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BRACHYURAN CRABS OF COCOS ISLAND (ISLA DEL COCO), COSTA RICA: LEUCOSIIDAE, CALAPPIDAE, AND PARTHENOPIDAE, WITH DESCRIPTIONS OF TWO NEW SPECIES

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ABSTRACT

Recent additions from Cocos Island, Costa Rica, to the collections of the Natural History Museum of Los Angeles County have increased the number of species in the brachyuran crab families Leucosiidae, Calappidae, and Parthenopidae known from the island from 4 to 10. Two of these are described: *Thyrolambrus verrucibrachium,* new species, and *Osachila kaiserae,* new species. Review of all material in the LACM collections for these species has resulted in range extensions and increases in the known maximum size for several of the species. The increase in species richness suggested by these collections may make Cocos the most speciose single island in the eastern Pacific, after the remaining crab families are studied. The zoogeographic relatedness of the oceanic islands of the eastern Pacific is supported, and the link between Cocos and the Revillagigedo Islands is strengthened.

Cocos Island, which is now one of the national parks of Costa Rica, sits on the Cocos Ridge at 5°32′57″N, 86°59′17″W, 494 km west of Cabo Blanco, Costa Rica, 673 km northeast of La Pinta (Abingdon) Island in the Galapagos, and 2,375 km southeast of Clipperton Island. Cocos is volcanic in origin, with lavas dated at around two million years old (Bellon *et al.,* 1983; Castillo *et al.,* 1988), and is covered by wet tropical forest. Much of the 23.3 km of coastline is bounded by steep cliffs, and only two areas afford protected anchorage: Chatham Bay and Wafer Bay. The island is situated in the path of the eastward flowing North Equatorial Countercurrent for much of the year, but from December–April westerly currents reach the island from the mainland when the counter current shifts to the south (Wyrtki, 1965).

The brachyuran fauna of Cocos Island has been somewhat undercollected, when compared to the other oceanic islands of the tropical eastern Pacific (Revillagigedo, Clipperton, and the Galapagos Islands), although numerous collecting expeditions have visited Cocos Island in the past. Among those cruises reporting decapods were the *Albatross* in 1891 (Faxon, 1895), the *Arcturus* in 1925 (Boone, 1927), the *Velero III* in 1933 and 1938 (Fraser, 1943), and the Presidential Cruise of 1938 (*U.S.S. Houston*) (Schmitt, 1939). None of these expeditions stayed at the island for more than a few days, and only 31 species of Brachyura were listed by Hertlein (1963), who reported on what was known of the fauna of the island at the time. A review of the literature by the authors has increased this number to approximately 42 species. As a result, the brachyuran fauna of Cocos seems comparable to the other eastern Pacific oceanic islands, such as the Revillagigedo Islands (45 species at Clarion, 38 species at Socorro, 61 species total) (Garth, 1992a), Clipperton (34 species) (Garth, 1965), and the Galapagos (120 species) (Garth, 1991). However, this conclusion may be premature, especially when one considers that Cocos is the least isolated of the islands. In comparison, the more intensively studied fish fauna of the island is diverse, with ~300 species, nearly three-fourths of the number found on the Galapagos (Lavenberg, 1989).

In recent years, the material from Cocos Island held by the Natural History Museum of Los Angeles County has expanded greatly, providing the opportunity to add to the knowledge of the brachyuran fauna of the island. This is the first in a series of papers describing the decapod fauna of Cocos Island.

MATERIALS AND METHODS

Species from the brachyuran crab families Leucosiidae, Calappidae, and Parthenopidae from Cocos Island, Costa Rica, eastern Pacific, either held in the Crustacea collections of the Natural History Museum of Los Angeles County (LACM) or found in the literature, are reported.

LACM specimens have resulted from the following expeditions (dates indicate Cocos stations; primary interest and techniques in parentheses): *Velero III*; (2–4

February 1932) (28 February–3 March 1933), (13–14 January 1938) (crustaceans *et al.*; shore collecting, dredge). *Velero IV*; (2–3 June 1973) (fishes; trawl). *Searcher*; (30 March–6 April 1972) (fishes; trawl, hook and line, ichthyocide, and SCUBA). Malacology survey expeditions; 1987, 1988, 1989, 1991, 1992 (mollusks *et al.*; shore collecting, dredge, SCUBA, tangle net). LACM–Taylor Fund Expedition; (23–30 April 1988) (fishes and invertebrates; shore collecting, SCUBA, hook and line). LACM–*Undersea Hunter* Expedition; (21–28 February 1994) (decapod crustaceans and echinoderms; shore and SCUBA).

The vast majority of our specimens were collected through the efforts of Kirstie Kaiser in collaboration with Michel Montoya, Donald Shasky, Henry Chaney, and others, whose malacological surveys of the island have yielded vast numbers of crustaceans as bycatch. This is due not only to the many hours of shallow-water collecting with SCUBA, but also to the efficiency of tangle nets used in deeper waters. Another large number of decapods from the island has resulted from the efforts of Gordon Hendler, Darryl Felder, Anna Dittel, Nicholas Gotelli, Lisa Torres, Sergio Nates, Charles Mitchell, and the two authors who intensively collected the shallow waters (using SCUBA) and intertidal areas of the island from 21–28 February 1994.

Specimens from Cocos and/or comparison material from other areas reported herein are held in the collections of either the United States National Museum of Natural History, Smithsonian Institution (USNM), the Museo de Zoología, University of Costa Rica (UCR), or the Natural History Museum of Los Angeles County, including specimens cataloged with LACM numbers (LACM), cataloged and/or identifiable by Allan Hancock Foundation numbers or *Velero III* and *Velero IV* station numbers (AHF), and *Zaca* station numbers (Zaca).

When applicable, male right first and second pleopods were removed, placed in glycerol and drawn using a Nikon Labophot–2 compound microscope with drawing tube, and with phase contrast stage set at intermediate points between light field and dark field. Other drawings were made using a Wild model M–5 APO dissecting microscope with drawing tube. All measurements were made using a Mitutoyo Digimatic caliper.

Statistical analyses were made using NCSS 6.0.1 (Hintze, 1995).

Station data of material examined have been given verbatim from museum labels (with the exception of bracketed information). Inconsistencies in spelling of location names on labels have been kept for the sake of curation management.

Single asterisks indicate range extensions and/or size increases. Abbreviations are as follows: CW = carapace width at widest part; CL = carapace length at midline. fms = fathoms. Many descriptive terms have been taken from Arnold (1965).

Results

Family Leucosiidae Samouelle, 1819
Subfamily Ebaliinae Stimpson, 1871a
Genus *Ebalia* Leach, 1817
Ebalia clarionensis Rathbun, 1935

Ebalia clarionensis Rathbun, 1935: 2; 1937: 132, pl. 82, figs. 3, 4.—Garth, 1992a: 3 (tab. 1), 4.—Hendrickx, 1995a: 128 (list); 1997: 115, fig. 84.

Type Material.—Sulfur Bay, Clarion Island, Mexico; 32 fms (59 m); nullipores; 5 January 1934, *Velero III* Station 136–34, Hancock Galapagos Expedition, 1 ♂ holotype (USNM 69343) CW 6.7 mm, CL 6.3 mm.

Material Examined (5 specimens).—COCOS:—Off Nuez [Manuelita] Island, 56.7–91.5 m, 13 January 1938, *Velero III* Station 773–38, 1 ovigerous ♀ (homeotype) (LACM 38–32.4).—Off Nuez [Manuelita] Island, 55–91.5 m, 14 January 1938, *Velero III* Station 779–38, 1 ♂ (homeotype) (LACM 38–38.13).—Chatham Bay, 73.2–84.2 m, 14 January 1938, *Velero III* Station 780–38 1 ♂ (LACM 38–295.1).—Bahía de Chatham (~5°33.15′N, 87°00.45′W), 90 m, 2 April 1992, collected by K. L. Kaiser, 1 ♀ (LACM 92–18.2).—NW of Isla Cascara, Bahía Wafer (5°33.15′N, 87°04.15′W), 95–100 m, sand and rubble, 6–7 April 1992, collected by K. L. Kaiser, 1 ♀ (LACM 92–30.2).

Diagnosis.—Surface covered with crowded punctae. No marginal teeth at widest part of carapace. Small median hollow on cardiac region (after Rathbun, 1937).

**Measurements.*—Largest (both Cocos): *Male (LACM 38–38.13) CW 9.3 mm, CL 8.5 mm. *Female (LACM 38–32.4) CW 8.6 mm, CL 7.7 mm.

**Range.*—Clarion Island (Revillagigedos), *Cocos Island.

Depth.—55–100 m.

Habitat.—Nullipores, sand and rubble.

Remarks.—*Ebalia clarionensis* is similar in general appearance to *E. cristata* Rathbun, 1898, in that the posterior portion of the carapace (cardiac and branchial regions) is inflated, and the subhepatic, lateral, and posterior lobes/teeth are rounded and not prominent (as they are in *E. hancocki* Rathbun, 1933). The chelipeds are similar in thickness to those of *E. cristata*; however, the thin, produced, dorsal edge (crista) on the propodus and dactylus that characterizes *E. cristata* is absent. Similarities to *E. hancocki* include: the hint of erosion, or relief, prevalent on the carapace of *E. hancocki*; the narrow, more produced anterior portion of the carapace; and the general shape of the chelipeds. Although Rathbun (1937: 128) stated that the chelipeds are less swollen than those of *E. hancocki,* we have found just the opposite. In addition, the flattened granules of *E. clarionensis* seem to be packed together more closely than are those of the other two species.

Although this species has been considered to be endemic to Clarion Island for over 60

years (Rathbun, 1937; Garth, 1992a; Hendrickx, 1995a), it has in fact been known from Cocos for nearly as long. Three of the specimens (LACM 38–32.4, 38–38.13, and 38–295.1) were collected in 1938 by the *Velero III.* Two of these (homeotypes) were compared (by Garth) to the type specimen in 1939 (according to tags in the vials). However, these specimens were unreported until now.

It should be noted that the type information given by Rathbun (1937) is in error. According to the logs of the *Velero III,* the date of collection should read 1934 instead of 1935. Garth (1992a, appendix) erroneously listed the station number as 135–34 instead of 136–34.

Family Calappidae de Haan, 1833
Subfamily Calappinae de Haan, 1833
Genus *Calappa* Weber, 1795
Calappa convexa de Saussure, 1853

Calappa convexa de Saussure, 1853: 362(9), pl. 13, fig. 3.—Rathbun, 1924: 159; 1937: 206, pl. 62, figs. 1–3, and synonymy.—Boone, 1927: 280, fig. 99.—Garth, 1946a: 360–361, pl. 62, fig. 6; 1948: 19.—Del Solar *et al.,* 1970: 25.—von Prahl and Alberico, 1986: 98 (list).—von Prahl and Sanchez, 1986: 23, fig. 1.—Hendrickx, 1995a: 128 (list); 1995b: 578, fig. 3, 580.—Hendrickx *et al.,* 1997a: 5 (tab. 1), 11.

Calappa flammea.—Cano, 1889: 249. Not *Calappa flammea* (Herbst, 1794).

Type Material.—Mazatlan, Sinaloa, Mexico (Geneva Museum) (according to Boone, 1927; not found by Rathbun, 1937).

Material Examined (6 specimens).—COCOS:—Isla Manuelita, 30 m, 23 April 1987, collected by K. L. Kaiser, 3 juveniles (LACM 87-287.1).—Bahía de Chatham, 27 m, 29 March 1989, collected by K. L. Kaiser, 1 ♂ (LACM 89-207.1).—Wafer Bay, intertidal, under rock, collected by D. Felder and J. Martin, 1 immature ♀ (LACM 94-131.1). OTHER:—Caleta La Cruz, Tumbes, Peru, 12–30 m, sand, collected by E. M. Del Solar, 1 ♂ (AHF 1970-2).

Diagnosis.—Carapace broad, about 1.5 times as wide as long in adults, rounded in front, surface granulate with low tubercles, posterior third with short transverse granulated ridges. Chela with 2 large tubercles near dentate crest of manus; additional tubercles in some specimens continuing ventrally as 2 parallel rows. Finger tips dark (modified from Rathbun, 1937, and Garth, 1946a).

**Measurements.*—Largest: Female (USNM 50652) CL 98.2 mm, CW 142.4 mm. Width at sinus in front of "wings" 114.5 mm (Rathbun, 1937). *Male (LACM 89-207.1) CL 96 mm, CW 153 mm, width at sinus 130.4 mm.

Range.—From Magdalena Bay, Baja California, and Penasco Point, Sonora, Mexico, to Caleta La Cruz, Tumbes, Peru (AHF 1970-2) (Hendrickx, 1995a); Galapagos Islands (Williams Expedition) (according to Garth, 1946a.—See remarks for *C. saussurei* Rathbun, 1898); Cocos Island (but see Remarks).

Depth.—Recorded 0–75 m (Hendrickx *et al.,* 1997a). Cocos 0–30 m.

Habitat.—Sand, and occasionally muddy sand (Hendrickx, 1997b).

Atlantic Analogue.—*C. flammea* (Herbst, 1794).

