granulate on upper 2/3 of outer surface with deeper longitudinal groove above; movable finger of major chela with large tooth at base of cutting edge; immovable finger of major chela with large tooth just distal to large basal tooth of movable finger; dark color of immovable finger extending to palm, but not spreading upward; tips of both fingers white; fingers of minor chela elongate without prominent tooth at base of movable finger, deflexed slightly downward; tips of fingers slightly crossing when closed.

Walking legs (Figure 16*a*) slender, with scattered setae; tip of dactylus acute, brown; carpus with faintly defined longitudinal groove below superior margin; superior margin with fine granules.

First abdominal segment of male slightly broader than third; third with lateral extremities rounded; third to fifth segments

fused; sixth broader than long; seventh as long as sixth, with rounded triangular tip.

Accessory process of male gonopod (Figure 16*d,e*) with sharply pointed tip; median process rounded transversely with two or three spines inside; one lateral tooth not long, sharply pointed. Female gonopore (Figure 17*g*) longitudinally rounded.

VARIATION.—The present species is highly variable, and it is difficult to define the limits of the variation. Marked variation occurs in the shapes of the carapace, anterolateral teeth, frontal margin, and supraorbital margin. In addition, variation exists in the number and robustness of granules on the carapace and chelipeds. Because the general shape of the male gonopod is almost identical among specimens, we tentatively refer all specimens to one variable species. We identify three main "types" among the present species, although there are intermediate forms among the three "types." The first type (Figure 16*a–e*) is found in specimens with the characteristics described above. Most individuals of this type are very small, and there are numerous ovigerous females. For example, males (n = 64) of type I ranged in size from cb 2.8 to cb 6.2 mm, females (n = 36) from cb 3.0 to cb 7.4 mm, and ovigerous females (n = 30) from cb 3.0 to cb 5.4 mm. In addition we examined 102 juveniles of this type. In specimens of the second type (Figure 17*a–g*), the general shape of carapace is more oval than those of the first and third types because the tips of the anterolateral teeth are more rounded and directed forward; the second anterolateral tooth is much larger than the first tooth; the furrows defining the regions of carapace are deeper than those of the first type, but less deep than those of the third type; and the granulation on the carapace and chelipeds is more prominent than that of the first type, but less prominent than that of the third type. We examined 41 males (cb 3.5–8.7 mm) and 58 ovigerous females (cb 4.2–9.0 mm) of type II specimens. In specimens of the third type (Figure 18*a–e*), the general shape of the carapace is more hexagonal because the anterolateral teeth are more prominent and directed distinctly outward; the sinus between the first and the second anterolateral teeth is the deepest among the three types; the lateral margin of the third tooth is almost straight; the sinuses between the teeth are wider than those of the first and second types; and there is no large tooth on the base of the immovable finger of major chela, but there is one large tooth there in the first and second types. The granulation on the carapace and on the cheliped is more prominent than that of the first and second types; the granules on the palm of the minor chela extend almost to the bottom of the palm in females. There were only three specimens, all males (cb 6.2, 6.3, 8.3 mm), of this type.

Variations in the male gonopod exist in the number of spines on the median process, which varies from two to three among all specimens.

REMARKS.—The present species is most closely allied to *P. bermudensis*. The type-series of *P. bermudensis* consists of different-sized specimens deposited in the same lot. Large specimens of the type-series of *P. bermudensis* are almost identical with the picture in Rathbun (1930, pl. 165), but small specimens are quite different and much more similar to the first type of the present specimens. The anterolateral teeth of small specimens of the type-series of *P. bermudensis* are more obtuse and the sinuses between the teeth are narrower than in the first type of the present species. Thus, the general shape of *P. bermudensis* is much more oval. *Panopeus bermudensis* was reported from Chamela Bay, Mexico, by Garth (1961), who noted that "when considered independently, the Chamela Bay specimens could scarcely be reconciled with specimens from Bermuda to which the name *bermudensis* was originally applied.... While as a result of studies now in progress it may be decided to segregate the Pacific material from the Atlantic as a distinct species.... The small size of the females, all of which are ovigerous, is noteworthy." We do not know whether the material from Chamela Bay, Mexico, reported by Garth (1961) belongs to the present species or not, but that material probably belongs to the first type of the present species. *Panopeus bermudensis* was also reported from the north coast of Colombia, Caribbean Sea, by Lemaitre (1981). His figure 5a (drawing of the carapace) is very similar to the second type of the present species. We do not know whether the present species occurs in the eastern Pacific only or in both the eastern Pacific and western Atlantic. We tentatively place the present species in the genus *Panopeus* because the general shape of the carapace is similar to those of existing species of the genus even though the general shape of the male gonopod is very atypical for *Panopeus* (See Martin and Abele, 1986).

ETYMOLOGY.—The specific name is from the Miraflores Locks, Panama Canal, to which the type locality of the present species belongs.

67. *Panopeus purpureus* Lockington, 1877

Panopeus purpureus Lockington, 1877:101.—Rathbun, 1930:344, pl. 158: fig. 1, pl. 159.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta 110-1: 1 ♂; sta 130-2-a: 1 ♂).

MEASUREMENTS.—Males, cb 31.5–36.9 mm.

TYPE LOCALITY.—Magdalena Bay and La Paz.

DISTRIBUTION.—In the eastern Pacific, Magdalena Bay and Guaymas, Mexico; Gulf of Fonseca, El Salvador; Nicaragua; Puntarenas, Costa Rica; Canal Zone, Panama; Mouth of Rio Tumbes, Peru.

REMARKS.—This species is very similar to *Panopeus lacustris*. The coalesced first-second anterolateral tooth is narrower than that of *P. lacustris*, and the lateral margin of the second tooth is longer than that of *P. lacustris*.

68. *Panopeus rugosus* A. Milne Edwards, 1880

Panopeus rugosus A. Milne Edwards, 1880:314, pl. 57: fig. 4.—Rathbun, 1930:353, pls. 162, 163.—Hildebrand, 1939:23.

MATERIAL EXAMINED.—Miraflores Locks (sta 77-3: 1 ♂, 12 juv.; sta 203, U-M-2-W: 1 juv.; U-M-3-W: 1 ♂, 1 juv.; sta 1719: 1 ♂; sta 1730: 1 ♂); Miraflores Locks spillway (sta 130-2-b: 2 ♂, 1 ovig. ♀); Miraflores Upper Lock (2 ♂, 26 Aug 1974); Miraflores Locks (upper east chamber: 1 ♂, 17 Jan 1972).