Remarks.—Based on the material from Cocos, the juveniles of this species exhibit many features much more strongly and/or differently from the adults. The ratio of CW to CL increases from 1.0:1.0 in the smallest individuals examined (CW 3.75 mm) to 1.6:1.0 in the largest (CW 153 mm). This results in a much greater convexity to the carapace in the smaller individuals. The juvenile carapace also has much greater relief, due to the relatively greater size of the tubercles. The gastric region is separated from the hepatic region by depressions. Larger tubercles on the outer surface of the palm form two parallel rows running along the bottom third before turning upward at an angle of about 120° proximal to the dactylar junction. Finger tips can be wholly or mostly white. Three small teeth are present in the digital cleft of the major cheliped in opposition to the basal tooth of the dactylus.

Hertlein (1963) listed this species as reported from Cocos but we have been unable to locate his source. Subsequent authors (e.g., Lemaitre and Alvarez León, 1992; Hendrickx, 1995a) have not included Cocos as part of the range of this species.

Calappa saussurei Rathbun, 1898

Calappa saussurei Rathbun, 1898: 609, pl. 41, fig. 6; 1937: 206, pl. 63, figs. 1–4, 43.—Finnegan, 1931: 611, fig. 1.—Crane, 1937a: 98.—Garth, 1948: 19; 1961: 121; 1966: 12.—Del Solar *et al.,* 1970: 25.—von Prahl and Alberico, 1986: 98 (list).—von Prahl and Sanchez, 1986: 23, fig. 1.—Hendrickx, 1990: 44; 1995a: 128; 1995b: 578, fig. 4, 581.—Hendrickx *et al.,* 1997a: 5 (tab. 1), 11.—Lemaitre and Alvarez León, 1992: 51 (list).

Type Material.—La Paz Bay, Gulf of California (24°18′00″N, 110°22′00″W), 26.5 fms (49 m), broken shell, 30 April 1888, *Albatross* Station 2823, 1 ♂ (USNM 21596); CW at middle 23.6 mm, greatest width 24.4 mm, width at posterolateral angles 22.9 mm, CL 20.5 mm.

Material Examined (2 specimens).—COCOS:—Bahía de Chatham (~5°33.15′N, 87°00.45′W), 85.5 m, 2 April 1992, collected by K. L. Kaiser, 1 juvenile (LACM 92-18.1). OTHER:—Off Peru (03°43′S, 81°03′W), 300 m, mud bottom, collected by E. M. Del Solar, 31 August 1970, 1 ♀ (LACM 70-323.1)

Diagnosis.—Carapace narrow, widest at antepenultimate tooth of lateral margin; dorsum covered with well-spaced mammillate/conic tubercles; outer face of chelipeds with large, evenly spaced tubercles.

Measurements.—Largest: Male CW 42.3 mm, CL 34.5 mm (*Zaca* Station 150 D-27). Female CW 42.6 mm, CL 34.8 mm (*Zaca* Station 224 D-3) (both in Garth, 1966).

**Range.*— From Tosca Point, west coast of Baja California, and throughout Gulf of California, Mexico (Hendrickx, 1990, 1995a), to off Peru (03°43′S, 81°03′W) (LACM 70-323.1) (Del Solar *et al.,* 1970); *Cocos Island.

Depth.—1–300 m (Garth, 1966; Del Solar *et al.,* 1970).

Habitat.—Shell and rubble, and sand (Hendrickx *et al.,* 1997a).

Atlantic Analogue.—*C. tortugae* Rathbun, 1933 (see Williams and Child, 1988).

Remarks.—Rathbun (1937) reported one young of this species from the Galapagos Islands (USNM 69334), which Garth (1946a) later determined to be *C. convexa,* along with a second specimen from the Galapagos (USNM 69758). Garth noted that "It [*C. convexa*] may be distinguished from nearly related *C. saussurei* by the short, transverse, granulated ridges on the posterolateral portions of the carapace, those of *C. saussurei* being extended beyond the margin of the carapace onto the teeth at the posterolateral angles." This statement is in error. The granular ridges of *C. convexa* extend from the carapace to the tips of the posterolateral teeth. The granules on the posterolateral teeth of *C. saussurei* may line up beginning at the tip of the tooth, but they are not conspicuous, and do not extend onto the carapace. This leaves the question as to the identity of the Galapagos specimens. The photograph of the South Seymour Island specimen (USNM 69753; Garth, 1946a, pl. 63, fig. 6) shows these to be *C. convexa.* The distinguishing characters are the notched, or bidentate, rostrum and the rough "bumpy" appearance of the carapace. The rostrum of *C. saussurei* appears singular and rounded (unless the specimen is tilted forward), and the carapace appears smoother, with more evenly spaced clumps of granules. The pattern of tubercles on the chelipeds is another character that can be used to separate juveniles. Those of *C. saussurei* are smaller, granulate, more numerous, and evenly spaced into rows running along the face of the propodus, while those of *C. convexa* are fewer, larger, irregular in size and may form a double-angled row (see remarks for *C. convexa*). In addition, the tips of the chelipeds of *C. saussurei* are never darkly colored.

Juvenile specimens of *C. gallus* (Herbst, 1803), the third eastern Pacific species of *Calappa,* were not available for comparison. However, adult specimens of *C. gallus* from Hawaii (USNM 29892) and Panama (USNM 43996) share the general features of *C. convexa* except that the rostrum extends past the lower margin of the orbital cup in dorsal view, and pits define the hepatic regions, with furrows separating the gastric and cardiac regions from the branchial regions of the carapace. From these comparisons, we are confident that the juvenile specimen from Cocos is *C. saussurei.*

Genus *Cryptosoma* Brullé, 1837

Fig. 1A, B

Cryptosoma bairdii (Rathbun, 1898) form *garthi* Galil and Clark, 1996.

Synonymy for *garthi* form only:

Cycloes bairdii Rathbun, 1898: 610.—Finnegan, 1931: 613.—Garth, 1960: 121 (tab. 5) (part); 1992a: 3 (tab. 1) (part), 5 (part).—Lemaitre and Alvarez León, 1992: 51 (list).

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Fig. 1. Male right first pleopod tips of *Cryptosoma bairdii* form *garthi* (LACM 89-197.2) from Cocos Island, (A) dorsal and (B) ventral view; and *Cryptosoma bairdii* form *bairdii* (LACM 96-90.1) from San Juanito Island, Mexico, (C) dorsal and (D) ventral view. Both tips together when drawn for each view, relation of B to D unaltered (as seen when drawn).


A
C
B
D

Cycloës bairdii.—Rathbun, 1937: 229 (part), 230 tab. 74 (part).—Garth, 1946a: 362, figs. 7, 8, pl. 62; 1946b: 620; 1948: 19 (part); 1966: 1 (list) (part), 13 (part).—von Prahl and Sanchez, 1986: 24, fig. 2.—Hendrickx, 1995a: 128 (list) (part).

Cryptosoma garthi Galil and Clark, 1996: 190, figs. 5D–F, 8A, B, 9A.

Type Material (for *C. garthi*).—See remarks.

Material Examined (283 specimens sexed to a CW of 15 mm).—COCOS:—Off Nuez [Manuelita] Island 56–92 m, 13 January 1938, *Velero III* Station 772–38, 1 ♀ (LACM 38-31.3).—Wafer Bay, 3.5–7.5 m, sand, 2 March 1933, *Velero III* Station 108–33, 2 juveniles (LACM 33-115.5).—Chatham Bay E. of Punta Pacheco in lee of Isla Ulloa (5°33′12″N, 87°02′14″W), 6 m, sand against coral reef, 1 April 1972, ichthyocide and SCUBA, *Searcher* Station 511, 3 immature ♂♂, 2 immature ♀♀, 8 juveniles (LACM 72-382.1).—Off Bahía Chatham (~5°33.68′N, 87°02.37′W), 91 m, coral bits, 24 March 1989, tangle net, collected by K. L. Kaiser, 1♂, 1♀ (LACM 89-197.2).—Bahía de Chatham (~5°33.5′N, 87°02.3′W), 46 m, 26 March 1989, dredge, collected by K. L. Kaiser, 1 immature ♂ (LACM 89-164.1).—Bahía Chatham (~5°33.14′N, 87°02.38′W), 24–30 m, sand, 27 March 1989, collected by K. L. Kaiser, 1 immature ♂ (LACM 89-299.1).—Off Bahía Chatham (~5°33.54′N, 87°00.60′W), 82 m, rocks and sand, 10 February 1991, tangle net, collected by K. L. Kaiser, 1 ♂, 1 ♀ (LACM 91-143.7).—Off Bahía Chatham (~5°33.54′N, 87°00.60′W), 82 m, rocks and sand, 11 February 1991, tangle net, collected by K. L. Kaiser, 2 ♂♂, 1 ♀, (LACM 91-143.8).—Off Bahía Chatham (~5°33.54′N, 87°00.60′W), 82 m, rocks and sand, 10–13 February 1991, tangle net, collected by K. L. Kaiser, 2 ♂♂ (LACM 91-143.6).—Bahía de Chatham (~5°33.15′N, 87°00.45′W), 90 m, 2 April 1992, collected by K. L. Kaiser, 1 immature ♀ (LACM 92-18.6).—S. of Bahía Iglesias (5°29.48′N, 87°03.05′W), 95–100 m, hydrocorals and debris, 5 April 1992, tangle net, collected by K. L. Kaiser, 2 ♂♂, 2 ♀♀ (LACM 92-28.1).—Bahía Wafer, NW of Isla Cascara (5°33.15′N, 87°04.15′W), 95–100 m, sand and rubble, 6, 7 April 1992, collected by K. L. Kaiser, 1 ♀ (LACM 92-30.6). OTHER: REVILLAGIGEDOS:—Braithwaite Bay, Socorro Island, 36 m, 4 January 1934, *Velero III* Station 133-34, 1 ♂, 6 juveniles (LACM 34-6.5).—Socorro Island, 7–19 m, 8 June 1934, *Velero III* Station 291-34, 4 juveniles (AHF).—Socorro Island, 36 m, 8 June 1934, *Velero III* Station 294-34, 1 ♀ (AHF).—Clarion Island, 101 m, 11 June 1934, *Velero III* Station 301-34, 1 juvenile (AHF).—Clarion Island, 37 m, 11 June 1934, *Velero III* Station 304-34, 2 juveniles (AHF).—3 mi off Pyramid Rock, Clarion Island, 101 m, 12 May 1936, *Zaca* Station 163, D-2, 3 ♂♂, 1 ♀ (LACM).—North of Clarion Island, 56–103 m, 17 March 1939, *Velero III* Station 921-34, 2 ♂♂ (AHF).—Off Sulfur Bay, Clarion Island, 73 m, 11 June 1934, *Velero III* Station 382-34, 1 ♂, 1 ♀ (AHF). GALAPAGOS.—"Velero" Bay, South Seymour Island, 3–8 m, 19 February 1933, *Velero III* Station 87-33, 1 ♂, 2 juveniles (AHF 33013).—Gardner Bay, Hood Island, 55 m, *Velero III* Station 204-34, 1 ♂, 2 juveniles (AHF 34044–LACM 34-78.9).—Academy Bay, Indefatigable Island, 18–46 m, 25 January 1938, *Velero III* Station 807-38, 1 immature ♂, 8 juveniles (AHF). MAINLAND: COSTA RICA:—Puerto Culebra, dredge, 25 February 1934, number 257, collected by W. L. Schmitt, 1 ♂ (USNM 69174). PANAMA:—Piñas Bay, 27.5 m, 29 January 1935, *Velero III* Station 440-35, 3 juveniles (AHF).—Secas Island, 26 m, 5 February 1935, shells and nullipores, *Velero III* Station 450-35, 6 juveniles (AHF).—Secas Island, 5.5 m, 2 March 1938, *Velero III* Station 865-38, 1 ♂, 1 ♀, 4 juveniles (AHF). COLOMBIA:—Port Utria, 18 m, 24 January 1935, *Velero III* Station 417-35, 2 juveniles (AHF).—Port Utria, 37 m, 25 January 1935, *Velero III* Station 423-35, 1 juvenile (AHF). ECUADOR:—Solango Islands, 15 m, 18 January 1935, *Velero III* Station 399-35, 1 immature ♂ (AHF).

Mixed Material (with *C. bairdii* sensu strictu and/or intermediate specimens).—MEXICO:—Isabel Island, Sinaloa, 18–27.5 m, 8 March 1938, *Velero III* Station 870-38, 2 immature ♂♂, 2 immature ♀♀, 1 juvenile (AHF).—Tartar Shoals S of Acapulco, 24 m, 22 May 1968, 2 immature ♀♀ (AHF 1969-8).—1.75 mi. N.E. of Cape San Lucas, Gulf of California, 18.2 m, 11 March 1949, *Velero IV* Station 1724-49, 2 ♂♂, 1 ♀ (AHF).—Chacahua Bay, Oaxaca, 9–19 m, 9 January 1938, *Velero III* Station 765-38, 2 immature ♀♀, 107 juveniles (AHF).—Chacahua Bay, Oaxaca, ? m, 20 March 1939, *Velero III* Station 927-39, 2 immature ♂♂, 1 immature ♀, 32 juveniles (AHF).—Tangola Tangola Bay, 29 m, 13 December 1939, *Zaca* Station 196 D-16, 3 immature ♂♂, 3 immature ♀♀, 24 juveniles (LACM). COSTA RICA:—Puerto Culebra, 25 February 1934, collected by W. L. Schmitt, *Velero III* Station 257, 2 ♂♂, 5 juveniles (USNM 69174).—Gulf of Dulce, 18–41 m, 26 March 1939, *Velero III* Station 939-39, 1 ♂, 7 immature ♂♂, 4 immature ♀♀ (AHF).

Diagnosis.—Carapace slightly broader than long, broadest anterior to lateral spine, regularly convex, median regions well defined; surface finely and densely granulate. Branchial ridges with tuberculate warts. Front with subtriangular, median notch. Anterolateral margin with beaded edge, 5 or 6 denticles behind orbit; short sharp tooth or spine at lateral angle.

Chelipeds strong, dissimilar; outer surface of palm granular, separated into 3 zones. Upper margin of chela with 9 teeth; irregular row of granules parallel to lower margin, obtuse tooth proximal to row; dactyl of major chela with stridulating band of 30 transverse ridges on inner surface (modified from Williams, 1984, and Galil and Clark, 1996).

Color.—In alcohol the majority of individuals have a tan-gray carapace fading to cream on the legs and underside. Two specimens from Cocos (LACM 92-28.1, two largest males), however, are much more colorful. The smaller of the two has a deep grayish-red ground color (orange red in life) on the carapace and upper surface of the chelipeds. Faint red spotting can be seen in these areas. The merus of the last pereiopods has a wide purple/red stripe running the length of the dorsal (posterior) face, and a narrow purple/red

stripe running dorsal to it. A photograph taken while this specimen was alive indicates that, although the colors have faded, the same pattern was present with the exception that the red on the merus of the last pereiopods extended to the other segments. The larger of the two was much paler, with more pronounced spotting, and a thinner red line on the face of the merus of the last pereiopod (more similar to the color description by a Petersen in Garth, 1946a). This indicates that coloration is variable even among individuals within a single location. Color notes for a specimen from Socorro (AHF 294–34) indicate purple dots on the carapace and chelipeds with eight prominent yellow spots on the chela and two on the merus; walking legs each with a longitudinal purple stripe.

Measurements.—Largest: Male (AHF–*Velero III* Station 302–34, Clarion Island) CW 55.1 mm, CW between spines 51.1 mm, CL from rostral sinus 48.8 mm, CL from rostral tip 50.2 mm. Female (USNM 22125) (Bay of Panama); CW 49 mm, width between spines 47.5 mm, CL 45.8 mm (Rathbun, 1937). Cocos specimens: Male (LACM 92–28), CW 54.6 mm, CW between spines 52.3 mm, CL from rostral sinus 48.4 mm, CL from rostral tip 49.4 mm. Female (LACM 92–30), CW 44.1 mm, CW between spines 42.6 mm, CL from rostral sinus 39.3 mm, CL from rostral tip 40.2 mm.

Range.—Eastern Pacific from Cape San Lucas, Baja California, Mexico, to La Libertad, Ecuador; Revillagigedos, Cocos, and Galapagos Islands.

Depth.—2.7–266 m (Rathbun, 1937).

Habitat.—Sand and rubble.

Remarks.—Although *C. bairdii* form *garthi* occurred with the new *Osachila* sp. at four of six stations between 1989 and 1992 and seemed to be fairly common, only two other specimens have been reported from Cocos (Rathbun, 1937). This is odd in that the *Velero III* and *Velero IV* collected *Osachila* from Cocos in 1938 and in 1973, respectively, and the *Searcher* collected *Osachila* in 1972, but neither brought up any *Cryptosoma*. This may be due either to changing community structure or to the use of tangle nets and dredges during the 1989–1992 samplings.

Although the invariability of cheliped characters distinguishing those populations to the south of Costa Rica on the mainland, and on the offshore islands, is strong evidence for species recognition, we are not convinced by the existing evidence that the mainland population to the north is distinct and separate. We have, therefore, chosen to regard *Cryptosoma garthi* Galil and Clark (1996) as a form of *C. bairdii* rather than as a distinct species or subspecies. Our arguments for this are as follows. Galil and Clark stated that several characters distinguish *C. garthi*:

(1) "Color pattern." We do not feel that coloration is a reliable character separating *C. garthi* from *C. bairdii*. The color retained by the specimens mentioned above after four years in alcohol gives us confidence in the variability among individuals. Two individuals (LACM 96–90.1) (clearly identifiable as *C. bairdii* form *bairdii* based on cheliped characters) from Isla San Juanito, Mexico, in alcohol for only five months, showed similar variation and pattern as those specimens from Cocos. They also did not fit the color description by Crane (in Garth, 1966). Both were tan–gray fading to cream. The smaller female had orange spots on the upper surface of the chelipeds and carapace, while the larger male shared the same ground color, showed only the faintest hint of spots, but had a red stripe on the upper face of the merus of the last pereiopods.

(2) "Sharply converging posterolateral margins, somewhat rougher carapace, obtuse rather than acuminate tooth proximally on chela, and a beaded line rather than an uneven granulate ridge parallel to lower margin of cheliped." We have not been able to use the convergence of the posterolateral margins as a diagnostic character. Individuals with larger granulation on the carapace tend to have less relief to the carapace, and an obtuse tooth and beaded line on the chela. However, some individuals are more or less intermediate in these characters. We have found it difficult to separate young individuals based on the morphological characters, and in some instances lots from throughout the range of *C. bairdii* sensu Galil and Clark arguably contain adults and/or juveniles of both morphs. This is true for both type localities [Cape San Lucas, *Velero IV* Station 1724–49 (AHF) and Puerto Culebra, Costa Rica (USNM 69174)].

(3) Gonopod morphology. After placing right first pleopods from two males (form *bairdii* from Isla San Juanito, Mexico [LACM

96–90.1, CW 39.5 mm], and form *garthi* from Cocos Island [LACM 89–197.2, CW 37.6 mm]) side by side under the microscope, so that the tips could be drawn together, we could find no differences warranting specific status (Fig. 1A–D). Our illustrations for either form differ slightly from those of Galil and Clark (1996). After viewing the pleopods of the presumed holotype of *C. garthi* and also those of individuals from Cocos much larger than those used for Fig. 1, we feel that the variation observed among the first pleopods may be due to ontogeny.

Therefore, without stronger evidence of geographic isolation on the mainland for *C. bairdii* sensu stricto, a distinct hybrid zone, character displacement, or genetic sequence divergence, we cannot consider *C. garthi* to be a distinct species or subspecies at the present time.

In addition, there is confusion regarding the proposed holotype and paratypes for *C. garthi.* Galil and Clark (1996) separated the specimens cataloged as USNM 69174 into the following: *C. bairdii.* "Puerto Culebra, 25.ii.1934. coll. W. L. Schmitt, id. M. J. Rathbun, 1 m 26.0 (USNM 69174)." *C. garthi.* "Puerto Culebra, 25.ii.1934, *Velero III,* Station 257, coll. W. L. Schmitt, id. M. J. Rathbun, 1 m 29.1 (USNH 69174), holotype; 6 juv. (USNM 69174), paratypes."

Assuming that the USNH is a typographical error, the USNM lot cataloged as number 69174 should have a total of eight specimens in it, two males and six juveniles, according to Galil and Clark (1996). There are no supplementary tags in the LACM or USNM materials identified as *C. garthi* in Galil and Clark (1996) (K. Reed and R. Lemaitre, personal communication). There are, however, two USNM lots "69174." These are thought to contain the type material; each contains only an original label. Labels read: "69174, 2 ♂ 5y, Cycloës bairdii Stimpson, Puerto Culebra, Costa Rica, Feb. 25 1934, Sta 257 Velero III. Waldo L. Schmitt coll. Id. M. J. Rathbun" (= lot with seven specimens). "69174, 4 ♂, 10 juv., Cycloës bairdii Stimpson, Costa Rica: Puerto Culebra, Dredging around isles in bay, Feb. 25, 1934, # 257. W. L. Schmitt (coll. & Don.) Acc. No. 128938" (= lot with one male specimen with separate vial containing first and second pleopods).

The two males in the first lot measure [(CL including frontal teeth) CL at midline]: (21.5) 21.0 mm and (29.4) 28.3 mm. The larger male fits the description of *C. bairdii,* not *C. garthi.* The single specimen in the second lot (male, CL (29.3) 28.7 mm, CW 30.3 mm) has had its left first and second pleopods removed, and the first pleopod matches fig. 8 of Galil and Clark (1996). Therefore, this specimen is most certainly the specimen on which the description of *C. garthi* was based. It is our opinion that the second lot contains the holotype male, while the first lot contains six paratypes (the smaller male and the five young) plus the single individual of *C. bairdii* listed as having a CL of 26 mm in Galil and Clark (1996) (instead of the actual 28.3 mm).

These specimens have, therefore, been separated, and are now cataloged as follows:—USNM 69174, *Cryptosoma garthi* Galil and Clark, 1996, 1 ♂, CL (29.3) 28.7 mm, CW 30.3 mm, holotype.—USNM 260893, *Cryptosoma garthi* Galil and Clark, 1996, 1 ♂, CL (21.5) 21.0 mm, CW 22.2 mm, 5 juveniles, paratypes.—USNM 269894, *Cryptosoma bairdii* (Stimpson, 1860), 1 ♂, CL (29.4) 28.3 mm, CW 29.8 mm.

From a biogeographical standpoint, the presence of populations consisting entirely of the *garthi* form from the Bay of Panama southward, the Galapagos, Cocos, and most of the specimens from the Revillagigedo Islands, it seems probable that there is some genetic cohesiveness within this region, and possible unidirectional gene flow toward the Mexican and northern Central American mainland, either from the islands or from the mainland to the south. This would account for the variation seen in the northern mainland population.

Family Parthenopidae Macleay, 1838
Genus *Parthenope* Weber, 1795
Parthenope exilipes (Rathbun, 1893)

Lambrus (Parthenolambrus) exilipes Rathbun, 1893: 234.
Lambrus hassleri Faxon, 1893: 152; 1895: 14, pl. 3, figs. 1–1a.
Lambrus exilipes.—Rathbun, 1898: 581.
Parthenope (Platylambrus) exilipes.—Rathbun, 1925: 523, pls. 184, 185; pl. 277, figs. 1, 2.—Boone, 1927: 172, fig. 57.—Crane, 1937b: 64.—Garth, 1946a: 409, pl. 69, fig. 2; 1958: 439, pl. Z_1, figs. 3–3a; pl. 48, fig. 2; 1959: 121; 1960: 115; 1992a: 3 (tab. 1), 5.—Del Solar, 1970: 44.—Del Solar *et al.,* 1970: 36.—Sosa-Hernández *et al.,* 1980: 34, pl. 12A [in part, not female from Station A25
=*Parthenope (Parthenope) hyponcha* (Stimpson)].—Hendrickx, 1990: 46; 1993: 312 (list 15).—Hendrickx *et al.,* 1990: 145.—Hendrickx *et al.,* 1997a: 5, 14.

Parthenope exilipes.—von Prahl *et al.*, 1990: 27.—Lemaitre and Alvarez León, 1992: 54 (list).—Moran and Dittel, 1993: 614.—Hendrickx, 1995a: 133.

Type Material.—Off San Domingo Point, Baja California, Mexico, 74 fms (135 m), *Albatross* station 3043, 1 ♂ (USNM 17365).

Material Examined (11 specimens).—COCOS:—Off Bahía de Chatham (approximately 5°33.54′N, 87°00.60′W), 82 m, rocks, 10 February 1991, collected by K. L. Kaiser, 1 ovigerous ♀ (LACM 91-143.2).—Off of Bahía de Chatham (approximately 5°33.54′N, 87°00.60′W), 82 m, rocks, 10–13 February 1991, collected by K. L. Kaiser, 1 ovigerous ♀, egg size 0.27 mm (average of 10) (LACM 91-143.1). MAINLAND: COSTA RICA:—Golfo de Papagayo, Guanacaste Province, Costa Rica, 66–67 m, 13 November 1987, 3 ♂♂, 2 ♀♀ (LACM 87-214.2).—Golfo de Papagayo, Guanacaste Province, Costa Rica, 78–80 m, 3 December 1987, collected by W. Bussing, 1 ♂, 2 ♀♀ (LACM 87-215.1). PERU:—Off Puerto Chicama, La Libertad, Peru (08°05′S, 80°05′W) , 150 m, mud, January 1966, 1 ♂ (LACM 66-382.1).

Diagnosis.—Carapace high, tuberculate; interregional depressions shallow; hepatic and interbranchial pits deep. Tooth at lateral angle largest of marginal teeth. Four prominent median and one large branchial tubercle. Rostrum channeled, trilobate. Propodi and dactyli furred. Male first pleopod stout, tapering to tip; tip truncate and twisted; cluster of setae on lip of groove; other short setae lateral and terminal. Male second pleopod nearly as long as first, sinuous, tip elongate, slender, subterminal denticulate tooth (from Garth, 1958).

**Measurements.*—Largest: *Male (LACM 87-214.2), CW with spines 52.1 mm, CW without spines 45.3 mm, CL with rostrum 34.9 mm, rostrum 3 mm. Female (USNM 21966; Rathbun, 1925), CW 40.3 mm, CL 29.7 mm. Female (LACM 87-215.1), CW with spines 41.2 mm, CW without spines 36.2 mm, CL with rostrum 29.3 mm, rostrum 1.5 mm.