MEASUREMENTS.—Males, cb 20.6–47.5 mm; ovigerous female, cb 18.6 mm.

TYPE LOCALITY.—Bahia, Brazil.

DISTRIBUTION.—Known from the Gulf of Mexico, through Central America to the State of Santa Catarina, Brazil; West Indies; Miraflores Locks, Panama.

REMARKS.—The present male specimens agree well with the photograph of the female in Rathbun (1930, pl. 163: figs. 1, 2) but do not match the drawing of the male in the same volume (1930, pl. 162). The posterior lateral margin of the carapace in the present male specimens is concave just behind the fifth lateral tooth, whereas the posterior lateral margin is very rounded in the drawing (1930, pl. 162).

Pilumnus Leach, 1815

69. *Pilumnus dasypodus* Kingsley, 1879

Pilumnus dasypodus Kingsley, 1879:155.—Rathbun, 1930:493, pl. 200: figs. 5, 6.—Powers, 1977:105.—Coen and Heck, 1983:220.—Williams, 1984:425, figs. 335, 340a.

MATERIAL EXAMINED.—Gatun Locks (LGA 74-4: 2 ♂, 4 ♀, 2 ovig. ♀, 1 juv.; sta 81-1: 1 ♀; sta 81-2: 2 ♂, 1 juv.).

MEASUREMENTS.—Males, cb 4.3–8.5 mm; females, cb 6.5–6.8 mm; ovigerous females, cb 6.7–7.8 mm.

TYPE LOCALITY.—Key West, Florida.

DISTRIBUTION.—Known in the western Atlantic from off Cape Hatteras, North Carolina, through Gulf of Mexico, Panama, Caribbean Sea, and the West Indies; Colombia to State of Santa Catarina, Brazil.

REMARKS.—Female specimens have brown, sharp spines on one-third of the upper, outer surfaces of the palms of the major chelae and on the upper surfaces of the carpi of the chelipeds, but in males the same regions have small tubercles rather than spines.

70. *Pilumnus reticulatus* Stimpson, 1860

Pilumnus reticulatus Stimpson, 1860:214.—Rathbun, 1930:521, pl. 209: figs. 4, 5, pl. 210.—Lemaitre, 1981:257.—Hendrickx and van der Heiden, 1983:110.

MATERIAL EXAMINED.—Miraflores Locks (sta 78: 1 ♀; sta 78-2: 1 ♂; sta 1720: 2 ♂, 1 ♀, 1 juv.).

MEASUREMENTS.—Males, cb 7.9–10.8 mm; females, cb 6.1–10.1 mm.

TYPE LOCALITY.—St. Thomas, Virgin Islands.

DISTRIBUTION.—Known in the western Atlantic from Jamaica, Puerto Rico, St. Thomas, Virgin Islands, Brazil, and Argentina to Patagonia; in the eastern Pacific, at Gulf of California and Pacific side of Panama.

REMARKS.—Rathbun (1930) noted that "on the legs there are two tubercles at proximal end of carpus and one at distal end of propodus." Of the material examined, female specimens have one tubercle at the proximal end and two at the distal end of the carpus, a small one just behind the distal tubercles and two at the proximal, and one at the distal end of the propodus on each walking leg.

Rhithropanopeus Rathbun, 1898

71. *Rhithropanopeus harrisii* (Gould, 1841)

Pilumnus harrisii Gould, 1841:326.

Rhithropanopeus harrisii.—Hay and Shore, 1918:441, pl. 35: fig. 5.—Rathbun, 1930:456, pl. 183: figs. 7, 8.—Powers, 1977:108.—Williams, 1984:401, figs. 316, 317, 331f.

MATERIAL EXAMINED.—Pedro Miguel Locks (1 ♂, 3 ♀ (two broken), 1 juv., 3 Feb 1969).

MEASUREMENTS.—Male, cb 7.1 mm; female, cb 6.1 mm.

TYPE LOCALITY.—Cambridge Marshes and Charles River, Massachusetts.

DISTRIBUTION.—The original range of this species is presumed to be in fresh to estuarine waters from the southwestern Gulf of St. Lawrence, Canada, to Veracruz, Mexico; Pedro Miguel Locks, Panama; northeast Brazil. The species has been introduced on the west coast of the United States and in parts of Europe (Williams, 1965).

REMARKS.—In young specimens, this species can be distinguished from related species by the transverse groove in the frontal margin of the carapace; the very sinuous coalesced first-second tooth; and two subparallel, granulated, transverse ridges on the protogastric region of the carapace.

Superfamily GRAPSIDOIDEA

Family GRAPSIDAE

Glyptograpsus Smith, 1870

72. *Glyptograpsus impressus* Smith, 1870

Glyptograpsus impressus Smith, 1870:154.—Rathbun, 1918:275, pl. 72: figs. 1, 2.—Holthuis, 1954:37, fig. 15.—Abele and Blum, 1977:246.

MATERIAL EXAMINED.—Rio Cocoli where it drains into the Panama Canal (LGA 74-8: 2 ♂, 1 ♀, 28 May 1974, coll. by L.G. Abele).

MEASUREMENTS.—Male, cl 3.0–22.0 mm; female, cl 8.0–18.0 mm (Abele and Blum, 1977).

TYPE LOCALITY.—Acajutla, El Salvador.

DISTRIBUTION.—Known from Acapulco, Mexico; Acajutla, El Salvador; Panama (Abele and Blum, 1977).

Goniopsis De Haan, 1833

73. *Goniopsis cruentata* (Latreille, 1802)

Grapsus cruentatus Latreille, 1802:70.
Goniopsis cruentata.—Rathbun, 1901:15, pl. 1; 1918:237, pl. 57.—Chace and Hobbs, 1969:160, fig. 49.

MATERIAL EXAMINED.—Miraflores Locks (sta 87-3: 1 ♂; Miraflores Locks spillway (sta 110-1: 1 ♀; sta 130-2-a: 2 ♂, 1 ovig. ♀, 1 juv.; sta 130-3: 1 juv.).

TYPE LOCALITY.—The islands of South America.

DISTRIBUTION.—Bermuda to Estado de São Paulo, Brazil; eastern Atlantic from Senegal to northern Angola; now reported from the eastern Pacific at Miraflores Third Locks Lake, Panama.