**Range.*—From San Domingo Point, Baja California, Mexico, and Estero Tastiota, Sinaloa, Mexico; Revillagigedo Islands, Cocos Island, and Galapagos Islands (Hendrickx, 1995a); south to off *Puerto Chicama, La Libertad, Peru (AHF 1969-16).

Depth.—Intertidal to 150 m.

Habitat.—Mud, rocks.

Atlantic Analogue.—Parthenope (*Platylambrus*) *pourtalesi* (Stimpson, 1871a).

Remarks.—The Cocos Island specimens are not as spinose as some with which they were compared. Although both specimens are the same size (CL 24.53 mm, and 24.34 mm) and are from the same area, the smaller of the two has worn away the corneous tips of all dactyli and the dentition of the chelae. Futhermore, it is slightly fouled with filamentous growths (hydrozoans?) and calcareous worm or gastropod tubes. A lack of pubescence on the legs and a reduced amount of setation overall are unique to this specimen. Identification of the specimens was reached after comparison with LACM specimens of *P. exilipes* from Mexico (AHF 965-05, *Velero III* Station 767-38, and *Zaca* stations 184, D-2 and 150, D-27); El Salvador (AHF 1968-2); Costa Rica (Zaca Station 214, D-3 and D-4); Panama (*Velero III* Station 948-39); Colombia (*Velero III* Station 239-34); Galapagos Islands (*Velero III* stations 190-34, and 814-38); Peru (AHF 1969-16, *Velero III* stations 393-35 and 843-38). Tuberculation of the legs and chelae separate the Cocos specimens from *P. johngarthi* Hendrickx and Landa-Jaime, 1997.

This is the second record of this species from Cocos. The first specimen, reported by Faxon (1893) as *Lambrus hassleri,* was collected at *Albatross* Station 3368 (5°32′45″N 86°54′30″W), 66 fms (121 m).

Genus *Solenolambrus* Stimpson, 1871a
Solenolambrus arcuatus Stimpson, 1871b

Solenolambrus arcuatus Stimpson, 1871b: 101.—A. Milne Edwards, 1878: 162.—Rathbun, 1910: 576; 1925: 538.—Finnegan, 1931: 625.—Garth, 1946a: 413, pl. 69, figs. 3, 4; 1948: 31; 1958: 459, pl. Z_3, figs. 9–9a, pl. 52, fig. 1; 1959: 122; 1960: 115; 1992a: 3 (tab. 1), 5.—Hendrickx *et al.*, 1990: 145.—Hendrickx, 1993: 312; 1995a: 133 (list).—von Prahl *et al.*, 1990: 27.—Lemaitre and Alvarez-León, 1992: 54.—Moran and Dittel, 1993: 614.

? *Solenolambrus typicus.*—Cano, 1889: 102, 187. Not *S. typicus* Stimpson, 1871a.

Type Material.—Panama, holotype ♀, not extant (according to Garth, 1958).

Material Examined (2 specimens).—COCOS:—Isla Cascara, Bahía Wafer (5°33.15′N, 87°04.15′W), 95–100 m, sand and rubble, 7 April 1992, collected by K. L. Kaiser, 1 ♂ (LACM 92-30.1).—76–92 m, dredged, 21 March 1997, collected by K. L. Kaiser, 1 ♂ (LACM 97-130.1. OTHER: MEXICO:—Tepoca Bay, Gulf of California, Mexico (Velero Station 1078-40), 20–24 m, 4 February 1940, 1 ♀ (AHF 40325).

Diagnosis.—Two erect prominences on midline of carapace, one cardiac, one gastric; a smaller tooth at midpoint of branchial ridge. Superior crests of manus 9-toothed, surface between crests smooth; retracted dactylus at

right angle with palm. Sternum between chelipeds smooth, concave. Male first pleopod short, thick, [human] thigh-shaped; groove open basally, lip of groove produced, plumosely setose, dense covering of plumose setae elsewhere. Male second pleopod three-fourths as long as first, tapering, tip corneous, concavity denticulate (from Garth, 1958).

**Measurements.*—Largest: *Male CW 16.9 mm, CL with rostrum 13.2 mm, rostrum 2.1 mm (LACM 97–130.1). Female CW 14.6 mm, CL 11.2 mm, rostrum 0.7 mm (AHF 40325) (Garth, 1958).

**Range.*—Cape San Miguel and Tepoca Bay, Gulf of California, Mexico, to Santa Elena Bay, Ecuador; Revillagigedo and Galapagos Islands (Hendrickx *et al.,* 1990); Gorgona Island (von Prahl and Alberico, 1986); *Cocos Island.

Depth.—2.7–109.8 m (Garth, 1958).

Habitat.—Mud, sand, and shell rubble (Garth, 1958).

Atlantic Analogue.—Solenolambrus typicus Stimpson, 1871a.

Remarks.—Although only two specimens have been found at Cocos, Garth (1958) remarked on the abundance and wide range of habitats of this species in other areas. Both specimens from Cocos are slightly larger than previously reported specimens.

Genus *Thyrolambrus* Rathbun, 1894
Thyrolambrus verrucibrachium new species
Figs. 2–4

Thyrolambrus glasselli.—Garth, 1958: 452, (tab. 99) (in part; cheliped from Cocos).—Hertlein, 1963: 246 (same). Not *T. glasselli* Garth, 1958.

Thyrolambrus astroides.—Garth, 1992a: 3 (tab. 1), 5; 1992b: 1, fig. 1.—Hendrickx, 1995a: 133 (list). Not *T. astroides* Rathbun, 1894.

Material Examined (6 specimens).—*HOLOTYPE.*—Cape Henslow, Socorro Island, Revillagigedo Islands, Mexico, 26 November 1984, collected by P. L. Haaker, 1 ♂ (LACM 84–514.1). *PARATYPES:* COCOS:—Roca Sucia (Dirty Rock) (~5°33.7′N, 87°02.30′W), 24 m, from shakings, 26 March 1989, collected by K. L. Kaiser, 1 immature ♂ (LACM 89–165.1).—Isla Manuelita (~5°33.7′N, 87°02.78′W), 21–24 m, under rocks, 22 March 1989, collected by K. L. Kaiser, 1 ♀ (LACM 89–194).—East of Isla Manuelita (~5°33.8′N, 87°03.02′W), 18 m, 21 March 1989, collected by M. Montoya and K. L. Kaiser, 1 juvenile ♀ (LACM 89–178).—Punta Rodriguez (~5°30.57′N, 87°05.63′W), 15–19.8 m, under rocks, 13 February 1991, collected by K. L. Kaiser, M. Montoya, and D. Shasky, 1 ♂ (LACM 91–145.1). *OTHER:* COCOS:—Wafer Bay, 2–4 fms (3.7–7.3 m), 2 March 1933, *Velero III* Station 108–33, 1 partial chela (LACM 33–115.4).

Diagnosis.—Reticulation of surface robust, not frostlike (in *T. astroides,* asterlike tips of granules making up reticulations are distinctive, with rays extending out from ridges. This, combined with light color of tips, contrasting with base tan color, resembles a network composed of snowflakes or frost in preserved specimens). Dorsum even, not trilobed, hepatic region not depressed. Posterolateral margins with about 8 indistinct tubercles, none acute. Chela moderate, covered with warty tubercles, armed on inner side with 2 rows of thickened spines; hands long, moderately thick.

Description (Holotype and Paratypes).—Carapace.—Width of posterior margin 1.5 times length (from 1.39 in smallest individuals); posterior/posterolateral angle strongly oblique (~167°); posterolateral edges with about 8 moderately distinct bumps, edge continuing as bluntly dentate ridge around subbranchial region stopping at weakly dentate subhepatic swelling; posterolateral/lateral angle approximately 100°, apex sharp; lateral/anterolateral angle (~130°) broadly curving to slight hepatic swelling; lateral and anterolateral margin thick, face perpendicular to dorsum, top edge rounded; angle between anterolateral margins approximately 108°. Surface unevenly granulate, paxilliform granules coalescing to form reticulations, individual granules usually rounded, not pointed and crisply asterlike; dorsal surface flat except for shallow transverse intestinal depression and moderate branchial depressions, branchial depressions deepest at cardiac/gastric junction, extending along hepatic juncture but not reaching margin; frontal area deflexed, shallow depression between orbits preceded by small pit. Rostrum thick, produced, deflexed, rounded in dorsal view, tipped with small downward pointing tooth prolonged into interantennular septum. Orbits small, circular; eyestalks with 3 rows of simple granules proximally, independent fourth row of uneven acute granules next to cornea.

Antennae.—Basal article mobile under slight pressure, anteromedial angle of basal article nearly touching front, anterolateral angle of same extending beyond suborbital angle of orbital hiatus, second article filling remainder of orbital hiatus (orbital hiatus filled

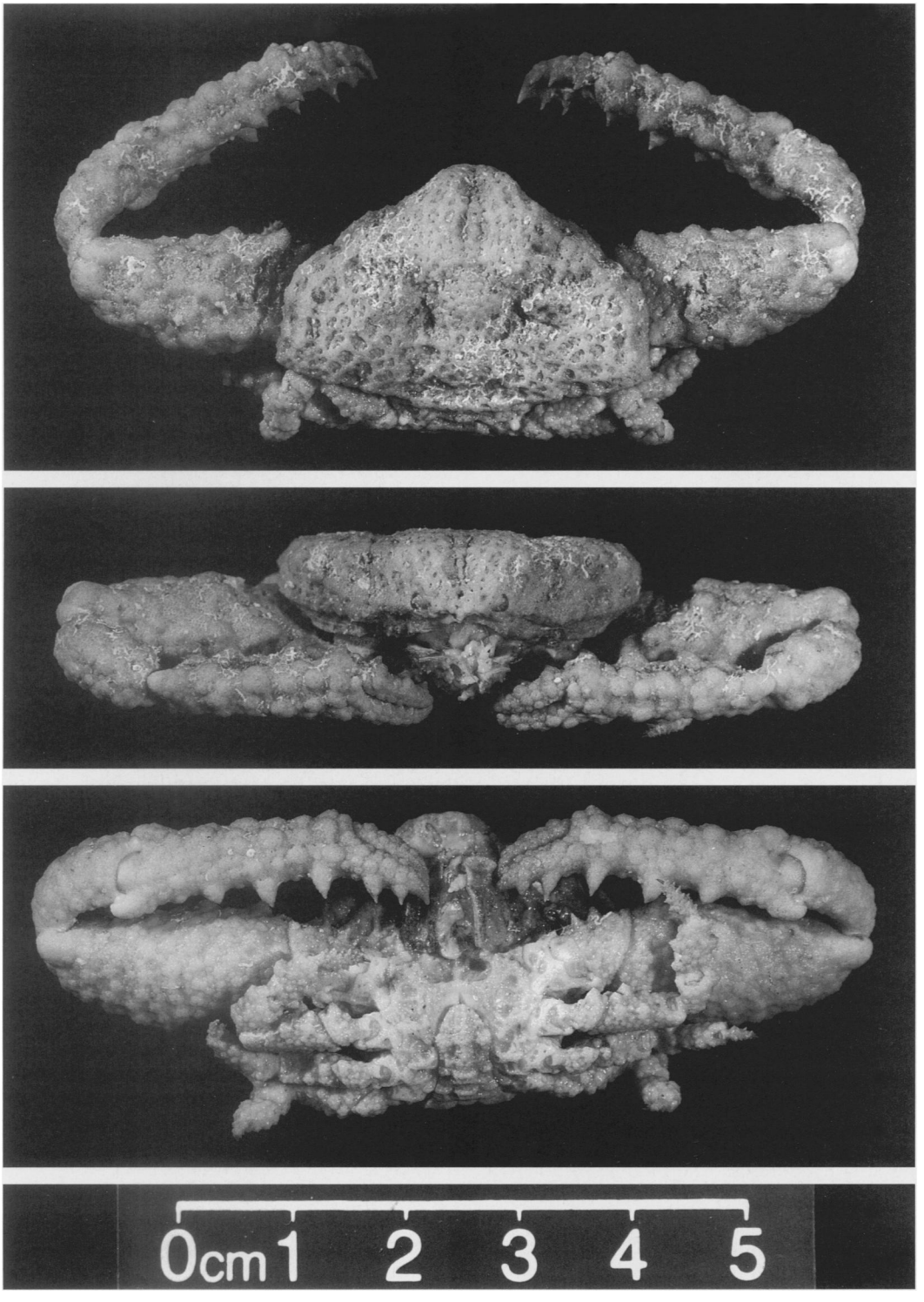

Fig. 2. *Thyrolambrus verrucibrachium,* new species, holotype male (LACM 84–514.1), CW 32.1 mm.