Pachygrapsus Randall, 1840

74. *Pachygrapsus gracilis* (De Saussure, 1858)

Metopograpsus gracilis De Saussure, 1858:443, pl. 2: fig. 15.
Pachygrapsus gracilis.—Stimpson, 1871:113.—Rathbun, 1918:249, pl. 60: fig. 3, pl. 61: fig. 1.—Chace and Hobbs, 1969:167, figs. 51, 52j.—Lemaitre, 1981:259.

MATERIAL EXAMINED.—Gatun Locks (LGA 74-3: 1 ♀; LGA 74-4: 1 ♂, 1 ♀, 1 ovig. ♀, 1 juv.; sta 81-2: 1 ovig. ♀; sta 176, M-1-W: 3 ♂, 1 ♀; M-2-W: 2 ♀, 1 juv.; M-3-W: 3 ♂, 5 ♀, 5 juv.; M-4-F: 2 ♂; M-4-W: 1 ♀; M-5-F: 1 ♂, 1 ♀, 1 juv.; sta 177, L-3-W: 1 ♀; sta 1686: 1 ♀; Upper Gatun Lock (1 ♂, 1973); Gatun Middle Lock (lower chamber: 7 ♂, 12 ♀, 4 Mar 1974); Gatun Locks (from floor of dewatered Upper Lock, middle to lower portion: 1 ♀, 3 Mar 1974, coll. by J. Rosewater); Gatun Middle Lock (mid to lower part before entering small chamber: 8 ♂, 1 ♀, 4 juv., 4 Mar 1974); Gatun Middle Lock (upper to middle portion: 2 ♂, 2 ♀, 4 Mar 1974).

MEASUREMENTS.—Males, cb 6.0–15.5 mm; females, cb 5.7–14.1 mm; ovigerous females, cb 6.5–6.9 mm.

TYPE LOCALITY.—St. Thomas, Virgin Islands.

DISTRIBUTION.—Known from the western Atlantic, Bahamas, Cuba, Jamaica, Puerto Rico, Colombia, Florida, and Caribbean side of Panama to Rio Parahyba do Norte, Brazil; Bermudas; in the eastern Atlantic from Senegal to Zaire, West Africa.

75. *Pachygrapsus transversus* (Gibbes, 1850)

Grapsus transversus Gibbes, 1850:181.
Pachygrapsus transversus.—Gibbes, 1850:182.—Rathbun, 1918:244, pl. 61: figs. 2, 3.—Chace and Hobbs, 1969:169, fig. 52K.—Lemaitre, 1981:259.—Williams, 1984:459, fig. 368.

MATERIAL EXAMINED.—Miraflores Locks (sta 77-9: 1 ♀; sta 78: 1 ♂; sta 78-2: 1 ♀; sta 1525: 1 ♂; sta 1730: 1 ♀; Gatun Locks (sta 176, M-1-F: 2 juv., 1 ♀; M-3-F: 1 ♀, 1 juv.).

MEASUREMENTS.—Male, cb 10.4–14.2 mm; females, cb 10.9–15.1 mm.

TYPE LOCALITY.—Key West, Florida.

DISTRIBUTION.—Known from Cape Lookout, North Carolina, to Montevideo, Uruguay; Bermuda; Mediterranean Sea to northern Angola, West Africa; eastern Pacific from California through Miraflores Locks, Panama, to Peru; the Galapagos Islands. This species has a wide distribution in tropical and subtropical seas and has been carried to higher latitudes than it normally inhabits by transport on ships' bottoms (Williams, 1965).

Sesarma Say, 1817

76. *Sesarma aequatoriale* Ortmann, 1894

Sesarma aequatorialis Ortmann, 1894:722, pl. 23: figs. 14, 14K, Z.
Sesarma (Sesarma) aequatorialis.—Rathbun, 1897c:112.
Sesarma (Sesarma) aequatoriale.—Rathbun, 1918:292, fig. 146.
Sesarma aequatoriale.—Abele, 1977b:495, figs. 1, 2, 5c,d; 1981:437.—Abele and Blum, 1977:241.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta 130-2-a: 1 ♂).

MEASUREMENTS.—Male, cb 10.0 mm; females, cl 9.6–13.7 mm (Abele and Blum, 1977).

TYPE LOCALITY.—Ecuador.

DISTRIBUTION.—Acapulco (Mexico), Costa Rica, Panama, and Ecuador.

REMARKS.—This species has been confused with *S. sulcatum* in the past (Abele, 1977b), but *S. aequatoriale* occurs in almost fresh water, where *S. sulcatum* is absent.

77. *Sesarma americanum* De Saussure, 1858

Sesarma americana De Saussure, 1858:441.
Sesarma (Holometopus) tampicense Rathbun, 1914:124, fig. 4, pl. 8.
Sesarma (Holometopus) americanum.—Chace and Hobbs, 1969:178, figs. 62a-f.

MATERIAL EXAMINED.—Barro Colorado Island (on dock: 1 ♂, 20 Jul 1969, coll. by T. Zaret).

MEASUREMENTS.—Males, cb 12.8–22.6 mm; females, cb 12.7–21.0 mm; ovigerous females, cb 18.5–18.6 mm.

TYPE LOCALITY.—St. Thomas (probably an error; see Chace and Hobbs, 1969).

DISTRIBUTION.—Tampico, Mexico; Honduras; Caribbean coast of Costa Rica and Panama. A reexamination of all available material suggests that this species occurs only on the Central American mainland and does not occur in the West Indies.

78. *Sesarma angustum* Smith, 1870

Sesarma angusta Smith, 1870:159.
Sesarma (Sesarma) ophioderma Nobili, 1902:44.
Sesarma (Holometopus) angustum.—Rathbun, 1918:314, pl. 92.—Abele, 1977a:637, figs. 3i-n, 4, 5.
Sesarma angustum.—Abele and Blum, 1977:246.—Abele, 1981:438.

MATERIAL EXAMINED.—Rio Cocoli where it enters Panama Canal (LGA 74-8: 3 juv.).

MEASUREMENTS.—Males, cb 4.9–20.9 mm; females, cb 7.5–17.8 mm (Abele, 1977a).

TYPE LOCALITY.—Panama: Pearl Islands, Gulf of Panama.