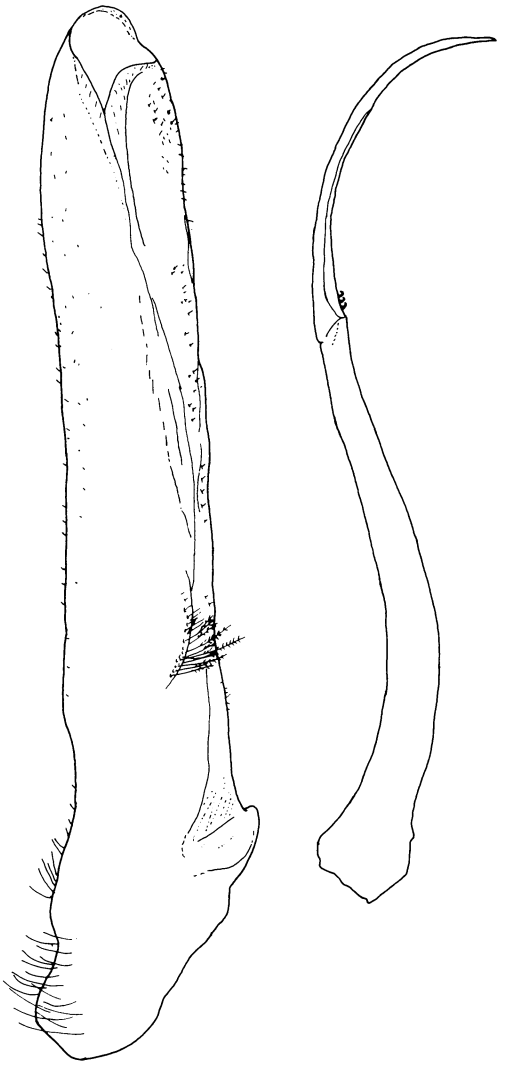

Fig. 3. *Thyrolambrus verrucibrachium,* new species, holotype male (LACM 84–514.1) right first and second pleopods.

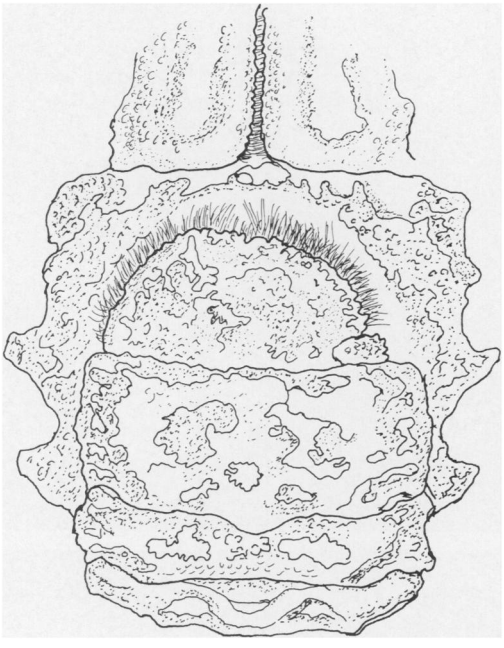

Fig. 4. *Thyrolambrus verrucibrachium,* new species, paratype female (LACM 89–165.1) deformed abdomen.

with second and third antennal articles in smaller individuals).

Third Maxilliped.—Covered with granules and small tubercles. Endopod: ischium with central groove widening posteriorly, regions next to groove swollen, larger clumps of granules forming 2 indistinct teeth on each side, inner margin with fringe of setae. Merus with distolateral corner produced and proflexed, distomedial corner indented; tooth in proximolateral quadrant following in line with 2 lateral teeth of ischium. Carpus with 3 dentate teeth along dorsal edge; granules continuing down one-fourth width of face. Propodus with 1 dentate tooth on dorsal edge. Exopod lateral edge with 4 teeth, most proximal inset from edge; face with uneven row of tubercles.

Sternum.—First segment with moderately deep eroded pit in front of abdominal groove (males only); small spine/tooth present just beyond lateral edge of pit; several small teeth present just posterior (absent in female, indistinct in juveniles); anterior slope of abdominal furrow with deep sulcus, transverse depression forming at base of sulcus extending laterally to 2 deep pits in second segment; pits surrounded laterally and posteriorly by 2 setal fields (absent in female); tooth present above groove on each side of furrow lateral to setal fields; region lateral to abdominal furrow of sternites 2–5 eroded.

Chelipeds.—Entire surface granulose, covered with low warty tubercles (reticulate pattern of granules seen only in juveniles). Ischium anterior edge with 3 strong denticulate teeth. Merus thigh-shaped, tapering distally; two-thirds visible in dorsal view; with 3 larger acute tubercles on proximal leading edge in line with teeth of ischium. Propodus: left and right equal; not narrower than carpus;

Table 1. Measurements (in mm) of adult holotype and paratype specimens of *Thyrolambrus verrucibrachium,* new species. Carapace: CWPA = width at posterolateral angle, CWAA = width at anterolateral angle, and CL = carapace length. Right cheliped: ML = length of merus from distal point of ischium to distodorsal knob, PLD = length of propodus dorsally from proximal knob to distodorsal edge, PLV = length of propodus ventrally from proximal knob to tip of fixed finger, and PW = width of propodus.

Specimen	CWPA	CWAA	CL	ML	PLD	PLV	PW
LACM 84-514.1 ♂	32.1	30.9	21.3	20.0	16.9	25.5	5.1
LACM 89-194.1 ♀	22.2	22.6	15.8	10.7	9.5	14.2	3.0
LACM 91-145.1 ♂	19.0	19.1	13.2	10.0	9.1	13.4	2.2

knobs present at dorsal and ventral carpal condyles; ventral knob followed by 1 small tubercle and 5 thick-based spines (3 on manus, 2 on fixed finger); inner dorsal edge of propodus with line of 5 larger tubercles, third of which being diminutive, distal 2 (fourth and fifth) spine-tipped; these followed on dactylus by 3 spines. Dorsal face of propodus straight, dorsal junction with dactylus not expanded upward (as in *T. astroides* Rathbun, 1894, and *T. glasselli* Garth, 1958). Fixed finger slightly thicker than dactylus. Both fingers deflexed downward when closed, equal in thickness to face of manus, not tapering until distal spine (fingers tapering evenly from base in juveniles); tips spinous, curved inward.

Second Pereiopod.—Ischium with large tooth preceded by small tooth. Merus with 3 ventral teeth, smallest proximal, largest adjacent on anteroventral edge, third midway along posteroventral edge; dorsal edge with 4 large granulate tubercles, most proximal inset. Carpus with largest 2 tubercles at each end of dorsal edge. Propodus with 2 swollen toothlike protuberances on both dorsal and ventral edges. Dactylus covered with small spinous projections; tip corneous.

Third–Fifth Pereiopods.—Pattern similar to P1 but teeth reduced to granulate tubercles; dactylus of P5 diminutive in proportion to propodus.

Male First Pleopod.—Thick, straight, tip not reaching much past locking tubercles of sternum, proximal edge of tip aperture even with tubercle.

Variation.—Larger granules sometimes asterlike but not paxilliform on certain areas such as telson and maxillipeds, especially in larger individuals. Female: sternal pit preceding abdominal furrow indistinct (unlike in *T. astroides* and *T. glasselli* where pit is discernible, shallow, and covered by telson). Setal fields on first sternite absent. Genital pores on third sternite with hinged operculum. Female with deformed telson; left side reduced laterally, with small podite present at origin of uropod in more primitive decapods (Fig. 4). Juveniles: reticulation more defined but not as frostlike as in *T. astroides.* Pattern continuing onto merus of chelipeds. Granules more toothlike; many toothlike projections seen on larger individuals indistinguishable from other granules in juveniles. Carapace width about 1.35 times length in smallest individuals. Fingers of cheliped tapering evenly from base. Basal article of antenna not reaching orbital hiatus, hiatus filled by second and third articles.

Measurements.—See Table 1.

Range.—To date, collected only on Socorro Island and Cocos Island in the eastern Pacific.

Depth.—15–24 m.

Habitat.—Found under rocks.

Atlantic Analogue.—Thyrolambrus astroides Rathbun, 1894.

Remarks.—Garth (1992b) reported on the Socorro specimen here designated as holotype. Because he relied on the published descriptions, Garth was unable to differentiate that specimen from *T. astroides,* noting the necessity of comparing gonopods before a definite identification could be made. He also commented on the biogeographical problem caused by the few known specimens of *T. astroides* (six held in the U.S. National Museum of Natural History, USNM; [five from Havana, Cuba, and one from Mauritius in the Andaman Sea], one reported from the Caribbean Coast of Colombia [Campos and Manjarres, 1990], and one from Socorro Island in the eastern Pacific). The problem was in understanding how *T. glasselli* (found from Magdelena Bay, Baja California, to Gorgona Island, Colombia, as well as Clarion and So-

corro Islands in the Revillagigedos), could be the Pacific analogue of *T. astroides* if the latter species still occurred in the eastern Pacific. And why would *T. astroides* be a relic on the islands instead of *T. glasselli*?

Originally, we could not convincingly differentiate our specimens based on the damaged holotype and allotype without knowing the range of variation in the Atlantic specimens. We were able later to compare our specimens with the entire holdings of the USNM (all five specimens from Havana, Cuba, and the Mauritius specimen), as well as the type of *T. glasselli* and also specimens of *T. erosus* (Miers, 1879) and *T. cariei* (Bouvier, 1914), both from Eniwetok atoll. Although there are slight differences in gonopod morphologies, based mainly on relative curvature of the second pleopod (*T. astroides*) or first pleopod (Mauritius specimen) (Zimmerman and Martin, unpublished data), it is easier to use other characters to distinguish the species. The most striking gonopod-related difference is seen while the appendages still lie in the abdominal furrow. The tips of the gonopods of *T. astroides* and the Mauritius specimen reach well beyond the locking tubercles of the sternum, while those of *T. verrucibrachium* reach only just past those tubercles. We are certain that the specimens from the eastern Pacific are distinct from the Atlantic *T. astroides,* and that the Mauritius specimen is also different. It should be noted that the gonopod of *Daldorfia horrida* (Linné, 1758) figured by Dai and Yang (1991, fig. 89.1) appears to be nearly indistinguishable from *T. verrucibrachium* (Fig. 3) or *T. astroides,* and identical to the Mauritius specimen. However, the gonopod tips of *Daldorfia horrida* (AHF–Apre Harbor, Guam) fall short of the locking tubercle.

The differences between *T. verrucibrachium* and *T. astroides,* other than the amount of relief on the dorsum of the carapace, and the placement of the male first pleopod, are a matter of degree, mainly due to the size and shape of the granules covering the body. Both species are very different from *T. glasselli* in the proportion and structure of the cheliped and male first and second pleopods. Therefore, we feel that *T. verrucibrachium* is probably the eastern Pacific analogue of *T. astroides,* which has been displaced (or replaced) on the mainland by a congener whose origins lie elsewhere.

Etymology.—From the Latin *verruca* = wart, and *brachium* = arm, referring to the warty appearance of the chelipeds.

Genus *Daldorfia* Rathbun, 1904
Daldorfia garthi Glassell, 1940 (in Garth, 1940)

Parthenope (Pseudolambrus) excavata Boone, 1927: 173, fig. 58. Not *Lambrus excavata* Stimpson, 1871b.

Daldorfia garthi Glassell, 1940 (in Garth, 1940): 67, pl. 17, figs. 1–11.—Garth, 1946a: 412, pl. 55, figs. 1–11; 1958: 455, pl. Z_2, figs. 7–7a, pl. 51, fig. 2; 1959: 122; 1991: 126 (list).—Crane, 1947: 74.—Lemaitre and Alvarez León, 1992: 54 (list).—von Prahl and Alberico, 1986: 103, 104 (tab.).—Hendrickx, 1995a: 133 (list).

Type.—Sulivan Bay, James Island, Galapagos Islands, 1 ♂, with 1 ovigerous ♀ paratype) (AHF 3811).

Material Examined (2 specimens).—COCOS:—Isla dos Amigos (north islet) (5°30.55′N, 87°06.07′W), 15–24 m, rock/rubble, 4 April 1992, collected by K. L. Kaiser, 1 ♀ (LACM 92–26.1).—Isla Cascara, 9–22 m, rock shakings, collected by K. L. Kaiser, 1 immature ♂ (LACM 97–130.2)

Diagnosis.—Carapace triangular, deeply eroded, lower anterolateral margins spined posteriorly, posterolateral margins straight. Meri of ambulatory legs with overlapping teeth (forming perforations), propodi with bidentate lower margins. Chelipeds massive, unequal. Semiovoid sternal pit (Garth, 1946a). Male first pleopod cylindrical, coiled, scarcely tapering, groove open throughout most of length; double row of stout setae at lip of groove basally, surface elsewhere with scattered short setae. Male second pleopod length greater than first; corneous tip greatly elongated, its concave surface channeled (modified from Garth, 1958).

Measurements.—Largest: male (holotype) CW 48.6 mm, CL 31.2 mm. Female (paratype) CW 45.4 mm, CL 29.3 mm. Cocos: CW 13.1 mm, CL 9.1 mm.

**Range.*—Cape San Lucas, Baja California and Guatulco, Oaxaca, Mexico, to Octavia Bay, Colombia; Galapagos Islands (Garth, 1958, 1959; Hendrickx, 1995a); Gorgona Island (von Prahl and Alberico, 1986). *Cocos Island.

Depth.—3.6–55 m.

Habitat.—Found among rocks and rubble.

Atlantic Analogue.—None.