DISTRIBUTION.—The species ranges on the Pacific coast from Tenacatita Bay, Mexico, to Ecuador.

79. *Sesarma occidentale* Smith, 1870

Sesarma occidentale Smith, 1870:158.
Sesarma (Holometopus) Festae Nobili, 1902:42.
Sesarma (Holometopus) occidentale.—Abele, 1977a:632, figs. 1, 2, 3a–h.
Sesarma occidentale.—Abele, 1981:438.

MATERIAL EXAMINED.—Miraflores Locks (sta 77-7: 2 ♂ (one broken)).

MEASUREMENTS.—Male, cb 9.2 mm.

TYPE LOCALITY.—Acajutla, El Salvador.

DISTRIBUTION.—Known from the eastern Pacific from Acajutla, El Salvador; Panama to Esmeraldas, Ecuador.

80. *Sesarma rhizophorae* Rathbun, 1906

Sesarma (Sesarma) rhizophorae Rathbun, 1906:99; 1918:294, pl. 79.
Sesarma rhizophorae.—Abele, 1981:438.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta 110-1: 1 ♂; sta 130-2-a: 4 ♂, 1 ♀.

MEASUREMENTS.—Males, cb 6.0–14.6 mm; female, cb 8.3 mm.

TYPE LOCALITY.—Boca del Jesus Maria, Costa Rica.

DISTRIBUTION.—Known from Boca del Jesus Maria, Costa Rica, and Panama.

81. *Sesarma rubinofforum* Abele, 1973

Sesarma (Holometopus) rubinofforum Abele, 1973:333, figs. 1–3.
Sesarma rubinofforum.—Abele, 1981:438.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta 130-2-a: 1 ♂).

MEASUREMENTS.—Male, cb 7.0 mm.

TYPE LOCALITY.—Diablo Heights, Balboa, Panama.

DISTRIBUTION.—Pacific side of Panama.

Superfamily POTAMOIDEA

Family PSEUDOTHELPHUSIDAE

Potamocarcinus H. Milne Edwards, 1853

82. *Potamocarcinus richmondi* (Rathbun, 1893)

Pseudothelphusa richmondi Rathbun, 1893:654, pl. 75: figs. 6–10; 1905:303.
Pseudothelphusa (Megathelphusa) richmondi.—Smalley, 1964:9, figs. 4–6.—Pretzmann, 1972:70, figs. 373–376, 366–368.
Potamocarcinus (Megathelphusa) masimbari.—Pretzmann, 1971:20; 1972:71, figs. 540, 541.
Potamocarcinus richmondi.—Rodríguez, 1982:113, figs. 69c, 70g,n, 71g,k, 73a–c, 132.

MATERIAL EXAMINED.—Barro Colorado Island (LGA 69-61: 3 ♂, 2 ♀; LGA 69-63: 5 ♂, 2 ♀).

MEASUREMENTS.—Males, cb 17.8–80.5 mm; females, cb 38.0–64.0 mm.

TYPE LOCALITY.—Rio Escondido above Bluefields, Nicaragua.

DISTRIBUTION.—Nicaragua; Costa Rica; Panama.

Ptychophallus Smalley, 1964

83. *Ptychophallus goldmanni* Pretzmann, 1965

Ptychophallus (Microptychophallus) goldmanni Pretzmann, 1965:5; 1971:21; 1972:90, figs. 527–529, 544–546.
Ptychophallus goldmanni.—Rodríguez, 1982:86.

MATERIAL EXAMINED.—Barro Colorado Island (Zetek trail below tower: 2 ♂, Jul 1969, coll. by T. Zaret).

MEASUREMENTS.—Male, cl 16.8 mm.

TYPE LOCALITY.—Panama Canal.

DISTRIBUTION.—This species is known only from Barro Colorado Island and an unknown locality in the Panama Canal.

Superfamily OCYPODOIDEA

Family OCYPODIDAE

Uca Leach, 1814

84. *Uca festae* Nobili, 1902

Uca festae Nobili, 1902:51.—Rathbun, 1918:420.
Uca (Celuca) festae.—Crane, 1975:267, pl. 36A–D, figs. 71C,D, 101.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta 130-3: 1 ♂).

MEASUREMENTS.—Male, cb 11.1 mm.

TYPE LOCALITY.—Rio Daule Inferiore, Ecuador.

DISTRIBUTION.—El Salvador; Panama; Colombia; Ecuador.

REMARKS.—The present specimen has the anterolateral angle of the carapace more divergent laterally than that of the northern form of this species and the meri of the walking legs broader than those of the northern form.

85. *Uca oerstedi* Rathbun, 1904

Uca oerstedi Rathbun, 1904:161; 1918:414, pl. 152: figs. 1, 2.
Uca (Celuca) oerstedi.—Crane, 1975:251, pl. 33E–H, figs. 70I, 93, 101.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta 130-2-a: 1 ♀; sta 130-3: 1 ♂, 1 juv.; sta 130-4: 2 ♂, 4 ♀, 1 juv.).

MEASUREMENTS.—Males, cb 7.1–9.8 mm; females, cb 7.9–9.6 mm.

TYPE LOCALITY.—Punta Arenas, Costa Rica.

DISTRIBUTION.—Gulf of Fonseca, El Salvador, to Panama.

86. *Uca pygmaea* Crane, 1941

Uca pygmaea Crane, 1941:174, fig. 4b, pl. 1: fig. 1, pl. 2: fig. 4.—Garth, 1948:61.
Uca (Minuca) pygmaea.—Crane, 1975:161, pl. 22E-H, figs. 66E, 100.

MATERIAL EXAMINED.—Miraflores Locks spillway (sta 130-2-a: 1 ♂).

MEASUREMENTS.—Male, cb 6.9 mm.

TYPE LOCALITY.—Golfito, Costa Rica.

DISTRIBUTION.—Golfito, Costa Rica, to Buenaventura, Colombia; Perlas Islands and Miraflores Locks, Panama.

87. *Uca thayeri umbratila* Crane, 1941

Uca umbratila Crane, 1941:181, fig. 7, pl. 7: fig. 34.
Uca (Bororuca) thayeri umbratila.—Crane, 1975:113, pl. 17A-D, fig. 73B.

MATERIAL EXAMINED.—Miraflores Locks (sta 87-2: 1 ♂, 1 juv.); Miraflores Locks spillway (sta 130-3: 1 juv.).

MEASUREMENTS.—Male, cb 9.2 mm.

TYPE LOCALITY.—Puntarenas and Ballenas Bay, Costa Rica; Balboa, Canal Zone, Panama.

DISTRIBUTION.—El Salvador; Costa Rica to Panama.

88. *Uca tomentosa* Crane, 1941

Uca tomentosa Crane, 1941:179, figs. 4h, 6.
Uca (Celuca) tomentosa.—Crane, 1975:261, pl. 35A-D, figs. 70E, 101.

MATERIAL EXAMINED.—Miraflores Locks (sta 87-2: 2 ♀; Miraflores Locks spillway (sta 130-2-a: 4 ♂, 1 ♀; sta 130-3: 1 ♂).

MEASUREMENTS.—Males, cb 5.9–7.9 mm; females, cb 7.0–10.0 mm.

TYPE LOCALITY.—Puntarenas, Costa Rica.

DISTRIBUTION.—Known from Los Blancos, El Salvador, to Puerto Pizarro, Peru; now from the Miraflores Locks, Panama.

Discussion

SPECIES COMPOSITION.—The present study is concerned with the decapod crustaceans that occur in the Panama Canal from the lower Miraflores Locks on the Pacific coast through Gatun Lake to the lower Gatun Locks on the Caribbean coast. We have not included the marine fauna that occurs seaward of the locks on both coasts (see Abele, 1976). The freshwater fauna of Gatun Lake is included but not that of the river drainages beyond Gatun Lake or the Panama Canal. We have omitted, for example, several species of pseudothelphusid crabs that occur in the Chagres drainage but were not collected in Gatun Lake.

The decapod crustacean fauna of the Panama Canal, thus restricted, consists of 88 species representing 35 genera in 15 families. Six genera (*Macrobrachium, Panopeus, Sesarma, Petrolisthes, Callinectes,* and *Uca*) account for 44% of the species, and three families (Xanthidae, Palaemonidae, and Grapsidae) account for 43% of the genera. Seven of the species were previously undescribed (*Macrobrachium crebrum,* new species, *M. digitus,* new species, *Synalpheus recessus,* new species, *S. superus,* new species, *Eurypanopeus canalensis,* new species, *Panopeus gatunensis,* new species, and *P. mirafloresensis,* new species), and five species were previously known from only one or a few records in the eastern Pacific (*Heterocrypta craneae, H. colombiana, Pelia tuberculata, Hexapanopeus beebei,* and *Uca pygmaea*). Additional collecting in the Panama Canal, and especially in the Miraflores Locks area, will almost certainly yield additional species.

It seems worthwhile to provide a brief description of the locks as a habitat for the decapods collected there. Each lock chamber is 304.8 m long, 33.5 m wide, and more than 20 m high. The sides and bottom are concrete, and the gates are metal. Sediment and sessile organisms accumulate on the bottom and sides, and the results can be quite spectacular. In one of the chambers of the Gatun Locks hundreds of square meters of the walls are covered with a monospecific stand of a bivalve (*Isognomon* sp.) along a line apparently following a salinity gradient that exists despite great turbulence in the lock. The floors can be covered with polychaetes, sponges, and other fouling organisms in a mud matrix more than 25 cm thick. Approximately 165 species of invertebrates have been collected from the lock chambers (M.L. Jones, personal comm.). The physical conditions within the locks are also rather spectacular. During the filling of a single chamber, some 98,417,800 liters of water flow into the chamber through 100 conduits, each about 1 m in diameter, in the floor of the chamber. It requires only eight minutes for the flooding to occur, creating great turbulence. This action and that of ships probably results in near-complete mixing (the above description of filling is from Jones and Dawson, 1973).

DISTRIBUTION OF SPECIES IN THE PANAMA CANAL.—Table 3 summarizes the distribution of the decapod fauna by collection locality.

The Miraflores Locks consist of upper and lower chambers and an adjacent spillway. There is, in addition, a large adjacent lake (Miraflores Third Locks Lake) that was to form the basis for a third set of locks (see Bozniak et al., 1969). The project was abandoned in 1946. Collections were made in all of these areas though only at the edge and drainage of the Third Locks Lake because of the nearly vertical basaltic cliffs that surround the lake.

The spillway and ditch area of the Third Locks Lake are under limited tidal influence and receive freshwater runoff from the canal. The salinity ranged from 6 to 30‰. The region consists of metal culverts, concrete drainage ditches, mangroves, and mud-clay tidal flats. Thirty species were collected in this area (Table 3). This was the only area with a tidal flat sampled, and this habitat accounts for the presence of five species of *Uca*. It is also in this area that a number of Atlantic species have been collected (*Callinectes exasperatus, Eurypanopeus dissimilis, Panopeus rugosus,* and *Goniopsis cruen-*

Table 3.—List of species by collection locality within the Panama Canal (includes all species from this and previous reports).

GATUN LOCKS
Lower chambers—Salinity 8–15 ‰
Alpheus armillatus
A. heterochaelis
Callinectes danae
C. sapidus
Clibanarius vittatus
Eurypanopeus dissimilis
Hexapanopeus carribaeus
H. paulensis
Leander paulensis
Lysmata intermedia
L. wurdemanni
Macrobrachium acanthurus
Menippe nodifrons
Pachygrapsus gracilis
Panopeus gatunensis
P. lacustris
Pelia mutica
Petrolisthes armatus
P. galathinus
P. robsonae
Pilumnus dasypodus
Synalpheus apioceros
Middle chambers—Salinity 2–8 ‰
Callinectes sapidus
Eurypanopeus dissimilis
Hexapanopeus carribeaus
Leander paulensis
Macrobrachium olfersi
Pachygrapsus gracilis
P. transversus
Panopeus lacustris
Upper chambers—Salinity essentially zero
Callinectes sapidus
Macrobrachium olfersi
Pachygrapsus gracilis
Panopeus rugosus

BARRO COLORADO ISLAND—Fresh water
Atya innocous
A. scabra
Macrobrachium carcinus
M. crenulatum
M. heterochirus
Micratya poeyi
Palaemon pandaliformis
Potamocarcinus richmondi
Potimirim glabra
P. mexicana
Ptychophallus goldmanni
Sesarma americanum