Remarks.—These specimens were compared with the holotype and paratype specimens held at the LACM (AHF 3811; Velero stations

446–35, 114–33, 447–35, and 444–35). In both *Thyrolambrus glasselli* and *Thyrolambrus verrucibrachium*, new species, which are similar to and with which *Daldorfia garthi* occurs, males have a shallow sternal pit. In addition, some male specimens of *T. glasselli* have a gaping major chela, and both species of *Thyrolambrus* have a scalloped, dentate lower anterolateral margin on the carapace (but it is much more obvious in *D. garthi*). Small specimens of *D. garthi* can be distinguished readily from both *Thyrolambrus* spp. by the perforated dorsal margin of the meri of the walking legs. Adults of both sexes are generally larger than either of the species of *Thyrolambrus* and can be easily identified by the robust, gaping, major chela and deep sternal pit.

Genus *Aethra* Latreille, 1816
Aethra scutata Smith, 1869a

Aethra scutata Smith, 1869a: 120; 1869b: 230.—Flipse, 1930: II.—Guinot, 1966a: 748, figs. 1, 5; 1966b (1967): 828–841 (part), figs. 25, 28, 38.—Garth, 1992a: 3 (tab. 1), 5.—Hendrickx, 1995a: 133 (list).—Hendrickx *et al.*, 1997b: 52, fig. 1.—Ng, 1999:114, fig. 2.

Oethra scruposa var. *scutata*.—A. Milne Edwards, 1878: 170, pl. 31, figs. 2, 2e.

Cryptopodia fornicata Aurivillius, 1889: 60. Not *Cancer fornicata* Fabricius, 1793.

Aethra scruposa scutata.—Rathbun, 1925: 552, pl. 195.—Garth, 1946a: 415, pl. 70, figs. 1, 2; 1958: 468, pl. Z_3, figs. 12–12a, pl. 53.

Type Material.—La Paz, Baja California, Mexico, holotype ♂, CW 56.6 mm, CL 35.3 mm, in Yale University Museum.

Material Examined (21 specimens).—COCOS:—Chatham Bay, east end (5°33′15″N, 87°02′38″W), 10.5–13 m, sand under large coral rubble, 30 April 1988, collected by K. L. Kaiser, 1 ♀ (LACM 88–40.7).—Bajo Alcyone (~5°00.58′N, 87°03.40′W), 34 m, rock, 25 March 1989, 1 immature ♀ (LACM 89–193.1).—East Point, Wafer Bay (~5°33.08′N, 87°04′W) , 12–15 m, 16 February 1991, collected by K. L. Kaiser, 1 immature (LACM 91–141.1).—Isla Cascara (~5°04.00′N, 87°04.00′W), 12–21 m, rocks and rubble, 10 February 1991, collected by K. L. Kaiser and M. Montoya, 1 ♂ (LACM 91–147.1).—Isla Cascara, NW of Wafer Bay (5°33.07′N, 87°04.00′W), 15–22.9 m, rocks and rubble, 4 April 1992, collected by K. L. Kaiser, 1 ♀ (LACM 92–24.1). GALAPAGOS:—Gardner Bay, Hood Island, 3.7 m, fish trap, 25 January 1933, 1 ♂ (LACM 33–206.1).—Sulivan Bay, James Island, shore, 21 January 1938, *Velero III* Station 796–38, 1 ♂, 2 ♀♀ (LACM 38–58.17).—Culpepper Bay, Darwin Island, 1984, 1 ♂ (LACM 84–512.1). REVILLAGIGEDOS:—Braithwaite Bay, Socorro Island, 28 November 1984, collected by H. L. Haaker, 1 ♂ (LACM 84–511.1). MAINLAND, MEXICO:—Cabo San Lucas, 1 ♂ (LACM A-1207).—Guaymas, 15 m, 4 July 1952, collected by L. Besson, 1 ♂ (LACM 52–79.1).—Playa Las Hadas, Santiago Peninsula, Manzanillo, Colima (19°05′57″N, 103°19′36″W), 0–4.5 m, 21–24 March 1963, collected by J. H. McLean and C. Tenny, 1 juvenile (LACM 63–10.63).—Maria Cleopha Island, east anchorage, Tres Marias Islands (21°25′N, 106°25′W), 5–9 m, on *Porites* reefs and ledges, 16–10 March 1965, collected by McLean and Miller, 1 juvenile (LACM 65–12.40).—Pulmo Bay, Baja California (23°22′N, 109°25′W), 1.5–6 m, on boulders, and ledges, some coral, 6–7 April 1966, collected by J. H. McLean and P. Oringer, 2 immature ♂♂ (LACM 66–19.59).—Pulmo Bay, Baja California, shore, 26 December 1966, collected by P. Vreeland, 1 ♂ (LACM 66–381.1).—Isla San Pedro, Nolasco, Sonora, 14 m, sand and rock, 15 July 1979, collected by A. Kerstitch, 1 ♀ (LACM 79–231.1). Guaymas, Sonora, 21–24 m, 22 June 1981, collected by A. Kerstitch, 1 ♀ (LACM 81–255.1).—Isla Maria Magdalena, Tres Marias Islands (21°32.480′N, 106°29.812′W), 15–23 m, under rock, 12 May 1996, collected by K. L. Kaiser, 1 ♀ (LACM 96–86.1). PANAMA:—Islas Ladrones, Gulf of Chiriqui (7°53.30′N, 82°28.30′W), 10.7–13.7 m, rocks, 13–14 April 1993, collected by K. L. Kaiser, 1 ♂ (LACM 93–62.1).

Diagnosis.—Carapace broadly elliptical, front arcuate, lateral margins lamellate, dentate, incised. Chelipeds and walking legs concealed from dorsal view, crested and dentate, especially on lower margins. Male first pleopod long, slender, tapering to acute tip, basally and apically setose. Male second pleopod almost as long as first, corneous extension occupying almost third of total length, channeled to blunt tip, subterminal projection (from Garth, 1958).

Measurements.—Male: CW 110.3 mm, female: CW 125.1 mm (Hendrickx *et al.*, 1997b).

Range.—San Pedro Nolasco Island, Sonora, Mexico (Gulf of California) to the Ladrones Islands, Gulf of Chiriqui, Panama; tip of Baja California Sur, Mexico; Las Tres Marias, Revillagigedos, Cocos, and Galapagos Islands.

Depth.—Intertidal to 34 m.

Habitat.—Rocks, rubble with sand, boulders, and ledges.

Atlantic Analogue.—None. Affinities are with the Indo-Pacific species *Aethra scruposa* (Linné, 1764) and *Aethra edentata* Edmondson, 1951.

Remarks.—A. Milne-Edwards (1878) regarded the American form to be a variation of the Indo-Pacific *A. scruposa* (Linné, 1764) based upon the known variation of *A. scruposa* (one specimen of *A. scutata* [from Mazatlan] and a photograph of the type specimen of *A. scutata*). Garth (1958) remarked

that "the ultimate decision as to one or two species should be based on pleopod studies." Guinot (1966b, figs. 39–41) figured pleopods for both *A. scruposa* and *A. scutata,* and it is evident from these figures, and those of Garth (1958) (fig. Z_3, 12, 12a), that these crabs should be considered two distinct species (see also Hendrickx *et al.,* 1997b; Ng, 1999). Therefore, we recognize four species of *Aethra*; *A. scutata* Smith, 1869a, found in the eastern Pacific; *A. scruposa* (Linné, 1764), from Guam and the Cook Islands to the east coast of Africa (Dai and Yang, 1991; Ng, 1999); *A. edentata* Edmondson, 1951, from Hawaii, Ogasawara (=Bonin), Mariana and the Marquesas Islands, and *A. seychellensis* Takeda, 1975, from Seychelles Bank (Ng, 1999).

The regression of CW on CL using the present material of *A. scutata* is linear (CW = 1.6 × CL – 1.27; R^2 = 0.998). The specimen of *A. scruposa* pictured in Sakai (1938) and the specimens examined by Ng (1999) fall below the lower 95% predicted confidence limits of individuals for *A. scutata.* The small juvenile and three adults measured by Ng (1999) all had CW:CL ratios between 1.41 and 1.433, while only the smallest individual of *A. scutata* measured by us (LACM 65–12.40; CW 18 mm, CL 12.1 mm) approached this with a ratio of 1.49. ANCOVA followed by Bonferroni (all pairs), Newman-Keuls, and Tukey-Kramer pairwise comparison tests indicate that *A. scutata* is narrower than both *A. scruposa* and *A. edentata* (the latter two species did not differ significantly in width ratio). This difference may be difficult to discern in very small specimens (<20 mm CW).

The key to the species of *Aethra* provided by Ng (1999) may be misleading, in that it uses depth of the median longitudinal groove to separate *A. scutata* from *A. scruposa* and *A. seychellensis.* This is based upon observation of two small juvenile specimens of *A. scutata.* The range of variation for this character in a larger sample of *A. scutata* indicates possible great overlap in both depth of the groove and rugosity of the lateral ridges, based on similarity to the photograph of the juvenile male *A. scruposa* (see Ng, 1999, p. 112).

The ratio of the measurements given by Edmondson (1951) for the holotype of *A. edentata* do not correspond with the photograph, to the other two specimens seen, or to the measurements reported by Ng (1999). Therefore, it is felt that the published measurements are in error.

Genus *Osachila* Stimpson, 1871a
Osachila kaiserae, new species
Figs. 5–7

Osachila sona.—Moran and Dittel, 1993: 602. Not *O. sona* Garth, 1940.

Material Examined (72 specimens; sex determined for CW of 15 mm and greater).—HOLOTYPE:—Off Bahía de Chatham, Isla de Coco (Costa Rica), East Pacific (~5°33.54′N, 86°00.60′W); 82 m, from rocks, 10 February 1991, collected by K. L. Kaiser, 1 ♂, CW 45.7 mm, CL 35.7 mm (LACM 91-143.5). PARATYPES: COCOS:—Off Nuez [Manuelita] Island 57–91.5 m, 13 January 1938, *Velero III* Station 772–38, 1 ♂, 1 ♀ (LACM 38–31.2).—Off Nuez [Manuelita] Island 57–91.5 m, 13 January 1938, *Velero III* Station 773–38, 1 immature ♂, 1 immature ♀ (LACM 38–32.5).—Chatham Bay, 73–84 m, 14 January 1938, *Velero III* Station 780–38, 3 immature ♀♀ (LACM 38–295.2).—1 mi NNW of Punta Gissler (5°33′27″N, 87°05′08″W), 110 m, 5 April 1972, *Searcher* Station 540, trawl, collected by R. Lavenberg, 1 immature ♀ (LACM 72–369.1).—1 mi 092°T from Isla Ulloa, 92 m, 2 June 1973, *Velero IV* Station 19040, 1 ovigerous ♀, (LACM 73–113.3).—1 mi 092°T from Isla Ulloa, 92 m, 2 June 1973, *Velero IV* Station 19040, 1 ovigerous ♀ (LACM 73–113.4).—1.1 mi 343°T from Isla Manuelita, 174 m, 2 June 1973, *Velero IV* Station 19043–73, beam trawl, 1 ♂, 2 ♀♀, 6 juveniles (LACM 73–116.3).—0.29 mi 038°T from Isla Manuelita, 92 m, 2 June 1973, *Velero IV* Station 19039, 1 ♀ (LACM 73–112.2).—2.1 mi 033°T from Isla Manuelita, 128 m, 2 June 1973, *Velero IV* Station 19042–73, 4 ♀♀ (LACM 73–115.4).—2 mi 055°T from Isla Manuelita, 109 m, 2 June 1973, *Velero IV* Station 19041–73, 1 ♂, 1 ♀, 1 ovigerous ♀, 1 immature ♀ (LACM 73–114.3).—2.75 mi 037°T from Isla Manuelita, 146 m, 3 June 1973, *Velero IV* Station 19044–73, 1 ovigerous ♀ (LACM 73–117.2).—Off Bahía de Chatham (~5°33.68′N, 87°02.37′W), 91 m, coral bits, 24 March 1989, tangle net, collected by K. L. Kaiser, 3 ♂♂, 1 ♀ (LACM 89–197.1).—Off Bahía de Chatham (~5°33.54′N, 87°00.60′W), 2 m, rocks, 11 February 1991, collected by K. L. Kaiser, 1♂, 1 immature ♂ (LACM 91-143.4).—Off Bahía de Chatham (~5°33.54′N, 87°00.60′W), 2 m, rocks, 10–13 February 1991, collected by K. L. Kaiser, 1 ♀, 1 juvenile (LACM 91-143.3).—Off Chatham Bay, 2 April 1992, collected by J. M. Montoya, 1 ♂, 1 ♀ (USNM 264617).—Off Bahía de Chatham (~5°33.15′N, 87°00.45′W), 90 m, coralline rubble, 2 April 1992, dredged, collected by K. L. Kaiser, 5 ♀♀, 1 ovigerous ♀ (LACM 92–18.3).—Off Bahía de Chatham (~5°33.15′N, 87°00.45′W), 90 m, coralline rubble, 2 April 1992, dredged, collected by K. L. Kaiser, 1 immature ♂, 1 immature ♀, 5 juveniles (LACM 92–18.4).—Off Bahía de Chatham (~5°33.15′N, 87°00.45′W), 90 m, coralline rubble, 2 April 1992, dredged, collected by K. L. Kaiser, 1 immature ♂ (LACM 92–18.5).—Bahía de Chatham (5°34.45′N, 87°02.27′W), 130 m, 2 April 1992, collected by K. L. Kaiser, 1 ♂ (LACM 92–19.1).—S of Isla Juan Bautista, SE of Bahía Iglesia (5°30.15′N, 87°02.25′W), coralline and shell rubble, 90 m, 5 April 1992, dredged, collected by K. L. Kaiser, 1 juvenile (LACM 92–29.2).—S of Isla Juan Bautista, SE of Bahía Iglesia, 90 m,