VARIOUS STREAMS EMPTYING INTO PACIFIC DRAINAGES OF THE PANAMA CANAL (NOT INCLUDING SPECIES LISTED ELSEWHERE)
Atya margaritacea
Glyptograpsus impressus
Sesarma angustum

PEDRO MIGUEL LOCKS—Fresh water
Atya tenella
Callinectes toxotes
Elamenopsis kempi
Macrobrachium americanum
M. digueti
M. panamense
Palaemon gracilis
P. pandaliformis
Palaemonetes schmitti
Penaeus stylirostris
Petrolisthes lindae
Rhithropanopeus harrisii

MIRAFLORES LOCKS AREA
Locks spillway and drainage into Third Locks Lake—Salinity 6–30 ‰
Alpheus firmus
A. colombiensis
Callinectes arcuatus
C. exasperatus
C. toxotes
Eurypanopeus dissimilis
Eurytium tristani
Goniopsis cruentata
Hexapanopeus beebei
Macrobrachium crebrum
M. digueti
M. panamense
M. rathbunae
M. tenellum
Palaemon gracilis
Palaemonetes schmitti
Panopeus purpureus
P. rugosus
Penaeus brevirostris
P. stylirostris
Petrolisthes zacae
Portunus asper
Sesarma aequatoriale
S. rhizophorae
S. rubinofforum
Uca festae
U. oerstedi
U. pygmaea
U. thayeri umbratila
U. tomentosa

MIRAFLORES LOCKS
Upper chambers—Salinity 0–5 ‰
Alpheus firmus
Callinectesa arcuatus
C. toxotes
Elamenopsis kempi
Eurypanopeus canalensis
Hexapanopeus beebei
Leander paulensis
Macrobrachium digitus
M. panamense
M. tenellum
Notolopas lamellatus
Pachygrapsus transversus
Palaemon gracilis
P. hancocki
Palaemonetes schmitti
Panopeus chilensis
P. mirafloresensis
P. rugosus
Pelia tuberculata
Penaeus stylirostris
Petrolisthes armatus
P. lindae
P. robsonae
Sesarma occidentale
Synalpheus superus
Lower chambers—Salinity 10.6–30 ‰
Calcinus obscurus
Callinectes arcuatus
Callinectes toxotes
Euceramus transversilineatus
Heterocrypta colombiana
H. craneae
Hexapanopeus beebei
Macrobrachium panamense
Notolopas lamellatus
Pachygrapsus transversus
Palaemon gracilis
Palaemonetes schmitti
Panopeus chilensis
P. mirafloresensis
P. rugosus
Pelia tuberculata
Penaeus stylirostris
Petrolisthes lindae
P. robsonae
Pilumnus reticulatus
Portunus asper
Synalpheus recessus
S. superus

tata). McCosker and Dawson (1975) pointed out that several Atlantic fish species as well as some other typically Atlantic organisms also occur in this Pacific habitat. They raise the question of why these species have not established breeding populations outside of this area. McCosker and Dawson suggest that additional data are needed. It would not be a trivial undertaking to design and carry out the experiments necessary to examine this question.

The salinity of the lower Miraflores Locks ranges from about 10 to 30 ‰, and 23 species were collected there (Table 3). Most of these species are fairly typical of marine areas. The upper locks are influenced by the fresh water of Miraflores Third Locks Lake, and the salinity ranges from 0 to 5 ‰. Although many of the 25 species found there are typical of fresh water or low salinity (e.g., species of *Macrobrachium, Palaemon, Callinectes*), there are some surprising occurrences. Members of the spider crab family Majidae are virtually all marine, but both *Notolopas lamellatus* and *Pelia tuberculata* were collected in almost fresh water there as well as in higher salinity. It was also surprising to collect a species of *Synalpheus, S. superus*, in such low-salinity waters. The Atlantic shrimp *Leander paulensis* was also collected in this lock.

The Pedro Miguel Locks consist of a single set of chambers and are fresh water. Twelve species (Table 3) were collected there, including the Atlantic shrimp *Paleomon pandaliformis* and two apparently introduced crabs, the xanthid *Rhithropanopeus harrisii* and the Iraqian hymenosomatid *Elamenopsis kempi* (cf. Abele, 1972a).

Barro Colorado Island was formed when the Chagres River was dammed during the building of the canal. It is a 15.6 km^2 nature preserve in the middle of Gatun Lake. There are numerous streams on this beautiful island (see Rubinoff and Smythe, 1982) where 12 species of freshwater decapods occur, including the possibly endemic freshwater crab *Ptychophallus goldmanni*.

Twenty-five species were collected in the Gatun Locks, four in the fresh water of the upper chamber, eight in the 2–8 ‰ waters of the middle chamber, and 22 in the 8–15 ‰ waters of the lower chamber. The large portunid crab *Callinectes sapidus* occurred in all three chambers. Although it has been successfully introduced into Europe and the Mediterranean Sea (Williams, 1984), it does not appear to have spread through the canal into the eastern Pacific.

The data from the Panama Canal and elsewhere suggest that salinities between about 3 ‰ and 5 ‰ seem to be a barrier between marine and freshwater species and represent a species minimum for both groups (Remane, 1934; Gainey and Greenberg, 1977). Abele (1982) demonstrated this relationship for the decapods of the Panama Canal. There are many physiochemical discontinuities in the ionic composition of seawater at these salinities, and the ability of many taxa to respond physiologically seems to be limited (Gainey and Greenberg, 1977).

There has been relatively little exchange between the Atlantic and Pacific regions. Seven Atlantic species (*Palaemon pandaliformis, Leander paulensis, Callinectes exasperatus, Eurypanopeus dissimilis, Panopeus rugosus, Rhithropanopeus harrisii, Goniopsis cruentata*) were collected from the Pacific drainage, and one Pacific species (*Petrolisthes robsonae*) was collected in the Atlantic drainage for the second time (Haig, 1960). However, we do not know if these species have established breeding populations outside of the Panama Canal.

It seems clear from the above data that the fresh water of Gatun Lake remains a barrier to the distribution of marine decapods. What is not clear is why more Atlantic freshwater species have not spread into the Pacific and vice versa. For example, *Potimirim mexicana* and *Micratya poeyi* are common in Atlantic coastal streams and occur in the canal on Barro Colorado Island but have not been found in any of the Pacific drainage streams emptying into the canal. Of the many freshwater decapods in both drainages of Panama (Abele, 1972b), only *Palaemon pandaliformis* from the Atlantic has spread throughout the canal.

It is also not clear why none of the six remaining Atlantic immigrants has apparently established breeding populations outside of the Miraflores Locks and Third Lock areas.

In closing, we note that, although little has been said in recent years concerning a sea-level canal or a salinization program for Gatun Lake, much more study of the biota of the Panama Canal is necessary and even more of the ecology of the species living there. The available data do suggest that salinization of Gatun Lake would result in extensive interchange of Atlantic and Pacific decapods. Clearly a sea-level canal or salinization program is inappropriate under these conditions.

Appendix

List of Stations from the Panama Canal

1. Gatun Locks.
   LGA 71-4: Stream adjacent to Lower Lock.
   Date: 24 Jan 1971
   Collector: L.G. Abele
   Species: 9
   LGA 74-3: Upper Gatun Locks.
   Date: 3 Mar 1974
   Collector: L.G. Abele
   Species: 53, 74
   LGA 74-4: Lower (seaward) chamber.
   Date: 5 Mar 1974
   Collector: L.G. Abele
   Species: 10, 27, 30, 53, 57, 60, 61, 62, 64, 65, 69, 74
   Station 81: Lower west chamber.
   Date: 20 Mar 1972
   Collector: M.L. Jones
   Substations:
   81-1: Walls of outer platform.
   81-2: Floor of outer platform (wooden log by edge).
   81-3: Lock edge.
   81-4: Outer sill.
   81-5: At water edge outside of caisson.
   81-6: Flats inside lock.
   81-7: Scraping from area of water inlet.
   81-8: Submerged log.
   81-9: Chamber floor.
   Remarks: Salinity, 28.0 ‰; depth, 0 m.
   Species: 27, 31, 34, 37, 39, 40, 45, 51, 53, 57, 60, 61, 62, 65, 69, 74
   Station 176: Middle east chamber.
   Date: 4 Mar 1974
   Collectors: M.L. Jones, C.E. Dawson, J. Rosewater, and H. Kaufman
   Substations: Station was subdivided evenly into five substations from upper chamber side to lower chamber side (1 to 5). Each substation consists of two collecting sites, floor (F) and wall (W). M-1-F, M-1-W, M-2-F, M-2-W, M-3-F, M-3-W, M-4-F, M-4-W, M-5-F, M-5-W.
   Species: 10, 53, 57, 60, 65, 74, 75
   Station 177: Lower east chamber.
   Date: 5 Mar 1974
   Collectors: M.L. Jones, H. Kaufman, C.E. Dawson, and J. Rosewater
   Substations: Station was subdivided evenly into six substations from upper chamber side to lower chamber side (1 to 6). Each substation consists of two collecting sites, floor (F) and wall (W). L-1-F, L-1-W, L-2-F, L-2-W, L-3-F, L-3-W, L-4-F, L-4-W, L-5-F L-5-W, L-6-F, L-6-W.
   Species: 27, 30, 37, 42, 53, 57, 60, 65, 74
   Station 1530: Lower west chamber.
   Date: 20 Mar 1972
   Collectors: C.E. Dawson and M.L. Jones
   Remarks: Main collections were from sump behind sea gate and sump behind cofferdam; ichthyocide and nets.
   Species: 10, 27, 35, 37, 53, 62, 65
   Station 1685: East lane of upper chamber.
   Date: 3 Mar 1974
   Collectors: C.E. Dawson, M.L. Jones, J. Rosewater, and H. Kaufman
   Remarks: Noxfish and nets, during dewatering.
   Species: 53
   Station 1686: East lane of middle chamber.
   Date: 4 Mar 1974
   Collectors: C.E. Dawson, M.L. Jones, J. Rosewater, and H. Kaufman
   Remarks: Noxfish and nets, during dewatering; from sump and vicinity lower gate.
   Species: 53, 65, 74
   Station 1687: East lane of lower chamber.
   Date: 5 Mar 1974
   Collectors: C.E. Dawson, M.L. Jones, J. Rosewater, and H. Kaufman
   Remarks: Noxfish and nets, during dewatering; from sump and sill at sea gate and from middle sump.
   Species: 51, 53, 62

2. Pedro Miguel Locks.
   LGA 69-21: Pedro Miguel Locks.
   Date: 3 Feb 1969
   Collector: L.G. Abele
   Species: 6, 17, 25
   Station 209.
   Date: 10 Feb 1975
   Collector: M. Jones
   Substations: Station was subdivided evenly into five substations from Gatun Lake to Miraflores Lake (1 to 5). Each substation consists of two collecting

sites, floor (F) and wall (W). 1-F, 1-W, 2-F, 2-W, 3-F, 3-W, 4-F, 4-W, 5-F, 5-W.
Species: 47