Fig. 5. *Osachila kaiserae,* new species, paratype female (LACM 92–29.3), CW 43.9 mm.

coralline and shell rubble, 5 April 1992, dredged, collected by K. L. Kaiser, 1 juvenile (LACM 92–29.1).—S of Isla Juan Bautista, SE of Bahía Iglesia, dredged, 90 m, coralline and shell rubble, 5 April 1992, collected by K. L. Kaiser, 1♀, 4 juveniles (LACM 92–29.3).—Bahía Wafer, NW of Isla Cascara (5°33.15′N, 87°04.15′W), 95–100 m, sand and rubble, 6 April 1992, collected by K. L. Kaiser, 1 immature ♂, 1 juvenile (LACM 92–30.4).—Bahía Wafer, NW of Isla Cascara (5°33.15′N, 87°04.15′W), 95–100 m, sand and rubble, 6–7 April 1992, collected by K. L. Kaiser, 6 juveniles (LACM 92–30.5).—Bahía Wafer, NW of Isla Cascara (5°33.15′N,

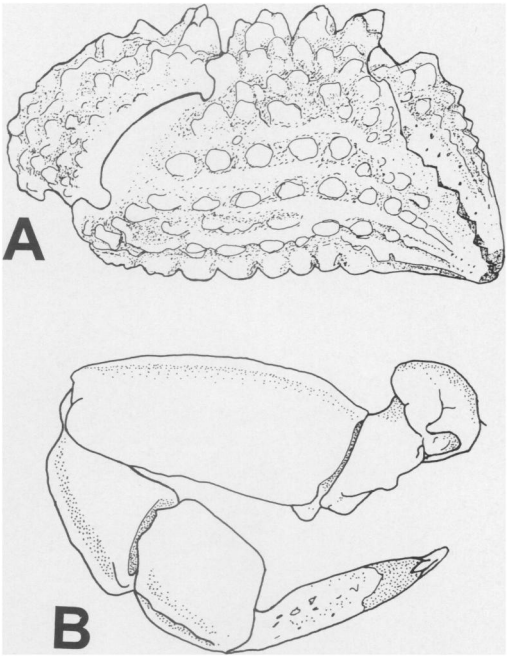

Fig. 6. *Osachila kaiserae*, new species, paratype female (LACM 92–29.3) (A) right cheliped, and (B) left fifth pereiopod.

87°04.15′W), 95–100 m, sand and rubble, 7 April 1992, collected by K. L. Kaiser, 1 juvenile (LACM 92–30.3). OTHER: MAINLAND, COSTA RICA:—Mouth of Gulf of Nicoya, 8.4 mi 232°T from Isla Herradura, Puntarenas Province, Costa Rica, 219 m, 17 May 1973, beam trawl, *Velero IV* Station 18942–73, 1 juvenile (LACM 73–110.3).

Diagnosis.—Carapace semioval anteriorly converging posteriorly; Anterolateral margins with 4 tripartite teeth separated by short sutures, cusps of teeth low, obtuse, nearly equal; posterolateral margins straight, with 4 subequal obtuse to rectangular teeth, anterior largest, slightly protruding; dorsum uneven but not rough, with triangular pattern of nodulose swellings. Manus of chelipeds with 8 widely spaced rows of protruding subcapitate peglike tubercles (Fig. 6A). Hind walking leg with smooth cristate dorsal margin, smooth face; posteroventral margin of merus carinate, straight or slightly convex, edge smooth or slightly irregular; ventral margin of dactylus not flared, velvet not extending more than one-third noncorneous length of dactylus (Fig. 6B).

Color.—In alcohol: ivory (often with wine-red freckling on dorsum), freckle (usually) present at supraorbital margin; velvet on dactyli of walking legs tan (to dark brown). In life: dorsum may have gray or tan over ivory base color.

Description.—Holotype and paratypes from LACM lots 89–197.1, 91–143.3, 91–143.4, 92–18.3, 92–18.4, 92–18.5, 92–29.1, 92–29.2, and 92–29.3 with reference to additional paratypes. Variation seen in paratypes placed in parentheses.

Carapace.—Surface very uneven, 5 major asperous swellings anterior to gastric depressions forming triangular pattern, with 2 metagastric, 2 mesobranchial, and 1 mesogastric swellings; 2 minor asperous swellings flank each mesobranchial swelling, 1 laterally and 1 posterolaterally, 2 frontal/rostral lobes sitting as apex to triangle; pattern reversed with less distinct swellings posterior to gastric depressions; wrinkled sulcus sometimes present on either side of intestinal region in larger specimens; epibranchial and hepatic regions sloping more or less evenly from protuberances (region not distinctly concave or convex). Texture microscopically smooth with minute dimpling caused by tiny pits; tops of swellings nodulose/asterlike (some individuals more nodulose over entire dorsum, especially posteriorly). Shape broad, semioval anteriorly, converging posteriorly; posterior margin narrow, posterior/posterolateral angle approximately 145°, posterolateral margins straight with rectangular or obtuse teeth, edges slightly thickened, anteriormost tooth slightly produced; anterolateral margins nearly parallel posteriorly, arcuate anteriorly; 4 anterolateral teeth separated by short sutures, sutures ending at small pits dorsally, teeth tripartite, cusps low, obtuse, nearly equal, median marginally larger, some cusps showing hint of additional denticle; toothed margin descending anteriorly to pterygostome as tuberculate ridge; hepatic and frontal margin straight, wide, parallel to posterior margin. Rostrum not much produced; dorsal margin lateral to orbits with small unequal tubercles, diffused tubercles continuing on subhepatic region. Orbits small, round, visible dorsally, ventral edge of orbit fringed with minute pubescence; eyestalks short, smooth, cornea narrower than peduncle; rostrum short, squared, or slightly rounded, sloping upward, bisected by suture ending at small oblong pit dorsally, edge pitted, frontal lobes fairly flat, not swollen. Subbranchial region setose over

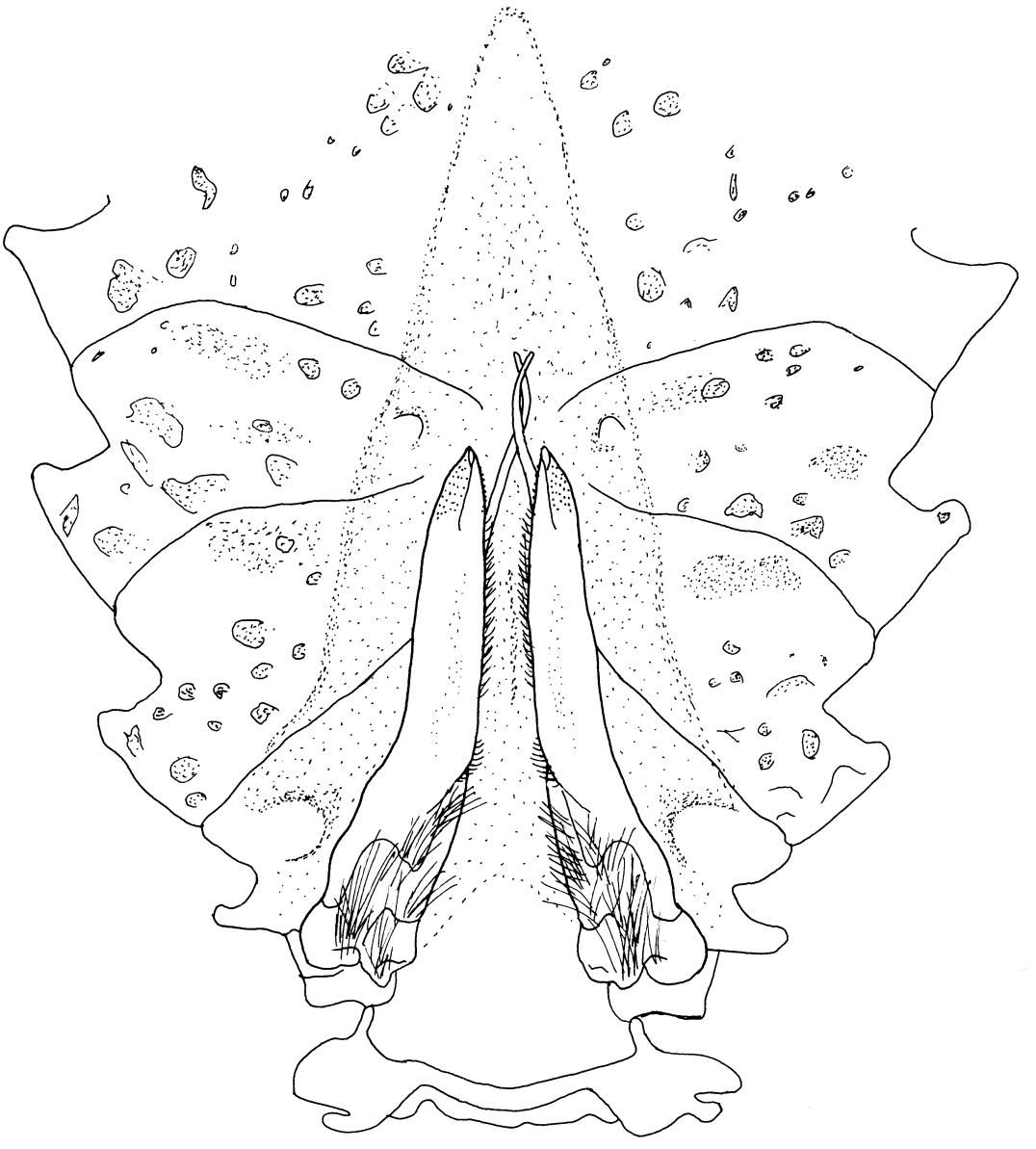

Fig. 7. *Osachila kaiserae,* new species, paratype male (LACM 89–197.1) ventral view with abdomen removed.

walking legs (may be worn), tooth (or protuberance) present between coxae of each pereiopod.

Face (delimited as area between rostrum and ischiomeral junction of third maxilliped vertically, and angle of subhepatic margins laterally).—Perpendicular to sternum; rostrum slightly extended, edge pitted, suture extending into interantennular septum; septum, antennules, and epistome smooth, not pitted (or less pitted than adjacent areas); antennules oblique; antennae and adjacent suborbital and subepistomial area dimpled with pits, basal segment of antennae about three-fifths wide as long, curving slightly inward, extending past lateral angle of orbital hiatus but not reaching dorsal angle of hiatus, third segment reaching angle; subhepatic, suborbital, and pterygostomial regions uneven with small obsolescent tubercles; pterygostomial area with slightly stronger tubercles; subhepatic region slightly inset from pterygostome, separated

by an oblique tubercle-edged shelf; pterygostomial and subbranchial regions ventral to face smooth except line of pubescence along ecdysial suture.

Third Maxillipeds.—Forming smooth spade-shaped appearance while held together, upturned at region of ischiomeral joint; pubescent band (often worn) beginning on sternum at base of cheliped and running across basis and proximolateral corner of ischium, then crossing to exopod at proximomesial curve before extending across exopod to outer edge, proximal third (¼–⅓) and distal third (¼–½) of exopod outer edge bare. Endopod: *Ischium* longer than merus, dimpled with small pits; more uneven with obsolescent tubercles distally; longitudinal row of 15 pits (11–15) forming slightly sinuous furrow, lateral to furrow obsolescent tubercles becoming stronger in distal third of segment. Merus tapering to point, with efferent branchial orifice at tip; lateral edge not distinctly curved, oblique to inner/mesial edge; inner/mesial edge extending slightly past lateral edge at efferent orifice; face of merus with longitudinal row of 10 pits (5–10), proximal 5 and 6 deepest, beginning lateral to ischial furrow, pits flanked on either side by row of appressed tubercles. Exopod smooth (or less pitted) proximal to pubescence, dimpled distally, double row of tubercles on distal third.

Sternum and Abdomen.—Weakly eroded. Male abdomen tapering fairly evenly with slight lateral protrusions at base of fifth and end of third segments, segments 3–5 fused. Female abdomen penultimate segment flared proximally.