3. Miraflores Locks.
Station 77: Upper east chamber.
Date: 17 Jan 1972
Collector: M.L. Jones
Substations:
77-1: Stranded jelly fish.
77-2: Scrapings bottom of lock.
77-3: On lock bottom and under rocks.
77-4: Poisoned pool under middle gate.
77-5: Loose substrate on bottom (fixed entire).
77-6: Fine mud from inside a bottle.
77-7: From walls near bottom, dry for nearly 24 hours.
77-8: Scraping from between upper and lower chamber.
77-9: Scraping north end of upper chamber.
Species: 10, 20, 26, 28, 33, 39, 41, 42, 44, 46, 50, 54, 56, 59, 66, 68, 75, 79
Station 78: Lower east chamber.
Date: 17 Jan 1972
Collectors: M.L. Jones and P. Glynn
Substation:
78-1: From floor of "intermediate" chamber.
78-2: From walls of "intermediate" chamber (lock doors).
78-3: From north end of chamber.
78-4: From middle of chamber.
78-5: From south end of chamber.
Remarks: Hard substrate; depth, 0 m.
Species: 32, 33, 36, 38, 41, 42, 44, 46, 48, 54, 55, 59, 63, 66, 70, 75
Station 87: Third Lock drainage ditch.
Date: 16 Apr 1972
Collectors: C.E. Dawson, J. Byas, and M.L. Jones
Substations:
87-1: Shelf adjacent to road.
87-2: Inlet to area on other side of road; coarse sand.
87-3: Mainly crustaceans collected from beyond outlet after poisoning for fish.
Remarks: Salinity, 10 ‰.
Species: 20, 21, 28, 29, 52, 57, 73, 87, 88
Station 110: Miraflores Locks spillway.
Date: 4 Nov 1972
Collectors: C.E. Dawson, H. Kaufman, R. Brown, and M.L. Jones
Substations:
110-1: Rocky muddy area.
110-2: Coarse sand gravel at water's edge.
Species: 22, 58, 67, 73, 80
Station 130: Miraflores Locks spillway.
Date: 2 Apr 1973
Collector: A.S. Beforg
Substations:
130-1: Pool at and away from bridge pier.
130-2-a: Inter- and supratidal.
130-2-b: Tide pools.
130-3: 5–6 ft above standing water—seived.
130-4: Flocculent layer at bottom of standing water.
130-5: On bottom of standing water (include substrate).
Species: 1, 2, 21, 23, 26, 28, 42, 43, 50, 59, 67, 68, 73, 76, 80, 81, 84, 85, 86, 87, 88
Station 203: Upper chamber.
Date: 26 Aug 1974
Collectors: M.L. Jones, J. Rosewater, H. Kaufman, and C.E. Dawson
Substations: Station was subdivided evenly into five substations from Miraflores Lake side to lower chamber side (1 to 5). Each substation consists of two collecting sites, floor (F) and wall (W). U-M-1-F, U-M-1-W, U-M-2-F, U-M-2-W, U-M-3-F, U-M-3-W, U-M-4-F, U-M-4-W, U-M-5-F, U-M-5-W. U-M-6-F: Floor, step down to lower level next to U-M-5-F. U-M-6-W: Wall, step down to lower level next to U-M-5-W.
Species: 26, 28, 39, 41, 42, 47, 54, 56, 59, 63, 66, 68
Station 204: Lower chamber.
Date: 26, 27 Aug 1974
Collectors: M.L. Jones, J. Rosewater, H. Kaufman, and C.E. Dawson
Substations: Station was subdivided evenly into six substations from upper chamber side to Pacific Ocean side. Each substation consists of two collecting sites, floor (F) and wall (W). L-M-1-F, L-M-1-W, L-M-2-F, L-M-2-W, L-M-3-F, L-M-3-W, L-M-4-F, L-M-4-W, L-M-5-F, L-M-5-W, L-M-6-F, L-M-6-W.
Species: 26, 41, 42, 44, 49, 50, 59, 63, 66
Station 1524: Upper east chamber.
Date: 17 Jan 1972
Collectors: C.E. Dawson, M.L. Jones, P. Glynn, R. Rubinoff, and others
Remarks: Collections were from middle sump and east sump of drained locks; seine and ichthyocide. Salinity in middle sump, 20.2 ‰.
Species: 2, 16, 20, 26, 50
Station 1525: Lower east chamber.
Date: 17 Jan 1972
Collectors: C.E. Dawson, M.L. Jones, P. Glynn, and others
Remarks: Collections were from east sump (first sump, west of sea gate); ichthyocide.
Species: 2, 20, 26, 44, 46, 63, 66, 75
Station 1536: Third Lock, drainage ditch.
Date: 16 Apr 1972
Collectors: C.E. Dawson, M.L. Jones, and J. Bayas
Remarks: Rocks, silty bottom; ichthyocide. Salinity,

10.0 ‰; depth, 0–0.2 m.
Species: 1, 2, 54
Station 1718: East lane, middle sump of upper chamber.
Date: 25 Aug 1974
Collectors: C.E. Dawson, M.L. Jones, and H. Kaufman
Remarks: Ichthyocide and nets during dewatering.
Species: 20, 26, 54, 59, 66
Station 1719: East lane, lower sump of upper chamber.
Date: 25 Aug 1974
Collectors: C.E. Dawson, M.L. Jones, and H. Kaufman
Remarks: Ichthyocide and nets during dewatering.
Species: 16, 20, 22, 23, 24, 26, 50, 56, 59, 68
Station 1720: East lane, sump, lower chamber.
Date: 26 Aug 1974
Collectors: C.E. Dawson, M.L. Jones, and H. Kaufman
Remarks: Ichthyocide and nets during dewatering.
Species: 23, 26, 32, 33, 41, 44, 46, 66, 70
Station 1728: Upper chamber, west lane, lower sump.
Date: 26 Jan 1976
Collectors: C.E. Dawson, M.L. Jones, and K. Millard
Remarks: Ichthyocide and nets during dewatering. Salinity, 5.0 ‰.
Species: 2, 26, 50, 56, 59, 63
Station 1729: Upper chamber, west lane, chain slot near middle chamber.
Date: 26 Jan 1976
Collectors: C.E. Dawson, M.L. Jones, and K. Millard
Remarks: Ichthyocide and nets during dewatering. Salinity, 4.0 ‰.
Species: 20, 26, 50
Station 1730: Lower chamber, sump, west lane.
Date: 13 Jan 1976
Collectors: C.E. Dawson, M.L. Jones, and K. Millard
Remarks: Ichthyocide and nets during dewatering.
Species: 26, 44, 54, 55, 59, 63, 66, 68, 75
Station 1731: Third lock; lake and drainage stream.
Date: 14 Jan 1976
Collectors: C.E. Dawson and M.L. Jones
Remarks: Ichthyocide; small rocks, weeds mud. Salinity, 6.0 ‰; depth, 0–0.6 m.
Species: 14, 54

4. Barro Colorado Island.
LGA 69-25, 26: Area surrounding laboratory loading dock.
Date: 12 Feb 1969
Collectors: L.G. Abele and T. Zaret
Remarks: Bottom mud covered with dead leaves. Night collecting.
Species: 13
LGA 69-61: Ollie's Creek.
Date: 24 Jun 1969
Collector: L.G. Abele
Species: 8, 82
LGA 69-63: Luntz Stream.
Date: 26 Jun 1969
Collector: L.G. Abele
Species: 3, 8, 9, 15, 82

5. Rio Cocoli.
LGA 73-25: Rio Cocoli at K-6 road crossing, to 4 m wide.
Date: 26 Feb 1973
Collectors: L.G. Abele and M.H. Robinson
Species: 4
LGA 74-8: Rio Cocoli, small stream at bridge to Cocoli (first bridge from Pan Am Hwy on road to Cocoli), emptying into west side of Panama Canal.
Date: 28 May 1974.
Collector: L.G. Abele
Species: 72, 78

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