Chelipeds.—With pubescent patch on ball of basis just reaching ischium and extending onto coxa. Ischium with carina on anteroventral edge (more distinct in juveniles). Merus ventral/flexor face nearly smooth, few distinct small denticles mesially; inner/anterior face smooth ventrally, pubescent mesially and dorsally; outer/posterior face with lower margin defined by irregular low tubercles, tubercles flattening and coalescing into low reticulations mesially before strengthening as tubercles dorsally, hairs present on tubercles; distoventral corner produced as thickened subquadrate knob at condyle; dorsal ridge tuberculate, hairs present; outer distal edge at carpus produced with irregular rounded teeth; inner distal edge pilose/pubescent with sparse irregular denticles; distal face irregular with few small distinct denticles. Carpus outer face with widely spaced longitudinal lines of irregular tubercles, surface smooth between tubercles; dorsal edge tuberculate; distal corner produced as flattened dentate tooth; distal edge of upper/inner face with 4 strong blunt teeth, largest ventral. Propodus (Fig. 6A) inner face smooth, with carina running to tip of fixed finger; carina irregular or tuberculate on palm, 1 or 2 denticles over proximal end; manus lower edge crenate and pilose/pubescent to base of fixed finger (some specimens having pubescence on inner face of dorsal crest at distal tooth as well); dorsal crest with 3 strong irregular teeth, proximal widest; outer face of teeth with additional cusps or tubercles (tubercles associated with distal tooth sometimes filling gap between crest and first tubercle row); outer face with 8 (including ventral but not dorsal edge) widely spaced longitudinal rows of large protruding subcapitate tubercles; dorsal rows irregular; top 2 rows angling down distally to cleft of fingers; third row short (3 large tubercles, 1 or 2 small) extending distally only to middle of manus; fourth and fifth rows continuing onto fixed finger, fourth as row and fifth as crenulate ridge; sixth row stopping short of fixed finger, seventh row sometimes somewhat coalesced, continuing onto fixed finger as crenulate ridge; lower margin [row 8] with 7 tubercles plus longer thickened proximal corner, 2 ridges continuing onto fixed finger from base of distalmost tubercle. Dactylus proximal half of dorsal edge with 5 or 6 evenly spaced denticles; distal half smooth; inner face smooth, outer face with 2 well-spaced rows of tubercles, tubercles fading distally; dorsal row appressed to denticles of dorsal edge; ventral row approximately two-thirds down face; 6 dactylar teeth, fitting closely between those of fixed finger; tip semicorneous.

Second Pereiopod.—Coxa with ventral face bare; posterior face with patch of pubescence; dorsal and anterodistal edge pilose (some specimens with scattered setae only). Merus surface smooth; dorsal edge carinate, weakly and irregularly crenulate, with sparse setae; posterior face with longitudinal row of obsolescent tubercles dorsally, tubercles with 1 or 2 setae each. Posteroventral and anteroventral margins somewhat sinuous, anteroventral edge more pronounced, uneven, carinate; posteroventral edge less pronounced, obsolescently crenulate; ventral face

smooth; anterior face smooth. Carpus with anterodorsal edge carinate, uneven, distal corner high; dorsal/extensor face smooth (or slightly irregular), with very faint longitudinal row of small obsolescent tubercles; posterodorsal edge uneven, ending as blunt denticle over propodal condyle; posterior face smooth, leading edge smooth; posteroventral edge smooth, carinate, flared distally; ventral face smooth, distal margin with 1 or 2 faint denticles mesially (sometimes indiscernible); anteroventral edge smooth. Propodus anterodorsal edge faintly crenulate, carinate, higher proximally; dorsal face smooth, concave transversely; posterodorsal edge uneven, slightly carinate; posterior face with 2 uneven indistinct longitudinal ridges; face between rows with shallow corrosions; anteroventral and posteroventral edges straight, smooth carinate; ventral face smooth, transversely concave; anterior face with faint longitudinal row of small indistinct obsolescent denticles, largest proximal. Dactylus anterodorsal and posterodorsal edges low, straight, nearly smooth; posterior face with longitudinal ridge, ridge slightly less pronounced than dorsal edges, ridge flanked by row of small corrosions on each side; posteroventral edge thick, fairly straight distally, curved proximally, outward curve short low smooth not flared; ventral face with few corrosions along edges; anteroventral edge thick straight; anterior face similar to posterior face but median longitudinal ridge more dorsal; tip sharp corneous; dactylar velvet tan, lighter than tip, extent short, less than 30% total noncorneous length, dorsal extent slightly greater than ventral, medial extent about half dorsal extent, rounded or squared on posterior face, V-shaped on anterior face.

Third Pereiopod.—Similar to second.

Fourth Pereiopod.—Similar to second except: merus dorsal edge nearly smooth, few setae proximally, longitudinal line of tubercles on posterior face vestigial or lacking; carpus with convex subcristate anteroventral edge; posterodorsal edge obsolescent; posteroventral edge highly carinate and flared distally; posterior face of propodus wide, nearly subquadrate.

Fifth Pereiopod (Fig. 6B).—Coxa with small corrosions; anterodistal margin pilose with plumose setae. Basischium uneven. Merus with convex, smooth thin subcristate dorsal edge; posterior face smooth with sparse setae proximodorsally; posteroventral edge straight or slightly convex, smooth (or slightly irregular) thin cristate; anteroventral edge uneven concave, proximal corner produced as flattened blunt tooth. Carpus with smooth cristate anterodorsal edge; posterodorsal edge absent; posterior face smooth; posteroventral edge not much produced; anteroventral edge rounded; anterior face smooth. Propodus with subquadrate posterior face; face smooth except for few shallow pits; posteroventral edge smooth straight compressed; anteroventral edge vestigial proximally, lacking distally; anterior face smooth except for few corrosions; anterodorsal edge smooth, cristate; posterodorsal edge weaker, obsolescent distally. Dactylus anterodorsal and posterodorsal edges thick; dorsal face reduced to groove with corrosions; posterior face smooth except for corrosions; posteroventral edge thick to corneous tip, sinusoidal proximally, straightening distally, outward curve shallow, not flared; anteroventral edge straight obsolescent subordinate; tip sharp corneous; velvet extending approximately one-third noncorneous length and less than 1.5 times length of corneous tip dorsally; ventral extent about three-fourths dorsal extent; medial extent irregular and about one-half dorsal extent on posterior face, V-shaped and ≤dorsal extent on anterior face.

Male Pleopods.—First pleopods extending to locking tubercles on sternum; second pleopods reaching beyond tubercles to or slightly past imaginary point where margin of first sternite crosses edge of abdominal furrow; pleopods crossing once and meeting or almost crossing again at tip.

Juveniles.—Similar to adults except for the following: edges on juvenile pereiopodal segments tending to be more highly defined and carinate; tubercles on manus of chelipeds large but not subcapitate, rows appressed, not widely spaced; small juveniles with only 5 or 6 deep pits on merus of third maxilliped.

Measurements.—Largest: Male (AHF 203–05) CW 61.4 mm, CL with rostrum 46.4 mm, rostrum 3.1 mm (back of orbits forward). Female (AHF 772–38) CW 50.6 mm, CL with rostrum 39.6 mm, rostrum 2.6 mm. Smallest mature female CW 33.5 mm. Smallest ovigerous female CW 37.7 mm.

Range.—Cocos Island, and mouth of Gulf of Nicoya, Costa Rica.

Depth.—57–219 m.

Habitat.—Sand, rocks, coralline and shell rubble.

Remarks.—These specimens have been compared with the holotypes of *O. sona* Garth, 1940, *O. galapagensis* Rathbun, 1935, and *O. levis* Rathbun, 1898, as well as with specimens of *O. lata* Faxon, 1893 (homeotype, *Zaca* Station 184, D2, Manzanillo, Mexico; see Garth, 1966), and *O. acuta* Stimpson, 1871b (AHF 959–39; AHF 959–39 CN221; AHF 960–39).

Although specimens from Cocos have been in the Hancock collections from 1938 (as *O. lata*), and from 1973 (as *O. levis*), these records do not seem to have been published. It is surprising that this species went unnoticed, since we were unable to convincingly identify it using the key and plates in Rathbun (1925), and it did not fit with any of the more recently described eastern Pacific species. Museum labels indicate that Garth (unpublished) identified specimens as both *O. lata* (1938 specimens) and *O. levis* (1973 specimens); Haig (unpublished) also identified 1973 specimens as *O. levis,* and Williams (unpublished) (who lacked material of many of the eastern Pacific species) identified others as *O. sona* (those listed in Moran and Dittel, 1993). In reality, the new species has more characters in common with *O. lata* and *O. levis* than with the other species of *Osachila* examined, but which of these two may be its closest relative is uncertain. Length and orientation of the second pleopods of *O. kaiserae* (Fig. 7) seem to be intermediate between those of *O. lata* (whose second pleopods do not reach the first sternite, and do not cross), and of *O. levis* (which are relatively longer and cross much more at the tip) (Zimmerman and Martin, unpublished data).

Specimens (UCR 1609, 1610, and 1611) collected by J. M. Montoya off Chatham Bay, although listed as *O. sona* in Moran and Dittel (1993), almost certainly belong to the proposed species, since they were collected from the same area as, and only one month later (in 1992) than several of our specimens (e.g., LACM 92–18.3–5, LACM 92–19.1, LACM 92–29.1–3, LACM 92–30.3–5). The male and female specimens (USNM 264617) seen by one of us (TLZ) that were originally identified as *O. sona* were presumably collected with the LACM specimens collected on the same date, since the collector, J. M. Montoya, was onboard ship with K. L. Kaiser during this period.

Osachila kaiserae at first seemed to be a Cocos Island endemic. However, after examining all specimens of *Osachila* in the LACM collections, we are convinced that one small individual (9.1 mm CW), collected from mainland Costa Rica, belongs to this species. It would be unwise to base any biogeographic hypothesis on relative abundance or frequency of occurrence. Therefore, we will say only that *Osachila kaiserae* is the only species of *Osachila* to be found on Cocos, and the reason for its appearance in mainland waters, whether due to chance dispersal from Cocos, or as a part of an established historical but as yet unseen population, must be left to conjecture.

Etymology.—The new species is named for Kirstie L. Kaiser, collector and donator to the LACM of many specimens from Cocos Island and other eastern Pacific locations.

Discussion

The crab species in the families Leucosiidae, Calappidae, and Parthenopidae generally make up a small percentage of the total number of brachyuran species within a faunal assemblage. This percentage seems to be fairly consistent (10–18%). Hertlein (1963) reported three species from Cocos, *Calappa convexa, Thyrolambrus glasselli* (=*Thyrolambrus verrucibrachium,* new species), and *Parthenope exilipes.* Moran and Dittel (1993) added another, *Osachila sona* (=*Osachila kaiserae,* new species). This amounts to about 9.5% of the island's total number of brachyuran species, which is slightly lower, but comparable to the entire eastern Pacific (450 species, 20 leucosiids, 15 calappids, 18 parthenopids = 11.8%; Hendrickx, 1995a), and other eastern Pacific oceanic islands (Revillagigedos: Clarion 1L, 2C, 2P = 11.1%; Socorro 1L, 1C, 5P = 18.4%; combined 2L, 2C, 6P 16.4%; Garth, 1992a; Galapagos: 5L, 3C, 8P = 13.3%; Garth, 1991) except for Clipperton (0L, 1C, 0P = 3%; Garth, 1965). Therefore, it may be possible to use these crabs as a rough estimate of the total number of brachyuran species.

The increase in the number of known Cocos leucosiid + calappid + parthenopid spe-

cies from 4 to 10 (1L, 3C, 6P) would indicate that the entire number of brachyuran species from the collections at hand might be somewhere in the neighborhood of 55–105 species. This would be more than either Clarion (45 spp.) or Socorro (38 spp.), both of comparable size to Cocos. It would approach the total number of species recorded so far from the Galapagos (120 spp.) (consisting of more than 13 islands, each ≥ the size of Cocos). This number is impressive when one considers that the windward side of Cocos has not been extensively collected. However, it may not be surprising when one considers that Cocos is closer to the mainland than the other islands, and is situated off the center rather than on the edges of the tropical Panamic and Mexican faunal regions as in the case of the other islands.

The islands of the Galapagos do not seem to be a major source of endemic brachyuran species for Cocos, as one might expect from their proximity and the high number of galapagean endemics (26 species) (based on Garth, 1986; 1991; Guinot and Iliffe, 1990; and Garth and Iliffe, 1992). Even though 29 of 42 Cocos species (69%) occur in both areas, only one is shared exclusively (*Euprognatha granulata* Faxon, 1893) (see Garth, 1991). Surprisingly, even though Cocos shares fewer species with the Revillagigedos (23 of 42 = 55%) this study has found two species (*Ebalia clarionensis* and *Thyrolambrus verrucibrachium*) exclusive to these widely separated islands. The presence of *Ebalia hancocki* and the cyclodorippid crab *Deilocerus laminatus* (Rathbun, 1935) in both the Galapagos and Revillagigedos would lead us to expect that they may eventually be found at Cocos. The distance between the Revillagigedos (or Clipperton) and the Galapagos seems too great for larval transport between the two areas.

The idea that the brachyuran faunas of the islands of the tropical eastern Pacific are linked in some way as proposed by Garth (1991) is supported here. In addition, the pattern seen with the *garthi* form of *Cryptosoma bairdii* would suggest either that isolation and genetic differentiation is occurring in southern populations (i.e., the Bay of Panama, Cocos, or the Galapagos), with subsequent colonization to the north, or that isolation is occurring in the Revillagigedos with subsequent transport to the southeast. General current patterns (Wyrtki, 1965) do not provide a strong basis for either hypothesis. It seems unlikely, from the current patterns, that there is a direct route from the Revillagigedos or Clipperton to the Galapagos Islands. Either way, Cocos may be serving as the cross roads for the dispersal of insular species.

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